Southern Steelhead Resources Evaluation

Identifying Promising Locations for Steelhead Restoration in Watersheds South of the Golden Gate

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Center for Ecosystem Management and Restoration

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Executive Summary

While populations of steelhead and rainbow trout (*Oncorhynchus mykiss*) continue to occur in the majority of the watersheds in the historical range south of the Golden Gate, the distribution of the sea-run (anadromous) form of the species has contracted substantially over time. Abundance, as measured in the average number of spawning individuals (i.e., run size), appears to be a fraction of historical values in most watersheds in the region. Reduced habitat availability due to creation of passage barriers and habitat degradation are the likeliest causes of steelhead's decline.

Ongoing conservation efforts are producing inspiring results throughout the region south of San Francisco, with many local, regional, state, and federal agencies cooperating with non-governmental organizations and others to address passage and habitat quality issues in steelhead streams. Nevertheless, the continuing perilous condition of steelhead suggests that a well-reasoned, comprehensive program to protect the best steelhead resources and alleviate continuing threats be developed as quickly as possible. This report responds to this need, recognizing limitations on funding, expertise, political will, and agency and non-governmental organization staff time, to identify a vital set of restoration actions in the regionally significant watersheds and streams.

This study analyzes information on rearing habitat to identify these regionally significant, or "anchor," watersheds. Using a systematic approach we determine which watersheds offer the greatest potential for producing steelhead smolts, including oversummering opportunities and conditions favoring high growth rates. Within these anchor watersheds we then identify the "essential" streams or reaches that offer the best habitat resources. We suggest that near-term restoration actions should protect and enhance cold-water habitat with adequate food supply in the essential streams, and should connect them with the ocean during key migration and movement periods.

We designated 25 anchor watersheds out of the 142 evaluated (18 percent). This figure represents about 26 percent of the 96 watersheds with evidence of recent steelhead use or other compelling reasons for consideration. Although the anchor watersheds contain almost 400 mainstem and tributary streams that are used by steelhead/rainbow trout, there are 88 essential streams that on a county-by-county basis contain between 52 and 86 percent of the available rearing habitat. These essential streams, which account for the majority of the available rearing habitat south of the Golden Gate, should be the near-term focus of steelhead restoration efforts in the region.

Across the study area, an additional 17 watersheds are considered non-anchor important watersheds. As described in the report, these watersheds are in pristine condition, have particularly proactive stakeholder groups, extend the range of the species, or otherwise merit special attention.

It is important to note that the amount of habitat in anchor watersheds and essential streams varies significantly across the region, as would be expected given the large climatic gradient that exists in the study area from the wetter north to the drier south. Given that the southern-most anchor watersheds represent the extreme southern extent of the species'

range, it is not surprising to find lesser amounts of rearing habitat in anchor watersheds of Los Angeles, Orange, and San Diego counties than in the anchor watersheds of San Mateo and Santa Cruz counties. Our approach identifies anchor watersheds by comparing available habitat with habitat in other proximate watersheds rather than comparing potential productivity between geographically (and climatically) distinct portions of the study area. We believe the steelhead in the southern anchor watersheds will require multiple "refugia" to withstand environmental variability in the future, giving each watershed capable of supporting reproduction and rearing special significance.

For the anchor watersheds, essential streams, and other important watersheds we used available information to characterize factors limiting steelhead production, the status of ongoing conservation efforts, and future restoration needs. Consistent with our experience in the San Francisco Estuary, the Eel River, and elsewhere, we found important restoration projects centered on three basic areas: passage barriers, instream flow provision for all phases of the steelhead life history, and channel and riparian enhancement. Our study placed particular emphasis on barrier removals and modifications to provide a scientific basis for capital spending priorities. In many streams the severity of existing barriers has not been determined, and in these instances we could not prioritize these projects. We encourage spending in the anchor watersheds to apply the standardized, powerful assessment tools currently available to the remaining un-surveyed barriers.

There are several high-profile dam removal projects in various stages of planning in the study area. In particular, San Clemente Dam (Carmel River), Matilija Dam (Ventura River), and Rindge Dam (Malibu Creek), represent major dam removal projects that are required to allow access to the bulk of the historical habitat. Important barrier modifications also should be pursued in the tributaries of Malibu Creek. Ongoing efforts to improve passage at the Vern Freeman diversion facility on the Santa Clara River, combined with passage projects in Santa Paula and Sespe creeks, have the potential to increase production in this important system. An unusual passage project affecting the sandbar at the mouth of San Mateo Creek (San Diego County) may be necessary to create migration opportunities.

Regarding flows, we recommend that a comprehensive program to connect high quality spawning and rearing habitats within the anchor watersheds be undertaken. Rearing steelhead may migrate away from habitats of declining quality (*e.g.*, due to declining spring baseflow) and require hydrologic connectivity between these areas and other habitat refugia for survival. Several anchor watersheds have long migration corridors between suitable spawning and rearing habitat and the ocean where existing conditions appear to limit potential production. The Carmel, Santa Maria, Ventura, and Santa Clara rivers are important examples of watersheds suffering from poor passage conditions due to flow considerations in the lower watershed. More commonly, habitat quality is reduced by the cumulative effect of water diversions. Instream flows are being analyzed in a number of important watersheds of the study area including San Gregorio Creek, Pajaro River tributaries, and the Big Sur River. Significant gaging, analysis, and modification of diversion practices will be necessary in many of the essential streams to allow for successful restoration.

Channel and riparian work recommended in this report also must be thoughtfully developed. In particular, we noted a lack of applied geomorphic studies throughout the region that identify and rank erosion control and other channel improvement projects. In these instances we were only able to recommend further study. Channel and riparian enhancement opportunities also are severely limited by access to private property and by stream setback policy and enforcement. While it is beyond the scope of the current report to propose policy changes, we acknowledge that anchor watershed restoration cannot be completed without the cooperation of local jurisdictions and private landowners in protecting and restoring stream corridors.

Several anchor watersheds would benefit from establishing a public process that engages local stakeholders and other interested parties in defining and advancing restoration priorities. In particular, restoration in the Salinas River in its tributary Arroyo Seco would benefit from the opportunity for all stakeholders to consider passage, flows, and other habitat quality issues in a proactive and integrated manner. This also appears to be the case in the Little Sur River in Monterey County, Arroyo de la Cruz and San Carpoforo Creek in San Luis Obispo County, Jalama Creek in Santa Barbara County, and San Mateo Creek in San Diego County. The experiences of those involved in salmonid restoration in coastal California and beyond clearly indicate the necessity of stakeholder involvement for successfully implementing the often complex, costly, and time-consuming projects that are required for watershed restoration.

Estimating costs for the various projects and programs recommended to rehabilitate the streams of the anchor watersheds was beyond the scope of this study. In most cases, necessary information is lacking and must be developed through conceptual design efforts for specific barrier modification or stream enhancement projects. Implementing the actions envisioned here (and to monitor and adaptively manage the associated, long-term restoration processes) will require a significant and ongoing commitment of financial resources. We believe the most promising and equitable funding approach is to establish a fee for the use of ecological services provided by streams (*e.g.*, water supply, public trust resources, stormwater discharge, *etc.*). This approach could generate a stable revenue source commensurate with the restoration tasks before us. Ideally, funds would be administered by a local conservation district accountable to the ratepayers. Such a program has the potential to raise stakeholder awareness of impacts to streams (decreasing future restoration costs), increase public involvement, and accomplish watershed-wide goals such as maintaining adequate flows and intact stream corridors.

Finally, we hope that the current study is helpful in advancing steelhead restoration efforts on a finite numbers of actions in the most important central and southern California coastal watersheds. Achieving consensus on priorities is key to achieving habitat conditions that show, with adequate monitoring, a biological response that can be used to build further support. Restored steelhead runs can inspire the public to protect our waterways, and will provide a valuable focus for ecosystem-scale planning and management.

Introduction

This report is the result of a study comprising the third and final stage of the Southern Steelhead Resources Project, or SSRP. In the first phase, we collected available information concerning the distribution of steelhead trout (*Oncorhynchus mykiss*) in the area of coastal California south of the Golden Gate. The study entailed collecting and analyzing thousands of references and interviewing dozens of people with expertise about steelhead in almost 700 streams contained in nearly 150 watersheds comprising the study area[1] (Figure 1). The second phase evaluated the references and produced a convenient and authoritative reference for planners, resource agency staff, watershed group members, and others with professional responsibility for, or interest in, the issue of conserving and restoring steelhead (Becker and Reining 2008).

In the process of researching the distribution report, staff at the Center for Ecosystem Management and Restoration (CEMAR) also collected information about stream habitat and the various factors affecting steelhead populations of the southern California coast. The current study examines this habitat-related information to make conclusions regarding the most important restoration opportunities in the various watersheds and streams of the region. The effort was undertaken specifically to provide the California Ocean Protection Council (OPC) with a guidance document useful in determining steelhead conservation priorities south of the San Francisco Bay. It should be noted that this project builds from earlier work supported by the California State Coastal Conservancy and that the report also is intended to help inform decision-making by Conservancy staff.

Activities that benefit steelhead such as modifying fish passage barriers, reducing sedimentation, and providing instream flows for habitat are being undertaken throughout the region. A variety of stakeholders including water and flood control districts, parks, cities, counties and regional resource agencies, watershed groups, the Department of Fish and Game (DFG), the National Marine Fisheries Service (NMFS), and others are pursuing many important projects and studies through a set of diverse funding sources. The Ocean Protection Council and the Conservancy receive a large number of requests for support of such stream restoration-related efforts, and the potential benefit to steelhead is cited regularly as a rationale for funding. With limited funds available for restoration, OPC staff determined that an analysis of steelhead restoration opportunities in the south coast region was likely to allow for more efficient expenditures toward the goal of steelhead conservation and restoration.

This study was conducted similarly to CEMAR's analysis of restoration opportunities in watersheds tributary to the San Francisco Estuary (Becker *et al.* 2007) in that we created a geographic information system (GIS) database for purposes of depicting habitat data and comparing watershed and stream habitat resources quantitatively.[2] We reviewed thousands of references for information relevant to steelhead rearing habitat and developed additional materials through interviews with biologists and others with knowledge about steelhead

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[1] A companion DVD also has been produced that contains electronic versions of the numerous documents obtained from various offices of the Department of Fish and Game (DFG) that relate to steelhead and steelhead habitat. The DVD may be obtained by contacting CEMAR at (510) 420-4565.

[2] The *San Francisco Estuary Watersheds Evaluation* may be obtained by contacting CEMAR.

resources. This intuitive approach relies on a combination of empirical data and professional judgment to identify critical steelhead resources in the region.

After populating the GIS database, we screened watersheds using two criteria to identify and characterize steelhead resources (*i.e.*, populations and habitat) in the region. We then assigned watersheds to one of three categories based on the estimated habitat, measured in stream miles, supporting the anadromous life history form of *O. mykiss* populations. Watersheds containing the most extensive habitat resources are deemed “anchor watersheds,” and are described further in terms of 1) steelhead resources, 2) causes of population decline, 3) ongoing conservation activities, and 4) future restoration actions necessary to conserve and restore steelhead habitat. Our analysis also enumerates a number of “essential streams” within the anchor watersheds, or streams that stand out for their significant potential contribution to the regional steelhead population.

A second category of watersheds consists of "other important" habitat resources. Watersheds assigned to this category do not offer the extensive production potential of the anchor watersheds but are notable for reasons explained in the text. Substantial stakeholder support (making restoration actions likely to occur), pristine habitat conditions, and high degrees of protected lands were typical reasons for deeming other watersheds important. The last category consists of non-“anchor”, non-“other important” watersheds. These are discussed in the Appendix.

This report identifies a set of capital projects that will expand and improve habitat in the anchor watersheds and essential streams most directly. These projects, together with various new capacity-building efforts, studies, and policy implementations, may be considered critical elements of a regional restoration strategy aimed at conserving steelhead resources in the anchor watersheds and in a second group of other notable watersheds.

The approach used in this study stresses the importance of conserving and restoring watersheds with larger amounts of habitat based on our understanding that they offer the greatest potential for producing steelhead smolts. It may be argued that stream restoration actions in watersheds with lesser steelhead resources merit priority based on cost efficiency, public education value, the presence of other target species or assemblages, or other factors. While we support stream restoration in general, we seek to identify the set of watersheds in which restoration actions are mostly likely to secure and/or increase steelhead production in the near term. This goal appears to correspond with the basis for recovery planning efforts being made by staff at NMFS. As part of the basis for recovery planning, NMFS produced an analysis of the historical population structure of steelhead in coastal stream systems (Bjorkstedt *et al.* 2005). The analysis established “functionally independent populations” amongst the south coast drainages as well as “potentially independent populations.” Watersheds in these categories are typically larger and are deemed capable of supporting steelhead populations with a high likelihood of persisting over 100-year time scales. The NMFS report notes that “dependent” populations (usually located in smaller watersheds) “are not themselves dominant sources of dispersers,” yet serve other roles in maintaining the regional population. Just as NMFS’ steelhead recovery planning places a lesser but important role on “dependent” populations for achieving long-term population viability, the current study de-emphasizes immediate steelhead restoration-related expenditures in non-anchor, typically smaller watersheds while acknowledging the important functions these systems serve, including providing a buffer against catastrophic disturbance and pathways for incremental dispersal. We encourage restoration of such systems, particularly when conducted as part of a regional, prioritized action plan.

Because the geographic area treated in this study is so vast, we sought review of draft descriptions by a large group of people with in-depth understanding of steelhead resources within particular watersheds or larger portions of the south coast. In addition, we solicited comments from individuals with expertise in particular topics with relevance to the study including fish passage engineers, ecologists, and restoration planners. Most importantly, reviewers added information from recent observations and recent developments of restoration activities.

A secondary goal of this report is to stimulate discussion leading to consensus on a science-based, proactive program of steelhead related stream restoration activities with the highest possible degree of return on investment. Focused work in anchor and other watersheds during the next decade has the potential to prevent further decline of the "threatened" and "endangered" steelhead in the region, thus avoiding the fate of coho salmon. The apparent extirpation of coho from watersheds south of the Golden Gate and those tributary to the San Francisco Estuary is due in part to insufficient documentation of coho habitat resources and inadequate efforts to protect them. It is critical that steelhead not be similarly lost for want of awareness.

This report represents a synthesis of the opinions of biologists and other researchers working throughout the last 60 or more years on the problem of maintaining steelhead in south coast streams. As such, it should not be considered as providing definitive evidence that restoration of a particular stream system is more valuable than restoring another by virtue of affecting more habitat resources. Rather, the information provided here consists of the collective "best professional judgment" of those well-suited to make determinations about restoration priorities. Our hope is that the report is helpful in guiding the funding of projects in south coastal watersheds and that its conclusions are consistent with management and recovery planning efforts.[3]

[3] Staff from the California Department of Fish and Game have contributed to this report. However, the report does not constitute current DFG policy or position regarding the assessment, management, or restoration of steelhead in California. Similarly, the report has no relationship to National Marine Fisheries Service recovery planning or other processes, although NMFS staff have provided substantial review and consultation regarding its content.

Figure 1. Study area

Approach and Methods

The overall approach employed in this study involves several assumptions regarding the status of steelhead resources, steelhead ecology, and restoration strategy in assigning priorities to watersheds, streams, and projects. These assumptions are reviewed briefly in the following prior to describing the specific methods we used to evaluate watersheds and streams.

In a comprehensive review of the California coast south of the Golden Gate, Becker and Reining (2008) estimated that about 82 percent (95 of 116) of watersheds with steelhead historically present continued to support the species (*i.e.*, evidence of presence within about 15 years). We believe that the persistence of *O. mykiss* in much of its historical range can mask the status of the anadromous life history form. While maintaining the potential for anadromy, resident rainbow trout are "far less likely to emigrate downstream than anadromous fish" (Hayes *et al.* unpublished manuscript).

Unfortunately, there are very few metrics available for determining the productivity of the steelhead resources of the study area. Our previous study found evidence of recent anadromy in less than 63 percent (73 of 116) of the historical steelhead watersheds, suggesting that a substantial number of systems no longer provide conditions (*e.g.*, passage, high growth rate habitat) necessary for anadromous reproduction. Virtually all of the watersheds where steelhead continue to reproduce show at least anecdotal evidence of severe declines in run size. (Reliable abundance data and population estimates are lacking for most streams of the study area.) Average run size appears to be a small proportion of historical levels (< five percent by many estimates).

This study used rearing habitat related information to identify areas with high potential for steelhead production. It is based on the assumption that restoration that secures these areas from further degradation and improves these habitats will have the greatest immediate effect on maintaining and increasing abundance.[4] In particular, we sought to show the stream reaches, often in upland areas, where juveniles steelhead are likely to encounter high growth rate habitat favorable to smolting and ocean survival. We note that recent research indicates that estuary-reared steelhead comprise a very high proportion of returning adults in systems with estuarine and upland rearing areas. Thus estuaries may serve as "critical nursery habitat, and steelhead population persistence in southern margin ecosystems may well depend upon healthy estuaries" (Bond *et al.* 2008, p. 2242). While we considered the existence of estuarine rearing areas in our assessment of important steelhead resources, we did not find sufficient data across the study area to be able to add corresponding values for weighted estuarine habitat area to our rearing habitat estimates.

We initially considered all watersheds with reliable evidence of historical use by steelhead as candidate "anchor watersheds" (*i.e.*, most important). On a county-by-county basis, we then screened watersheds for recent observations of reproducing *O. mykiss* populations (*e.g.*, spawning, multiple age classes). Watersheds that had such observations then were evaluated

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[4] See Doppelt *et al.* 1993,. pp. 45-56.

for the extent of rearing habitat they contained. Additional detail regarding the screening and evaluation criteria and the method of application are provided below.

1. Reproducing *O. mykiss* populations

This characteristic indicates the presence of functioning spawning and rearing habitat in a watershed over time. Evaluation under this criterion was based largely on information contained in Becker and Reining (2008). In some instances, we made additional inquiries to supplement the record concerning the location of reproducing *O. mykiss* populations. For a watershed to advance in the evaluation, it had to have evidence of *O. mykiss* occurring during the last ten years. A small number of watersheds without recent evidence of reproducing *O. mykiss* populations also were advanced in the evaluation based on evidence of historical habitat suitability. This conservative approach allowed for considering watersheds where recolonization could occur or where the lack of recent surveys could result in a false negative interpretation of our criterion.

2. Available *O. mykiss* rearing habitat

We reviewed information in Becker and Reining (2008), its source materials, and a substantial number of additional sources to determine the stream reaches with suitable *O. mykiss* rearing habitat. We did not attempt to differentiate between habitat used exclusively by resident rainbow trout or by anadromous steelhead, as information regarding the life history form of *O. mykiss* populations in southern coastal watersheds is not well developed.[5] Rather, habitat was considered suitable if sufficient observational or other information existed to indicate that it supported rearing or could support rearing given reasonably anticipated management changes.

The amount of information available and its quality varied considerably amongst watersheds, and we made every effort short of conducting additional field work to complete the record regarding this criterion. It should be noted that habitat estimates do not include weighting for the quality of the habitat and resulting variable juvenile salmonid growth rates. Also, we did not estimate habitat available in different water year types. Our approach provides screening level estimates of rearing habitat in average water years as data do not exist on which to base more elaborate evaluations. In some cases, we used professional judgment to "standardize" information. For example, various habitat assessment methods relied on various qualitative and quantitative ranking systems, and we attempted to include habitat most closely associated with the descriptor "good" in our data set. While we attempted to be consistent in our interpretation of the available information, substantial uncertainty is inherent in this analysis due to the varying methods and descriptive approaches used by biologists to classify habitat.

Three principal types of information were considered in our analysis:

1. Descriptions of habitat. Relevant documents were reviewed for descriptions of locations of suitable *O. mykiss* rearing habitat in streams of the study area. Where we found references

[5] Ongoing research in a small number of watersheds (notably Scott Creek in Santa Cruz County) is allowing detailed understanding of differentiation between resident trout and steelhead populations that co-occur.

to "good" or "suitable" rearing habitat, we noted its location. We also noted statements indicating that stream reaches regularly support steelhead or rainbow trout. Reaches described as containing "marginal" or "poor" habitat were not included.

2. Information from maps. Maps compiled by other researchers often provided useful information for determining *O. mykiss* habitat. We included as rearing habitat stream reaches having medium to high steelhead density on maps indicating sampling results, and areas designated as "rearing habitat" or "nursery habitat" in other reliable sources.

3. Observations of *O. mykiss*. We also reviewed *O. mykiss* sampling results and other reports of observations, and used the presence of juvenile fish in a specific area to indicate the existence of rearing habitat. Many of these observations used were summarized in Becker and Reining (2008).

The watersheds considered under this criterion are known to have existing reproducing populations of *O. mykiss*. However, recent habitat and *O. mykiss* distribution information was not available for some streams, where we relied on older information. Historical information was used in several instances to establish the extent of suitable rearing habitat in a given stream.

Steelhead habitat was mapped using ArcGIS, allowing us to estimate habitat quantities for the study area streams. Large variations in the quality of the data reviewed required us to apply professional judgment in many cases to produce reasonable estimates of the location and extent of habitat. Specifically, we employed the following techniques:

1. Where habitat was illustrated on a map or described in a supporting document, we transferred the upper and lower extents to our ArcGIS database to calculate habitat in stream miles.

2. In survey reports, two sample sites containing juvenile *O. mykiss* were said to bound a suitable habitat area when the distance was less than one mile and the intermediate reach was not highly urbanized.

3. Under certain circumstances, areas downstream from single sampling sites containing juvenile *O. mykiss* were considered to provide habitat. Specifically, non-urbanized areas downstream from known areas of suitable habitat were included unless information regarding passage barriers, land use, or stream features such as bed material suggested otherwise.

4. When we encountered *O. mykiss* presence information without corresponding habitat information we assumed a suitable habitat reach length of 0.5 miles centered on the observation location.

5. The presence of juvenile *O. mykiss* upstream from partial barriers was interpreted to indicate potentially available habitat even when anadromous ancestry could not be established.

6. Upstream limits of anadromy were determined by reviewing information regarding total

barriers and by the method described in Ross Taylor & Associates (2006). This approach considers the upper limit of anadromy to be where the channel slope exceeds eight percent slope for 300 feet.

Habitat mapping and length estimates relied on the 1:100000 scale stream-based routed hydrography shapefile produced by the California Department of Fish and Game (and available via the CalFish website and other sources). We sought estimates in stream miles, leading us to use this dataset (and not the NHD or other datasets), and to convert values from feet to miles. The "route identify" tool in ArcGIS was used to locate the points of upper and lower habitat extent. A route table was produced using these points wherein the lower measure was subtracted from the upper measure. Values were converted to stream miles and rounded to the nearest one tenth of a mile. The route table was used to create the linear referenced shapefile displayed on our maps.

We then identified total barriers to fish passage using published information and, in some cases, interviews and professional judgment. Habitat downstream from total passage barriers was retained in our calculations as "available," although in some instances available rearing habitat may be overestimated due to the presence of partial barriers that prevent access under some conditions. Our analysis assumes that such barriers may be modified in important steelhead streams. We determined the likelihood of barrier modification by evaluating factors such as the existence of plans for modification, statements made by representatives of barrier-owning institutions, and fiscal and institutional hurdles. Most importantly, large, functioning water supply dams without an existing removal planning process in place were considered unlikely to be modified. This step resulted in estimates of habitat available to anadromous steelhead.

Our analysis discounts the value of streams with reproducing resident rainbow trout and substantial rearing habitat upstream from total barriers unlikely to be modified for passage. The approach should be viewed as reflecting current agency guidance that discourages long-term trap and haul programs or similar efforts to use habitat upstream from total barriers toward steelhead recovery rather than an endorsement of this policy. We support protecting these "above barrier" populations and have included as a separate chapter a discussion of their potentially important role in steelhead restoration planning (Chapter 10).

It should be noted that some rearing habitat counted in our analysis may not contribute to steelhead production due to lack of outmigration flows. We do not exclude these areas on the basis that flows may be provided in the future (through re-operation of water supply facilities, channel modification, or other method) and because we find insufficient evidence regarding outmigration success to discriminate between rearing areas in the region for their relative contribution to the steelhead population.

The values for available habitat were compared within county groups to evaluate anchor watershed designation and to inform selection of a group of non-anchor important watersheds. Watersheds with the most extensive available habitat (*i.e.*, anchor watersheds) and non-anchor important watersheds received additional review and characterization.

Within the anchor watersheds we identified "essential streams," or streams with greatest amount of available *O. mykiss* rearing habitat. This process relied on a comparison of available habitat in the various anchor watershed mainstems and tributaries. We tabulated available habitat values in anchor watershed streams; the group of mainstem and tributaries with the most extensive habitat were deemed essential streams. It should be noted that not all tributaries in the anchor watersheds have been considered in this step. We are aware of a small but not insignificant number of streams for which there is evidence of steelhead presence but little or no characterization of habitat. It is beyond the scope of this project to undertake habitat assessments, and therefore some streams have been "missed."

As noted in the introduction, we emphasize that our approach is not intended to discourage restoration activities in non-anchor watersheds or in streams not deemed essential. Rather, we intend to use the available information to focus attention on the relative value of restoration actions in a select number of streams.

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Chapter 1. San Mateo County

According to our review, 22 coastal San Mateo County watersheds were associated with some fisheries related information, of which 18 provided habitat for steelhead historically (Table 1). Of these, 14 are believed to continue to provide spawning and rearing opportunities for *O. mykiss*. However, Purisima Creek does not support anadromy, and was not advanced to a comparison of habitat resources.

Table 1. San Mateo County Watersheds Screening by *O. mykiss* population

Watershed	***O. mykiss* population?**
San Pedro	**Y**
Martini	**Y***
San Vicente	**N**
Denniston	**Y**
Deer	**N**
Frenchmans	**Y**
Pilarcitos	**Y**
Cañada Verde	**N**
Purisima	**Y'**
Lobitos	**Y**
Tunitas	**Y**
San Gregorio	**Y**
Pomponio	**Y**
Pescadero	**Y**
Arroyo de los Frijoles	**N**
Gazos	**Y**
Whitehouse	**Y**
Cascade	**N**
Green Oaks	**N**
Año Nuevo	**Y**
Finney	**N**
Elliot	**N**

Notes:
*Insufficient information to determine habitat.
'A waterfall near the mouth of the creek precludes anadromy.

Available data and supplemental information were used to estimate rearing habitat in watersheds hosting *O. mykiss* populations, as shown in Table 2. The results indicate that the San Gregorio and Pescadero creeks systems (Figure 3) contain the vast majority of the county's steelhead resources.

Table 2. San Mateo County Watersheds Screening by Habitat

Watershed	Area (sq.mi.)	Habitat (stream miles) Total[1]	Available[2]
San Pedro	7.4	3.9	3.9
Denniston	3.8	2.8	0.8
Frenchmans	4.2	2.3	2.3
Pilarcitos	28.7	11.8	7.7
Lobitos	4.0	2.5	0.6
Tunitas	11.6	4.0	4.0
San Gregorio	52.2	32.8	32.8
Pomponio	7.1	1.7	1.7
Pescadero	81.0	50.7	49.3
Gazos	11.6	6.4	6.4
Whitehouse	4.3	2.9	2.9
Año Nuevo	2.4	0.8	0.8

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

To further refine the areas containing suitable and available rearing habitat, mainstems and tributaries in the San Gregorio and Pescadero creeks watersheds were examined, as shown in Table 3. In the two San Mateo County anchor watersheds, we identified eight streams (of 35 candidates) that appear to account for the majority of the high value rearing habitat. Various aspects of steelhead habitat within the anchor watersheds are described below.

Table 3. San Mateo County Anchor Watershed Habitat by Stream

Watershed	Mainstem/Tributary	Habitat (stream miles) Total[1]	Available[2]
San Gregorio		**32.8**	**32.8**
	San Gregorio	8.6	8.6
	Coyote	0	0
	Clear	0	0
	El Corte de Madera	4.5	4.5
	Bogess	4.9	4.9
	Kingston	*	*
	Harrington	1.7	1.7
	La Honda	4.9	4.9
	Woodhams	0	0
	Langley	1.5	1.5
	Woodruff	1.5	1.5
	Alpine	5.3	5.3
	Mindego	2.7	2.7
	Rodgers Gulch	--	--

Table 3, continued

Watershed	Mainstem/Tributary	Habitat (stream miles) Total[1]	Available[2]
Pescadero		**50.7**	**49.3**
	Pescadero	25.6	25.6
	Butano	3.0	3.0
	Little Butano	*	*
	South Fork Butano	*	*
	Bradley	1.9	1.9
	Shaw Gulch	1.0	0
	Tahana Gulch	--	--
	Honsinger	0.9	0.9
	Weeks	0.1	0.1
	McCormick	0.2	0.2
	Hoffman	0	0
	Tarwater	2.2	2.2
	Peters	4.9	4.9
	Evans	0	0.4
	Bear	0	0
	Lambert	1.0	1.0
	Fall	0	0
	Slate	1.3	1.3
	Oil	5.2	5.2
	Little Boulder	0.8	0.8
	Waterman	2.0	2.0

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers
*Supports a reproducing *O. mykiss* population above natural limit of anadromy
--Insufficient information to determine habitat

Anchor Watersheds

San Gregorio Creek

Steelhead Resources

San Gregorio Creek was one of four "A-1" streams noted in San Mateo County in a 1912 DFG letter. Steelhead run size estimates from the 1960s vary between 300 and 1,000 individuals (DFG 1962a). In 1975, the system was deemed "one of the more important salmonid spawning and nursery resources along the coast of central California" (DFG 1975).

The majority of the watershed's rearing habitat has been documented in mainstem San Gregorio Creek, and in Bogess, La Honda and Alpine creeks (Table 3). El Corte de Madera Creek also offers extensive habitat resources, as well as substantially shorter migration distance to available spawning habitat than upstream tributaries. Additionally, researchers note, "…a substantial portion of potential smolt production is in the relatively large lagoon…" (Smith 1994). A recent watershed management plan for San Gregorio notes, "Based on CDFG sampling in 2005 and 2006, steelhead rearing in the lagoon consisted primarily both age 0+ and age 1+ (>90%) and occurred for up to approximately eight months…. A variety of freshwater life histories were identified (Stillwater Sciences *et al.* 2010, p. 105). The plan goes on to state, "Amount and quality of lagoon habitat alleviates the effects of habitat restrictions in the upper watershed during years when the lagoon can form, and limit steelhead production when the lagoon can not [sic] form due to breaching or lack of freshwater" (p. 114). Accordingly, "actions affecting lagoon quality probably have the biggest effect on steelhead production" (Smith 1994).

Causes of Decline

Critical summer flows are likely to be an important factor that limits steelhead production in the creek (DFG 1971). A 2001 letter staff from the Division of Water Rights (DWR) stated, "…our preliminary analysis of water availability in the San Gregorio Creek watershed indicates that collectively, existing approved water demands exceed 50 percent of the estimated average unimpaired flow from October 1 to March 31 at the San Gregorio gage. According to guidelines… diversion of over 10 percent of the average unimpaired flow is likely to cause adverse effects on coho salmon and steelhead trout habitat in San Gregorio Creek" (SWRCB 2001). The watershed is fully adjudicated and there are numerous individuals seeking to obtain water rights.

Lack of summer and winter rearing habitat have been cited as limiting factors in recent reports (DFG 1996a; Stillwater Sciences *et al.* 2010). According to the 2010 watershed management plan, "A natural lack of boulders in some reaches, a lack of [large woody debris], and embeddedness of cobble/boulder substrates by fine sediment are the main causes of limited winter habitat" (Stillwater Sciences *et al.* 2010, p.114). Lack of summer rearing habitat has been attributed to low instream flows, filling in of pools with fine sediment, and lack of cover to control water temperature in rearing pools (DFG 1996a; Stillwater Sciences *et al.* 2010). As noted above, mechanical breaching of the lagoon or lack of freshwater inputs to the closed lagoon can significantly impact the steelhead population.

The San Gregorio watershed is listed as impaired by sediment pursuant to §303(d) of the Clean Water Act. The 2010 watershed management plan notes, "Due to its geology, steep gradients, and tectonic activity, the San Gregorio Creek watershed has the potential for a relatively high fine sediment yield" (Stillwater Sciences *et al.* 2010, p. 57). Anthropogenic sources of sediment have been observed to exert additional pressure on the system. According to the management plan, "Pool filling appears to be occurring from sediment transport from upslope sources and has been noted to reduce available habitat throughout the San Gregorio Creek watershed since the 1970s from logging, agriculture, and urbanization" (Stillwater Sciences *et al.* 2010, p. 110).

A 1985 stream survey of El Corte de Madera Creek noted, "Cattle grazing and logging have been the two major problems which have greatly reduced the amount of salmonid spawning [and rearing] habitat" (DFG 1985a). Cattle impacts were reiterated in a 1996 DFG survey (Hickethier and Miles 1996). Also, erosion of roads and trails in the upper portion of the basin appear to be contributing to high sedimentation rates (NMFS 2001).

La Honda Creek has suffered from historical logging practices, over-appropriation of flows, high sedimentation due to encroachment and poor road maintenance, and water quality impacts from dumping and discharge to the creek (DFG 1962b; DFG 1973; DFG 1985b; DFG 1996a).

Alpine Creek similarly has been impacted by sedimentation and excessive diversion (DFG 1996a; DFG 1997a). The 2010 management plan notes, "Alpine Creek Road parallels much of the creek, and it is likely that landslides and road-maintenance activities contribute fine sediment to the channel" (Stillwater Sciences *et al.* 2010, p.11).

Conservation Activities

The San Gregorio Environmental Research Center (SGERC) and multiple partners are participating in ongoing collaborative restoration planning to develop the San Gregorio Watershed Assessment and Plan, a comprehensive program that includes the scientific assessment of watershed conditions, continuous water quality and stream flow monitoring, and preparation of a watershed management plan. The plan, published in June, 2010, provides an overview of the current state of the watershed's steelhead resources and includes management objectives and restoration recommendations. In addition, the San Gregorio Watershed Information System, an online database that contains a compilation of studies and reports about the watershed, was recently developed.

The San Gregorio Environmental Resource Center and other partners receiving funding from the State Water Resources Control Board succeeded in re-activating the USGS gauging station at Stage Road and purchased equipment to implement continuous monitoring of instream flows and water quality. Funding was obtained to modify a passage barrier at the Alpine Creek fish ladder identified by Ross Taylor & Associates in 2004. Though the project was not implemented due to conflict with the property owner, the funding may be used for restoration in other parts of the watershed.

American Rivers obtained an EPA grant for a project entitled "San Gregorio Creek Watershed - Filling Critical Flow Needs." The goal of this project is to increase water quality and habitat through a non-regulatory approach to healthy river flow while maintaining agricultural productivity.

A joint project by Trout Unlimited and CEMAR began in winter 2009 to install gages in two mainstem locations as well as in tributaries including Alpine and El Corte de Madera creeks. The project also incorporates data from the SGERC-maintained gage in La Honda Creek and the USGS gage in San Gregorio Creek. When sufficient data are collected and analyzed, a stream management plan will be developed that identifies opportunities--such as providing increased storage and altering location and timing of diversion--for purposes of reducing the impact of diversion on dry season habitat quality. The project is being supported the California State Coastal Conservancy with support from American Rivers.

Open space preserves in the San Gregorio watershed provide additional opportunities for steelhead habitat enhancement. The Midpeninsula Regional Open Space District (MROSD) manages preserves within the El Corte de Madera and La Honda Creek sub-basins. The El Corte de Madera Creek Open Space Preserve consists of 2,817 acres in the San Gregorio Creek watershed headwaters and the La Honda Creek Open Space Preserve consists of 5,759 acres within the La Honda Creek, Harrington Creek, and Bogess Creek sub-basins.

The MROSD worked with other agencies to develop a watershed protection program for the Preserve directed toward improving overall watershed condition and functioning and protecting salmonid habitat in the lower San Gregorio watershed by identifying problematic upland sources of erosion and reducing sediment input to the system. Road and trail erosion inventory reports were commissioned by the MROSD for the El Corte de Madera Creek Preserve (Best 2002) and the La Honda Creek Preserve (Best 2007). The reports identify sediment sources, assign priority rankings for treatment, and outline treatment prescriptions. Of the 200 sites inventoried in the El Corte de Madera Creek Preserve, 73 received "moderate" to "high" treatment priority. Of the 157 sites inventoried in the La Honda Creek preserve (including the Driscoll Ranch property), 85 received moderate to high treatment priority, 40 of which were located within the Driscoll Ranch parcel.

Restoration Opportunities

A review of passage barriers in the San Gregorio watershed was conducted using the PAD, supplemented by various references. Key barriers are listed in Table 4 and labeled in Figure 3. Passage barrier modification and other restoration opportunities for essential streams within the San Gregorio watershed are discussed below.

Table 4. San Gregorio Creek Watershed Key Passage Barriers

Barrier ID	Watershed	Stream	Description	Type	Source
82-02	San Gregorio	El Corte de Madera	Bear Gulch Road crossing	Partial	PAD
82-03	San Gregorio	El Corte de Madera	Dam with 2’ step	Partial	PAD
84-01	San Gregorio	Bogess	San Gregorio Creek Rd. crossing	Partial	DFG 1996
84-02	San Gregorio	Bogess	Private road crossing	Partial	DFG 1996
94-01	San Gregorio	Alpine	Concrete apron d/s of fishway	Partial	Taylor 2004

No anthropogenic passage barriers were noted on mainstem San Gregorio Creek. The most important restoration actions for mainstem San Gregorio include curtailing diversions during the dry season to maintain rearing habitat and provide freshwater input to the lagoon. The use of off-stream water tanks to store water during winter high flows as an alternative to pumping water from the streams during the dry season is recommended here and in the 2010 watershed management plan. Other recommendations in the 2010 watershed management plan and supported here include avoiding human-caused summer sandbar breaching, conducting stream flow monitoring to identify critical instream flow needs for over-summering steelhead and coho salmon, and monitoring steelhead and coho populations.

In El Corte de Madera Creek, the Bear Gulch Road crossing (Barrier 82-02) is located at approximately stream mile 2.8. Staff from the San Mateo Resource Conservation District (RCD) visited this crossing in February 2010 and noted that it “appeared very clearly to be a partial barrier” (K. Nelson pers. comm.). As substantial habitat exists upstream of this barrier, we recommend assessing its potential to limit steelhead migration and modifying it for passage in accordance with other passage barrier modification priorities. Another barrier on El Corte de Madera Creek, described in the PAD as a dam with a two-foot step (Barrier 82-03), is located on private property approximately 0.7 miles downstream from the upper limit of anadromy. We recommend obtaining permission from the landowner to assess the severity of this barrier.

In Bogess Creek, the San Gregorio Road crossing and a private road crossing (Barriers 84-01 and 84-02) create potential passage constraints in the most downstream half mile. As substantial habitat exists upstream of these crossings, we recommend assessing their severity and modifying them if they prove to be problematic for migrating steelhead in accordance with other passage barrier modification priorities.

No anthropogenic barriers were noted on La Honda Creek. A 2006 report recommends implementing treatments for road-related sedimentation for sources identified in previously prepared sediment assessments (Baglivio and Kahles 2006).

On Alpine Creek, a concrete apron downstream of a fishway was identified as a partial barrier (Barrier 94-01). As noted above, funding was obtained to modify this passage barrier, but the project was not implemented due to conflict with the owner. According to staff from the San Mateo RCD, the concrete apron does not likely create significant passage problems and should not be considered a priority project, as NOAA staff and Department of Public Works roads crews recently observed adult steelhead and coho salmon spawning upstream of this site (K. Nelson pers. comm.).

Pescadero Creek

Steelhead Resources

Pescadero Creek also was one of four "A-1" streams noted in San Mateo County in a 1912 DFG letter and it appears to have supported the largest steelhead run in San Mateo County historically. In a 1967 report, the annual steelhead run of Pescadero Creek was estimated to consist of 1,500 individuals (DFG 1967).

Extensive habitat areas occur on mainstem Pescadero Creek in Pescadero Creek County Park and in Portola State Park. A watershed assessment noted high quality habitat in the mid and upper Pescadero Creek watershed and lower in the Butano Creek watershed (ESA 2004). Watershed assessment work indicates that several headwaters tributaries including Peters and Oil creeks should receive "special attention in regards to conservation and restoration" (ESA 2004). Additionally, the system offers estuarine habitat that, if managed properly, can provide important rearing habitat. According to a principal researcher, up to 80 percent of the steelhead population of the watershed may rear in the lagoon (SWRCB 1996).

Causes of Decline

A 1946 DFG report states, "Undoubtedly, the condition of Pescadero Lagoon and the lower part of Pescadero Creek has deteriorated over the years, the lagoon becoming shallower and the summer flows in the stream smaller. The principal causes have been the increasing use of water for irrigation and domestic use, deforestation of the drainage basin, and silting created by highway construction and erosion of cultivated fields" (DFG 1946).

A 1962 DFG survey report noted that Pescadero Creek was "under-utilized" due to passage barriers and sedimentation (DFG 1962c). High sedimentation rates have been observed in Oil Creek due to past logging practices and to poor road maintenance (DFG 1962d; DFG 1997b). Pescadero Creek is listed as impaired by sediment pursuant to §303(d) of the Clean Water Act, and Total Maximum Daily Load (TMDL) requirements are being developed by the San Francisco Regional Water Quality Control Board.

A 2004 recent watershed assessment identified several primary limiting factors for the Pescadero Creek system including lack of pool habitat (due in part to logging effects) and sedimentation (ESA 2004). The existence of extensive protected land uses in the upper watershed suggests that upland rearing habitat may remain in relatively good condition into the future.

Lagoon conditions continue to limit steelhead restoration in the Pescadero Creek system. The lagoon and marsh are expected to transition seasonally from an open estuarine system to a closed lagoon system when a sandbar forms across the mouth of Pescadero Creek. In years when the closed lagoon converts to freshwater conditions, it provides important summer and fall rearing habitat for juvenile steelhead and can account for the majority of smolt production in the watershed. Sufficient freshwater inflows at the time of closure allow the lagoon to rapidly convert from saltwater to freshwater.

Restoration work in the Pescadero Marsh was implemented by State Parks between 1993 and 1997 as part of the Pescadero Marsh Natural Preserve Hydrological Enhancement Project to address habitat issues in lower Pescadero Creek. Observations made by Dr. Jerry Smith and others indicate that although sandbar formation in the 1980s typically occurred between the months of May and July, bar formation since completion of the enhancement project may be delayed until September or October. Late sandbar formation has been linked to a strongly salinity-stratified lagoon in fall with severe hypoxia and anoxia. Hypoxic/anoxic bottom water conditions observed while the sandbar is in place have been observed to persist until several days after the breaching of the sandbar. Fish kills (including steelhead) coinciding with the breach of the sandbar have been observed in multiple years since completion of the enhancement project. The first large fish kill was documented in 1995, and is believed to be a result of rapid mixing of anoxic bottom water into the main area of the lagoon at the time of the sandbar breach.

Conservation Activities

A 2003 sediment assessment report for the Pescadero Park complex, consisting of Memorial, Pescadero and Sam MacDonald parks, identified projects to reduce sediment input to Pescadero Creek (PWA 2003). Sediment reduction projects were implemented along Old Haul, Tarwater, and Camp Pomponio roads between 2003 and 2006 based on recommendations in the report.

The San Mateo County Farm Bureau, Red Tree Properties, and multiple resource agencies coordinated the removal of a 12 foot high legacy log dam barrier in Waterman Creek, a tributary to Pescadero Creek, with funding from American Rivers and the local Native Sons of the Golden West. The project was implemented between 2008 and 2010 and provided steelhead access to approximately 1.5 miles of previously unavailable habitat.

Public agencies and other stakeholders formed the Pescadero Marsh Working Group (PMWG) with the mission to protect and enhance the ecological health of the Pescadero Marsh ecosystem through collaborative, science-based planning and action. In December 2008 PMWG held a restoration forum in the Town of Pescadero at which stakeholders discussed problems facing the marsh and generated a list of potential restoration goals and actions. The working group is preparing a set of recommended goals and hypotheses to assess to improve the conceptual model of the Pescadero Marsh.

Environmental Science and Associates (ESA) has conducted extensive studies for State Parks to assess current conditions in the marsh, impacts of human activities, and potential restoration options. To address fish kills in the short term, bladder dams may be placed at locations in the marsh to isolate anoxic water away from the main lagoon at the time of the sandbar breach. The PMWG has decided that further study of the marsh system is required before long-term solutions can be developed. Such investigations will help determine appropriate restoration actions necessary to increase the quality of the lagoon steelhead habitat.

Restoration Opportunities

A review of passage barriers listed in the PAD and other sources indicates a number of potential restoration projects for the Pescadero watershed. Key barriers are listed in Table 5 and labeled in Figure 3.

Table 5. Pescadero Creek Watershed Key Passage Barriers

Barrier ID	Watershed	Stream	Description	Type	Source
100-01	Pescadero	Pescadero	hay bale and plank dam	Partial	PAD
100-02	Pescadero	Pescadero	Constructed branch dam	Partial	PAD
100-03	Pescadero	Pescadero	sand bag dam	Partial	PAD
100-04	Pescadero	Pescadero	Constructed log dam	Partial	PAD
100-05	Pescadero	Pescadero	summer flashboard dam	Partial	PAD

A 2004 ESA report notes, "Few barriers to fish migration, other than natural falls, were seen by our field crews or noted in previous surveys, except in small tributaries and high in some larger tributaries. We did not find that artificial barriers are a major impediment to the fishery in this watershed" (p. 2-18). However, as the above listed potential barriers are located downstream from a substantial portion of mainstem and tributary habitat, they warrant assessment. Staff from the San Mateo RCD are developing plans to visit the barriers listed in Table 5 to confirm their presence and assess their severity (K. Nelson pers. comm.).

A 1996 DFG survey report recommended restoration actions including assuring adequate stream flows for over-summering, reducing nutrient loading, and decreasing sedimentation through land use improvements and revegetation (DFG 1996b). Staff from DFG also has recommended pursuing only off-stream reservoirs in the watershed and establishing minimum flows to be measured in the area near the mouth of the creek (SWRCB 1996). Revegetation of denuded areas along essential stream corridors would help address sedimentation and water quality issues. Other important physical improvements in the watershed likely will include alteration of the lagoon and marsh configuration coupled with provision of adequate streamflow into the marsh following sandbar closure, and erosion and runoff control in the Butano Creek basin.

Other Important Watersheds

As shown in Table 2 (above), substantial additional habitat occurs in Pilarcitos and Gazos creeks watersheds (Figure 3). We reviewed available information regarding the steelhead resources of these watersheds, and determined that Gazos Creek's potential production and relatively high quality habitat merit consideration for restoration priority. Information regarding Pilarcitos Creek is provided in the Appendix, while Gazos Creek is described further below.

To further refine the areas containing suitable and available rearing habitat, mainstem and tributaries in the Gazos Creek watershed were examined, as shown in Table 6. The majority of the rearing habitat occurs in the Gazos Creek mainstem.

Table 6. San Mateo County Important Watershed Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available[2]**
Gazos		**6.4**	**6.4**
	Gazos	5.7	5.7
	Old Woman's	0.7	0.7

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

Gazos Creek
Steelhead Resources
A 1912 report on San Mateo County streams noted perennial flow in Gazos Creek. The creek was given an "A-1" rating for fishing (Smith 1912). Records from sampling of numerous Gazos Creek sites between the years 1992 and 1997 indicate the consistent presence of juvenile *O. mykiss* (Smith 1997). This research has led to the characterization of the creek as having "relatively high, stable abundances of young-of-the-year" (Alley 2003). Staff from the San Mateo County RCD recently described Gazos Creek as a "small but highly productive system" (K. Nelson pers. comm.). Recent sampling indicates, however, that steelhead density in the creek has declined, although researchers report the continuing presence of high quality habitat as reason to give priority to the watershed (Smith 2007; K. Nelson pers. comm.).

Causes of Decline
In a 1955 stream survey report, DFG staff noted "considerable damage to [Gazos Creek] by… logging" (DFG 1955). A 1964 survey report recommended investigating the effect "of the diversion near the mouth, which stops all flow to the ocean, and the downstream migration of young salmon and steelhead" (DFG 1964). In a Gazos Creek survey report from 1978, DFG staff found "siltation and flow reduction due to diversion are significant habitat alteration factors in the lowermost reach" (DFG 1978). The report recommended monitoring and regulating existing diversions, and protesting additional diversion "to insure adequate bypass conditions" (DFG 1978).

Documentation associated with a 1993 trapping effort notes that Gazos Creek Road is a source of sediment introduced into the creek and recommends a program to address the issue (Nelson 1994). A fishery assessment was conducted for Gazos Creek and the results published in 2003. Fine sediment originating from Old Woman's Creek was said to "likely restrict YOY steelhead and coho production" in Gazos Creek downstream from the confluence (Alley 2003).

Regarding lagoon habitat the assessment states, "The Gazos Creek estuary is generally small and shallow, offering no saltwater transition between the Creek and the ocean. A concern is that if too much streamflow is diverted in dry years, the sandbar may close prematurely to block smolt out-migration for coho and steelhead" (Alley 2003). The report notes that this effect is likely exacerbated by activity at the pumping station located 0.25 miles upstream from Highway 1. The study also noted low baseflow as a factor limiting juvenile salmonid growth in the spring and early summer.

Conservation Activities

A watershed assessment and enhancement plan was prepared for Gazos Creek in 2003. The report identified prioritized restoration projects, including, most importantly, reducing erosion on lower Old Woman's Creek Road, purchasing water rights, improving large wood-formed instream habitat, and constructing off-stream water storage (CWC 2003). The plan also points to the need for conducting erosion risk assessments in various parts of the watershed.

The PAD notes that San Mateo County proposed in 2008 to modify log jams to at stream miles 1.8, 2.4, 3.25, and 4.2 on Gazos Creek. Repairs on the log jam at stream mile 3.25 have been completed (K. Nelson pers. comm.).

Restoration Opportunities

A review of passage barriers using the PAD and other references was conducted for Gazos Creek. No anthropogenic passage barriers were noted. A report on sampling conducted in Gazos Creek in 2006 notes two large log jams at road mile 2.4 and 4.2 that are likely impassable (Smith 2007).

The following projects pertaining to steelhead restoration are proposed in the 2003 enhancement plan for Gazos Creek:

1) "Create additional starter wood jams…The high-priority locations are in the mainstem of Gazos Creek upstream from mile 3 to the extent of anadromy, because few large wood jams are there, and because that area seems to be the important area for coho spawning and rearing.

2) Build off-stream reservoir to store winter flow to reduce reliance on baseflow diversions.

3) Conduct erosion-risk assessments on private roads in North Fork, Slate Creek, and Middle Fork" (CWC 2003).

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Figure 2. Map legend

Figure 3. Anchor and other important watersheds of San Mateo County, California

Chapter 2. Santa Cruz County

Our review of available information indicates that Santa Cruz County has 16 watersheds with evidence of steelhead presence historically.[6] All 16 watersheds are believed to continue to provide spawning and rearing opportunities for *O. mykiss*. (Table 7).

Table 7. Santa Cruz County Watersheds Screening by *O. mykiss* Population

Watershed	*O. mykiss* population?
Waddell	Y
Scott	Y
Molino	Y
Ferrari	Y
San Vicente	Y
Liddell	Y
Yellow Bank	Y
Laguna	Y
Majors	Y
Baldwin	Y
Wilder (Medor)	Y
San Lorenzo River	Y
Arana Gulch	Y*
Soquel	Y
Aptos	Y
Pajaro	Y

Notes
*Insufficient information to determine habitat.

Available data and supplemental information were used to estimate rearing habitat in Santa Cruz County watersheds hosting *O. mykiss* populations, as shown in Table 8. Our analysis shows that the San Lorenzo and the Pajaro rivers (Figures 4 and 5, respectively) contain the vast majority of the region's available habitat. The San Lorenzo River watershed appears to have hosted the most consistent and largest annual steelhead runs of Santa Cruz County watersheds historically. A 1954 DFG memo states, "The San Lorenzo River is the best winter steelhead stream in existence south of San Francisco Bay" (DFG 1954a). The Pajaro River's historical importance is expressed in a 1961 DFG memo stating, "Warden Smith feels that the Pajaro River provides more fish and fishing than any other stream in this area" (DFG 1961a).

A second group of watersheds consisting of Waddell, Scott, Soquel, and Aptos creeks (Figure 4) collectively comprise about one quarter of the available habitat. These four creeks and the two larger river systems are considered the anchor watersheds of Santa Cruz County for purposes of examining steelhead resources and restoration opportunities in the following discussion.

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[6] We assign watersheds to specific coastal counties based on the location of the stream mouth. The Pajaro River, however, defines the border of Santa Cruz and Monterey counties. The Pajaro was designated a "Santa Cruz County watershed" because the majority of the habitat occurs in Santa Cruz and Santa Clara counties.

Table 8. Santa Cruz County Watersheds Screening by Habitat

		Habitat (stream miles)	
Watershed	**Area (sq.mi.)**	**Total[1]**	**Available[2]**
Waddell	24.0	9.7	9.7
Scott	29.9	13.2	13.2
Molino	1.6	0.8	0.8
Ferrari	1.9	1.2	0.0
San Vicente	11.3	4.0	4.0
Liddell	3.4	3.8	2.1
Yellow Bank	1.4	0.9	0.0
Laguna	8.0	1.4	1.4
Majors	5.0	0.6	0.6
Baldwin	3.0	1.1	1.1
Wilder (Medor)	5.3	2.8	2.8
San Lorenzo	136.2	97.8	97.4
Soquel	42.5	21.9	21.3
Aptos	24.6	8.8	8.8
Pajaro	1300.0	75.8	56.9

Notes

[1]Includes all habitat located downstream from natural limits of anadromy

[2]Excludes habitat located upstream from impassible anthropogenic barriers

To further refine the areas containing important rearing habitat resources, mainstems and tributaries in the six Santa Cruz County anchor watersheds were examined, as shown in Table 9. Various aspects of steelhead habitat within the anchor watersheds are described below.

Table 9. Santa Cruz County Anchor Watershed Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available[2]**
Waddell		**9.7**	**9.7**
	Waddell	3.4	3.4
	West Waddell	3.7	3.7
	West Waddell tributary (Buck)	0.1	0.1
	Henry	0.7	0.7
	Henry tributary	0.1	0.1
	Berry	0.1	0.1
	Kelly	0.1	0.1
	East Waddell	1.3	1.3
	Last Chance	0.1	0.1
	Opal	*	*
	Blooms	*	*
	Sempervirens	*	*

Table 9, continued

Watershed	Mainstem/Tributary	Habitat (stream miles) Total[1]	Available[2]
Waddell (cont.)	Union	*	*
Scott		**13.2**	**13.2**
	Scott	6.5	6.5
	Scott tributary (Quesaria)	0.9	0.9
	Little	1.2	1.2
	Big	1.5	1.5
	Boyer	0.0	0.0
	Mill	2.4	2.4
	Scott tributary (Bettencourt Gulch)	0.8	0.8
San Lorenzo		**97.8**	**97.4**
	San Lorenzo	26.8	26.8
	Branciforte	9.3	9.3
	Carbonera	3.8	3.8
	Branciforte tributary (Glen Canyon)	0.9	0.9
	Branciforte tributary (Redwood)	0.9	0.9
	Granite	2.2	2.2
	Crystal	1.3	1.3
	Tie Gulch	--	--
	San Lorenzo tributary (Powder Mill)	0.5	0.5
	San Lorenzo tributary (Eagle)	0.2	0.2
	Gold Gulch	1.1	1.1
	Shingle Mill	0.7	0.7
	Zayante	7.6	7.6
	Bean	5.9	5.9
	Lockhart Gulch	1.4	1.4
	Ruins	0.4	0.4
	Mackenzie	1.0	1.0
	Lompico	3.2	3.2
	Mountain Charlie Gulch	2.6	2.6
	Zayante tributary	1.7	1.7
	Bull	0.0	0.0
	Fall	1.5	1.5
	Bennett	0.0	0.0
	South Fork Fall	0.0	0.0
	Newell	0.9	0.9
	Love	3.4	3.4
	Smith	0.0	0.0
	Fritch	0.8	0.8
	Marshall (Hubbard Gulch)	0.2	0.2
	Alba	0.0	0.0
	Clear	0.2	0.2

Table 9, continued

Watershed	Mainstem/Tributary	Habitat (stream miles) Total[1]	Available[2]
San Lorenzo (cont.)	Boulder	3.3	3.3
	Foreman	0.0	0.0
	Bracken Brae	*	*
	Jamison	0.6	0.6
	Hare	0.4	0.1
	Bear	6.4	6.4
	Deer	3.3	3.3
	Two Bar	1.1	1.1
	Kings	3.6	3.6
	Logan	0.5	0.5
Soquel		**23.8**	**23.1**
	Soquel	13.2	13.2
	Bates	0.6	0.6
	Grover Gulch	0.7	0.0
	Soquel tributary (Laurel Glen, Moore's Gulch)	2.2	2.2
	West Branch Soquel	4.8	4.8
	Hester	0.8	0.8
	Laurel	*	*
	Burns	*	*
	Hinckley	1.1	1.1
	Amaya	0.4	0.4
Aptos		**8.8**	**8.8**
	Aptos	5.7	5.7
	Valencia	1.7	1.7
	Trout Gulch	0.0	0.0
	Bridge	1.4	1.4
Pajaro		**75.8**	**56.9**
	Pajaro	0.0	0.0
	Corralitos (Salsipuedes)	3.2	3.2
	Casserly	1.0	1.0
	Green Valley	0.9	0.9
	Browns (Browns Valley)	2.8	2.8
	Ramsey Gulch	0.9	0.9
	Gamecock Canyon	0.9	0.9
	Rider	0.0	0.0
	Eureka Gulch	0.0	0.0
	Shingle Mill Gulch	1.0	1.0
	Rattlesnake Gulch	0.4	0.4

Table 9, continued

Watershed	Mainstem/Tributary	Habitat (stream miles) Total[1]	Available[2]
Pajaro (cont.)	Diablo Gulch	*	*
	Coward	0.0	0.0
	Pescadero	6.0	6.0
	Star	--	--
	San Benito	0.0	0.0
	San Juan Canyon	--	--
	Bird	1.0	1.0
	Tres Pinos	0.0	0.0
	Pescadero	0.0	0.0
	Picacho	--	--
	Uvas (Carnadero)	19.6	12.3
	Tar	3.1	3.1
	Tick	--	--
	Bodfish	2.5	2.5
	Bodfish tributary (Renz Gulch, Granite)	0.3	0.3
	Renz Gulch (Granite) tributary	0.4	0.4
	Blackhawk Canyon	0.9	0.9
	Bodfish tributary	--	--
	Little Arthur	4.6	4.6
	Uvas tributary	0.4	0.4
	Croy	2.4	0
	Llagas	14.9	5.7
	Machado	0.0	0.0
	Tequisquita Slough	--	--
	Santa Ana	0.0	0.0
	Arroyo de las Viboras	0.0	0.0
	Sulfur	--	--
	Arroyo dos Picachos	2.4	2.4
	Lone Tree	--	--
	Pacheco	4.6	4.6
	Harper Canyon	--	--
	Cedar	1.5	1.5
	North Fork Pacheco	0.3	0.3
	East Fork Pacheco	--	--
	South Fork Pacheco	0.0	0.0

Notes

[1]Includes all habitat located downstream from natural limits of anadromy

[2]Excludes habitat located upstream from impassible anthropogenic barriers

*Supports a reproducing *O. mykiss* population above natural limit of anadromy

--Insufficient information to determine habitat

The data presented in Table 9 reveal mainstem and tributary streams expected to offer the greatest smolt production potential by virtue of offering extensive high value rearing habitat.

Candidate essential streams were reviewed using stream survey reports, habitat inventories, and professional opinion for purposes of confirming their importance to their respective steelhead fishery. In some instances, streams with a high value for stream miles of rearing habitat have been deemed of lesser importance and not included in this group. Rationale for inclusion in the list of essential streams is provided in the steelhead resources section of the following watershed descriptions. Within the six anchor watersheds of Santa Cruz County, we identified 23 streams (of 121 candidates) that appear to account for the majority of the high value rearing habitat.

Anchor Watersheds

Waddell Creek

Steelhead Resources

Between 1933 and 1942 as part of a study of coho salmon and steelhead, an average of 432 in-migrant steelhead were collected per season (DFG 1954b). In a 1967 report concerning Love Creek (tributary to the San Lorenzo River), the annual steelhead run of Waddell Creek was estimated to consist of 450 individuals (DFG 1967a). A 1997 plan notes, “Upstream of the lagoon juvenile steelhead production has been both high and stable for the last 5 years…, with an adult run in excess of 200 fish per year” (Smith 1997a).

In 1980, DFG noted that steelhead used the area between the mouth and the confluence of the East Fork and the West Fork, as well as the 0.6 mile portion of the East Fork immediately upstream from the confluence (DFG 1980). Researchers also have stated, “…about 1/3 of returning adults reared in the lagoon as juveniles” (Smith 1997a).

Long term sampling conducted between 1992 and the present indicate the consistent presence of 0+ and age 1+ *O. mykiss* in the Waddell Creek watershed (Smith 1997b; Smith 2007a). Substantial habitat is noted to occur in the mainstem and in West Fork Waddell Creek.

Causes of Decline

In a 1996 memo concerning habitat limitations in central coast streams, DFG staff note the impact of debris clearing for flood control and water diversions on Waddell Creek (DFG 1996a). Another memo from 1996 found that diversion of flows from Sempervirens Creek adversely affected salmonid habitat.

Long term sampling indicates that fine sediment in the stream has increased in recent years, and was attributed to a “substantial increase” in streambed and bank disturbance by feral pigs (Smith 2007a). Fish kills in the East Fork and mainstem have occurred annually since 1999. A 2007 report on sampling suggests that pollution sources in the Last Chance Creek drainage likely cause the fish kills downstream (Smith 2007a).

Conservation Activities

According to DFG staff, *O. mykiss* abundance in mainstem Waddell Creek in the years preceding 2007 has been lower than expected. Staff from DFG noted in 2007 that investigations were planned to increase the understanding of the under-production issue (J. Nelson pers. comm.).

The California Department of Transportation is planning to replace the Highway 1 bridge that crosses Waddell Creek near the mouth. The County of Santa Cruz Fish and Game Advisory Commission, NMFS, and staff from San Jose State University have recommended replacing the existing short-span bridge with a full-span bridge to improve estuary function and lagoon rearing habitat.

Restoration Opportunities
A review of passage barriers using the PAD and other references was performed for the Waddell Creek watershed. No anthropogenic passage barriers were found to be present. A 2007 report recommends modification of a log jam on West Waddell Creek near trail mile 3.6 that has accumulated a large amount of debris since 1998 and has possibly become impassible except during high flows (Smith 2007a). Recommendations in a 1997 management plan focused on managing diversion rights and practices to maintain stream flow appropriate for the season and water year type. Recommendations from a 1997 stream inventory included allowing the accumulation of woody debris, treating sediment sources, and planting riparian vegetation (DFG 1997a).

A 2007 report identifies the following restoration efforts as high priority in the Waddell Creek watershed:

1) eliminate the toxic kills on East Fork and mainstem Waddell from pollution within the Last Chance Creek watershed
2) modify the log jams to provide fish passage on…West Fork Waddell [Creek]; and
3) address impacts to the [lagoon] during the replacement of the Highway 1 [Bridge] at…Waddell [Creek]. (Smith 2007a, p. 2).

These recommendations are echoed in the recently published draft coho recovery plan (NMFS 2010), which emphasizes the importance of lagoon enhancement and addressing the East Fork Waddell Creek fish kills.

Scott Creek

Steelhead Resources
A 1953 DFG survey stated, "The lower parts [of Scott Creek] are nursery and spawning areas for SH and salmon [and] the upper parts are trout waters" (DFG 1953a). In a 1961 survey, DFG staff called *O. mykiss* "common throughout" Scott Creek (DFG 1961b). The creek was characterized as a "good spawning and nursery stream" (DFG 1961b).

A study conducted between 2002 and 2005 found that the Scott Creek estuary provides critical steelhead nursery habitat (Bond *et al.* 2008). The study report concludes, "Estuarine waters in Scott Creek now comprise less than 5% of the habitat available to steelhead, yet the vast majority of the adult population is a product of that environment" (Bond *et al.* 2008, p. 9).

Steelhead runs in the Scott Creek watershed have typical sizes of 200 to 400 adults in recent years. A 2008 report notes, "Anecdotal estimates of run sizes from Scott Creek prior to highway development suggest spawning adult numbers two to three times larger than those observed today" (Bond *et al.* 2008, p. 9). Spawning occurs primarily in upper Scott, Big and Mill creeks (S. Hayes pers. comm.). Stream surveys since the 1960s have noted "under-utilization" of Big Creek, possibly due to erosion, removal of woody debris, and reduced water flows (DFG 1960a; 1996a). In 1993, DFG noted abundant *O. mykiss* production in Mill Creek (DFG 1993). While sampling in lower Little Creek indicates that spawning occurs "almost every year," the lesser extent of rearing habitat did not suggest that this stream be considered as highest priority for restoration attention.

Causes of Decline

A 1987 DFG memo documents the effects of seasonal dams on lower Scott Creek. The memo states, "In Scott Creek, dewatering of the stream below the diversion has eliminated almost 50% of available lagoon habitat for juvenile steelhead trout" (DFG 1987).

In reporting on 2006 sampling Dr. Jerry Smith states, "…in years when the sandbar forms and remains in place in summer to provide rearing habitat, yearling and YOY steelhead can rear to large size in the resulting lagoon… However, over the last 2 decades the lagoon provides little summer rearing habitat in the majority of years because of heavy water diversion during dry years…and because of artificial breaching of the sandbar… In addition, the straightened estuary (modified during the construction of the Highway 1 Bridge) at Scott Creek is normally very shallow and mostly fresh water in spring prior to sandbar formation. It provides little opportunity for either feeding or adapting to salt in a brackish environment…" (Smith 2007a).

In a 1996 memo concerning habitat limitations in central coast streams, DFG staff note the impact of channel modifications associated with the Highway 1 bridge on Scott Creek, as well as siltation effects from local land uses, and other impacts (DFG 1996a). A 2004 report on sampling in Scott Creek states, "The amount of fine sediment present in late summer appears to have increased…in recent years. Streambed and bank rooting by feral pigs substantially increased on Scott and Waddell creeks from 1999 to 2002, and is probably a major factor in the increase in sediment" (Smith 2004, p. 4).

On Mill Creek, a reservoir is located upstream from the natural limit of anadromy. Water diversion and regular removal of woody debris were deemed problematic to the Mill Creek fishery in a 1996 review of coastal stream habitat (DFG 1996a).

Conservation Activities

The Scott Creek Watershed Council prepared a watershed assessment for Scott Creek in 2004, identifying priority restoration projects for the watershed. Several projects were selected for Integrated Watershed Restoration Project (IWRP) funding in 2004 based on recommendations included in the watershed assessment, including re-establishment of the USGS gauging station on Scott Creek, erosion control projects in lower Mill Creek, and identification and prioritization of road related sediment sources.

A recent fish passage and habitat improvement project on Quesaria Creek, tributary to Scott Creek, included the removal of three stream crossings, riparian corridor restoration, and modification of a straightened section of channel.

Restoration Opportunities

A review of passage barriers using the PAD and other references was performed for the Scott Creek watershed. No anthropogenic passage barriers were found to be present.

Maintaining and improving lagoon habitat should be considered a high priority for the watershed. This should include preventing the artificial breaching of the sandbar and providing sufficient freshwater inflows while the lagoon is closed to maintain high-quality rearing habitat. A 2008 research paper states, "As flows in these watersheds are at constant risk of being reduced even more by human consumption demands, this has become a critical management issue that will probably only increase in importance over time. In addition to the challenges of low flows in the upper watershed, there is a need to maintain connectivity with the estuary. Fish may need to take refuge from the estuary by moving upstream during periods of extreme temperature or low oxygen levels" (Hayes *et al.* 2008, p. 126).

The California Department of Transportation is planning to replace the Highway 1 bridge that crosses Scott Creek near the mouth. The County of Santa Cruz Fish and Game Advisory Commission, NMFS, and staff from San Jose State University have recommended replacing the existing short-span bridge with a full-span bridge to improve estuary function and lagoon rearing habitat.

San Lorenzo River

Steelhead Resources

Staff from DFG counted steelhead spawners at the Felton Diversion Dam in 1977. The seasonal total was 1,614 individuals (DFG 1979). The 1978-1979 steelhead run was estimated by DFG to be 625 individuals (Sullivan 1988). A 1982 draft report by the State Water Resources Control Board noted an estimated steelhead run of about 750 individuals (SWRCB 1982). Recent studies indicate low population numbers in mainstem San Lorenzo in relation to other coastal watersheds.

There are 12 main tributaries in the San Lorenzo River system, and the most important fisheries resources in the watershed likely are contained in Branciforte, Zayante (including the tributaries Bean and Mountain Charlie Gulch creeks), Fall, Boulder, and Bear creeks (K. Kittleson pers. comm.). Habitat resources of the watershed are characterized briefly below.

Smolt production has been attributed to two key portions of the San Lorenzo: the mainstem downstream from the Boulder Creek confluence and the upper mainstem and tributaries (Alley 2004). Branciforte Creek contains extensive habitat areas and has been deemed an "important producer of YOY's and yearlings" (Alley 2004). Although the Branciforte tributary Carbonera Creek and the San Lorenzo tributaries Granite and Love creeks also contain suitable rearing habitat (DFG 1957; Alley 2004), smolt production in these streams has been observed to be low in recent years (K. Kittleson pers. comm.).

Zayante Creek was studied in terms of production potential and it was estimated that its habitat was capable of producing a run of 800 individuals (DFG 1973a). It was called "the most productive [tributary] in terms of YOY's and smolt-sized fish [in the San Lorenzo system]" and has importance as a contributor to summer baseflow in the mainstem (Alley 2004). The Zayante tributary Bean Creek was estimated "to be to be one of the better producers of steelhead in the San Lorenzo drainage" (DFG 1956).

Fall Creek was assessed as "the most important tributary stream for coho salmon and steelhead trout in the San Lorenzo River watershed" in 1988 (DFG 1988a). Subsequently, *O. mykiss* numbers have been found to be "fairly stable" and the stream called one of seven "important producers of YOY's and yearlings" (Alley 2004).

Since the 1950s, qualitative assessments and population estimates regarding Boulder Creek have suggested its importance to the San Lorenzo River fishery. Recently, it was deemed one of seven "important producers of YOY's and yearlings" despite exhibiting "precipitous decline" in numbers in some recent years (Alley 2004).

Historical production of Bear Creek was estimated in a 1982 report to be about 1,400 individuals, though the estimation method is not described (SWRCB 1982). As with Boulder Creek, a "precipitous decline" in juvenile steelhead was noted during sampling between 1998 and 2000, but the creek is considered an important contributor to smolt production of the San Lorenzo River system (Alley 2004).

Causes of Decline

The San Lorenzo River lagoon historically provided important rearing habitat for juvenile steelhead, particularly during dry years when upstream nursery areas were dewatered. A principal researcher stated that channelization and artificial breaching have led to "poor summer rearing habitat" in the lagoon (Smith 1994). In a memo regarding lagoon management he also noted, "[The San Lorenzo River lagoon] is open due to breaching in summer so calm habitats are reduced. Steelhead would benefit from keeping [the] sand bar closed in summer and providing sufficient inflows to convert most of the system to freshwater" (Smith 2007b).

Passage barriers in the San Lorenzo system that have been associated with impacts to the steelhead fishery include several on Branciforte, Zayante, and Fall creeks (Table 10). Additional information regarding barrier modifications is provided in the following.

Monitoring between 1994 and 2001 indicated that habitat loss due to sedimentation was occurring in "key reaches such as the Middle [San Lorenzo] River" (Alley 2004, p. ES-1). More recently, staff from DFG indicates that the San Lorenzo system continues to be heavily impacted by land uses and that restoration opportunities may be limited by the amount of private land ownership. According to the Central Coast Water Board, water quality in the San Lorenzo and in tributaries such as Branciforte, Carbonera, Bean, Zayante, and Bear creeks is impaired by sedimentation from specialty crop production, silviculture, road construction, disturbed sites, erosion, and nonpoint sources (CCWB 2006). Other impaired tributaries including Lompico, Shingle Mill, Newell, and Kings creeks also affect downstream sedimentation.

In a 1996 memo concerning habitat limitations in central coast streams, DFG staff noted that water diversions reduce flows sufficiently to impact the San Lorenzo system, particularly during summer when low flow occurs naturally (DFG 1996a). The memo cited the reduction of flow reaching the San Lorenzo River lagoon due to operations of Loch Lomond Reservoir. A 2001 enhancement plan states, "Flow reductions at [the diversion facilities at] Tait Street can be significant, especially during summer months. Although the City is not required to bypass flow, it currently adjusts pumping rates to maintain a minimum flow downstream" (Alley 2004). Impacts of diversion also have been noted in Branciforte Creek (DFG 1996a), Zayante Creek (DFG 1996a; Alley 2004), Bean Creek (Alley 2004), Fall Creek (DFG 1996b; Alley 2004), Boulder Creek (Alley 2004), and Bear Creek (DFG 1996a).

Lack of woody debris or other instream cover problems also have been attributed as causes of steelhead population decline in San Lorenzo tributaries. Branciforte, Carbonera, Zayante, and Fall creeks in particular have been cited as lacking cover (HSA 1982; DFG 1996c; DFG 1996d; DFG 1996b; DFG 1997b). Degraded riparian conditions limiting habitat value have been cited in Carbonera and Fall creeks (DFG 1996a; DFG 1996b).

Conservation Activities

Santa Cruz County staff are coordinating the Santa Cruz County Stream Habitat and Juvenile Salmonid Sampling Program in partnership with local water agencies to track salmonid spawning and rearing conditions, prioritize restoration and conservation efforts, provide permitting and project monitoring data, and inform land and water use decisions. A database is being created to organize and manage data.

The Resource Conservation District of Santa Cruz County and the California Coastal Conservancy developed the Integrated Watershed Restoration Program (IWRP) in 2004 to conduct stream restoration projects in Santa Cruz County. Under the IWRP, funding has been obtained remove fish passage barriers and implement erosion control measures to improve sedimentation conditions in the San Lorenzo River system. The county has commissioned assessments of roads for sediment-related improvements, while the Santa Cruz RCD has worked extensively on roads and other erosion control projects (D. Roques pers. comm.). Funding was approved in 2004 for the Zayante Road Landslide Erosion Control and Salmonid Habitat Improvement Project, which will reduce sediment input into Zayante Creek.

Culvert restoration and erosion control projects were completed in Kings Creek along Kings Creek Road in 2007, including one culvert replacement and three culvert retrofits. Construction on a Gold Gulch Creek culvert replacement project was completed in November of 2009, improving fish passage to approximately 0.75 miles of habitat. The project included channel restoration and erosion control components to prevent approximately 1,800 cubic yards of sediment from entering Gold Gulch Creek and flowing into the mainstem San Lorenzo River.

Sustainable Conservation's 2009 annual report notes that a failing bridge and a series of undersized metal culverts on Deer Creek associated with problematic flooding and streambank erosion were with replaced with a free-span bridge, providing steelhead un-restricted passage to two miles of upstream habitat. Also, streambanks were stabilized with native vegetation. Restoration work was conducted by Partners in Restoration, Natural

Resources Conservation Service, the Santa Cruz County RCD, and local landowners (Sustainable Conservation 2009).

Restoration Opportunities

The San Lorenzo River system likely offers the greatest restoration potential of the watersheds in the study area. In the following, we describe the set of barrier modifications, sediment reduction activities, instream cover enhancements, and riparian improvements that have been identified in plans and through expert opinion as most important for improving habitat function in the watershed's essential streams. Additional key efforts will determine and implement instream flow provisions and develop policies to protect riverine and riparian areas.

Passage barriers in the San Lorenzo basin were identified using the Passage Assessment Database and other sources. Key barriers are listed in Table 10 and labeled in Figure 4.

Table 10. San Lorenzo River Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
193-01	San Lorenzo	Tait diversion	Partial	Alley 2004
193-02	San Lorenzo	Felton diversion	Partial	Alley 2004
193-08	San Lorenzo	flashboard dam apron and base	Partial	Alley 2004
193-11	San Lorenzo	flashboard dam apron and base	Partial	Alley 2004
193-12	San Lorenzo	Boulder Creek recreation district dam	Partial	PAD
193-15	San Lorenzo	Fern Rd. flashboard dam	Partial	PAD
193-16	San Lorenzo	Camp Campbell flashboard dam	Partial	PAD
193-21	San Lorenzo	Hwy 9 bridge apron	Partial	Alley 2004
194-01	Branciforte	Branciforte flood control channel	Partial	PAD
194-02	Branciforte	dam - concrete ford	Partial	PAD
194-04	Branciforte	Santa Cruz Diversion Dam	Partial	PAD
194-05	Branciforte	Dam with steep pass ladder	Partial	PAD
194-06	Branciforte	Diversion dam at Happy Valley Lodge	Partial	PAD
194-07	Branciforte	Branciforte Dr. bridge w/ concrete weirs	Partial	PAD
194-11	Branciforte	Culvert	Partial	PAD
194-13	Branciforte	two culverts	Partial	PAD
194-14	Branciforte	Culvert	Partial	PAD
204-01	Zayante	Redwood Camp summer dam	Partial	PAD
204-02	Zayante	Woodwardia seasonal dam	Partial	PAD
205-01	Bean	Mount Hermon Road culvert	Partial	PAD
205-02	Bean	Bean Creek Rd. crossing	Partial	PAD
205-03	Bean	perched culvert	Partial	PAD
205-04	Bean	perched culvert	Partial	PAD
205-05	Bean	Culvert	Partial	PAD
213-01	Fall	fish ladder at diversion	Partial	Alley 2004
236-01	Bear	Flashboard dam	Partial	PAD

On the mainstem San Lorenzo River, the Tait diversion (Barrier 193-01) has been identified as a potentially significant limiting factor in terms of inhibiting smolt out-migration during drought periods (Alley 2004). Determining instream flow needs for critical migration periods and monitoring diversion rates at this barrier during low-flow periods is recommended.

According to Alley (2004), the Felton Diversion Dam (Barrier 193-02) in the middle San Lorenzo River may have posed passage problems under certain flow conditions prior to 1996. The report notes that a set of requirements for operation of the dam to allow for fish passage have been in place since 1996, but adds that, as no program is in place to monitor steelhead passage past the dam, success of the modified operation is unknown. A monitoring program to assess steelhead passage past this barrier is therefore recommended.

Numerous flashboard dams on the mainstem San Lorenzo River (Barriers 193-08 to 193-16) are identified as potential barriers in the 2004 Alley report. The severity of the passage impediment posed by these flashboard dams is unknown. A detailed assessment of is therefore recommended, followed by removal or modification of those barriers determined to be most problematic.

Alley (2004) notes, "Passage impediments on the lower and middle mainstem of the San Lorenzo River are potential limiting factors for the entire River since they can restrict access to important spawning habitat in the tributaries. Good quality spawning habitat may be limiting in the lower and middle River, so access to higher quality tributary spawning habitat is important to steelhead abundance in both the mainstem and the tributaries" (p. ES-10).

Alley (2004) recommends the following in regard to management of flashboard dams in the watershed:

1) "Flashboard dams that could create problems for fish movement should not be installed before June 15th.
2) Bypass flows should be maintained during filling of the pools to prevent dewatering downstream.
3) Removal of flashboard dams in the fall should be gradual enough to prevent stranding, displacement, or injury to fish.
4) Evaluate and mitigate on a case-by-case basis other impacts of flashboard dams"

On Branciforte Creek, the flood control channel (Barrier 194-01) extends one mile upstream from the confluence with the San Lorenzo River. Although the concrete channel has a fish passage channel built through the middle, the channel frequently clogs with sediment and vegetation, posing a significant barrier to fish passage as well as a flood risk. As substantial habitat exists upstream, ensuring unimpaired migration through the flood control channel is considered a high priority and is recommended here and by Alley (2004).

Additional information regarding the severity of the remaining barriers listed in Table 10 on mainstem and tributaries was not readily available. Alley (2004) recommends conducting a more detailed study of identified potential barriers to assess their impact on fish passage. Staff from DFG and Santa Cruz RCD have begun collaborating on a project to assess and prioritize all potential barriers in the watershed (K. Kittleson pers. comm.). In addition to the above listed barriers, numerous abandoned flashboard dams were identified by Alley (2004) and are denoted in Figure 4. Investigation of these flashboard dams is recommended.

Other recommendations for the watershed include maintaining and enhancing streamflow, and reducing fine sediment inputs. Sediment reduction projects should accord with the following recommendation from Alley (2004):

> "Sediment reduction efforts should focus on tributaries such as Kings, Two-Bar, Boulder and Bear Creeks that deliver sediment directly to the Middle river and Boulder and Bear Creeks that deliver sediment directly to the Middle river and on Zayante and Branciforte Creeks, which have high habitat value"

Riparian buffers should be developed for the essential streams in accordance with the following recommendation:

> "Increase the width of no-impact riparian buffers where appropriate to protect aquatic habitat from excessive sedimentation"

The 2001 San Lorenzo River enhancement plan contained recommendations for timing and quantity of minimum bypass flows for the Felton Diversion between January 1 and April 1. It also recommends providing sufficient bypass to maintain hydraulic continuity to the estuary and an open sandbar to the ocean between April 1 and June 1 (Alley 2004). Flow determinations also are recommended for the San Lorenzo River, and should be consistent with the following:

> "…encourage the prohibition of additional summer water diversions at existing diversion sites and new sites to maintain summer flows at a level adequate to sustain existing and future salmonid populations" (Alley 2004).

Soquel Creek

Steelhead Resources

As part of a water rights application process, DFG summarized the steelhead resources of Soquel Creek in a 1973 memo. The average annual steelhead run was estimated to be 500-1,000 individuals (DFG 1973b). A 1996 City of Santa Cruz estimate of the steelhead run size in Soquel Creek was 100 individuals, although the estimation method was not provided in the reference (Sutfin 1996).

In 1959, DFG staff said Soquel Creek upstream of the West Branch confluence appeared to be the most productive stream reach in the drainage based on a count of 11,500 "steelhead rainbow trout" (DFG 1959). According to a 1973 memo, steelhead use about 20 miles of the creek while "resident rainbow trout exist in about 16 miles of stream above barriers to migrating anadromous fishes" (DFG 1973b).

The Soquel Creek lagoon appears to be critical for juvenile rearing, and research indicates that a substantial portion of the smolt-sized juveniles in the mainstem are reared there (Alley 2004b).

Causes of Decline

Staff from DFG state that "a major threat to the existence of Soquel Creek fishes has been low flows, siltation, and pollution caused by accelerated development and resource use in the watershed" (DFG 1973b). A 1988 DFG memo documented a fishkill produced by dewatering of about 0.5 miles of Soquel Creek through over-diversion (DFG 1988b). In a

1996 memo concerning habitat limitations in central coast streams, DFG staff note that water diversions reduce flows sufficiently to impact habitat in the Soquel Creek mainstem and lagoon, particularly during summer when low flow occurs naturally (DFG 1996a).

Other habitat impacts in the Soquel Creek watershed result from flood control, logging, quarrying, and road maintenance activities (DFG 1996a). In addition, water quality in the lagoon is impaired by sedimentation from construction/land development (CCRWQCB 2006).

Conservation Activities

Passage barriers at Olson Road and Tucker Road on West Branch Soquel Creek that were considered priority restoration projects were recently removed through the IWRP, providing access to approximately 3.5 miles of habitat (K. Kittleson pers. comm.).

Restoration Opportunities

A review of passage barriers in the Soquel Creek watershed was performed using the PAD and other references. A notable barrier is listed in Table 11 and labeled in Figure 4, and other important restoration actions for the watershed are summarized below.

Table 11. Soquel Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
254-03	West Branch Soquel	Laurel Mill Dam	Total	Alley 2003

The Laurel Mill Dam on West Branch Soquel Creek (Barrier 254-03) is considered the upstream limit of anadromy. However, modification of this barrier for passage is not considered high priority since steelhead are prevented from reaching the dam by natural bedrock chutes further downstream except in years with extremely high flow. The 2003 enhancement plan recommended implementing erosion control and revegetation projects downstream from the Laurel Mill Dam.

Recommended restoration actions listed in the Soquel Creek Watershed Assessment and Enhancement Project Plan (SCCRCD 2003) relate to revegetation and invasive species control:

1) "The vegetation assessment identified several locations where solar radiation is particularly intense and where tall trees planted above the bankfull level could provide shading to reduce water temperatures."

2) "Perimeter re-vegetation along the left bank at stream mile 2.4."

3) "Remove *Arundo donax* at the six locations where it occurs" (SCCRCD 2003).

Flow related recommendations in the enhancement project plan include:

1) "Establish Stakeholder Group to Pursue Increased Baseflow …to assure diversion of streamflow…is consistent with perpetuation of Soquel Creek coho salmon and steelhead."

2) "…develop a plan to preserve streamflow [in the lower West Branch] during periods when diversion of streamflow would substantially reduce the amount of habitat…"

Other recommendations for the watershed include preventing large wood in the vicinity of Redwood Lodge Road from travelling downstream in Soquel Creek (K. Kittleson pers. comm.).

Aptos Creek

Steelhead Resources

In 1960 DFG staff called Aptos Creek, "…one of the larger steelhead spawning and nursery streams in the Santa Cruz and San Mateo County areas" (DFG 1960b). In a 1965 survey, DFG staff said that Aptos Creek watershed contained approximately eight miles of *O. mykiss* nursery area. The population of the creek was estimated to be almost 43,300 individuals, and the stream was called "an important spawning and nursery area for steelhead trout" (DFG 1965a). High quality habitat was noted in the Aptos Creek mainstem and in Valencia Creek in a 2001 habitat assessment (HES 2003).

Causes of Decline

Consultants sampled Aptos Creek in 1981, noting that substrate and lack of cover were the primary factors limiting production (HSA 1982). Multiple sources cite the role of sediment in lowering the productivity of the Aptos Creek watershed. A 1996 memo states, "From a fisheries standpoint, the most significant factor influencing quality and quantity of habitat in the Aptos Creek watershed is sediment" (DFG 1996e). The report from a 2001 habitat assessment states, "Sediment is likely the major factor limiting salmonid production on both a watershed and individual reach scale" (HES 2003, p. 52). According to the CCRWQCB, water quality in the creek is impaired by sedimentation from disturbed sites and channel erosion (CCRWQCB 2006).

In a 1996 memo concerning habitat limitations in central coast streams, DFG staff specifically cite development within the floodplain and channel confinement in lower Aptos Creek as producing impacts on habitat conditions in Soquel Creek. The memo also notes that water diversions reduce flows sufficiently to impact habitat in the Aptos Creek mainstem and lagoon (DFG 1996a). The report from a 1998 Aptos Creek survey recommended discontinuing the practice of constructing rock crossings of the creek (DFG 1998).

Conservation Activities

An enhancement plan from 2003 prioritized restoration actions for the watershed. Based on recommendations in the report, a fishway was installed at the Soquel Avenue culvert. Three culverts on Valencia Creek were recently modified—one at Highway 1, one at the Soquel Drive crossing (modified with a fish ladder) and one at the Valencia Road crossing.

Restoration Opportunities

A review of passage barriers in Aptos Creek was performed using the PAD and other sources. A notable barrier is listed in Table 12 and labeled in Figure 4. A discussion of barrier modification and other recommended restoration projects is provided below.

Table 12. Aptos Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
267-01	Aptos	Spreckels Rd. weir	Partial	PAD

The 2003 enhancement plan identified Spreckels Road grade control modification as a priority project. Staff from the Santa Cruz RCD indicated that the county is in discussions to modify the Spreckels Road weir (Barrier 267-01) (K. Kittleson pers. comm.). The project is in the design phase and likely will be constructed in 2011 (J. Robins pers. comm.).

A principal researcher in the watershed noted, “If the sandbar were in place in summer, the [Aptos Creek] lagoon would probably convert mostly to freshwater, improving mixing and reducing temperature and DO problems” (Smith 2007b). According to a contractor with Santa Cruz County, water quality in the lagoon continues to impair habitat and staff from State Parks and resource agencies are working to develop restoration solutions (J. Robins pers. comm.).

Improved riparian cover in the lower mainstem/lagoon area also is needed (J. Robins pers. comm.). The 2003 enhancement plan also recommended implementing an erosion reduction plan for Santa Cruz State Parks, including the Aptos Creek Road corridor (CWC 2003).

Pajaro River

Steelhead Resources

A 1960 DFG letter states, “…steelhead runs in the Pajaro apparently fluctuate greatly from a few fish to several hundred” (DFG 1960c). According to a DFG estimate, the 1963-1964 steelhead run comprised 1,500 individuals (DFG 1964). A 1966 memo states, “Over the last ten years it is estimated that the runs varied from a low of 500 to a high of 2,000 spawning pairs" (DFG 1966). DFG staff noted that most spawning in the Pajaro River system occurred in the mainstem between the Granite Rock Company Plant and the Llagas Creek confluence (DFG 1966). The memo characterized the Pajaro River lagoon as having “year-round fishery importance” due in part to its function of providing a holding area for downstream steelhead migrants.

A draft 2002 report states, “Steelhead apparently do not rear in the lagoon because spawning areas are far upstream within Pajaro River tributaries… However, the lagoon provides potentially important feeding habitat in spring for outmigrating smolts” (Smith 2002). The draft also notes, “The Pajaro River serves as a migration pathway for steelhead, but because of low and warm summer streamflows and substrate dominated by sand or silt it provides almost no potential rearing habitat for steelhead” (Smith 2002). According to Dr. Smith, spawning and rearing habitat occurs in Pescadero, Uvas, Llagas and Pacheco creeks. In 2002, NMFS staff found "viable" steelhead populations to exist in Corralitos, Uvas, Bodfish, and Llagas creeks (NMFS 2002).

Various stream surveys and assessments have noted the importance of steelhead resources in Corralitos Creek. In a 1994 report, Smith noted that the Corralitos Creek population "is likely to still retain a substantial native genetic component" (Smith 1994). Rearing habitat was deemed "good" and "very good" at two sites in 2006 (Alley 2007).

A 1967 report notes that Pescadero Creek "contributes about 7 miles of spawning and nursery area for steelhead" (DFG 1967b). Subsequent reports have deemed habitat quality to be "fair" and "relatively good" (HSA 1982; J. Nelson pers. comm.).

Uvas Creek habitat occurs downstream from Uvas Dam, but depends on flow releases. The tributary Bodfish Creek has been deemed an important component of the basin's habitat resources in surveys over 40 years, and substantial habitat occurs in the upstream Uvas Creek tributary, Little Arthur Creek (DFG 1967c; Smith 1975; Smith 1976; Alley 1983).

Causes of Decline

In 1965, DFG staff offered the following assessment:

> “The Pajaro River has lost the majority of its anadromous fish runs. Only a limited steelhead run persists in the lower reaches and enters several small tributary streams. Logging, conversion of land to agricultural crops, and construction of dams have resulted in the decline of this habitat in the drainage. Not much hope can be expressed for improving this situation.
>
> The limiting factor is siltation erosion of the spawning grounds. Maximum runs could be achieved only by stringent erosion control measures” (DFG 1965b).

In 1966, DFG staff wrote, "Some spawning takes place, but results are nil due to activities of flood control people with bull-dozers” (DFG 1966).

In 1975, Jerry Smith stated, “Three general factors affect the steelhead populations in the Pajaro system: the migration pathway, spawning sites, and nursery areas. Of the three, the most critical is suitable nursery areas” [emphasis original] (Smith 1975). In a 1996 memo, DFG staff noted that severe erosion resulting from the removal of riparian vegetation and illegal grading led to sedimentation of habitat in the mainstem Pajaro River (DFG 1996a).

A 2002 letter from NMFS staff addressed the flood control project in the lower portion of the Pajaro River. The letter states, “Existing impacts to the Pajaro River fishery include, but are not limited to, water diversions, permanent and seasonal dams, urban and agricultural pollution, sedimentation, timber harvest, loss of riparian and instream habitat, and channelization. Impacts to this fishery are pervasive, chronic, and ongoing" (NMFS 2002).

Research indicates that low spring flows can limit outmigration from the Corralitos Creek basin (Smith 2007c). Bypass flows at the City of Watsonville diversion dam affect downstream habitat quality and may be insufficient in some years, and the dam’s fishway has required maintenance in the past (Smith 2007a).

Habitat in Corralitos Creek is limited by low flow, siltation, and lack of riparian cover (HSA 1982; DFG 1996a). Pescadero Creek is limited similarly, with sedimentation resulting largely from logging and cattle operations (HSA 1982; DFG 1996a; J. Nelson pers. comm.).

Access to Uvas Creek habitat was limited by construction of Uvas Dam, although dam releases may provide summer rearing opportunities. Development along the creek appears to be affecting substrate quality and food availability, according to Smith (2002). On Little

Arthur Creek, numerous seasonal flashboard dams reduce flow at various times, potentially dewatering stream reaches and harming over-summering steelhead.

Conservation Activities

Flooding concerns in the lower watershed have led to development of various proposals for configuring the channel, including alternatives from the U.S. Army Corps of Engineers and a so-called "Environmental Alternative for the Pajaro River Flood Plan" (PWA 2003). The study concluded that a project could reconfigure the channel between the levees in such a manner as to interact with the floodplain on a roughly two-year recurrence interval, minimize excavation and vegetation removal, and avoid major levee height increases (PWA 2003).

The Santa Cruz County RCD runs water quality improvement, roads, and integrated water resources programs that address sedimentation and fish passage problems in the Pajaro River watershed. In 2008 two major culvert retrofits on Corralitos Creek were completed at the Eureka Canyon Road crossings at Post Miles 2.95 and 4.8. A third culvert at the Eureka Canyon Road crossing at Post Mile 5.24 also is slated for removal. A culvert at the Koinonia Camp Ground crossing on Shingle Mill Gulch Creek (tributary to Corralitos Creek) was removed, and replacement with a bridge will be completed at the end of 2010. All anthropogenic barriers in the Corralitos-Shingle Mill system are now either gone, retrofitted, or scheduled for removal in summer 2011 (J. Robins pers. comm.).

The City of Watsonville, NMFS, and DFG have established bypass flows in Corralitos Creek that will enhance rearing flows downstream of the Watsonville Diversion Dam. The fishway was recently reconstructed to improve fish passage (J. Robins pers. comm.). Additionally, the city is investigating switching to membrane filtration from sand filtration in order to increase wet season diversion capability. The City of Watsonville, DFG, and NMFS have signed an MOU supporting construction of a new filtration plant and implementing a new flow regime if possible (J. Robins pers. comm.).

Trout Unlimited and CEMAR, in cooperation with Coastal Habitat Education & Environmental Restoration, a local stakeholder group, are pursuing agricultural water management improvements in Little Arthur Creek. A streamflow gage was installed in Little Arthur Creek in winter 2009. When sufficient data are collected and analyzed, a stream management plan will be developed that identifies opportunities such as providing increased storage and altering the location and timing of diversion that reduce impacts on dry season habitat quality. The project also will involve removing an irrigation drain in the upper section of Little Arthur Creek that has dewatered lower stream reaches.

Restoration Opportunities

A review of passage barriers in the Pajaro River basin was conducted using the PAD and other references. Key barriers are listed in Table 13 and labeled in Figure 5. Barrier modification and other restoration projects are discussed below.

Table 13. Pajaro River Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
273-01	Pajaro	Channelization	Partial	PAD
273-02	Pajaro	Dam	Partial	PAD
281-01	Corralitos	Watsonville Diversion Dam	Partial	Smith 2007
354-01	Uvas	Bolsa Rd. UPPR crossing	Partial	PAD
354-02	Uvas	Uvas Dam	Total	Smith 2007
355-01	Bodfish	Seasonal dam	Partial	Smith 2007
358-01	Little Arthur	Flashboard dam	Partial	PAD
358-04	Little Arthur	Flashboard dam	Partial	PAD
358-05	Little Arthur	Flashboard dam	Partial	PAD
358-06	Little Arthur	Flashboard dam	Partial	PAD
358-07	Little Arthur	Flashboard dam	Partial	PAD
358-08	Little Arthur	Flashboard dam	Partial	PAD
358-09	Little Arthur	Concrete diversion dam with spillway	Total	PAD
358-10	Little Arthur	Vanumanutagi Ranch streambed stabilization	Partial	PAD
358-11	Little Arthur	Vanumanutagi Ranch drain with boulders	Partial	CEMAR
358-12	Little Arthur	Concrete diversion dam	Total	PAD
363-01	Llagas	Concrete pad and culvert crossing	Partial	Smith 2007
363-02	Llagas	Chesbro Dam	Total	Smith 2007
393-01	Pacheco	Abandoned concrete dam	Partial	PAD
393-02	Pacheco	Pacheco tunnel road crossing	Partial	PAD

Channelization in the lower Pajaro River (Barrier 273-01) may present a significant passage barrier in some years. The PAD notes high percolation rates in the channelized reach such that it can go dry in early summer during normal years and by April in drought years. Low flows the channelized reach also pose temperature problems. It is recommended that bypass flows through the channel be maintained during critical migration periods. Information on the severity of a dam on the lower Pajaro River (Barrier 273-02) was not readily available, and assessing the severity of this barrier is recommended. The barrier should be modified consistently with other passage barrier priorities in the basin. Due to the ongoing nature of passage problems at the Watsonville Diversion Dam (Barrier 281-01), this barrier should be monitored regularly.

The PAD indicates that a Denil ladder at the Union Pacific Railroad crossing on Bolsa Road on Uvas Creek (Barrier 354-01) can create a passage barrier when it clogs with debris (AMBAG 1983 as cited in the PAD). We recommend confirming the presence of this barrier, assessing its severity, and modifying the crossing if necessary in accordance with other barrier modification priorities in the basin. A significant amount of habitat is located upstream from this potential barrier.

The Uvas Creek dam (Barrier 354-02) precludes steelhead access to more than six miles of historical spawning and rearing habitat. It is not likely that passage will be provided past the dam, but as noted above, required releases from the dam may provide rearing habitat downstream. Recommended water management changes include increased instream flow releases from Uvas Reservoir for rearing and outmigration (Smith 2007d).

Smith (2007) recommended modification of the operation of seasonal flashboard dams on Little Arthur Creek (Barriers 358-03 to 358-08) as well as modifications for fish passage on Bodfish Creek (Barrier 355-01). Such modifications should occur in concert with a program to provide rearing flows in these creeks.

On Little Arthur Creek, modification of barriers 358-09 to 358-12 are not considered priority projects, as the gradient quickly increases upstream in the vicinity of the Vanumanutagi Ranch and likely precludes steelhead access under most flows. Ensuring adequate streamflow for migration and rearing (including efforts like the TU/CEMAR project discussed previously) is considered highest priority to improve the tributary's productivity.

A concrete pad and culvert on Llagas Creek (Barrier 363-01) is considered to be lower priority for modification, as little upstream rearing habitat occurs before Chesbro Dam (Barrier 363-02). This dam precludes access to significant historical habitat but is not expected to be modified soon. Smith (2002) notes that rearing habitat downstream from Chesbro Dam could be improved by increasing releases from the reservoir, and recommends developing required minimum releases for maintaining the quality of aquatic habitat.

On Pacheco Creek, the PAD notes the presence of an abandoned concrete dam (Barrier 393-01) that is passable at moderate to high flows (AMBAG 1983 as cited in the PAD). It is recommend that the presence of this barrier be confirmed and its severity assessed. If needed, it should be modified in accordance with other barrier priorities in the basin. A second barrier on Pacheco Creek consisting of the Pacheco Tunnel road crossing (Barrier 393-02) is not recommended for modification, as it is located upstream from suitable habitat on Pacheco Creek.

Additional projects with high potential for improving steelhead habitat in the Pajaro River basin include Corralitos Creek streambank stabilization and erosion control in Sycamore Creek, a tributary of upper Uvas Creek. Another important opportunity is developing Watsonville's new water treatment plant. This would allow removal of the diversion on Browns Creek as well as development of a new flow schedule for the Corralitos Diversion to provide increased summer flows (J. Robins pers. comm.).

Other Important Watersheds

There is substantial interest in conserving steelhead resources in San Vicente Creek (Figure 4) and a number of important restoration projects have recently been implemented in this basin, creating several miles of high quality steelhead habitat in the watershed (Table 14). San Vicente Creek is characterized below.

Table 14. Santa Cruz County Important Watershed Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available**
San Vicente		**4.0**	**4.0**
	San Vicente	3.3	3.3
	Mill	0.7	0.7

Notes

[1]Includes all habitat located downstream from limit of anadromy

San Vicente Creek

Steelhead Resources

In 1934 DFG staff noted, "San Vicente was at one time the best fishing stream along the coast" (DFG 1934). A 1953 report states, "The upper portion of this creek is a beautiful trout creek…" (DFG 1953b). A consultant's report from 1991 concludes, "San Vicente Creek is one of the most productive anadromous creek habitats in the greater Santa Cruz/San Mateo County area" (McGinnis 1991). A 2001 resource protection plan states, "San Vicente Creek…supports a healthy steelhead run…" (Elliot 2002).

Causes of Decline

Impacts of water diversion have affected the San Vicente Creek fishery since at least the 1930s, as noted by DFG staff: "[the creek] is a good fishing stream now yet only there is so much water taken out now that it is dry at mouth during the late summer" (DFG 1934).

A report on sampling in San Vicente Creek in 1981 found lack of riparian cover to be a primary limiting factor to production (HSA 1982). Habitat also is offered by an artificial off-channel pond that has been maintained in recent years by NMFS staff.

A 1991 DFG letter notes lack of progress "…in rectifying the impacts resulting from past and current [quarrying] operations which have primarily occurred to the aquatic habitats associated with the quarrying sites, as a result of excessive sedimentation and summertime water diversions" (DFG 1991). In a 1996 memo concerning habitat limitations in central coast streams, DFG staff note the impact of water diversions, improper grading, and an impassable barrier consisting of a tunnel on San Vicente Creek (DFG 1996a). The 2001 resource protection plan also notes, "…a disproportionate volume of the stream's sediment load is entering the system from the [Coast Dairies] property…" (Elliot 2002). According to the CCRWQCB, water quality in the creek is impaired by sedimentation from silviculture (CCRWQCB 2006).

Conservation Activities

A restoration plan was prepared to guide management of the Coast Dairies property with the stated goal of managing all salmonid streams "…in a manner that allows sufficient water flow and water quality to support migration, spawning, and rearing…" (ESA 2004). The plan also notes that necessary minimum flows were estimated in 2001.

More than 400 acres of coastal property were transferred to the Department of Parks and Recreation in 2006, and plans are in place to transfer about 5,700 additional acres into ownership by the Bureau of Land Management (BLM) during 2007 (T. Strickland pers. comm.). The BLM, in cooperation with the Santa Cruz RCD, has started a new planning process focused on protection and conservation of salmonid and red legged frog habitat (J. Robins pers. comm.)

Several limiting factors to steelhead have been addressed in recent years through the IWRP. Sedimentation issues in the San Vicente Creek have been lessened by ending the practice of cattle grazing near the stream channel. After ten years of exclusion, lower reaches are recovering stands of alders and willows. In 2008 the lower pond was dredged and the inlet reconfigured and reconnected. It is managed as a fish pond and no diversions are allowed. A 2009 project in the upper creek created a series of pools, habitat structures, and slow water refugia for steelhead rearing (J. Robins pers. comm.).

Restoration Opportunities

A review of passage barriers in San Vicente Creek was performed using the PAD and other sources. Key barriers are listed in Table 15 and labeled in Figure 4.

Table 15. San Vicente Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
177-01	San Vicente	Railroad crossing	Partial	PAD
177-02	San Vicente	Hwy 1 crossing	Partial	PAD
177-04	San Vicente	Bedrock tunnel	Total	DFG 1996

The railroad and Highway 1 crossings of San Vicente Creek (Barriers 177-01 and 177-02) act as partial barriers and do not appear to significantly affect steelhead migration to upstream habitat. However, the severity of these barriers during critical migration periods should be assessed, and they should be modified if necessary. A bedrock tunnel (Barrier 177-04) is considered the upstream limit of anadromy on San Vicente Creek and modification has not been recommended. Barriers 177-01 and 177-02 isolated San Vicente Creek from its historical lagoon area and is connected to the ocean year-round, thus eliminating migration restrictions caused by sandbar formation. Steelhead may enter San Vicente Creek during times when adjacent watersheds have closed sandbars that preclude access (J. Robins pers. comm.). Key restoration efforts in the San Vicente Creek watershed should improve habitat complexity by increasing large woody debris and expanding backwater and floodplain habitat (J. Robins pers. comm.).

The resource protection plan for the San Vicente Creek watershed notes that ceasing appropriations until permits (including bypass flow requirements) are secured would provide consistency with conservation goals.

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Figure 4. Anchor and other important watersheds of Santa Cruz County, California

Figure 5. Pajaro River watershed, Santa Cruz, California

Chapter 3. Monterey County

There is reliable evidence that steelhead/rainbow trout occurred in 25 Monterey County watersheds historically, and recent *O. mykiss* observations are available for 20 of these drainages (Table 16). The major steelhead systems of Monterey County were listed in 1965 as the Salinas, Carmel, Little Sur, and Big Sur rivers, accounting for some 540 miles of habitat, with an additional 121 miles of habitat in "the minor streams" (DFG 1965).

Table 16. Monterey County Watersheds Screening by *O. mykiss* Population

Watershed	*O. mykiss* population?
Salinas River	Y
Carmel River	Y
San Jose	Y
Malpaso	Y
Garrapata	Y
Rocky	Y
Bixby	Y
Little Sur River	Y
Big Sur River	Y
Partington	Y
McWay Canyon	N*
Anderson Canyon	N*
Burns	N[1]
Lime	N[2]
Big	Y
Vicente	Y
Limekiln	Y
Mill	Y
Prewitt	Y
Plaskett	Y
Willow	Y
Alder	Y
Villa	Y
Redwood Gulch	N[1]
Salmon	Y

Notes
*Historical population likely introduced.
[1]Historical presence unsubstantiated.
[2]Barrier assumed to prevent access.

Our estimates of total and available rearing habitat based on *O. mykiss* observations are provided in Table 17. Notably, despite the vastly greater area of the Salinas River watershed (Figure 6) than other Monterey County watersheds, the basin offers less available habitat than its neighbor to the south, the Carmel River watershed (Figure 7). This is due largely to the aridity of large portions of the Salinas River watershed, as well as to the isolation of habitat upstream from water supply features on the San Antonio and Nacimiento rivers. These watersheds, along with the Little Sur and Big Sur River drainages (Figure 7), are considered the anchor watersheds for Monterey County.

Table 17. Monterey County Watersheds Screening by Habitat

		Habitat (stream miles)	
Watershed	**Area (sq.mi.)**	**Total[1]**	**Available[2]**
Salinas	4780	98.9	55.0
Carmel	254	66.7	66.7
San Jose	14.1	9.0	8.7
Malpaso	3.3	0.2	0.2
Garrapata	10.6	3.5	3.5
Bixby	11.3	5.1	5.1
Little Sur	40	20.6	20.6
Big Sur	60	22.2	22.2
Lime	0.6	1.1	1.1
Big	22.3	4.3	4.3
Vicente	3.6	0.0	0.0
Limekiln	8.5	1.6	1.6
Mill	6.2	2.0	2.0
Prewitt	7.4	1.9	1.9
Plaskett	1.8	0.1	0.1
Willow	16.3	3.3	3.3
Alder	4.2	1.6	1.6

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

To further refine the areas containing important rearing habitat resources, mainstems and tributaries in the four Monterey County anchor watersheds were examined, as shown in Table 18. Various aspects of steelhead habitat within the anchor watersheds are described below.

Table 18. Monterey County Anchor Watershed Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available[2]**
Salinas		**98.9**	**55.0**
	Salinas	0.0	0.0
	Gabilan	0.9	0.9
	Arroyo Seco	12.8	12.8
	Vaqueros	0.8	0.8
	Piney	3.0	3.0
	Santa Lucia	0.8	0.8
	Tassajara	4.0	4.0
	Willow	1.1	1.1
	Lost Valley	6.2	6.2
	ZigZag	1.1	1.1
	Higgins	4.2	4.2
	San Antonio	6.4	0.0
	Bear Canyon	6.5	0.0
	North Fork San Antonio	4.9	0.0

Table 18, continued

Watershed	Mainstem/Tributary	Habitat (stream miles) Total[1]	Available[2]
Salinas (cont.)	Rattlesnake	2.0	0.0
	Pinal	1.2	0.0
	Santa Lucia (Sycamore)	3.7	0.0
	Carrizo	2.4	0.0
	Wizard Gulch	--	--
	Salsipuedes	1.6	0.0
	San Antonio tributary	2.6	0.0
	Nacimiento	4.4	0.0
	Dip	--	--
	Las Tablas	6.9	0.0
	Little Burnett	--	--
	Tobacco	--	--
	Stony	--	--
	San Miguel	--	--
	Negro Fork Nacimiento	1.5	0.0
	Huerhuero	0.0	0.0
	Paso Robles	8.0	8.0
	Santa Rita	4.6	4.6
	Rocky	--	--
	Sheepcamp	--	--
	Jack	0.6	0.6
	Graves	0.0	0.0
	Atascadero	1.7	1.7
	Eagle	0.8	0.8
	Hale	1.2	1.2
	Kathleen Valley	0.5	0.5
	Santa Margarita	--	--
	Trout	2.2	2.2
	Tassajera	0.5	0.5
	Rinconada	--	--
Carmel		**60.7**	**60.7**
	Carmel	24.9	24.9
	Potrero Canyon	1.5	1.5
	Robinson Canyon	0.0	0.0
	Las Garzas	2.6	2.6
	Hitchcock Canyon	1.5	1.5
	Tularcitos	4.3	4.3
	Chupines	0.0	0.0
	San Clemente	6.2	6.2
	Black Rock	2.8	2.8
	South Fork Black Rock	0.0	0.0
	Pine	2.4	2.4
	Cachagua	4.7	4.7
	Boronda	0.0	0.0

Table 18, continued

Watershed	Mainstem/Tributary	Habitat (stream miles) Total[1]	Available[2]
Carmel (cont.)	Conejo	0.0	0.0
	Finch	2.2	2.2
	Danish	1.5	1.5
	Rattlesnake	0.0	0.0
	Miller Fork Carmel	6.0	6.0
	Bruce Fork Carmel	0.0	0.0
	Hiding Canyon	0.0	0.0
	Carmel River tributary	0.0	0.0
Little Sur		**20.6**	**20.6**
	Little Sur	15.5	15.5
	South Fork Little Sur	5.1	5.1
Big Sur		**22.2**	**22.2**
	Big Sur	16.2	16.2
	Pheneger	0.0	0.0
	Juan Higuera	0.5	0.5
	Juan Higuera tributary	--	--
	Pfeiffer-Redwood	0.0	0.0
	Post	0.4	0.4
	Ventana	1.1	1.1
	Terrace	0.0	0.0
	Lion	1.0	1.0
	North Fork Big Sur	1.2	1.2
	Redwood	--	--
	South Fork Big Sur	1.8	1.8
	Mocho	0.0	0.0
	Pick	0.0	0.0

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers
*Supports a reproducing *O. mykiss* population above natural limit of anadromy
--Insufficient information to determine habitat

Within the four anchor watersheds of Monterey County, we identified 16 streams (of 81 candidates) that appear to account for the majority of the high value rearing habitat.

Anchor Watersheds

Salinas River

Steelhead Resources

In the early 1960s, the average Salinas steelhead run was estimated to consist of about 500 individuals (although estimation methods are not provided in the reference). The following excerpts from field notes by DFG staff from 1963 summarize conditions for steelhead in the Salinas system:

> "In the historical past, the river did support a fair steelhead run. It was probably largely supported by spawning and nursery areas in the upper main river, Nacimiento, San Antonio and Arroyo Seco rivers" (DFG 1965).

A 2001 report included discussion of the "Upper Salinas," which was defined as the 14-mile reach downstream from Santa Margarita Lake. The report summarized steelhead resources of the watershed as follows:

> "There is some suitable habitat for steelhead in the Upper Salinas Basin and possibly remnant steelhead populations. However, habitat in the Upper Salinas is of lower quality and is less extensive than that in the Arroyo Seco and its tributaries…The Upper Salinas is also less accessible for steelhead than the Arroyo Seco" (EDAW 2001).

Rearing habitat is clustered in five portions of the Salinas basin: Gabilan Creek, Arroyo Seco and its tributaries, the San Antonio and Nacimiento rivers basins, and in the headwaters streams Paso Robles, Atascadero, and Santa Margarita creeks. Based on the extent and accessibility of habitat in Arroyo Seco, this sub-basin appears to present the watershed's most important steelhead restoration opportunities. The mainstem Arroyo Seco east of the U.S. Forest Service ranger station provides substantial spawning habitat, but appears to be too warm for much of its length for *O. mykiss* to over-summer. This is also the case for most areas upstream of the Vaqueros Creek/Arroyo Seco confluence (D. Boughton pers. comm.). A review of habitat information for the Arroyo Seco suggests that the tributaries Piney (including the tributary Calaboose Creek), Tassajara (including the tributary Church Creek), Lost Valley, Higgins, and Horse creeks offer the most extensive habitat resources[7].

Causes of Decline

Large-scale water storage projects on the upper mainstem Salinas River and the Nacimiento and San Antonio rivers preclude steelhead access to the majority of historical spawning and rearing habitat, and are the primary cause of the steelhead population's decline in the watershed. Although some suitable habitat remains downstream of the Nacimiento and San Antonio dams and in several tributaries to the upper Salinas River, spawning steelhead can rarely access this habitat due insufficient migration flows (Smith 1994; NMFS 2001; NMFS 2007). In addition to the impacts to adult upstream migration, the Nacimiento and San Antonio dams have reduced significantly spring flows such that smolts cannot migrate from upstream rearing habitat to the ocean (NMFS 2005). The Arroyo Seco likely offers the only regularly accessible, extensive rearing habitat currently.

A 2007 biological opinion for the Salinas Valley Water Project describes the role of the Arroyo Seco sub-basin in conserving the Salinas River steelhead resource as follows:

> "Based on its current condition and the loss of spawning habitat in the Nacimiento and San Antonio rivers, the Arroyo Seco River is the most important remaining steelhead habitat in the Salinas River watershed…The relatively close proximity of the Arroyo Seco River to the ocean is likely the primary reason the anadromous form of *O. mykiss* persists in the Salinas River watershed. The Arroyo Seco River also contains the majority of spawning habitat in the basin and half of the rearing habitat... Anthropogenic manipulation of water flow in the Salinas River watershed

[7] Habitat in the Arroyo Seco tributaries Calaboose, Church, and Horse creeks is not depicted in Figure 6 due to the lack of reference information at the time of report preparation. However, recent surveys conducted by NMFS staff indicate substantial habitat resources in these areas (D. Boughton pers. comm.).

> has made successful migration into and out of the upper tributaries more difficult than migration opportunities to and from the Arroyo Seco River" (NMFS 2007, p. 65).

Regarding limiting factors in the Arroyo Seco sub-basin, the 2007 biological opinion states, "Steelhead and steelhead habitat in the Arroyo Seco River are adversely affected by Salinas River flows, conditions in the lower Arroyo Seco River, road crossings, and previous gravel mining activities. These factors hinder and prevent steelhead from reaching spawning and rearing habitat in the Arroyo Seco River and in some cases contribute to spawning and rearing habitat degradation" (NMFS 2007, p. 64).

While remnant *O. mykiss* populations in the upper portions of the watershed persist, the factors outlined above preclude meaningful contribution to the steelhead run in the Salinas at this time. Accordingly, the upper portions of the Salinas River watershed (including Santa Rita and Trout creeks, *e.g.*) are not considered as a target for near-term restoration activities in the following discussion.

Conservation Activities

Restoration of the steelhead resources of the Salinas River system depends on managing land and water resource use in the Arroyo Seco watershed so as to protect habitat. Effective restoration is contingent on the following key actions: 1) providing migration flows between the Arroyo Seco confluence with the Salinas River and the river mouth, and 2) ensuring passage at barriers both within the Arroyo Seco watershed and in the portion of the mainstem Salinas River located downstream of the Arroyo Seco confluence.

Operation of the recently completed Salinas Valley Water Project (SVWP) will enhance fish passage opportunities into the Arroyo Seco. The purpose of the SVWP is to remedy the overdraft of groundwater in the basin by reducing pumping and increasing recharge, which will be achieved through increased winter season storage at Nacimiento Dam, increased summer releases from the Nacimiento and San Antonio reservoirs, and operation of the Salinas River Diversion Facility. The diversion facility, located several miles from the mouth of the Salinas River, consists of an inflatable dam that operates from April to November. The diversion facility was constructed with a fish ladder and second rubber dam to allow steelhead to migrate past the inflated dam to habitat in Arroyo Seco, a screened diversion to avoid entrainment, and a low-flow passage channel to ensure fish passage past the deflated dam. Increased flow releases from the Nacimiento reservoir will improve upstream and downstream migration opportunities.

As part of the requirements outlined in the 2007 biological opinion for the SVWP, the Monterey County Water Resources Agency (MCWRA) conducts monitoring of steelhead smolt outmigration from March 15 to May 31 in the Arroyo Seco, Salinas and Nacimiento Rivers. A fly fishing blog summarized the results of the 2010 monitoring program as follows:, "Throughout the entire [2010] study period, no trout were found in the Nacimiento River, two trout were found in the Salinas River…, and 149 trout were found in the Arroyo Seco River" (Andy 2010).

The 2006 Salinas Valley Integrated Regional Water Management (IRWM) Functional Equivalent Plan identified as a regional priority providing steelhead passage to tributary habitat within the Salinas basin, with a short-term focus on projects that re-establish steelhead in the Arroyo Seco sub-basin. To help achieve this goal, MCWRA applied for and was recently awarded a grant for the SVWP Fish Habitat and Monitoring Program, which will:

1) "…quantify the presence of the threatened steelhead trout (*Oncorhynchus mykiss*) in the lower Salinas River system (population monitoring),
2) …monitor river flows to ensure adequate water for fish passage (migration monitoring) and
3) …monitor water quality to determine habitat suitability (habitat monitoring)" (MCWRA 2010).

In addition, the Monterey County Public Works Department removed a major fish passage barrier at the Thorne Road Crossing on the Arroyo Seco River in 2008, and The Nature Conservancy purchased a conservation easement on Los Vaqueros Ranch in the Arroyo Seco watershed in 2010, protecting 1,337 acres of land along two miles of the Arroyo Seco mainstem and a portion of its tributary, Vaqueros Creek.

Restoration Opportunities

A review of passage barriers was performed for the lower Salinas River and the Arroyo Seco sub-basin using the PAD and other sources. Key passage barriers are listed in Table 19 and labeled in Figure 6. Barrier removal or modification in the Arroyo Seco sub-basin will enable juveniles to retreat from spawning areas upstream of the Vaqueros Creek/Arroyo Seco confluence to cooler tributary habitat as the summer progresses (D. Boughton pers. comm.).

Table 19. Salinas River Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
425-01	Arroyo Seco	Road crossing	Partial	PAD
425-02	Arroyo Seco	Clark Colony diversion	Partial	ENTRIX and EDAW 2002
425-03	Arroyo Seco	Gravel mining site	Partial	ENTRIX and EDAW 2002
425-04	Arroyo Seco	Concrete ford with riprap	Partial	PAD
425-05	Arroyo Seco	Sycamore Flats Rd. Arizona crossing	Partial	ENTRIX and EDAW 2002
425-06	Arroyo Seco	Concrete ford	Partial	PAD
425-07	Arroyo Seco	Miller's Lodge low-flow crossing	Partial	ENTRIX and EDAW 2002
425-08	Arroyo Seco	Concrete ford	Partial	PAD
425-09	Arroyo Seco	Government Camp low-flow crossing	Partial	ENTRIX and EDAW 2002

On the Arroyo Seco River, four of the nine identified partial barriers (Barriers 425-01 to 425-04) are located in the lower river, downstream from all of the sub-basin's suitable habitat. The remaining five barriers (425-05 to 425-09) are located within reaches of the lower to middle mainstem that contain suitable habitat, with a substantial portion of the sub-basin's remaining habitat located above the upstream-most barrier.

ENTRIX and EDAW (2002) identified five stream crossings that create passage problems during low flows (Barriers 425-02, 425-03, 425-05, 425-07, and 425-09). We recommend ranking these barriers in terms of passage severity and modifying the barriers that create the most significant passage problems. As substantial habitat exists upstream from the upstream-most barrier, it is essential that steelhead be provided passage at these sites during critical migration periods.

We recommend assessing each of the remaining barriers listed in Table 19 and modifying those that create problems for steelhead passage. In addition, it would be useful to conduct a passage assessment of the anadromous portion of the Arroyo Seco sub-basin to identify other potential passage constraints.

Carmel River

Steelhead Resources

In a 1983 DFG letter, the average historical steelhead run (prior to dam construction) in the Carmel River was estimated to comprise 8,000 adults annually (DFG 1983a). According to a 1965 fish and wildlife plan, the Carmel River system contained about 93 stream miles of steelhead habitat (DFG 1965). At that time, the average annual steelhead run of the Carmel was estimated to consist of about 1,500 individuals. (It should be noted that estimation methods are not provided in these references.) A draft consultants' report from 1982 offered the following summary of Carmel River steelhead resources:

> "The Carmel River supports an annual run of steelhead that the Department of Fish and Game estimates averages about 2000 adults per year. Adults…spawn in the lower Carmel between Shulte Road and the San Clemente Dam. Some climb the ladder at San Clemente, spawn in the river between the two dams or in the tributaries of that reach, and some are passed over Los Padres to spawn in the upper Carmel and its tributaries" (Kelley 1983).

A 1992 memo summarized conditions in the Carmel system for the previous several years. It stated, "No sea run adults spawned in the Carmel River drainage in 1988, 1989 and 1990. Limited spawning occurred in 1991 and 1992. During the 1992 season, only 14 adult steelhead were recorded passing through the San Clemente Dam fishway" (Murphy 1992). In 1991, only a single steelhead was counted. An additional report notes, "Counts at the fishway increased to 317 for the 1993 migration period" (DFG 1995). Surveys of three Carmel River reaches upstream from Los Padres Dam were conducted in 1994. Staff from DFG concluded, "Even though only a small number of adult steelhead have been passed over the Los Padres Dam to spawn in the headwaters, the population size structure still reflects that of a steelhead population" (DFG 1995). A trap and haul program at Los Padres Dam is conducted annually. In recent years, the steelhead run size has been estimated to be in the range of several hundred individuals (D. Highland pers. comm.).

In a report on a 1957 survey of the portion of the Carmel River downstream of San Clemente Dam, the river was said to be "a good spawning stream, but only a fair to poor nursery" (DFG 1957a). About the reach between the dams DFG stated, "This section of the Carmel River contains the best spawning and nursery areas observed in the entire drainage… It is the most productive part of the entire river" (DFG 1957b). The reach upstream from Los Padres Dam also was surveyed. The report notes, "This appears to be an excellent resident trout stream. However, because of the limited spawning areas available in the main stream and tributaries, the productive capacity for steelhead in this stream section is considered to be limited" (DFG 1957c).

A 1986 Biological Assessment report for the Carmel River states, "Above Los Padres Reservoir the steelhead have access to 14.4 miles of the Carmel River and the tributaries, all of which contain large amounts of spawning and rearing habitat. Much of the area is in the Ventana Wilderness Area and is thus well protected from environmental damage caused by man" (Kelley 1986, p. 20).

Despite the large quantity of habitat that exists above Los Padres Dam, the majority of smolt production in the Carmel River watershed is thought to occur downstream of the dam due to poor juvenile outmigration passage combined with suboptimal adult immigration passage at the dam (K. Urquhart pers. comm.). Based on surveys results, the Carmel River lagoon appears to offer significant rearing habitat, at least in some years. The 2006 survey results were used to prepare an estimate of 3,734 juvenile fish in the lagoon (K. Urquhart pers. comm.). A 1983 DFG study of the *O. mykiss* standing crop concluded, "The lower Carmel River definitely has the capacity to sustain large populations of juvenile steelhead" (DFG 1983b).

Observations by Monterey Peninsula Water Management District (MPWMD) staff and volunteers with the Carmel River Steelhead Association (CRSA), who conduct annual rescues of steelhead from drying pools of the lower mainstem and various tributaries of the Carmel, suggest that the highest quality tributary rearing habitat is offered by Pine and San Clemente (including Black Rock) creeks, which have consistent annual flows (K. Urquhart pers. comm.). Las Garzas creek also contains high-quality rearing habitat (Entrix 2003), but is intermittent and often dries up during the summer rearing season (K. Urquhart pers. comm.). Cachagua, Tularcitos, and Hitchcock creeks have been observed to be "boom or bust" watersheds in terms of smolt production, depending on the water year type. Substantial production can occur in Tularcitos and Cachagua creeks under the right flow conditions, although they rarely occur in Tularcitos Creek (K. Urquhart pers. comm.).

Causes of Decline

Water supply has long been recognized as a primary factor limiting the Carmel River's potential steelhead production. Water demand in the Carmel River watershed far exceeds supply, which has reduced spawning and rearing habitat, particularly in the lower ten miles of stream, and has limited upstream migration of adults and downstream emigration of juveniles. The mechanism is described below:

> "Carmel River flows decrease in early summer, due to reduced runoff and water diversions… These diversions significantly alter the stream flows in the lower portions of the Carmel River to the extent that several miles of river are dewatered each summer and fall and a sand bar is formed at the mouth of the river. The dewatering of the stream channel significantly reduces rearing habitat below San Clemente Dam and strands early migrating juvenile trout in isolated pools in the lower river. Fish rescue operations are conducted by the Monterey Peninsula Water Management District in an effort to mitigate for water diversions. Fish rescued are transported and released into upstream reaches of perennial stream flow…[The] sand bar is artificially breached each winter in order to allow the upstream migration of steelhead from the ocean…" (DFG 1995).

A watershed plan prepared for the Carmel River in 2004 lists additional factors that have been identified as limiting to the Carmel River steelhead population, including lack of spawning gravels in the reaches downstream of the San Clemente and Los Padres dams; lack of riparian vegetation; excess sediment deposits due to bank erosion, cattle grazing activities, and development; passage barriers; and lack of large woody debris. The report emphasizes the need to couple projects that address these problems with restoration of instream flows, stating, "Dealing with dams, erosion/sedimentation, water quality for aquatic life…[and] riparian habitat restoration…are irrelevant if the lack of surface flow continues to be a problem" (CRWC 2004, p. 8).

Conservation Activities

The Monterey Peninsula Water Management District runs the Water Allocation Program, established in 1981 to regulate production of Carmel River surface water stored in San Clemente and Los Padres reservoirs and extraction of ground water via wells in the Carmel Valley and Seaside Groundwater Basin. An environmental impact report was prepared for the Water Allocation Program in 1990, leading to the creation of a mitigation program in 1991, established to address adverse impacts of the approved level of water production on fisheries, riparian vegetation, and lagoon function. The initial mitigation program was to run for five years, but the MPWMD extended it through 2001 and has since voted annually to renew the program.

Mitigation activities related to enhancing the steelhead population include spring rescues of outmigrating smolts, fall and summer juvenile rescues, transport of smolts over Los Padres Dam, and adult and juvenile population monitoring. Monthly streamflow conditions are monitored at the Sleepy Hollow Weir gaging station. Riparian mitigation activities include vegetation monitoring and irrigation, revegetation of denuded streambanks, and various erosion control measures. Lagoon habitat mitigation activities include monthly lagoon water level and water quality monitoring. A report on mitigation activities has been prepared annually since the program's inception.

Annual steelhead rescue efforts associated with the mitigation program are conducted by MPWMD staff and volunteers with the CRSA. During the dry season, juvenile steelhead are rescued from drying reaches of the Carmel River mainstem and tributaries and smolts and adults are rescued from the lagoon. In 2007, rescued juveniles were released into the Sleepy Hollow Rearing Facility, perennial habitat downstream of San Clemente Dam, or the lagoon. Rescued smolts and adults were released into the Carmel Bay or Stewart Cove (MPWMD 2008).

As part of the mitigation program, MPWMD conducts seasonal counts of adult steelhead migrating past San Clemente Dam. A fish counter and video camera are operated at the San Clemente fish ladder from October through June each year. Steelhead are also counted at the Los Padres Dam fish trap. In addition, juvenile population surveys are conducted downstream of Los Padres Dam.

The 2008 Mitigation Program Report summarizes the progress of the mitigation program to date:

> "Monitoring conducted by the District shows that the Carmel River steelhead population has recovered from remnant levels that prevailed as a result of the last drought and past water-supply practices. Since 1992, the spawning population had recovered from a handful of fish to levels approaching 900 adults per year, as counted at San Clemente Dam, before a six-year downward trend from 804 fish in 2001 to 222 fish in 2007. In 2008, the population rebounded somewhat to 412 adults at SCD. Redd surveys below SCD confirm that many adults are spawning in the lower river reaches, and not migrating upstream into the upper watershed, possibly contributing to the low counts at the ladder. This trend substantiates the fact that the habitat in the lower river continues to improve and now has both excellent spawning gravel and food production (BMI abundance) in many of these reaches. River-bank stabilization and restoration projects by the District have matured and now provide both improved rearing habitat and shade for juvenile steelhead in the lower reaches. In addition, the juvenile steelhead that are rescued by the District from the lower river and that survive to adulthood, are likely to return to the lower river to spawn" (MPWMD 2009, p. IX-8).

As recovered juvenile abundance has not translated into recovered run sizes at the San Clemente Dam, there is a need for redd surveys in the mainstem and tributaries below the San Clemente Dam or an annual count of spawning adults as close to the mouth as possible to develop a more accurate estimate of the current run size (K. Urquhart pers. comm.).

The Carmel River has the most monitoring data over the long term of any watershed south of the Russian River, and staff from the MPWMD have recommended that the Carmel River be the focus of NMFS/DFG efforts to create a Life Cycle Monitoring stream for the South Central California Coast ESU as part of DFG/NMFS Coastal Monitoring Program (K. Urquhart pers. comm.).

Restoration Opportunities

Two watershed assessments were published concerning the Carmel River in 2004. The MPWMD reviewed ten limiting factors to the steelhead population of the watershed, largely relating to water diversion, riparian condition, and sedimentation and proposed projects to address steelhead conservation. Two recommendations appear most critical:

(1) Develop alternative storage projects to allow for perennial flow in the Carmel River.
(2) Focus on small to medium scale erosion control projects including Tularictos, San Clemente, and Cachagua creeks (MPWMD 2004).

The Carmel River Watershed Conservancy's action plan delineates eight categories, including non-prioritized conservation efforts. Most importantly, the plan addresses flows by noting, "Guaranteeing surface flow in the Carmel River mainstem and its tributaries should be the single most important objective of the Carmel River Watershed Action Plan…The flow in tributaries is especially impacted due to extraction via wells, an element that is without adequate regulation and monitoring…" (CRWC 2004). Regarding the lower river, the plan states,

> "The lower 10 miles of the river (downstream of the Narrows), where the impacts from water extraction are concentrated, requires irrigation and maintenance of streamside vegetation, reconstruction of streambanks after high winter flows, annual

CRLF and steelhead rescues, habitat enhancement activities, and extensive monitoring" (CRWC 2004, p. 13).

A revised matrix that lists prioritized restoration project recommendations for each of the restoration categories included in the 2004 watershed assessment and action plan report was produced in 2007. High priority recommendations pertaining to groundwater include:

1) Develop a water budget for the entire watershed…Foremost in this assessment is the analysis of how upland bedrock aquifer withdrawals impact the resources of the lower valley.
2) Quantify the impact of groundwater extraction (multiple wells) in upland areas on summer surface flow…

High priority recommendations pertaining to habit include:

1) Expand on MPWMD program to create a watershed wide coordinated riparian vegetation restoration program that includes post-project monitoring and maintenance throughout the Carmel River watershed.
2) Extend the MPWMD mitigation program of periodic injections of gravels and cobbles downstream of Los Padres and San Clemente Dams to a level that restores the channel bottom to a condition similar to areas upstream of Los Padres Reservoir…

High priority recommendations pertaining to sediment management include:

1) Based on CRWC's Proper Functioning Condition tributary assessments and other watershed assessments, restore and revegetate unstable banks and incised reaches of tributaries and mainstem areas including: Conejo…Finch…James [and] Tularcitos [creeks]
2) Conduct assessment of rural and unpaved roads throughout the watershed to identify and prioritize road treatments…

High priority recommendations pertaining to steelhead restoration include:

1) Conduct a watershed-wide assessment and map culverts & fish barriers…
2) Remove or modify priority fish passage barriers throughout the watershed

A review of passage barriers in the Carmel River watershed was conducted using the PAD and other sources. Key barriers are listed in Table 20 and labeled in Figure 7.

Table 20. Carmel River Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
577-01	Carmel	Sleepy Hollow concrete ford	Partial	PAD
577-02	Carmel	Old Carmel River Dam	Partial	PAD
577-03	Carmel	San Clemente Dam	Partial	MPWMD 2004
577-04	Carmel	Los Padres Dam	Total	MPWMD 2004

Table 20, continued

ID	Stream	Description	Type	Source
585-01	San Clemente	Trout Lake fishway	Partial	D. Highland pers. comm.
585-03	San Clemente	Concrete ford	Partial	CRWC 2004

A concrete ford in the vicinity of Sleepy Hollow (Barrier 577-01) is noted in the PAD to create a passage barrier at low flows. As this site is located downstream from a substantial portion of suitable rearing habitat, we recommend assessing the barrier for potential modification.

The Old Carmel Dam (Barrier 577-02) has been identified by DFG and NMFS as a high priority for removal. The MPWMD applied for funding through DFG's Fisheries Restoration Grant Program in 2010 to develop designs for removal.

The San Clemente Dam (Barrier 577-03) is no longer functional due to infilling with sediment. Plans are in place to reroute the Carmel River around the dam, store the roughly 2.5 million cubic yards of sediment in the abandoned stream reach, and eventually remove the dam. The $84 million project will be funded in part by Cal Am with additional support from federal and state agencies.

The Los Padres Dam (Barrier 577-04) creates a complete barrier to migrating steelhead. Upstream migrating steelhead often fail to pass over the dam used in the trap and haul system due to lack of attraction flows at the fish ladder entrance to the traps (K. Urquhart pers. comm.). A study to resolve flow issues at the traps has been recommended. Similarly, flows are often insufficient to allow downstream migrating smolts to pass over the spillway (CRWC 2004). Proposed solutions include concentrating flow at the spillway to facilitate smolt outmigration and constructing a removable fish ladder to allow fish to pass into the spillway notch. Addressing passage issues at Los Padres Dam should be considered a high priority restoration action as this would greatly improve steelhead access to a significant quantity of high-quality spawning and rearing habitat upstream.

The fishway at Trout Lake (Barrier 585-01) has been identified as a partial passage barrier and is "in need of improvement" (D. Highland pers. comm.). A concrete ford on upper San Clemente Creek (Barrier 585-03) may present a partial barrier to migrating steelhead and should be assessed and modified if necessary in accordance with other barrier modification priorities. Seasonal recreational dams on San Clemente and Black Rock creeks have been observed to create passage problems (MPWMD 2004; M. Stoecker pers. comm.). It is recommended that these sites be inventoried and that agreements with seasonal dam operators be reached to ensure steelhead passage at these sites. In addition, the 2004 action plan notes that access to spawning habitat in Tularcitos, Potrero, Garzas, San Clemente, Cachagua, and Hitchcock Canyon creeks could be improved by modifying partial anthropogenic barriers on these streams (CRWC 2004).

Little Sur River

Steelhead Resources

According to the 1965 fish and wildlife plan, the Little Sur River system contained about 30 miles of steelhead habitat (DFG 1965). The annual steelhead run of the Little Sur River was estimated to consist of about 500 individuals. In testimony in the 1980s, a principal researcher likened the Little Sur River to north coast streams in terms of steelhead spawning as "…generally unaffected by drought" (Smith 1989). A DFG memo from 1999 stated, "This is one of the best steelhead streams in the county" (DFG 1999). In a 2003 report NMFS notes, "Little Sur drainage is probably the most productive steelhead river south of the San Francisco Bay at this time" (NMFS 2003).

Causes of Decline

A 1965 inventory noted "Heavy siltation from the county road system" as a critical factor impacting habitat in the Little Sur River (DFG 1965). A 1999 USFWS survey notes extensive streambank disturbance due to two road crossings and extensive foot traffic in the vicinity of the Pico Blanco Boy Scout Camp (USFS 1999a). A 2002 DFG survey report describes primary impacts to the steelhead fishery including sedimentation from land uses adjacent to the stream and hindrance of movement due to a flashboard dam and numerous rock dams (DFG 2003). A fishkill associated with use of a seasonal recreational dam at Pico Blanco Boy Scout Camp occurred in 2002 due to dewatering downstream of the dam.

Conservation Activities

FishNet 4C notes that Monterey County Public Works prepared a sediment assessment of Old Coast Road in 2004 that identified sources of sediment input to various streams in Monterey County, including the Little Sur River. The organization notes that funding to implement the restoration actions identified in the assessment is being sought. Los Padres ForestWatch notes that the U.S. Forest Service has studied the Little Sur River for inclusion into the wild and scenic river system, which would offer additional protection to the basin.

Following assessment by NMFS, the spillway of the seasonal dam at Pico Blanco Boy Scout Camp was modified to provide flows for upstream migration of steelhead, restoration work was conducted in the streambed downstream of the dam to improve habitat, and a fish ladder was installed. According to DFG staff, the dam was modified to include a fishway in about 2005 (M. Hill pers. comm.).

Restoration Opportunities

A protected waterway management plan for the Little Sur was certified in 1986. The plan presented numerous policies and recommendations largely regarding water conservation and land management. Several key recommendations are summarized below.

(1) Determine instream flow need and available water supply.
(2) Do not permit additional dry season flows without establishing compatibility with instream flow needs.
(3) Do not permit development without establishing compatibility with instream flow needs.
(18) Limit grazing intensities to minimize soil erosion.
(19) Consider removing grazing from the Department of Parks and Recreation lands.

(22) Enforce maintenance plans for roads on U.S. Forest Service and Monterey County lands.
(40) Study the utilization of the lagoon by rearing steelhead.
(47) Adopt and apply a Riparian Corridor Protection Ordinance for the lower Little Sur and all perennial tributaries (HSA *et al*. 1986).

A review of passage barriers in the Little Sur River watershed was conducted using the PAD and other sources. A key barrier is listed in Table 21 and labeled in Figure 7.

Table 21. Little Sur River Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
625-01	Little Sur	Camp Pico Blanco summer dam	Partial	M. Stoecker pers. comm.

According to recent observations, the Little Sur Pico Boy Scout Camp fishway may require improvement to allow steelhead passage past the seasonal dam (Barrier 625-02) (M. Stoecker pers. comm.).

Big Sur River

Steelhead Resources

According to the 1965 state fish and wildlife plan, the Big Sur River system contained about 17 miles of steelhead habitat (DFG 1965). The average annual steelhead run of the Big Sur River was estimated to consist of about 250 individuals. A 1981 memo summarized conditions in the watershed:

> "The clean, free-flowing waters provide ideal conditions for natural steelhead trout spawning. The lower seven miles of stream from the State Park to the ocean support a substantial run of steelhead; however, fish migration above the Park is blocked by a 26-foot barrier of boulders and compacted gravel" (DFG 1981).

A 1981 survey report cites a "large, thriving rainbow trout fishery" in the middle reach of the Big Sur River comprised of mainly young fish (USFS 1981a). The upper reach (from Barlow Camp to the confluence of the North and South forks) also had "abundant" rainbow trout (USFS 1981b). A 1990 resources inventory notes approximately three miles of "excellent habitat" in the lower portions of the watershed. The report states, "The majority of steelhead move upstream beyond Andrew Molera State Park to spawn… There are no barriers to migration for 8 miles" (DPR 1990).

Extensive sampling in the Big Sur watershed in 1993 revealed that steelhead smolts occurred in the lagoon and river outlet and not in the mainstem. The 1994 report on this study noted, "The lagoon appeared to be heavily used by presmolt steelhead as rearing habitat" (DFG 1994a). Staff from DFG surveyed the Big Sur River in 1994 between the Pfeiffer Big Sur Campground and the North Fork confluence. Rainbow trout were said to be "abundant" and "numerous" spawning areas were noted throughout the survey reach. The survey report states, "The Big Sur River has excellent potential as a wild trout fishery" (DFG 1994b).

Causes of Decline

A 2003 steelhead enhancement plan for the Big Sur River identified the "volume and intensity of visitor use" within Pfeiffer Big Sur and Andrew Molera State parks as a key limiting factor to the steelhead population in the watershed. The report states, "Where visitor use is concentrated, the visible impacts to salmonid habitat occur through trail erosion, trampling of riparian and instream habitat, and construction of rock dams and channel modifications. These instream activities may result in the degradation of spawning areas in late winter through spring and obstruction of juvenile passage throughout low flow periods. Effects of streambed modifications on aquatic invertebrates, which make up the drift-feeding steelhead's diet, are unknown. In addition, heavy use in the campground and picnic area riparian zones have resulted in notable loss of riparian understory, denuded banks and localized erosion" (Duffy 2003, p.15).

The report notes that the majority of habitat degradation on the Big Sur mainstem occurs within Pfeiffer Big Sur State Park. "Riparian encroachment, inner gorge roads, water extraction, and wastewater generation are concentrated in the Pfeifer Big Sur Park Campground reach and through the Highway 1/Big Sur corridor"(Duffy 2003, p. 5). In Post Creek, impacts consisted of "riparian degradation due to campground-related bank erosion, vegetation trampling and undersized road crossings" (Duffy 2003, p. 25). Staff from DFG have noted impacts from sedimentation, a partial barrier consisting of a concrete instream crossing, and the intensity of the grazing allotment (J. Nelson pers. comm.).

A 2009 DFG report on a planned instream flow study for the Big Sur River states, "Although the Big Sur River appears to be in a relatively pristine state containing one of the last strongholds of quality steelhead habitat on California's south coast, this habitat is at risk from pending water diversion applications requesting a large portion of available flow, existing permitted diversions, illegal unpermitted diversions, and dewatering (DFG 2009, p. 5).

Conservation Activities

A steelhead habitat enhancement plan was prepared in 2003. The plan identifies reach-specific limiting factors to the steelhead population for the portion of the Big Sur River (and its tributary Post Creek) that flows through State Park property. This portion of the basin is estimated to contain approximately 75 percent of the watershed's anadromous habitat. The report includes a list of recommended management actions and restoration projects as described in the following section.

The Department of Fish and Game is in the process of conducting an instream flow study on the Big Sur River to determine the necessary flows to maintain high quality spawning and rearing habitat and critical migration corridors. A study plan detailing the methods that DFG will use to determine adequate instream flows for the Big Sur steelhead population was prepared in 2009.

Restoration Opportunities

A protected waterway management plan for the Big Sur was certified in 1986. The plan presented numerous policies and recommendations largely regarding water conservation and land management. Several key recommendations are summarized below.

(1) Permit well withdrawals adjacent to the lower Big Sur River as riparian uses.
(2) Conduct a water resource study for the lower Big Sur basin.
(6) Do not permit additional dry season flows without establishing compatibility with instream flow needs.
(35) Establish instream flow needs for the lower Big Sur and "suitable tributary creeks".
(47) Adopt and apply a Riparian Corridor Protection Ordinance for the lower Big Sur and all perennial tributaries (Stanley 1986).

Key recommendations included in the Big Sur River Steelhead Enhancement Plan (Duffy 2003) are summarized below:

1) Conduct redd surveys during spawning seasons and close trails adjacent to spawning areas to public access.

2) Install riparian exclusion fencing and re-vegetate riparian areas within the Pfeiffer Big Sur campground and picnic Areas on the mainstem Big Sur and Post Creek. "Continue Creamery Meadow and Creamery Meadow Annex riparian woodland restoration project in Andrew Molera State Park" (Duffy 2003, p. 32).

3) Prohibit construction of rock dams and remove existing rock dams throughout the river.

4) Construct pedestrian bridges within the campground areas to minimize instream trampling.

5) Construct revetment at identified locations of road bank failure, including ranch roads within Andrew Molera State Park, Highway 1 in the vicinity of lower Pfeiffer Big Sur State Park, and in the vicinity of the lagoon. Reroute beach access trails away from bank failures.

Passage barriers in the Big Sur River watershed were identified using the PAD and other sources. A key barrier is listed in Table 22 and labeled in Figure 7.

Table 22. Big Sur River Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
637-02	Big Sur	Cement falls low water crossing	Partial	M. Stoecker pers. comm.

A cement low water crossing (Barrier 637-02) that extends from Highway 1 to a summer-only private campground has been identified as problematic for fish passage (M. Stoecker pers. comm.). This barrier should be assessed for modification options, as it is located downstream from a substantial portion of the watershed's suitable steelhead habitat. If the severity of the barrier warrants, it should be modified in accordance with other barrier priorities in Monterey County anchor watersheds.

Other Important Watersheds

Steelhead resources of the Big and Willow creeks watersheds (Figure 8) are discussed in this report on the basis of containing several miles of documented high-quality steelhead habitat (Table 23). Both basins have pristine conditions due to their largely undeveloped character.

Table 23. Monterey County Important Watershed Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available**
Big		**4.3**	**4.3**
	Big	3.1	3.1
	Devils Canyon	1.2	1.2
Willow		**3.3**	**3.3**
	Willow	3.2	3.2
	North Fork Willow	0.1	0.1

Notes
[1]Includes all habitat located downstream from natural limits of anadromy

Big Creek

Steelhead Resources

The Big Creek watershed is largely undeveloped and well-protected by virtue of having a high proportion of public ownership. The upper reaches of Big and Devils Canyon creeks are located within the Ventana Wilderness and the lower reaches of Big Creek flow through the 4,000-acre University of California Big Creek Reserve and the nearly 8,000-acre Big Creek State Marine Reserve.

A report from 1946 includes the following description of steelhead resources in Big Creek:

> "Good runs of steelhead ascend the stream from the sea and spawn in both forks below the falls. Resident fish of the steelhead-rainbow complex and possibly some survivors and descendants of stocked trout are present both above and below the falls in each fork" (DFG 1946).

A 1961 DFG survey report for Devils Canyon Creek DFG staff describes Big Creek, stating, "This watershed is by far the largest steelhead trout stream in the immediate Southern Monterey County area, being surpassed only by the Big Sur drainage on the north and the San Carpojo to the south, in San Luis Obispo County (DFG 1961a). The report from a 1961 survey of Big Creek states, "This stream provides approximately 1.5 miles of good to excellent steelhead waters…" (DFG 1961b).

According to researchers, habitat occurs in mainstem Big Creek downstream from the Devils Canyon Creek confluence, in upper Big Creek, and in the portion of Devils Canyon Creek accessible to inmigrating adults. It should be noted that available habitat is likely to vary depending on water year type, as the character of the Big Creek watershed (*e.g.*, areas of high gradient, numerous cascades, *etc.*) makes passage conditions changeable.

Causes of Decline

According to a 1961 report, "The crucial limiting factor [in Big Creek] is believed to be the lack of suitable spawning gravels" (DFG 1961b). Erosion of portions of the road adjacent to Big Creek may produce excess sedimentation in some proximate stream reaches (K. Merg pers. comm.). Also, an instream road crossing on private property could be addressed to improve fish passage.

Habitat impacts could be expected without control of invasive plants occurring in portions of the watershed. In particular, neighboring watersheds have been severely impacted by sticky snakeroot (*Ageratina adenophora*) (M. Readdie pers. comm.).

Conservation Activities

The steelhead population of the Big Creek watershed is the subject of ongoing research by staff at NMFS and the UC system. According to the resident director of the Big Creek Reserve, the undeveloped nature of the watershed has led to few habitat impacts in the watershed.

A weed plant management plan was prepared for the ecological reserve in early 2010 (Springer 2010). Ongoing efforts are expected to control the spread of invasive species, including importantly sticky snakeroot.

Restoration Opportunities

Identifying and addressing road-related sediment input into Big Creek could improve steelhead habitat, although the issue is not considered critical. In addition, improving the road crossings of Big Creek would be beneficial.

The most important restoration issue in the Big Creek watershed may be preventing the spread of invasive weeds. In particular, support for the program to remove sticky snakeroot is recommended.

Willow Creek

Steelhead Resources

A report on a DFG survey in 1961 offered this assessment of Willow Creek:

> "Fairly large numbers of steelhead are reported to utilize this drainage during normal years. These fish, moving upstream, have approximately 7 to 8 miles of stream available for spawning. This stream is one of the better steelhead streams of the Southern Monterey County Coastal area" (DFG 1961c).

Also in 1961 DFG staff stated, "…the size of the steelhead run…is probably of moderate size which might number anywhere from 100 to 1,000 fish" (DFG 1961d). As part of a larger study of streams of the Los Padres National Forest, USFS staff surveyed Willow Creek in 1999. The associated estuary was deemed "uniquely productive habitat" (USFS 1999).

Causes of Decline
A 1961 report noted, "Large steelhead spawning and nursery areas have recently been lost due to water being diverted to other uses" (DFG 1961c). Staff from USFS surveyed Willow Creek in 1981 and stated, "The streambed is being degraded by bank erosion from mining, debris barriers, and natural massing" (USFS 1981c). A concrete footing associated with the Highway 1 bridge does not appear to be a barrier to *O. mykiss* migration (D. Rundio pers. comm.).

Conservation Activities
No information was found regarding conservation activities in the Willow Creek watershed.

Restoration Opportunities
A review of passage barriers in Willow Creek was conducted using the PAD and other references. A barrier is noted in Table 24 and labeled in Figure 8.

Table 24. Willow Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
681-01	Willow Creek	Hwy 1 crossing	Partial	PAD

As the Highway 1 crossing on Willow Creek (Barrier 681-01) is located downstream from a significant portion of suitable habitat we recommend this site be assessed to ensure that modification is not necessary.

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Figure 6. Salinas River watershed, Monterey County, California

Figure 7. Anchor watersheds of northern Monterey County, California

Figure 8. Other important watersheds of southern Monterey County, California

Chapter 4. San Luis Obispo County

There is reliable evidence that at least 18 San Luis Obispo County watersheds supported steelhead historically. We found evidence of reproducing *O. mykiss* populations in recent years for each of these watersheds (Table 25).

Table 25. San Luis Obispo County Watersheds Screening by *O. mykiss* Population

Watershed	*O. mykiss* population?
San Carpoforo	Y
Arroyo de los Chinos	Y
Arroyo de la Cruz	Y
Oak Knoll	N*
Arroyo del Puerto	N*
Little Pico	N*
Pico	Y[1]
San Simeon	Y
Santa Rosa	Y
Villa	Y
Cayucos	N*
Little Cayucos	N*
Old	Y
Willow	N[2]
Toro	Y
Morro	Y
Chorro	Y
Los Osos	Y
Islay	Y
Coon	Y
Diablo Canyon	Y
San Luis Obispo	Y
Pismo	Y
Arroyo Grande	Y

Notes
*Evidence of historical presence unsubstantiated.
[1]Recent information unavailable due to management agreement.
[2]No evidence of historical presence.

San Luis Obispo Creek (Figure 10) accounts for approximately 25 percent of the available rearing habitat in watersheds of San Luis Obispo County (Table 26). Substantial additional steelhead habitat also occurs in Arroyo de la Cruz and Santa Rosa Creek (Figure 9) and in Chorro Creek and Arroyo Grande (Figure 10), which together account for approximately 40 percent of available rearing habitat in the county. These five watersheds are considered the anchor watersheds for San Luis Obispo County.

It should be noted that current habitat information for two watersheds included in the following discussion was not made available to authors of this report. The Arroyo de la Cruz and San Carpoforo Creek drainages (Figure 9), characterized below under the "anchor watershed" and "other important watershed" sections, respectively, are located within the boundaries of the Hearst Ranch property. In 2005, California State Parks, the Coastal Conservancy, the Wildlife Conservation Board, the American Land Conservancy, and the Hearst Corporation finalized a conservation easement for the 82,000 acre property, which placed limits on future development and included a transfer of thirteen miles of coastline (including the mouth of Arroyo de la Cruz) to the State of California. As part of the agreement, California Rangeland Trust conducts monitoring on the Hearst Ranch twice a year "to ensure that the steelhead habitat and other conservation values are being protected" (Cepkauskas pers. comm.). Management under the conservation easement combined with the undeveloped nature of these watersheds provides an important opportunity for steelhead resource conservation.

Table 26. San Luis Obispo County Watersheds Screening by Habitat

		Habitat (stream miles)	
Watershed	**Area (sq.mi.)**	**Total[1]**	**Available[2]**
San Carpoforo	35.7	5.5	5.5
Arroyo de los Chinos	1.8	0.3	0.3
Arroyo de la Cruz	42.7	10.9	10.9
Pico	13.4	3.3	3.3
San Simeon	32.1	3.6	3.6
Santa Rosa	47.4	13.7	13.7
Villa	19.1	8.6	8.6
Old	20.6	3.4	0.8
Toro	13.4	9.8	9.8
Morro	10.0	0.4	0.4
Chorro	45.0	15.3	10.9
Los Osos	22.9	2.1	2.1
Islay	9.4	1.6	1.6
Coon	8.6	4.6	4.6
Diablo Canyon	5.0	0.2	0.1
San Luis Obispo	84.8	29.6	27.1
Pismo	37.7	7.0	7.0
Arroyo Grande	155.0	18.5	9.2

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

To further refine the emphasis on areas containing rearing habitat resources, mainstems and tributaries in the five anchor watersheds of San Luis Obispo County were examined, as shown in Table 27. Within the anchor watersheds, we identified 13 streams (of 35 candidates) that appear to account for the majority of the high value rearing habitat. Information regarding steelhead resources of these and other important watersheds of the county is provided below.

Table 27. San Luis Obispo County Anchor Watershed Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available[2]**
Arroyo de la Cruz		**10.9**	**10.9**
	Arroyo de la Cruz	1.6	1.6
	Green Canyon	3.7	3.7
	Burnett	4.2	4.2
	Spanish Cabin	0.3	0.3
	Marmolejo	0.4	0.4
	West Fork Burnett	0.7	0.7
Santa Rosa		**13.7**	**13.7**
	Santa Rosa	13.6	13.6
	Perry	0.1	0.1
	Green Valley	0.0	0.0
Chorro		**15.3**	**10.9**
	Chorro	3.0	3.0
	San Bernardo	2.2	0.0
	San Luisito	2.2	0.0
	Pennington	4.3	4.3
	Dairy	3.7	3.7
San Luis Obispo		**29.6**	**27.1**
	San Luis Obispo	14.7	14.7
	Harford Canyon	2.8	2.8
	See Canyon	3.8	2.0
	Davis Canyon	0.7	0.0
	Castro Canyon	0.0	0.0
	Davenport	0.0	0.0
	Froom	0.8	0.8
	Prefumo	0.4	0.4
	Stenner	5.1	5.1
	Old Garden	0.1	0.1
	Brizzolara	0.9	0.9
	Reservoir Canyon	0.3	0.3
Arroyo Grande		**20.0**	**9.2**
	Arroyo Grande	9.0	9.0
	Los Berros	0.2	0.2
	Tar Spring	0.0	0.0
	Lopez Canyon	8.6	0.0
	Vasquez	0.0	0.0
	Little Falls	0.5	0.0
	Big Falls Canyon	0.3	0.0
	Wittenburg	0.0	0.0
	Huffs Hole	1.5	0.0

Notes

[1]Includes all habitat located downstream from natural limits of anadromy

[2]Excludes habitat located upstream from impassible anthropogenic barriers

Anchor Watersheds

Arroyo de la Cruz

Steelhead Resources

In a 1966 letter DFG states, "San Carpojo and Arroyo de la Cruz Creeks are the best steelhead waters in San Luis Obispo County" (DFG 1966). A 1973 draft report on the effects of potential water developments included estimates of (potential) steelhead run size in several San Luis Obispo County creeks. The estimated run in Arroyo de la Cruz was 2,200 individuals (Macias 1973).

A 1978 DFG report notes, "the lagoon area provided excellent habitat for numerous silvery juvenile" (DFG 1978). The survey report summarized, "Perennial waters and the excellent pooling characteristics of upper Arroyo de la Cruz Creek make it one of the better Coastal steelhead streams in San Luis Obispo County…" (DFG 1978). The upper two miles of Arroyo de la Cruz the lower three miles of Burnett Creek were characterized as the watershed's "prime nursery habitat" (DFG 1978). A 1973 DFG report notes that Green Canyon Creek "appeared to have an over abundance of young-of-the-year SH-RT" (DFG 1973).

A consulting firm studied Arroyo de la Cruz steelhead in 1985. The study report summarizes steelhead resources in the watershed:

> "Age 0+ fish are spawned and rear in the perennial reach, while age 1+ and older fish reside in the lagoon. Age group separation may represent an adaptation to the environmental conditions of Arroyo de la Cruz; *i.e.* limited habitat exists in both the perennial reach (during summer) and the lagoon (year-round); and a dry stream reach exist between the lagoon and perennial reach for about 5 months each year" (JSA 1986).

A population assessment and habitat evaluation was conducted on Arroyo de la Cruz in 1993. At the time of the survey only the uppermost 1.5 miles of the arroyo was wetted, where at least four *O. mykiss* year classes were observed. An estimate of the total *O. mykiss* population in mainstem Arroyo de la Cruz was more than 2,100 individuals. According to the resulting report, "Spawning and rearing habitat in the perennial reach is abundant and in relatively good condition…" (DFG 1994a).

The lagoon has been observed to provide important steelhead rearing habitat (Jones and Stokes 1981; Jones and Stokes 1985 as cited in DFG 1994a). A 2007 article notes that during the winter rainy season the Arroyo de la Cruz lagoon "is popular with catch-and-release anglers pursuing steelhead trout" (Sneed 2007).

Causes of Decline

The report on the 1993 habitat assessment of Arroyo de la Cruz notes "The major land use activities impacting the watershed are cattle grazing and dirt access roads" (DFG 1994a, p. 2). At the time of the survey, grazing was observed to be concentrated in the lower six miles of the Arroyo de la Cruz mainstem and in sections of Burnett and Marmolejo creeks. The report notes that most streambanks in the lower 9.7 miles of the mainstem were observed to be "eroding and completely denuded" and lacking riparian canopy. Water diversions also were noted to be impacting steelhead habitat (DFG 1994a).

Conservation Activities

The conservation easement for the Hearst Ranch property offers an important opportunity to protect and enhance steelhead resources in the Arroyo de la Cruz basin. Information regarding ongoing management of the watershed is not available.

Restoration Opportunities

A 1994 DFG report concerning Arroyo de la Cruz notes that protection of the watershed's steelhead resource was dependent upon maintaining spawning and rearing habitat in the perennial reaches and the lagoon. Diversion of high winter flows to off-stream storage for use during low flow periods and limiting future water diversions was recommended (DFG 1994a). The report notes, "Enhancing the habitat would involve obtaining more water and increasing the wetted stream length, especially in the anadromous portions of Marmolejo Creek and Burnett Creek" (DFG 1994a, p. 35).

While cattle grazing in the lower reaches of the Arroyo de la Cruz mainstem was not believed to have a significant impact on habitat, grazing in upper Burnett and Marmolejo creeks was associated with loss of rearing habitat and elevated water temperatures due to lack of canopy, bank instability, and erosion. Cattle exclusion fencing and riparian revegetation in in these areas was recommended (DFG 1994). The report also recommended conserving dry-season flows in Marmolejo Creek.

A review of passage barriers in the Arroyo de la Cruz watershed was performed using the PAD and other references. A key passage barrier is listed in Table 28 and labeled in Figure 9.

Table 28. Arroyo de la Cruz Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
696-01	Burnett	Weir with fishway	Partial	DFG 1994

A defunct diversion weir on Burnett Creek (Barrier 696-01) was noted in the DFG 1994 report to be decreasing rearing habitat in pools immediately upstream due to infilling with sediment in addition to creating a passage barrier. Removal of the weir was recommended.

The authors recommend that information related to steelhead habitat restoration in the Arroyo de la Cruz watershed be made public. We are not aware of other watersheds in the expansive study area covered in this report where information is similarly withheld, and believe the policy to be incompatible with conservation goals for the region.

Santa Rosa Creek

Steelhead Resources

A letter to DFG cites a Santa Rosa Creek study from 1969-1970 wherein the adult steelhead run in the creek was estimated to be 600 individuals (Seldon 1972). A 1970 DFG memo includes an estimate of 6,800 juvenile steelhead in the Santa Rosa Creek lagoon (DFG 1970). A 1973 study found that the relative abundance of steelhead in Santa Rosa Creek was the highest among the nine watersheds sampled in Santa Cruz, Monterey, and San Luis Obispo counties, with an estimated juvenile population of over 60,000 (Bailey 1973).

The steelhead population appears to have declined after 1973, with juvenile population estimated to be approximately 10,000 individuals in 1978 and 1993 (DFG 1994b). Sampling conducted in Santa Rosa Creek between 1998 and 2006 indicated a rebound, with juvenile population estimates ranging from 25,000 to 65,000 individuals, although juvenile abundance declined significantly during the multi-year study (Alley 2008a, cited in Greenspace 2010).

Steelhead can ascend Santa Rosa Creek to approximately stream mile 13. The highest quality spawning and rearing habitat in the watershed is found in the upper five miles of the anadromous reach (DFG 1994b; Alley 2008a, cited in Greenspace 2010). A 2010 draft watershed management plan for Santa Rosa Creek notes that recent research indicates "...a statistically significant shift in the use between the upper and lower reaches over a 23-year period, with increasing use of the upper creek and decreasing use of the lower creek. These results strongly suggest that the degraded physical habitat and reduced instream flows in the lower creek…have progressively rendered this area less and less suitable for rearing juveniles" (Greenspace 2010, p. 60). The 2010 draft management plan notes that although habitat quality in the lagoon is highly variable and the extent of its use for juvenile rearing is not well understood, "the lagoon is predicted to be a crucial component of the life history of steelhead in Santa Rosa Creek and has the potential to increase the carrying capacity of the watershed, alleviating some of the limitations from poor habitat conditions in stream reaches and contributing to recovery of the population" (Greenspace 2010, p. 74).

Causes of Decline

Anecdotal evidence from fishermen indicates that "…the numbers of adult fish that entered the creek from 1987 through 1991…declined significantly" (Rathbun 1991). A 1991 status report states. "[T]he principal cause of the declines [of steelhead] is the loss of instream flow and perennial standing water in the lower portions of the arroyo, including its lagoon" (Rathbun 1991). A report on a 1993 study noted several land use activities with adverse impacts on the creek including encroachment in the riparian area, grazing, agriculture, road building, and dumping. The report states, "The most severe human impact within the drainage is water diversion by local landowners with riparian or appropriative rights and by Cambria Community Services District" (DFG 1994b).

A draft management plan for the Santa Rosa Creek watershed notes that high inputs of fine sediment from the Perry/Green Valley Creek sub-basin into lower Santa Rosa Creek and the lagoon, periodic dewatering of the middle reaches of the mainstem, low summer instream flows, and a critical passage barrier in the lower mainstem have contributed to the decline of the steelhead population in the watershed (Greenspace 2010). Lack of large woody debris also was listed as a potential limiting factor.

Conservation Activities

Multiple stakeholders are working to prepare a management plan for the Santa Rosa Creek watershed with funding from DFG's Fisheries Restoration Grant Program. A draft version of the report was published in July 2010. The management plan summarizes limiting factors to the Santa Rosa Creek steelhead population based on recent research and provides prioritized restoration and research recommendations for steelhead recovery in the basin, including, most importantly, "actions to provide access to the more productive habitat in the upper watershed, improve summer and winter rearing conditions, and enhance lagoon rearing conditions..." (Greenspace 2010, p. 77).

In 2005 a streambank stabilization project was completed in Fiscalini Creek, a tributary to lower Santa Rosa Creek, to reduce sediment inputs to the lower mainstem. A critical passage barrier was removed at the Burton Street Bridge, located at approximately stream mile 1.9 in 2006. A steelhead habitat enhancement project was implemented in the section of Santa Rosa Creek located downstream from the Highway 1 Bridge between 2007 and 2008 (Greenspace 2010).

Restoration Opportunities

Staff from DFG have recommended addressing water rights issues, including "provisions to protect instream flow during low water years" (DFG 1994b). Protecting instream flows should address both surface water diversion and exploitation of groundwater (A. Spina pers. comm.). The 2010 draft management plan for Santa Rosa Creek lists the following flow-related management recommendations:

1) "Increase flows through the middle reaches [of mainstem Santa Rosa Creek]
2) Construct off-stream water storage
3) Identify critical steelhead instream flow requirements" (Greenspace 2010, p. 78).

A review of passage barriers in the Santa Rosa Creek watershed was conducted using the PAD and other sources. A critical passage barrier is listed in Table 29 and labeled in Figure 9.

Table 29. Santa Rosa Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
716-02	Santa Rosa	Ferrasci Rd culvert and Denil fish ladder	Partial	CCC 2005

In a regional prioritization of fish passage barriers, the culverts and fish ladder at the Ferrasci Road crossing on Santa Rosa Creek (Barrier 716-02) was ranked first (CCC 2005). Designs for a free span bridge to replace the culverts and ladder have been completed. Construction on the project was slated to begin in July of 2010, but did not occur due to complications with funding. The 2010 draft management plan states, "Despite plans for replacement with a free-spanning bridge, the culverts and fish ladder at Ferrasci Road…continue to restrict steelhead and other fish species to the lower reaches of the creek under a range of flow conditions. This lack of access is likely to have significant effects on the steelhead population in some years… Without these two barriers, steelhead…would have unimpeded access to approximately 12 river miles…on the mainstem creek between the ocean and…the natural limit of fish passage in the watershed" (Greenspace 2010, p. 39). Removal of this barrier is considered the highest priority restoration project in the watershed.

The draft management plan notes, "Until access to the upper watershed is consistently provided under a range of water year types, actions to improve spawning and rearing conditions in the lower watershed are also important to near-term steelhead recovery" (Greenspace 2010, p. 77). Other actions recommended in the plan include reducing fine sediment from Perry/Green Valley Creek and implementing large woody debris enhancement projects.

To better characterize the watershed's steelhead resource, the report recommends studies concerning steelhead abundance (in spring and fall), escapement, and smolt growth in and outside the lagoon (Greenspace 2010, p. 78). In addition, the plan notes that the Perry/Green Valley Creek sub-basin has not been evaluated for steelhead use or habitat suitability and recommends conducting a study. The report also recommends conducting a passage barrier assessment in the sub-watershed, stating, "there are a number of stream crossings on Perry and lower Green Valley creeks that have not been evaluated, but have the potential to exclude steelhead from nearly the entire sub-basin" (Greenspace 2010, p. 55).

Chorro Creek

Steelhead Resources

A 1958 DFG survey report for Chorro Creek states, "Chorro Creek has excellent spawning potential and [in] years of adequate rainfall has fair runs of steelhead" (DFG 1958a). According to a 1975 report, "Previous fishery data, collected by Dr. Lee A. Barclay in 1975, indicate that as many as 175 adult steelhead may utilize this drainage for spawning" (DFG 1976).

A DFG letter from 1995 noted that the current estimate for the Chorro Creek steelhead run was only "a fraction" of that estimated in 1975, citing reduced flows due to diversions as impacting the population. The letter states, "The Department believes that, with proper management, including the maintenance of stream flow, the Chorro Creek drainage could support a basin run of at least 450 adults" (DFG 1995a).

Most rearing habitat occurs in mainstem Chorro Creek and in Pennington and Dairy creeks (Table 27). San Luisito Creek also contains substantial habitat, but the tributary is currently inaccessible to steelhead due to barriers created by the Highway 1 box culverts and the Adobe Road crossing (Payne 2007). A 2001 stream survey report notes that high densities of the Sacramento pikeminnow in mainstem Chorro Creek reduce the suitability of the stream's rearing habitat due to predation of steelhead juveniles (CCC 2001a). Pikeminnow have not been observed in Pennington or Dairy Creeks upstream of Highway 1 (CCC 2001b; CCC 2001c).

A report regarding recent efforts to control the Sacramento pikeminnow in the Chorro Creek basin states, "Chorro Creek is the largest creek in the Morro Bay Watershed and has many important resources; limited development in the watershed, endangered species, reclaimed flood plains for sediment capture and strong support for restoration. The South-Central California Coast Steelhead trout…rely on Chorro Creek, as well as its five tributaries, for spawning habitat and rearing habitat with some remaining as residents" (MBNEP 2010, p. 2).

Causes of Decline

As noted above, the presence of the Sacramento pikeminnow has significantly impacted steelhead density and distribution in the Chorro Creek basin. High densities of the pikeminnow have been documented in the lower nine miles of mainstem Chorro Creek and in the Chorro Creek reservoir, as well as downstream of the Highway 1 culverts in Pennington, Dairy, and San Luisito creeks (CCC 2001a, 2001b, 2001c). A 2003 steelhead restoration planning report for Morro Bay notes, "Higher water temperatures in Chorro Creek due to loss of mature riparian canopies has converted the mainstem of Chorro Creek, especially the lower and middle reaches, to a habitat condition that favors warm water species, such as the pikeminnow, over cold water species, such as steelhead" (SHG 2003, p. 16). The report also notes that effluent from the Men's Colony's wastewater treatment plant discharged into Chorro Creek can significantly raise water temperatures in the summer. Surveys of Pennington and Dairy creeks have led to the conclusion that insufficient instream cover exists to allow steelhead to escape predation (CCC 2001b, 2001c).

Lack of canopy in the lower and middle mainstem of Chorro Creek has contributed to bank erosion and has been associated with sedimentation of spawning gravels (CCC 2001a). Stream survey reports from 2001 noted a high degree of fine sediment in the lower reaches of Pennington Creek and severe erosion from road cuts in the Dairy Creek basin in the vicinity of Camp San Luis Obispo National Guard Reservation (CCC 2001b, 2001c).

Numerous open grazing areas along the Chorro Creek mainstem and tributaries have been documented to contribute to erosion and water quality impairment in the basin (CCC 2001, MBNEP 2010). The mouth of Chorro Creek (Morro Estuary) is aggrading, largely due to sediment inputs from upstream sources cited above (A. Halligan pers. comm.).

Passage barriers prevent steelhead from accessing suitable habitat in San Luisito Creek, and multiple low flow crossings also have been identified in Pennington and Dairy creeks (Payne 2007; 2001b; 2001c). Passage barriers in Pennington and Dairy creeks appear to prevent the Sacramento pikeminnow from expanding into upstream reaches of these tributaries, and current policy is to postpone modifying these structures until the pikeminnow population is controlled (MBNEP 2010).

Conservation Activities

In 2006, multiple agencies began collaborating on a multi-phase project to eradicate Sacramento pikeminnow from the Chorro Creek basin. The project involves studying the distribution of the pikeminnow in the mainstem and tributary streams and implementing removal efforts starting in the upper reaches of the watershed and moving downstream. Intensive gillnetting of the pikeminnow was conducted annually in the Chorro Creek reservoir from 2006 to 2008 and has likely removed the basin's "seed source" (MBNEP 2010). The Morro Bay National Estuary Program (MBNEP) prepares annual reports on the project's progress.

A riparian fencing program to exclude cattle from accessing streambanks in Chorro Creek and its tributaries was initiated in 2005 (A. Halligan pers. comm.). A large-scale erosion control project involving channel restoration and bank revegetation was implemented in Walters Creek, a tributary to Chorro Creek, in 2008 to prevent sediment from entering the Chorro Creek mainstem and ultimately the Morro Estuary (MBNEP 2010b). Plans have been developed to reestablish historical flood plains in lower Chorro Creek on land recently acquired by conservation groups (A. Halligan pers. comm.).

Restoration Opportunities

Eradication of the Sacramento pikeminnow population is a main restoration focus in the Chorro Creek watershed. Priority projects involve reducing water temperatures by enhancing streamflow and revegetating denuded riparian areas. Increasing instream cover (*e.g.,* log and rootwad structures) in pools to improve shelter for juvenile steelhead also has been cited as an important restoration need.

A review of the PAD and other sources was made to produce a list of passage barriers in the Chorro Creek basin. Important barriers are noted in Table 30 and labeled in Figure 10.

Table 30. Chorro Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
730-01	Chorro	Dam	Partial	Taylor 2003
730-02	Chorro	Pipe crossing	Partial	Taylor 2003
730-04	Chorro	Chorro Dam	Total	CCC 2001a
732-02	San Luisito	Adobe Rd. culvert	Total	Taylor 2003
732-03	San Luisito	Hwy 1 crossing	Total	Taylor 2003
733-01	Pennington	Hwy 1 crossing	Partial	Taylor 2003
734-01	Dairy	Hwy 1 crossing	Partial	Taylor 2003
734-02	Dairy	Low elevation dam	Partial	Taylor 2003

As noted above, current policy of resource agencies and funding groups is to delay implementation of passage barrier modifications until Sacramento pikeminnow has been eradicated from the watershed. The pikeminnow distribution and abundance study conducted by MBNEP in the Chorro Creek watershed will end in November of 2010, after which staff from MBNEP plant to meet with resource agencies to discuss the possibility of re-issuing permits for barrier modification/removal projects and to develop a pikeminnow management plan (A. Halligan pers. comm.). Removing the total passage barriers at the Adobe Road and Highway 1 crossings on San Luisito Creek (Barriers 732-02 and 732-03) are considered the highest priority fish passage projects in the watershed (A. Halligan pers. comm.).

San Luis Obispo Creek

Steelhead Resources

A 1975 DFG study of San Luis Obispo Creek stated, "An estimated total of 1,005 sea-run adults are produced annually" (DFG 1975). In 2003, a basin-wide survey determined that the mainstem was one of the three greatest contributors to the *O. mykiss* population in the watershed, along with See Canyon and Stenner creeks (Payne 2004). In 2008, the total steelhead population in San Luis Obispo Creek was estimated to be 37,000 fish, with the highest quality habitat and highest densities of juveniles found in the lower mainstem San Luis Obispo Creek (Alley 2008b, cited in LCSLOC 2008).

Causes of Decline

A 1958 DFG survey report states, "…the stream may be lowered to almost intermittent flows if everybody irrigates at once – and in 'normal' water year may be dried" (DFG 1958b). In notes from a 1978 workshop DFG staff is quoted as saying, "San Luis Obispo Creek itself is now merely a transportation corridor for steelhead to get to spawning tributaries [whereas] in the past, the creek itself was one of the major spawning and nursery habitats… [T]he creek has been degraded not only from erosion, but from other pollutants as well" (CCCRWQCB 1978).

In a 1995 hydrologic survey report for San Luis Obispo Creek, accelerated erosion rates on stream banks were attributed to lack of riparian vegetation, urban encroachment, and receding water tables. Channelization in some sections of stream also was found to contribute to increased water velocities and downstream bank erosion (LCSLOC 1995, cited in DFG and USFWS 1999).

A 1995 steelhead habitat inventory for San Luis Obispo Creek report noted that "severely" limited pool habitat, fish migration barriers, embedded spawning gravels, and lack of riparian canopy and instream cover were limiting to the basin's steelhead population (LCSLOC 1995, cited in DFG and USFWS 1999). Excessive nutrient loading also was identified as a significant problem (CRI 1994, cited in DFG and USFWS 1999).

Conservation Activities

A restoration plan for the San Luis Obispo Creek watershed was prepared in 1999. The plan identified high priority restoration actions with a specific focus on enhancing steelhead habitat, including riparian corridor revegetation, streambank stabilization, *Arundo* removal, and ten passage barrier modification projects (DFG and USFWS 1999).

The Land Conservancy of San Luis Obispo County managed the implementation of the restoration projects identified in the 1999 restoration plan. In 2008, a set of restoration efforts was completed, including revegetation and bank repair projects in lower San Luis Obispo Creek near Highway 101, in the middle mainstem in the vicinity of the Filipponi Ecological Area, and in the upper mainstem at the Highway 101 Cuesta grade. Barrier removal projects occurred at one location in mainstem San Luis Obispo Creek, four locations in Stenner Creek, and four locations in Prefumo Creek. Additional work included invasive plant removal and a basin-wide steelhead monitoring survey (LCSLOC 2008). The Marre Dam in lower San Luis Obispo Creek also was recently modified for fish passage (D. Highland pers. comm.).

Restoration Opportunities

A review of passage barriers in the San Luis Obispo Creek watershed was performed using the PAD and other sources. Notable barriers are listed in Table 31 and labeled in Figure 10. A discussion of barrier modification projects is provided below.

Table 31. San Luis Obispo Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
740-02	San Luis Obispo	Marsh St. concrete apron	Partial	CCC 2005
740-03	San Luis Obispo	Cuesta Park fishway at Hwy 101	Partial	PAD

Table 31, continued

ID	Stream	Description	Type	Source
1557-01	See Canyon	Rock dam at Avila Ranch	Total	PAD
1557-02	See Canyon	Black Walnut Rd. crossing	Total	CCC 2005
1557-03	See Canyon	Black Walnut Rd. crossing	Partial	CCC 2005
741-01	Stenner	Murray St. crossing	Partial	CCC 2005
741-02	Stenner	Stenner Glen Dam	Partial	PAD
741-05	Stenner	Stenner Creek Rd. concrete apron	Partial	CCC 2005
741-07	Stenner	Stenner Creek Rd. Bridge	Partial	PAD
741-08	Stenner	Railroad crossing culvert	Total	PAD

The concrete apron at the Marsh St. crossing on San Luis Obispo Creek (Barrier 740-02) was identified as a high priority restoration project in a 2005 fish passage assessment report for San Luis Obispo County streams (CCC 2005). The report notes that the concrete apron creates a significant passage impediment to juvenile steelhead.

The Cuesta Park fishway at Highway 101 on San Luis Obispo Creek (Barrier 740-03) was modified to improve fish passage in 2003. However, channel incision may become a concern at this location. The installation of rock weirs to stabilize the downstream grade is being considered.

A rock dam at Avila Ranch on See Canyon Creek (Barrier 1557-01) creates a total passage barrier and should be modified to allow fish passage, as substantial high-quality habitat exists upstream in See Canyon and Davis Canyon creeks. Two Black Walnut Road crossings on upper See Canyon Creek (Barriers 1557-02 and 1557-03) are not considered high priority restoration projects as suitable habitat has not been documented upstream.

The Murray Street crossing on Stenner Creek (Barrier 741-01) is noted in a 2005 fish passage assessment report to create passage problems for all steelhead age classes. Modification of this barrier was recommended (CCC 2005).

The Stenner Glen Dam on Stenner Creek (Barrier 741-02) is noted in the PAD to require monitoring. This barrier was modified with a boulder weir in 2001 to improve fish passage.

The Stenner Creek Road bridge apron on Stenner Creek (Barrier 741-05) is noted in the PAD to potentially cause passage problems for juvenile steelhead at low flows. The installation of a weir below the crossing was recommended (LCSLOC 2002 cited in PAD).

The upper Stenner Creek Road crossing on Stenner Creek (Barrier 741-07) is identified in a 2005 fish passage assessment report as creating significant passage problems for all ages of steelhead. Modification to improve passage at the site was recommended (CCC 2005).

Future restoration efforts in the San Luis Obispo Creek watershed will focus on the passage barriers discussed above and on addressing downcutting downstream from the Highway 101 culvert (F. Otte pers. comm.).

Arroyo Grande

Steelhead Resources

According to NMFS' analysis, the steelhead population in the Arroyo Grande system may have been the most extensive of the small populations of the San Luis Obispo County coast (Boughton *et al.* 2006). Staff from DFG surveyed Arroyo Grande in 1960. The survey report states, "This stream ranks with the better streams of the San Luis Obispo area which enter the Pacific Ocean. Long sections of this stream contain permanent water throughout the entire year" (DFG 1960a).

A 1961 DFG letter on the proposed Lopez Dam project includes a run size estimate of "about 1,000 adult fish" (DFG 1961a). A memo from that year reported on the run size estimate produced through interviews with local residents and concluded, "1. The steelhead runs in Arroyo Grande Creek averaged at least 1000 fish annually 20 years ago. 2. Since 1940 the runs have decreased to an average of approximately 100-200 fish annually for the past 10 years" (DFG 1961b).

In a 1960 report on the proposed Lopez Dam DFG staff summarizes the effect on the steelhead fishery of the Arroyo Grande watershed:

> "The proposed dam would block off approximately 17 miles of steelhead spawning grounds and approximately 14 miles of nursery grounds used by the young of this species. All three miles of spawning grounds in Arroyo Grande Creek, three miles of spawning and nursery areas in Lopez Canyon Creek, and one mile of spawning and nursery area in Wittenberg Creek would be inundated by the proposed reservoir. Thus, six out of 21 miles of spawning water and four out of 14 miles of nursery water would be lost due to inundation by the reservoir" (DFG 1960b).

The report also notes, "…it can be anticipated that winter flows which normally attract and enable steelhead to ascend on their spawning migration would be reduced by storage at this time. This can be critical in a small stream as is this one" (DFG 1960b).

Current steelhead runs are estimated to be "in the dozens" and the vast majority of available habitat is found in the Arroyo Grande mainstem below Lopez Dam (Rischbieter 2004). Habitat also is available in Los Berros Creek, which typically has perennial flows but likely is experiencing over-exploitation of water resources (A. Spina pers. comm.).

Causes of Decline

Major alterations to the Arroyo Grande system, including the construction of Lopez Dam and the channelization of sections of the mainstem Arroyo Grande and Los Berros Creek, have impacted the basin's steelhead resources. Access to a substantial portion of historical habitat is precluded and streamflow and sediment dynamics in the accessible reaches of the basin are altered.

A 2004 report on the Arroyo Grande system states, "It appears the most significant potential impact to the fishery, including sensitive species such as steelhead, relates to the seasonality of surface flow. Lagoon water quality usually degrades during closed periods, especially if inflow is low, and poor water quality and lack of access to and from the ocean can impact steelhead… In 2004, severe dewatering was likely due to local agricultural groundwater pumping that exceeded the recharge available from the creek" (Rischbieter 2004).

A 2005 watershed management plan notes streamflow in lower Arroyo Grande Creek is most significantly impacted by the operation of Lopez Dam (CCSE 2005). Since dam construction, an average of 2,330 acre-feet of water has been released into Arroyo Grande between April and October to recharge ground water pumped for agricultural use downstream. Reservoir releases occur at a rate of about 1 to 11 cubic feet per second. Prior to 1998, releases for fisheries did not occur (SEI 2004; CCSE 2005).

A report discussing 1999 and 2000 surveys in the Arroyo Grande watershed states, "Spawning gravel quality and availability…is a potential limiting factor affecting steelhead abundance and reproductive success within Arroyo Grande… Although good and excellent habitat was present within various areas of the creek, overall habitat conditions for juvenile steelhead rearing were only fair" (SEI 2004).

A 2000 DFG survey report for Arroyo Grande noted lack of riparian vegetation, sedimentation, and passage problems in the study reach and recommended the following: "Assure adequate stream flows for adult and juvenile passage, summer and fall rearing, sediment flushing during winter and spring and high water quality during the summer and fall" (DFG 2000). Recent research suggests that the lack of channel flushing high flows in Arroyo Grande downstream for Lopez Reservoir has resulted in a narrow, simplified channel with excessive siltation (S. Wald pers. comm.).

A 2009 report regarding maintenance of the flood control channels in Arroyo Grande and Los Berros Creek notes "the most significant issue of concern relative to channel maintenance is still the large volume of sediment which has accumulated and remains in the bottom of the Arroyo Grande Creek from the Valley Road crossing area to the Guiton's Road Crossing area" (Haines 2009, p. 3). The report recommends removing excess sediment from areas of both streams, particularly "in Arroyo Grande Creek at the Railroad Bridge; and on Los Berros Creek between the confluence with Arroyo Grande Creek and the Valley Road Bridge, and at the Century Lane Bridge" (Haines 2009, p. 6).

Conservation Activities

A draft Habitat Conservation Plan (HCP) was published in 2004 for Arroyo Grande that included provisions for protection of steelhead. Specifically, the HCP describes releases from Lopez Dam to improve habitat, modifying the Arroyo Grande stream gage for fish passage, and funding a conservation account to be used for non-flow habitat enhancement projects.

Discussions between the County of San Luis Obispo and NMFS regarding the relationship between flows and habitat are ongoing, and should result in agreement on Lopez Dam operations within the next several years (D. Bird pers. comm.). Central Coast Salmon Enhancement and the County of San Luis Obispo cooperated to redesign the Arroyo Grande stream gage (S. Wald pers. comm.).

The County of San Luis Obispo is working with the San Luis Obispo County Resource Conservation District and landowners to develop a waterways management program for Arroyo Grande to improve flood capacity and simultaneously enhance steelhead habitat. The program is in the environmental review stage and will involve increasing stream channel roughness, increasing canopy cover, sediment removal in areas of channel aggradation, long term vegetation maintenance in the flood control channels, and raising portions of existing levees in the lower basin. A preliminary geomorphic study has been prepared for the basin (S. Wald pers. comm.).

Restoration Opportunities
The Arroyo Grande Creek Habitat Conservation Plan (Stetson *et al*. 2004) described important projects related to restoring steelhead trout habitat in the Arroyo Grande watershed. Selected important projects include in-channel rearing habitat improvements, securing easements and right-of-way agreements to improve channel bank stability and for riparian revegetation, implementation of Best Management Practices for stream maintenance and vegetation control, and implementation of a public education program (Stetson *et al*. 2004).

A review of passage barriers in the Arroyo Grande watershed was conducted using the PAD and other sources. Notable passage barriers in the basin are listed in Table 32 and labeled in Figure 10. A discussion of potential barrier modification projects is provided below.

Table 32. Arroyo Grande Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
749-01	Arroyo Grande	Two concrete dams	Partial	PAD
749-02	Arroyo Grande	Gaging station with Concrete Weir	Partial	CCC 2005
749-03	Arroyo Grande	Concrete Dam	Partial	PAD
749-04	Arroyo Grande	Cecchetti Road Culvert	Partial	CCC 2005
749-05	Arroyo Grande	"S" Rip-rap Dam	Partial	PAD
749-06	Arroyo Grande	Talley Vineyard Dam Footing	Partial	PAD
749-07	Arroyo Grande	Culverts at Biddle Regional Park	Partial	PAD
749-08	Arroyo Grande	Concrete Grade Control Weir	Partial	PAD
749-09	Arroyo Grande	Lopez Lake Dam	Total	CCC 2005

Two concrete dams in lower Arroyo Grande (Barrier 749-01) do not create significant passage problems for steelhead and are not considered high priority for modification (S. Wald pers. comm.). The concrete weir used in the stream gage on Arroyo Grande (Barrier 749-02) is considered the most significant barrier in the watershed downstream from Lopez Dam (CCSE 2005). A redesign has been completed and funding for modification is being sought (S. Wald. Pers. comm.)

A concrete dam on Arroyo Grande (Barrier 749-03) has been observed to create a barrier to upstream migrating juvenile steelhead, particularly during low flows (CCSE 2005). The dam should be assessed for severity and modified in accordance with other barrier priorities in the watershed.

The Cecchetti Road culvert on Arroyo Grande (Barrier 749-04) is considered a high priority restoration project. A conceptual design for a free span bridge at this site has been completed along with a project description (S. Wald pers. comm.).

A rip-rap dam on Arroyo Grande (Barrier 749-05) is filled with gravel in the middle section and currently serves as an important grade control structure. Modification rather than removal has been recommended to improve fish passage at this site (CCSE 2005).

A dam footing at the Talley Vineyard on Arroyo Grande (Barrier 749-06) creates a partial passage barrier, and the landowner is working with the county to improve fish passage at the site (S. Wald pers. comm.). A series of five culverts in Biddle Regional Park (Barrier 749-07) create passage difficulties for migrating steelhead. Modification feasibility should be examined at these sites.

A concrete grade control weir on Arroyo Grande (Barrier 749-08) may present a partial barrier to juvenile steelhead, although a 2005 report notes good flow at this site due to its proximity to Lopez Dam and states, "with good acceleration, passage could be achieved (CCSE 2005).

As noted previously, Lopez Dam (Barrier 749-09) precludes steelhead access to a large portion of historical habitat and is considered "solely the biggest impact to the decline of Steelhead trout in Arroyo Grande" (CCSE 2005). Related restoration recommendations at involve a continuing program to provide appropriate bypass flows to improve migration opportunities and rearing habitat in the lower basin.

Other Important Watersheds

Two additional streams, San Carpoforo and Pismo creeks (Figures 9 and 10, respectively), were identified as important to increasing steelhead production in San Luis Obispo County based on the quantity of available rearing habitat (Table 33). Substantial stakeholder interest exists for enhancing habitat quality in these basins. Although information about, and access to, San Carpoforo Creek is limited, steelhead resources of these two watersheds are further characterized below.

Table 33. San Luis Obispo County Important Watershed Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available**
San Carpoforo		**5.5**	**5.5**
	San Carpoforo	5.2	5.2
	Estrada	0.3	0.3
	Dutra	*	*

Table 33, continued

Pismo		**7.0**	**7.0**
	Pismo	5.5	5.5
	West Corral de Piedra	1.5	1.5
	East Corral de Piedra	0.0	0.0

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
*Supports *O. mykiss* upstream of a total natural barrier

San Carpoforo

Steelhead Resources

Staff from DFG surveyed San Carpoforo Creek in 1961 and found the highest *O. mykiss* population density in the lower one mile of the creek. The survey report included an estimate of "…155 adult steelhead in three holes between the mouth of the stream and the mine" in the late 1950s (DFG 1961c). The creek was deemed, "… a good steelhead nursery and spawning area" (DFG 1961c). A 1973 draft report estimated the steelhead run in San Carpoforo Creek to be 500 individuals (Macias 1973).

In a 1966 letter DFG states, "San Carpojo and Arroyo de la Cruz Creeks are the best steelhead waters in San Luis Obispo County" (DFG 1966). In 2010, a consulting biologist also characterized San Carpoforo Creek and Arroyo de la Cruz as "two of the best" steelhead streams south of the San Francisco Bay (M. Stoecker pers. comm.).

Surveys conducted between 1993 and 2003 indicated the consistent presence of multiple *O. mykiss* age classes in the San Carpoforo mainstem and lagoon (DFG 1995b; USFS 1999; NMFS 2002). According to NMFS staff, San Carpoforo Creek's watershed is potentially the least impacted drainage south of San Francisco due largely to Hearst Ranch and USFS land ownership.

Current information concerning steelhead resources in the San Carpoforo Creek watershed was not made available to the authors of this report, As noted in the discussion of Arroyo de la Cruz earlier, the conservation easement for the Hearst Ranch property has been interpreted to include stream management provisions conducted without provision for public reporting.

Causes of Decline

Limiting factors to steelhead in the basin are largely natural due to the low intensity land use in the watershed (M. Capelli pers. comm.). Information regarding limiting factors is not available due to the existing interpretation of the conservation easement.

Conservation Activities

The limited development and low intensity land use in the San Carpoforo Creek watershed offers an important opportunity to protect and enhance steelhead resources. It is largely on this basis that the watershed is identified as important in this report. However, information regarding restoration goals and ongoing projects was not made available to the authors.

Restoration Opportunities
A review of the PAD and other sources was made to locate fish passage barriers in the San Carpoforo Creek watershed. One barrier (ID 700054) is listed as "Unknown fish passage issue" in the PAD.

Specific and scientifically supported restoration recommendations for the basin could not be provided here. The authors recommend that information related to steelhead habitat restoration in the San Carpoforo Creek watershed be made public. We are not aware of other watersheds in the expansive study area covered in this report where information is similarly withheld, and believe the policy to be incompatible with conservation goals for the region.

Pismo Creek

Steelhead Resources
A 1958 DFG memo states that Pismo Creek supports "…a reasonably good run of steelhead (DFG 1958c). Steelhead also were observed during stream surveys in 1974 and 1975 (as cited in CCSE 2009).

Surveys conducted in Pismo Creek in 2005 by DFG staff found multiple *O. mykiss* age classes, and the survey reports noted that the majority of the watershed's rearing habitat was found in the Pismo Creek mainstem (DFG 2005). Some suitable rearing pools were observed in West Corral de Piedra Creek downstream from Righetti Dam, although a large portion of the stream downstream from the dam was noted to be dry. Upstream of the dam, high quality habitat and multiple *O. mykiss* age classes were observed (CCSE 2005). The portion of West Corral de Piedra Creek upstream from Righetti Dam has not been designated as critical habitat for the region's steelhead ESU (CCSE 2009).

Causes of Decline
A 2005 habitat assessment report for Pismo Creek noted impacts due to sediment inputs from denuded streambanks, cattle grazing, and excessive trampling and use by humans. The assessment also described a lack of riparian vegetation and the absence of instream flows in West Corral de Piedra Creek downstream from Righetti Reservoir. The presence of non-native vegetation in the streambanks, channel, and riparian corridor in mainstem Pismo and West Corral de Piedra creeks was noted to be obstructing streamflow, creating passage issues, and contributing to bank failure. Two significant passage barriers on mainstem Pismo Creek also were identified (DFG 2005).

Conservation Activities
A watershed plan for Pismo Creek was developed in 2009. The plan includes recommended steelhead restoration projects, including working with landowners to improve instream flows, planting native vegetation, and removing fish passage barriers (CCSE 2009). A program to assess water quality in the Pismo Creek estuary was recently initiated (S. Wald pers. comm.).

Restoration Opportunities
The 2009 watershed management plan for Pismo Creek (CCSE 2009) provides recommended actions to improve steelhead habitat in the basin based on information from the DFG (2005) habitat assessment report for Pismo Creek, including:

1) Ensure minimum instream flow releases from Righetti Reservoir for protection of steelhead habitat
2) Conduct instream flow studies to determine optimal flows for rearing habitat and fish passage
3) Remediate identified sediment sources on mainstem Pismo Creek. Install cattle exclusionary fencing
4) Conduct a watershed-wide sediment assessment to identify and prioritize sediment sources in tributaries
5) Plant denuded streambanks in West Corral de Piedra Creek with native trees from Highway 227 to Righetti Road Bridge
6) Implement aggressive program to remove *Arundo* and other non-native vegetation from stream banks and channels in Pismo Creek
7) Remove identified passage impediments

Key passage barriers in the Pismo Creek watershed are listed in Table 34 and labeled in Figure 10. A discussion of barrier modification recommendations is provided below.

Table 34. Pismo Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
744-01	Pismo	Concrete ford	Partial	DFG 2005
744-02	Pismo	UPRR crossing fish ladder	Partial	CCC 2005
745-03	West Corral de Piedra	Righetti Dam	Partial	DFG 2005

A concrete ford at stream mile 4.6 on Pismo Creek (Barrier 744-01) was identified as a barrier to juvenile steelhead migrating upstream and a possible barrier to adults at low flows (CCSE 2005). The 2009 watershed management plan for Pismo Creek recommends removing this barrier (CCSE 2009).

The Union Pacific Railroad crossing on Pismo Creek (Barrier 744-02) was characterized as creating significant passage problems for steelhead in a 2005 fish passage assessment report for streams of San Luis Obispo County (CCC 2005). The crossing was identified as the highest priority barrier modification project in the basin in the 2009 watershed management plan for Pismo Creek (CCSE 2009). Designs for a new fish ladder at the crossing were completed in 2009, and a portion of the funding for project implementation will be provided through DFG's Fisheries Restoration Grant Program (S. Wald pers. comm.).

As noted above, a high priority restoration project for the Pismo Creek watershed is implementing a bypass flow regime at Righetti Reservoir (Barrier 745-03) to improve rearing habitat quality and fish passage opportunities.

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Figure 9. Anchor and other important watersheds of northern San Luis Obispo County, California

Figure 10. Anchor and other important watersheds of southern San Luis Obispo County, California

Chapter 5. Santa Barbara County

We reviewed Santa Barbara County watersheds for historical steelhead presence and recent evidence of reproducing *O. mykiss* populations. Of the county's 32 watersheds with available fisheries information, 21 have sufficient supporting documentation to assume consistent historical use by steelhead. Of these watersheds, 16 have evidence of recently reproducing *O. mykiss* (Table 35).

Table 35. Santa Barbara County Watersheds Screening by *O. mykiss* Population

Watershed	*O. mykiss* population?
Santa Maria River	Y
San Antonio	N
Santa Ynez River	Y
Cañada Honda	N
Jalama	Y
Cañada del Cojo	N
Cañada de Santa Anita	Y
Cañada del Sacate	N
Cañada de la Gaviota (Gaviota)	Y
Cañada de San Onofre	N*
Arroyo Hondo	Y
Arroyo Quemado	Y
Tajiguas	N*
Cañada del Refugio (Refugio)	N*
Cañada del Venadito	N
Cañada del Corral	N*
Cañada del Capitan	N*
Gato Canyon	N
Dos Pueblos Canyon	Y
Eagle Canyon	N
Tecolote Canyon	Y
Bell Canyon	N
Goleta Slough Complex	Y
Arroyo Burro	N*
Mission	Y
Montecito	Y
Oak	N
San Ysidro	Y
Romero	Y'
Arroyo Paredon	Y
Carpinteria Salt Marsh Complex	N
Carpinteria	Y

Notes
*Observations of *O. mykiss* have occurred within the last two decades. Watershed advanced to habitat screening due to possible future steelhead use.
'Insufficient information to determine habitat.

Available information regarding rearing habitat was reviewed in order to compare Santa Barbara County watersheds with *O. mykiss* populations as well as several watersheds without recent evidence of *O. mykiss* populations deemed likely to be capable of supporting steelhead. As noted in Table 36, the Santa Maria River (Figure 11) and the Santa Ynez River (Figure 12) offer vastly more extensive habitat resources than smaller watersheds south of

Point Arguello. Both river systems have major dams, though only Bradbury Dam in the Santa Ynez basin (and not Twitchell Dam in the Santa Maria basin) appears to preclude access to significant amounts of historical habitat.

Table 36. Santa Barbara County Watersheds Screening by Habitat

		Habitat (stream miles)	
Watershed	**Area (sq.mi.)**	**Total[1]**	**Available[2]**
Santa Maria River	1827.7	53.2	36.8
Santa Ynez River	896.6	132.9	22.6
Jalama	24.5	11.0	9.0
Cañada de Santa Anita	3.2	1.9	0.0
Cañada de la Gaviota	20.0	7.1	6.7*
Cañada de San Onofre	2.1	0.7	0.0
Arroyo Hondo	4.3	1.9	1.9
Tajiguas	6.2	2.0	0.0
Cañada del Refugio	8.0	3.3	0.0
Cañada del Corral	6.4	3.4	0.0
Las Llagas Canyon	2.8	1.0	0.0
Cañada del Capitan	6.1	5.6	5.2
Dos Pueblos Canyon	8.4	3.7	0.0
Tecolote Canyon	5.7	2.7	0.0
Goleta Slough Complex	47.0	9.9	4.9
Arroyo Burro	9.0	1.9	0.0
Mission	10.4	4.5	3.1
Montecito	6.5	3.0	2.3
San Ysidro	3.1	2.7	2.3
Arroyo Paredon	4.0	2.9	2.1
Carpinteria	16.1	18.1	5.1

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers
*Estimated available habitat may be inaccurate due to a barrier at the mouth that has not been assessed.

To further refine the areas containing important rearing habitat resources, mainstems and tributaries in the two Santa Barbara County anchor watersheds were examined, as shown in Table 37. Various aspects of steelhead habitat within the anchor watersheds are described below.

Table 37. Santa Barbara Anchor Watershed Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available[2]**
Santa Maria		**53.2**	**36.8**
	Santa Maria	0.0	0.0
	Deal Canyon	1.0	0.0
	Reyes	3.6	0.0
	Beartrap	4.6	0.0
	Sisquoc	11.0	11.0
	Tepusquet	7.2	0.0
	La Brea	--	--
	North Fork La Brea	--	--

Table 37, continued

Watershed	Mainstem/Tributary	Habitat (stream miles) Total[1]	Available[2]
Santa Maria (cont.)	Horse Canyon	5.0	5.0
	Middle Fork Horse	0.2	0.2
	Manzana	11.4	11.4
	Davy Brown (Fir Canyon)	2.0	2.0
	Munch Canyon	0.5	0.5
	Sunset Valley	*	*
	Fish	1.1	1.1
	Abel Canyon	1.8	1.8
	South Fork Sisquoc	1.6	1.6
	White Ledge Canyon	0.2	0.2
	White Ledge Canyon trib	0.7	0.7
	Rattlesnake Canyon	0.2	0.2
	Big Pine Canyon	1.0	1.0
Santa Ynez		**134.2**	**28.9**
	Santa Ynez	25.35	3.4
	San Miguelito	6.9	0.0
	Salsipuedes	7.6	7.6
	El Jaro	11.2	11.2
	Los Amoles	--	--
	Ytias	2.4	2.4
	Nojoqui	2.5	0.0
	Alisal	3.0	0.0
	Alamo Pintado	1.5	0.0
	Quiota	3.4	3.4
	Quiota tributary	--	--
	Zanja de Cota	1.5	0.0
	San Lucas	--	--
	Hilton	0.8	0.8
	Cachuma	3.6	0.0
	Lion Canyon	1.0	0.0
	Tequepis Canyon	2.5	0.0
	Santa Cruz	3.6	0.0
	Peachtree Canyon	2.1	0.0
	Santa Cruz trib (Little Pine Spring)	0.7	0.0
	West Fork Santa Cruz	2.7	0.0
	Coche	3.1	0.0
	East Fork Santa Cruz	4.6	0.0
	Grapevine	4.1	0.0
	Kelly	2.7	0.0
	Bear	--	--
	Arroyo Burro	--	--
	Devils Canyon	0.8	0.0
	Gidney	0.6	0.0
	Camuesa	0.0	0.0

Table 37, continued

Watershed	Mainstem/Tributary	Habitat (stream miles) Total[1]	Available[2]
Santa Ynez (cont.)	Mono	14.4	0.0
	Indian	8.4	0.0
	Buckhorn	3.9	0.0
	Alamar Canyon	--	--
	Blue Canyon	3.8	0.0
	Escondido Canyon	0.3	0.0
	Agua Caliente Canyon	--	--
	Fox (Pipeline)	0.6	0.0
	Alder	2.1	0.0
	Franklin	--	--
	North Fork Juncal	2.0	0.0
	Santa Ynez trib (Steelhead)	0.4	0.0

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers
*Supports a reproducing *O. mykiss* population above natural limit of anadromy

Within the two anchor watersheds of Santa Barbara County, we identified nine streams (of 63 candidates) that appear to account for the majority of the high value rearing habitat.

Anchor Watersheds

Santa Maria River

Steelhead Resources

Steelhead use of the Santa Maria River has been consistently documented since the late 1800s, although data on historical run size estimates is lacking. A citation in a 2003 report states, "The last sizeable run of steelhead was in 1941 with a few adults reported in 1942-1943" (Titus *et al.* 2000, as cited in Stoecker 2003). Reports on the watershed indicate that the Santa Maria River dries during a significant portion of the year and therefore does not offer substantial rearing habitat, except for the estuary which may serve a critical function for steelhead rearing and is currently being studied as part of a larger instream flow. The two main tributaries to the Santa Maria River are the Cuyama River, which has a similarly arid mainstem and perennial upper tributaries, and the Sisquoc River, which has extensive perennial mainstem and tributary flow (DFG 1944; Stoecker pers. comm.).

Surveyors from DFG and USFS sampled the upper Sisquoc River in 1959 and found good natural propagation of resident *O. mykiss* in the stream (DFG 1959). Studies in the mid to late 1990s also produced evidence of ongoing *O. mykiss* reproduction (DFG 1996a; DFG 1996b; USFS 1999).

A 2005 steelhead population survey report states, "During years with high stream flow and ocean connectivity, the Sisquoc River likely has the most abundant high quality habitat currently accessible to sea-run steelhead in the entire Southern Steelhead ESU and possibly south of San Francisco. In addition, the Santa Maria/Sisquoc River watershed likely has the greatest potential to restore a large, self-sustainable run of wild steelhead for the least cost in the southern half of California. No major dams or physical structures requiring expensive fish passage projects are needed for the mainstem of the Santa Maria or Sisquoc Rivers and the vast majority of the high quality habitat and existing steelhead population is already protected within the Los Padres National Forest" (Stoecker 2005, p. 5).

During the 2005 steelhead population survey, relatively high densities of *O. mykiss* in the upper Sisquoc River were found to be "…indicative of the importance of higher gradient habitat in the upper reaches of watersheds for spawning and rearing" (Stoecker 2005, p. 14). Within the Sisquoc sub-basin, substantial habitat is found in Manzana Creek and its tributary Davy Brown Creek (including the tributary Munch Canyon Creek), and in the South Fork Sisquoc River (Stoecker 2005).

Surveys of the South Fork Sisquoc River were conducted in 1980 and 2005. Multiple *O. mykiss* age classes were noted in both instances. The 1980 survey report notes, "This fork of the Sisquoc supports a good RB trout fishery and provides water…" (USFS 1980). According to the 2005 survey report, "The South Fork Sisquoc River contained the highest overall steelhead density of any sections surveyed within the Sisquoc River watershed, a density almost three times higher than the next highest section surveyed (Davy Brown Creek)" (Stoecker 2005).

A 2009 fish passage assessment report for Davy Brown Creek notes that the Zaca fire of 2007 caused severe erosion and sediment deposition in Manzana Creek and resulted in the loss of a substantial portion of the stream's *O. mykiss* population and rearing habitat (Love and Stoecker 2009). The report states, "Davy Brown Creek and its tributaries were relatively unaffected by the more northern fire. As a result, habitat in Davy Brown and Munch Creek is still in excellent condition and is now more important than ever for the Sisquoc River's returning adult steelhead population…" (Love and Stoecker 2009, p. 4).

Causes of Decline

The Bureau of Reclamation's Twitchell Reservoir operations (on the Cuyama River) substantially affect the hydrology of the Santa Maria River, which serves as the critical migration corridor for steelhead trout accessing habitat in the upper basin. Currently, water releases are made primarily on the basis of water supply considerations and the Santa Maria River is consequently "dry most of the year in most years" (NMFS 2009). Groundwater withdrawals in the vicinity of the Santa Maria River also have been noted to reduce streamflow (Stoecker 2005).

Steelhead migration to and from the Sisquoc River sub-basin occurs only in very wet years when high winter flows on the Sisquoc River combined with releases from Twitchell Reservoir create adequate migration conditions between the mouth of the Santa Maria River and Sisquoc River. A 2005 survey report for the Sisquoc River states, "Ocean connectivity to the Santa Maria and Sisquoc Rivers may currently only occur a few times each decade" (Stoecker 2005, p. 5).

Gravel extraction operations in the lower Sisquoc River channel were noted to impede steelhead passage in a 2003 study of the sub-basin (Stoecker 2003). Numerous passage barriers on the Sisquoc River tributary Tepusquet Creek preclude steelhead access to high quality habitat in the stream. Passage barriers also have been noted in the Manzana Creek tributaries Davy Brown and Munch creeks (Stoecker 2003; Love and Stoecker 2009).

Conservation Activities

A major fish passage barrier on the Sisquoc River below the Garey Bridge was removed in 2005. The Tepusquet Road crossing barrier on the Sisquoc River also was removed and replaced with a bridge in 2010 (Stoecker pers. comm.). Horse Creek Dam on lower Horse Creek, a tributary to the Sisquoc River, was removed in 2006, providing steelhead unimpeded access to habitat in the stream. No *O. mykiss* were observed in the creek in a follow up survey conducted in 2007, when surface flows were limited due to low rainfall. It is expected that in years of higher rainfall, steelhead will use habitat in Horse Creek (Stoecker 2007).

The Ocean Protection Council is providing funding for a detailed instream flow study of the Santa Maria River. A memo from 2010 regarding the project notes, "It is anticipated that the contractor will use rainfall runoff simulations, groundwater evaluations, and review of annual hydrographs in the analyses. Additional analysis will include an investigation of the frequency of water flow events to evaluate the potential [steelhead] passage opportunities based upon annual runoff and releases from Twitchell Reservoir" (OPC 2010). The data from the analyses will be used by DFG and NMFS to develop stream flow recommendations for use by the State Water Resources Control Board, with the objective of improving passage opportunities and habitat for steelhead.

Restoration Opportunities

Steelhead restoration in the Santa Maria basin is contingent on significantly increasing migration opportunities between the ocean and habitat in the Sisquoc River sub-basin. A 2005 report on the steelhead population of the Sisquoc River watershed recommends revising the manual that governs releases for Twitchell Dam to "…include provision of passage of adult steelhead from the ocean through the mainstem of the Santa Maria River…and provision of passage of juvenile steelhead (smolts) from lower Sisquoc River to the ocean" (Stoecker 2005). Because no impassible migration barriers exist along the entire Sisquoc River, providing appropriate flow releases downstream from Twitchell Dam and improving management of groundwater pumping is the highest priority restoration need in the watershed.

Key passage barriers in the Santa Maria basin identified in a basin study (Stoecker 2003) are listed in Table 38 and labeled in Figure 11. A discussion of barrier modification projects is provided below.

Table 38. Santa Maria Watershed Key Passage Barriers

ID	**Stream**	**Description**	**Type**	**Source**
763-01	Sisquoc	Gravel extraction operation	Partial	Stoecker 2003
763-04	Sisquoc	Culvert crossing	Partial	Stoecker 2003

Table 38, continued

ID	Stream	Description	Type	Source
763-05	Sisquoc	Culvert crossing	Partial	Stoecker 2003
763-06	Sisquoc	USGS gaging station weir	Partial	Stoecker 2003
773-01	Davy Brown	Sunset Valley Rd. crossing #1	Partial	Stoecker 2003
773-02	Davy Brown	Sunset Valley Rd. crossing #2	Partial	Stoecker 2003
1565-01	Munch Canyon	Davy Brown campsite access rd. crossing	Partial	Stoecker 2003

A gravel extraction operation in the lower Sisquoc River (Barrier 763-01) is noted in Stoecker (2003) to impede steelhead migration and potentially strand fish by reducing surface flows and creating temporary barriers via road construction. The report recommends implementing a monitoring program to investigate the impacts to migrating steelhead and modifying operations to improve steelhead passage as necessary (Stoecker 2003).

A seasonal, earthfill culvert crossing on private property in the Sisquoc River (Barrier 763-04) was identified in Stoecker (2003) as a high priority for removal. The report notes, "This structure reduces the window of opportunity for upstream steelhead passage by producing shallow flows through the culverts during lower flows and excessive velocities during moderate to high stream flows prior to the crossing blowing out" (Stoecker 2003, p. 39). A second culvert crossing on private property (Barrier 763-05) also was identified in Stoecker (2003) as likely to limit passage. Evaluation of this barrier for potential modification is recommended.

The USGS gaging station weir on the Sisquoc River (Barrier 763-06) is considered a low priority partial barrier (M. Stoecker pers. comm.). Monitoring of this site to ensure adequate fish passage over time is recommended in Stoecker (2003).

Modification of three road crossings in the Manzana Creek tributaries Davy Brown and Munch creeks (Barriers 773-01, 773-02, and 1565-01) was recommended in Stoecker (2003) and Love and Stoecker (2009). The 2003 barrier assessment report notes, "All three of these partial barriers impede salmonid passage within this productive tributary that supports natural salmonid reproduction and a moderate to high abundance of *O. mykiss*" (Stoecker 2003, p. 118). As noted above, steelhead access to habitat in the Manzana Creek tributaries has become particularly important since the Zaca fire of 2007 damaged rearing habitat in Manzana Creek (Love and Stoecker 2009).

Addressing passage in Tepesquet Creek also was recommended in the 2003 barrier assessment report for the Sisquoc River. The report states, "A total of 29 structures were identified on Tepusquet Creek… Excellent potential exist to restore steelhead to over 13 miles of adequate spawning and rearing habitat known to currently support salmonids. In addition, during drier years, restored access to this tributary may benefit steelhead throughout the watershed as they are able to seek refuge up this tributary as the lower reaches of the Sisquoc River begin to dry up" (Stoecker 2003, p. 118).

While the Sisquoc River sub-basin is largely undeveloped by virtue of national forest land use, wilderness designation, and Wild and Scenic River designation, opportunities may exist to enhance rearing habitat downstream from diversion points for agricultural and other purposes. We recommend examining water use practices, particularly in relation to spring and summer low flow periods in such areas as the Rancho Sisquoc property, with the goal of achieving possible benefits from modifying storage capacity and diversion periods.

Santa Ynez River

Steelhead Resources

A 1944 memo concerning the Santa Ynez River system noted, "…during the 1943-44 season hundreds of Steelhead spawned in practically every tributary of the Santa Ynez River from the mouth to Gibralter Dam…" (DFG 1944b). A 1950 DFG memo states, "The Santa Ynez River is the only steelhead stream of major importance in Southern California" (DFG 1950).

A 1975 DFG memo describes the impact of Bradbury Dam construction (completed in 1953) by saying, "About 11 miles of good spawning area remained below the dam. However, due to lack of water releases for fishery maintenance that area is also lost for fish production" (DFG 1975). The memo noted perennial flow in El Jaro Creek.

Staff from USFS prepared a draft study regarding steelhead habitat in the Santa Ynez River watershed in 1997. Regarding mainstem Santa Ynez River, the draft report states, "Only the uppermost section from Bradbury Dam to Solvang (14 miles) is thought to be currently capable of supporting spawning and rearing steelhead" (USFS 1997a). The report adds, "Of the tributaries to the lower Santa Ynez, Salsipuedes Creek currently has the highest potential for steelhead spawning and rearing" (USFS 1997a). According to a NMFS biological opinion, "Steelhead appear to persist in the mainstem from 0-10 miles downstream of Bradbury Dam over the summers of some of the years observed…" (NMFS 2000).

A 1999 fish management plan identified "priority habitats" downstream of Bradbury Dam including lower Hilton Creek, El Jaro Creek, and portions of the lower mainstem Santa Ynez River (SYRTAC 1999). The plan notes that upper Salsipuedes Creek has "good" rearing habitat when flow is present (SYRTAC 1999). A 2000 biological opinion for operation and maintenance of Bradbury Dam notes, "Salsipuedes Creek appears a fairly consistent producer of juveniles" (NMFS 2000).

A 2004 barrier assessment report for the Santa Ynez River watershed notes "Quiota Creek is a critical spawning and rearing tributary for the Santa Ynez River steelhead population" (Stoecker 2004, p. 122). The report notes that naturally reproducing *O. mykiss* in habitat upstream from the Bradbury Dam "may be contributing to the persistent remnant anadromous steelhead population downstream of Bradbury Dam" (Stoecker 2004).

Causes of Decline

The construction of Bradbury Dam blocked steelhead access to the majority of the historical habitat in the basin. A 1999 management plan for the lower Santa Ynez River states, "Steelhead historically used the lower mainstem mainly as a migration corridor to the upper basin above Bradbury Dam, where headwater streams provided spawning and year-round rearing habitat" (SYRTAC 1999, p. 2-19).

Sedimentation issues have been noted consistently for the Santa Ynez River. A 1975 survey report states, "The banks are trampled by livestock" (Swift 1975). A 1993 survey report also noted severe sedimentation in the basin (DFG 1993a). According to a 1999 management plan, "Spawning habitat in Salsipuedes and El Jaro Creeks is moderate, due to the presence of fine sediments and sand in the stream, with some areas of good habitat" (SYRTAC 1999).

A 2004 barrier assessment report for the Santa Ynez River notes, "water storage limits the duration and magnitude of downstream peak flows and reduces the likelihood that the sandbar will be breached… Gradual downstream water releases in the summer and fall are usually not sufficient to breach the sandbar. The effect this type of operation has on sandbar breaching and steelhead migration can be dramatic" (Stoecker 2004, p. 15).

A gravel extraction operation in the mainstem Santa Ynez River was noted in a 2004 barrier assessment report to likely be impacting steelhead habitat. Multiple passage barriers in the mainstem Santa Ynez River and important tributary streams downstream from Bradbury Dam also were noted (Stoecker 2004). While surveys have not been performed, the 2007 Zaca fire may have damaged habitat and impacted potential source populations of *O. mykiss* upstream from Bradbury Dam (T. Robinson pers. comm.).

Non-native fish species occur in Lake Cachuma and may be introduced into downstream environments during releases. The degree to which these fish compete with and prey upon steelhead is not well understood (M. Stoecker pers. comm.).

Conservation Activities

The Cachuma Project Member Agencies, on behalf of the U.S. Bureau of Reclamation, partially funds and manages implementation of the Lower Santa Ynez River Fish Management Plan, designed to enhance and restore steelhead habitat downstream from Bradbury Dam, and addresses requirements set forth in a 2000 biological opinion for operations at Cachuma Reservoir. A number of steelhead habitat enhancement projects have been implemented through the management program since 2000 and are summarized briefly below.

The Lake Cachuma Surcharge Project was developed in 2004 to enhance storage at Lake Cachuma by 9,200 acre-feet through the use of flashboard extensions. The additional water is used to augment flows downstream of the dam and extend steelhead migration opportunities during two to three storms within the migration season and provide improved summer rearing habitat.

Construction of the Hilton Creek Watering System was completed in 2000. It provides high-quality perennial spawning and rearing habitat for *O. mykis*s by diverting water from Lake Cachuma through a pipeline and over a series of boulders and rocks to two release points in the creek (T. Robinson pers. comm.). The Cachuma Project Biology Staff (CPBS) conducts annual steelhead population monitoring in Hilton Creek. A study to develop a list of potential channel enhancement projects to provide additional habitat or improve the quality of existing habitat was planned for summer of 2010.

A low flow barrier created by the Highway 1 Bridge crossing on Salsipuedes Creek was modified in 2002, and a fish passage structure was constructed in the creek in 2004 to allow steelhead to migrate past the Jalama Road Bridge to high quality habitat upstream. The CPBS conducts annual steelhead monitoring in Salsipuedes Creek.

Streambed stabilization and revegetation projects were implemented in El Jaro Creek in 2003. Two fish passage improvement projects also were recently completed, providing steelhead access to approximately ten miles of habitat. A 62-foot long fishway was installed below the Rancho San Julian entrance bridge in 2008 through CDFG's Fisheries Restoration Grant Program, and a low flow crossing was backwatered at Cross Creek Ranch in 2009, funded by Cachuma Project Member Agencies and CDFG restoration grants (T. Robinson pers. comm.).

In 2008, a damaged low flow crossing and temporary bridge on Refugio Road along Quiota Creek were replaced with a 48-foot bottomless arched culvert with four rock weirs for grade control and pool habitat creation. This was the first of nine low flow crossings along the creek that are planned for removal (T. Robinson pers. comm.).

Restoration Opportunities

Since steelhead passage upstream from Bradbury Dam is not available presently, steelhead conservation and restoration activities are focused on the mainstem Santa Ynez River below the dam and in tributaries below the dam where steelhead have traditionally been observed, the most important of which are Salsipuedes/El Jaro Creeks and Hilton Creek. Maintaining flows and controlling sedimentation appear to be the highest priority activities for these areas. Avoiding or minimizing threats posed by floodplain gravel mining and road building operations that can impede migration and degrade habitat also have been recommended.

Key passage barriers in the Santa Ynez River mainstem and tributaries downstream from Bradbury dam identified in Stoecker (2004) and other sources are listed in Table 39 and labeled in Figure 12. Barrier modification projects are discussed below.

Table 39. Santa Ynez River Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
798-01	Santa Ynez	Earthen culvert crossing	Partial	Stoecker 2004
798-02	Santa Ynez	Channelization/gravel extraction	Partial	Stoecker 2004
798-03	Santa Ynez	Earthen culvert crossing	Partial	Stoecker 2004
798-04	Santa Ynez	Utility crossing	Partial	Stoecker 2004
798-05	Santa Ynez	Bradbury Dam	Total	Stoecker 2004
820-00	Quiota	Barrier near mouth	Partial*	Stoecker 2004
820-01	Quiota	Refugio Rd. crossing	Partial	Stoecker 2004
820-02	Quiota	Refugio Rd. crossing	Total	T. Robinson pers. comm.
820-03	Quiota	Refugio Rd. crossing	Partial	Stoecker 2004
820-04	Quiota	Refugio Rd. crossing	Partial	Stoecker 2004
820-05	Quiota	Refugio Rd. crossing	Partial	Stoecker 2004
820-07	Quiota	Refugio Rd. crossing	Partial	Stoecker 2004
820-08	Quiota	Refugio Rd. crossing	Partial	Stoecker 2004

Table 39, continued

ID	Stream	Description	Type	Source
820-09	Quiota	Refugio Rd. crossing	Partial	Stoecker 2004
825-01	Hilton	Hwy 154 culvert	Partial*	Stoecker 2004

Notes

*May constitute a total passage barrier

The 2004 barrier assessment report recommended obtaining permission from the landowner to assess fish passage severity at an earthen culvert crossing on the Santa Ynez River (Barrier 798-01), and to develop modification options at this site if necessary. A channelization/gravel extraction project on the Santa Ynez River (Barrier 798-02) was noted in the 2004 barrier assessment to have significantly altered the stream channel and riparian vegetation in the vicinity of the operation. The report notes that at the time of the survey, the crossing at the site was being removed, but adds that the operation should be assessed to determine long-term impacts to stream channel configuration, surface flows and fish passage (Stoecker 2004). The 2004 barrier assessment report recommended obtaining permission from the landowner to assess fish passage severity at a second earthen culvert crossing on the Santa Ynez River (Barrier 798-03), and to develop modification options at this site if necessary.

Permission to assess the severity of a utility crossing approximately 0.5 miles upstream from the Highway 154 Bridge on the Santa Ynez River (Barrier 798-04) was not obtained during a 2004 barrier survey (Stoecker 2004). The survey report notes, "The utility crossing may impede/prevent fish passage during certain flows and is likely a safety/utility hazard being exposed in the active stream channel" (Stoecker 2004, p. 19). Obtaining landowner permission to assess passage at the site is recommended.

The 2004 barrier assessment report recommends conducting studies to establish "a water release schedule from Bradbury Dam [Barrier 798-05] that provides the optimal amount and duration of stream flow for sandbar breaching and stream connectivity to available tributaries" (Stoecker 2004, p. 15). The author of the assessment has since recommended investigating potential benefits of early winter "pulse flow" releases coinciding with the natural hydrograph (M. Stoecker pers. comm.). Releases that maintain and improve downstream rearing habitat also are critical to steelhead restoration in the Santa Ynez River. Additional examination of non-native species interactions resulting from dam releases is recommended to avoid impacts on the steelhead population.

A potential passage impediment near the mouth of Quiota Creek (Barrier 820-00) was noted in 2010 (M. Stoecker pers. comm.). Due to its location near the mouth of the creek, it may limit steelhead access to the entire basin. Evaluation of this barrier for modification is considered a high priority.

Refugio Road crosses Quiota Creek in nine locations (Barriers 820-01 to 820-09), impeding fish passage at eight of these locations. The 2000 fish management plan for the lower Santa Ynez River recommended removal of all nine crossings. Crossings #2 and #6 (Barriers 820-02 and 820-06) are considered high priority barriers for removal (SYRTAC 2000). The

Cachuma Project Water Agencies are working with the Bureau of Reclamation and the County of Santa Barbara to remove all fish passage barriers pending acquisition of grant funding (T. Robinson pers. comm.).

The Highway 154 crossing on Hilton Creek (Barrier 825-01) is noted in the 2004 barrier survey report to create passage problems during low flows, and has been deemed a total passage barrier in recent years (T. Robinson pers. comm.) Modification of this culvert is recommended, but has been difficult to coordinate due to conflicts with the landowner.

Other Important Watersheds

Additional important Santa Barbara County watersheds were determined by reviewing available habitat information and through interviews with biologists and others most familiar with the steelhead resources of the county. Based on this review, five additional stream systems, including Jalama Creek, Gaviota Creek, the Goleta Slough complex, and Mission and Carpinteria creeks (Figure 12), were selected as important by virtue of their potential to offer substantial rearing habitat resources. Estimated habitat is shown in Table 40 and habitat resources are characterized in the descriptions following.

Table 40. Santa Barbara County Important Watersheds Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available[2]**
Jalama		**11.0**	**9.0**
	Jalama	3.7	3.7
	Espada	2.2	0.3
	Gasper	2.3	2.3
	Escondido	2.8	2.8
Cañada de la Gaviota		**7.1**	**6.7**
	Gaviota	5.6	5.6
	Las Canovas	0.4	0.0
	West Fork Gaviota	1.1	1.1
Goleta Slough Complex		**9.9**	**2.2**
	San Jose	2.7	0.0
	West Fork San Jose	0.5	0.0
	San Pedro	2.2	0.0
	Atascadero	0.2	0.2
	Maria Ygnacio	2.7	2.0
	San Antonio	1.5	0.0
Mission		**4.5**	**3.1**
	Mission	2.2	1.8
	Rattlesnake Canyon	2.3	1.3

Table 40, continued

Watershed	Mainstem/Tributary	Habitat (stream miles) Total[1]	Available[2]
Carpinteria		**18.1**	**5.1**
	Carpinteria	8.6	3.6
	Gobernador	3.5	1.5
	Steer	1.6	0.0
	Eldorado	2.0	0.0
	Sutton Canyon	2.3	0.0

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

Jalama Creek

Steelhead Resources

Although the Jalama Creek watershed supported a steelhead run in the past and adult steelhead were sighted in 1994, virtually no information regarding the run size or the historical condition of the habitat was found. A report on the streams of Vandenberg Air Force Base states, "Conditions of the small portion of [Jalama Creek] found on Vandenberg AFB were mostly good to excellent for steelhead" (Swift 2000a). Staff from NMFS found that steelhead was "absent" from the creek in 2002, but noted the presence of "above barrier" *O. mykiss* (NMFS 2003b). This stream likely has limited opportunity for steelhead and habitat observations due to a high proportion of private watershed land ownership. A 2002 watershed assessment report notes, "While it is likely that Jalama Creek supports a current salmonid population, including an active steelhead run, restricted access has limited recent documentation opportunities" (Stoecker *et al.* 2002, p. 73)

Jalama Creek is considered important primarily on the basis of a report prioritizing watersheds of the Conception Coast for steelhead restoration potential. Stoecker and the Conception Coast Project (2002) ranked the watershed second in the region in total habitat score (factoring quantity and quality) and third in terms of "Steelhead Recovery Priority." The report notes the presence of high quality habitat on three Jalama Creek tributaries, Espada, Gasper, and Escondido creeks (Stoecker *et al.* 2002).

Causes of Decline

As noted above, limited information on the steelhead resources of Jalama Creek is available. A 2000 report on the streams of Vandenberg Air Force Base recommended improving the condition of the lagoon to improve rearing conditions (Swift 2000). Numerous potential passage barriers, identified through aerial surveys of the basin conducted in 2001, may be impacting steelhead migration (Stoecker *et al.* 2002). Restricted access to the basin precludes an assessment of limiting factors.

Conservation Activities

Information on conservation activities in the Jalama Creek watershed is not available. Land ownership issues currently preclude public involvement in Jalama Creek conservation.

Restoration Opportunities

Limited information exists regarding Jalama Creek restoration opportunities. We recommend establishing a stakeholder group to study steelhead habitat, population, and limiting factors.

Potential passage barriers in the Jalama Creek basin identified in a 2002 barrier assessment report (Stoecker 2002) are listed in Table 41 and labeled in Figure 12. A discussion of recommended modifications is provided below.

Table 41. Jalama Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
861-01	Jalama	Dam on VAFB	Partial	Stoecker *et al.* 2002
861-02	Jalama	Jalama Rd. Bridge crossing	Partial	Stoecker *et al.* 2002
861-03	Jalama	Culvert stream crossing	Partial	Stoecker *et al.* 2002
861-04	Jalama	Culvert stream crossing	Partial	Stoecker *et al.* 2002
861-05	Jalama	Culvert stream crossing	Partial	Stoecker *et al.* 2002
862-01	Espada	Culvert stream crossing	Partial	Stoecker *et al.* 2002
862-02	Espada	Culvert stream crossing	Partial	Stoecker *et al.* 2002
863-01	Gasper	Jalama Rd. crossing	Partial	Stoecker *et al.* 2002
863-02	Gasper	Road crossing	Partial	Stoecker *et al.* 2002
864-01	Escondido	Jalama Rd. crossing	Partial	Stoecker *et al.* 2002
864-02	Escondido	Weir u/s from Jalama Rd	Total	Stoecker *et al.* 2002
864-03	Escondido	Culvert stream crossing	Partial	Stoecker *et al.* 2002
864-04	Escondido	Culvert stream crossing	Partial	Stoecker *et al.* 2002
864-05	Escondido	Culvert stream crossing	Partial	Stoecker *et al.* 2002

The 2002 assessment report recommended fish passage improvements in three Jalama Creek areas: the remains of a diversion dam or grade control structure on Vandenberg Air Force Base (Barrier 861-01), the downstream-most Jalama Road bridge (Barrier 861-02), and the Bixby Ranch Road crossing (Barriers 861-03 to 861-05) (Stoecker *et al.* 2002). Passage projects in the tributaries Espada, Gasper, and Escondo creeks may be higher priority than upper mainstem barriers projects, and collaboration with the landowner is recommended to determine habitat conditions and project priorities.

Cañada de la Gaviota (Gaviota) Creek

Steelhead Resources

A survey report of Gaviota Creek from the 1930s notes, "A few steelheads enter stream in winter" (DFG ca. 1934). The surveyor deemed the creek to have low importance as a trout fishery. In a 1986 memo DFG staff states, "SH adults probably use this creek almost every year considering the reports of observations, but I would anticipate the numbers in the runs to be very low" (Sasaki 1986).

A 1994 stream inventory report for Gaviota Creek states, "The presence of large numbers of YOY rainbow trout in the upper reaches of Gaviota Creek indicates that wild trout have successfully spawned in the stream… [T]he presence of the smolts indicates…stream conditions have allowed successful rearing up to smoltification for juveniles" (DFG 1994a, p.32).

A 2002 report on watersheds of southern Santa Barbara County notes consistent documentation of *O. mykiss* in Gaviota Creek from the 1930s to the present. The report includes a prioritization for focusing restoration efforts, in which Gaviota Creek received the highest ranking in terms of habitat quantity and the number two ranking for "Steelhead Recovery Priority" in the region (Stoecker *et al.* 2002). The report notes the presence of high quality rearing habitat in the mainstem, in Las Canovas Creek, and in the west fork of Gaviota Creek.

A 2007 report on fish passage in the Gaviota Creek watershed states, "Gaviota Creek produces relatively high summer base flows and maintains cool water temperatures in the headwaters of the mainstem, Las Canovas Creek, and the lower mainstem. The watershed also contains one of the largest lagoon systems along the southern Santa Barbara County coast, which is ideal for steelhead rearing, food production, and acclimation between fresh and saltwater. Also, the estuary mouth is open to the ocean longer than most streams in the region, providing good access for steelhead adults and smolts" (Love and Stoecker 2007).

Causes of Decline

A 1993 survey report for Gaviota Creek notes likely impacts on the creek from poor grazing practices in the basin of an upstream tributary, Cañada de las Cruces Creek (DFG 1993). A 1994 survey report notes sedimentation in the channel, lack of riparian canopy, shallow pools, and lack of cover in the section of the Gaviota Creek mainstem adjacent to Highway 101 (DFG 1994a). A 2007 report notes "extremely poor habitat conditions in the upper Las Cruces and West Fork [Gaviota] Creek tributaries, due to high levels of natural and human-influenced erosion and low summer stream flow" (Love and Stoecker 2007).

A 2007 report on fish passage in the Gaviota Creek watershed notes that severe migration barriers in the lower reach prevent steelhead access to high quality habitat upstream (Love and Stoecker 2007). A 2002 barrier assessment report also cited numerous passage barriers in the mainstem and tributaries, mostly related to Highway 101 infrastructure (Stoecker *et al.* 2002).

Conservation Activities

A stakeholder group has met intermittently regarding restoration activities in the Gaviota Creek watershed. A severe grade control structure barrier below an historical bridge near the Highway 1/101 intersection was assessed in 2007 and removed in 2008 (M. Stoecker pers. comm.). Also, an alternatives study is planned for a county-owned bridge near the Gaviota State Park campground, contingent upon receiving funding.

Restoration Opportunities

Modification of passage barriers to facilitate steelhead migration to high quality habitat appears to be the highest priority restoration need in the watershed. Other important actions include enhancing riparian canopy in the lower reaches of the creek, identifying and addressing erosion sources in the upper watershed, and installing exclusionary cattle fencing. A DFG memo states, "The scarcity of viable spawning and rearing streams for the declining southern steelhead trout suggests that Gaviota Creek should be provided with full protection from livestock grazing and further human development throughout its watershed" (DFG 1994a).

Passage barriers in the Gaviota Creek watershed identified in Stoecker *et al.* (2002) are listed in Table 42 and labeled in Figure 12. A discussion of barrier modification projects is provided below.

Table 42. Gaviota Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
870-01	Gaviota	Gaviota Beach Rd. crossing	Partial	Stoecker *et al.* 2002
870-02	Gaviota	Grade control structure	Partial	Stoecker *et al.* 2002
870-03	Gaviota	Grade control structure	Partial	Stoecker *et al.* 2002
870-04	Gaviota	Grade control structure	Partial	Stoecker *et al.* 2002
870-05	Gaviota	Grade control structure	Partial	Stoecker *et al.* 2002
870-06	Gaviota	Grade control structure	Partial	Stoecker *et al.* 2002
870-07	Gaviota	Confined stream channel	Partial	Stoecker *et al.* 2002
870-08	Gaviota	Placed boulder blockage	Partial	Stoecker *et al.* 2002
870-09	Gaviota	Grade control structure	Partial	Stoecker *et al.* 2002
870-10	Gaviota	Grade control structure	Partial	Stoecker *et al.* 2002
870-11	Gaviota	Grade control structure	Partial	Stoecker *et al.* 2002
870-12	Gaviota	Grade control structure	Partial	Stoecker *et al.* 2002
870-13	Gaviota	Grade control structure	Partial	Stoecker *et al.* 2002
870-15	Gaviota	Riprap channelization	Partial	Stoecker *et al.* 2002
870-16	Gaviota	Double box culvert	Partial	Stoecker *et al.* 2002
870-17	Gaviota	Stream realignment/grade control	Partial	Stoecker *et al.* 2002
870-19	Gaviota	Old Hwy bridge/grade control	Partial	Stoecker *et al.* 2002
871-01	Las Canovas	Hwy 101 culvert	Total	Stoecker *et al.* 2002
1956-01	West Fork Gaviota	Bank revetment	Partial	Stoecker *et al.* 2002
1956-02	West Fork Gaviota	San Julian Rd. crossing	Partial	Stoecker *et al.* 2002
1956-03	West Fork Gaviota	Concrete blockage	Partial	Stoecker *et al.* 2002

An undersized bridge at Gaviota Beach Road (Barrier 870-01) was noted in the 2002 barrier assessment report to be "highly susceptible to debris and sediment blockage during elevated stream flow events" (Stoecker *et al.* 2002). A 2007 fish passage assessment report notes that this crossing is planned for replacement (Love and Stoecker 2007).

Numerous grade control structures on Gaviota Creek associated with the Highway 101 bridge (870-01 to 870-06, 870-09 to 870-13) were identified as potentially impeding migration in the 2002 barrier assessment report and further assessment of these sites was recommended (Stoecker *et al.* 2002). A 2007 barrier assessment report identified modification projects as six of these sites as high priority, including Barriers 870-02, 870-04, 870-05, 870-06, 870-09, and 870-13 (Love and Stoecker 2007). The report identified a placed boulder blockage (Barrier 870-08) as a low flow barrier and noted that modification at this site also should be considered.

Barriers 870-16 and 870-17 consist of a double box culvert and stream realignment immediately upstream from the Las Cruces Creek confluence. The 2002 barrier assessment report notes, "While the double box culvert appears to be in fair condition with minimal wear and downstream bank erosion, the realigned stream channel reach upstream has experience significant bank erosion and scour near the concrete grade control at the upstream end… During high stream flows the culvert bottom may become exposed producing accelerated water velocities along the 97 feet of concrete. This situation would increase the severity of upstream migration at this site (Stoecker *et al.* 2002, p. 364). The report also notes that the stream realignment has had "a significant negative impact on steelhead habitat and migration conditions," citing factors such as lack of riparian vegetation, absence of surface flow, and accelerated rates of bank erosion.

The northern-most Highway 101 culvert crossing on Gaviota Creek[8] was identified in Stoecker *et al.* (2002) as a total barrier and was recommended as a "keystone" barrier removal project for the watershed. The PAD indicates that Caltrans replaced the culvert in 2008 and that this crossing no longer constitutes a passage barrier. Evaluating this site to ensure that steelhead passage is provided is recommended.

The 2002 barrier assessment notes the presence of three potential passage barriers on the west fork of Gaviota Creek (Barriers 1956-01 to 1956-03). These barriers were not discussed in detail in the report. Further evaluation of the severity of these sites and access to survey upstream habitat conditions is recommended.

Goleta Slough Complex

Steelhead Resources

San Jose and Atascadero creeks join immediately upstream from Goleta Beach and are considered parts of one watershed. The watershed also is referred to as the "Goleta Slough complex" and includes an expansive estuary.

Field notes from 1948 indicated DFG staff's opinion that San Jose Creek had "a total of 6 to 7 miles of good trout stream" (DFG 1949). A 1994 DFG memo notes the presence of high densities of *O. mykiss* in upper San Jose Creek (DFG 1994b). *Oncorhynchus mykiss* was observed in the Atascadero Creek mainstem in the 1970s and 1980s, and also was documented in the Atascadero Creek tributary Maria Ygnacio Creek from 1954 to 1967 (Stoecker *et al.* 2002).

A 2002 report on watersheds of southern Santa Barbara County notes *O. mykiss* observations in San Jose Creek from the 1980s to 2003 (Stoecker *et al.* 2002). The Conception Coast report combined habitat scoring values for San Jose and Atascadero creeks (including the Atascadero Creek tributary Maria Ygnacio Creek). This approach determined that this sub-basin of the larger Goleta Slough complex was the third ranked in the region in terms of habitat quantity and quality (Stoecker *et al.* 2002).

Causes of Decline

Numerous anthropogenic passage barriers in streams of the Goleta Slough complex, including concrete channelization of the lower reach of San Jose Creek, preclude steelhead

[8] Barrier not indicated on map due to recent modification

access to the majority of high quality habitat in the basin. Bank erosion associated with down-cutting at many passage impediments within the complex was noted in a 2002 barrier assessment report, and may impair habitat by contributing excess sediment to the stream (Stoecker *et al.* 2002).

Conservation Activities

In a 2002 fish passage prioritization for southern Santa Barbara County, modifying the concrete channel portion of San Jose Creek was considered one of seven "keystone barrier" projects (Stoecker *et al.* 2002). Goleta Valley Land Trust recently awarded a grant to the City of Goleta for modification of the concrete channel for fish passage, which will be included as a component of the San Jose Creek capacity improvement project. Work on the project is expected to begin in 2011, pending additional funding. While progress has been made on planning a barrier mitigation project on Maria Ygnacio Creek (tributary to Atascadero Creek), liability issues have precluded the involvement of an important stakeholder (M. Gomez pers. comm.).

Restoration Opportunities

Addressing passage barriers in the Goleta Slough complex to provide steelhead access to high quality habitat is the highest priority restoration need in the basin. Passage barriers identified in Stoecker *et al.* (2002) are listed in Table 43 and labeled in Figure 12. A discussion of barrier modification projects is provided below.

Table 43. Goleta Slough Complex Key Passage Barriers

ID	**Stream**	**Description**	**Type**	**Source**
895-01	San Jose	concrete flood control channel	Total	Stoecker *et al.* 2002
895-02	San Jose	grade control structure	Partial	Stoecker *et al.* 2002
895-03	San Jose	Grade control/gaging weir	Partial	Stoecker *et al.* 2002
895-04	San Jose	diversion dam	Partial	Stoecker *et al.* 2002
895-05	San Jose	stream crossing	Partial	Stoecker *et al.* 2002
895-06	San Jose	grade control structure	Partial	Stoecker *et al.* 2002
897-01	Maria Ygnacio	Paterson Ave. bridge and grade control structure	Partial	Stoecker *et al.* 2002
897-02	Maria Ygnacio	grade control structure	Partial	Stoecker *et al.* 2002
897-03	Maria Ygnacio	Hollister Rd. bridge and pedestrian path concrete channelization	Partial	Stoecker *et al.* 2002
897-04	Maria Ygnacio	channelization under UPRR and Hwy 101 bridges	Partial	Stoecker *et al.* 2002
897-05	Maria Ygnacio	grade control structure	Partial	Stoecker *et al.* 2002
897-06	Maria Ygnacio	grade control structure	Partial	Stoecker *et al.* 2002
897-07	Maria Ygnacio	grade control structure	Partial	Stoecker *et al.* 2002
897-08	Maria Ygnacio	Cathedral Oaks Rd. box culverts	Partial	Stoecker *et al.* 2002
897-09	Maria Ygnacio	Via Alba Rd. crossing	Partial	Stoecker *et al.* 2002
897-10	Maria Ygnacio	Via Regina Rd. bridge and riprap bottom	Partial	Stoecker *et al.* 2002
897-11	Maria Ygnacio	grade control structure	Partial	Stoecker *et al.* 2002
897-12	Maria Ygnacio	pipe crossing/concrete channelization	Partial	Stoecker *et al.* 2002

Table 43, continued

ID	Stream	Description	Type	Source
897-13	Maria Ygnacio	Old San Marcos Rd. bridge and apron	Partial	Stoecker *et al.* 2002
897-14	Maria Ygnacio	stream crossing	Partial	Stoecker *et al.* 2002
897-15	Maria Ygnacio	stream crossing	Partial	Stoecker *et al.* 2002
897-16	Maria Ygnacio	stream crossing	Partial	Stoecker *et al.* 2002
897-17	Maria Ygnacio	debris basin dam	Total	Stoecker *et al.* 2002
897-18	Maria Ygnacio	grade control structure	Total	Stoecker *et al.* 2002
897-19	Maria Ygnacio	stone dam	Partial	Stoecker *et al.* 2002

As noted above, modification of the concrete flood control channel on San Jose Creek (Barrier 895-01) is considered the highest priority barrier project in the watershed. Channel modification work at this site is planned for 2011.

The 2002 barrier assessment report notes that three grade control structures on San Jose Creek (Barriers 895-02, 895-03, and 893-06) may not pose significant passage problems to steelhead, but suggests that future downstream scour could impede steelhead passage at Barriers 893-02 and 893-06. The report recommends removal of these structures or monitoring to ensure steelhead can migrate past these sites (Stoecker *et al.* 2002).

A diversion dam on San Jose Creek (Barrier 895-04) was characterized in the 2002 barrier assessment report as creating a severe passage impediment. The report recommends assessing the feasibility of removing the obsolete structure (Stoecker *et al.* 2002).

The 2002 barrier assessment report recommended working with the landowner to assess the feasibility of replacing a concrete stream crossing on San Jose Creek (Barrier 895-05) with a bridge. Assessing impacts associated with sediment accumulated at the crossing also was recommended (Stoecker *et al.* 2002).

A conceptual design has been prepared for the modification of the concrete channel under the Union Pacific Railroad and Highway 101 on Maria Ygnacio Creek (Barrier 897-04). High priority passage projects in Maria Ygnacio Creek recommended in the 2002 barrier assessment report include modification of the pipeline/channelization barrier (Barrier 897-12) and Old San Marcos Road Bridge crossing (Barrier 897-13) and removal of the debris basin dam and concrete grade control structure (Barriers 897-17 and 897-18).

Mission Creek

Steelhead Resources

A 1986 study of Rattlesnake Creek (tributary to Mission Creek) states, "It seems probable that steelhead did historically run up most local streams, including Mission and Rattlesnake Creeks, before dams were built by Spanish Colonists" (UCSB 1986). Spawning steelhead were observed in lower Mission Creek in several years between 2000 and 2006 (C. Fusaro pers. comm.) and more recent observations indicate that the creek maintains fairly consistent returns of steelhead, although adequate spawning and rearing habitat in the lower creek downstream from the channelized reach is lacking (M. Stoecker pers. comm.).

In the 2002 prioritization of Conception Coast watersheds, Mission Creek received the fifth highest habitat value (accounting for quantity and quality) and the number five ranking for "Steelhead Recovery Priority" in the region (Stoecker *et al.* 2002). High quality habitat was noted in the Mission Creek mainstem and its principle tributary Rattlesnake Creek.

Causes of Decline

Numerous passage barriers in Mission Creek and its tributary Rattlesnake Creek, including concrete channelization of the lower reach of Mission Creek, preclude steelhead access to the majority of high quality habitat in the basin.

Conservation Activities

In a fish passage prioritization for watersheds of southern Santa Barbara County, modifying the lower portion of Mission Creek was considered one of seven "keystone barrier" projects (Stoecker *et al.* 2002). Designs have been developed for the lower Mission Creek concrete channels whereby the concrete bottoms would be modified for improved fish passage. The City of Santa Barbara plans to implement an initial phase in one of the channel sections by 2012 (M. Gomez pers. comm.; M. Stoecker pers. comm.).

Five additional passage projects involving grade control structures and bridges were identified in the 2002 assessment (Stoecker *et al.* 2002). Modification of the Tallant Road crossing is now complete. Passage projects in the channelized reach and the Highway 192 bridge sites are scheduled to begin in the summer of 2011 pending funding and permitting. The Community Environmental Council implemented a barrier modification project on Mission Creek at the Santa Barbara Museum of Natural History in 2005 (M. Gomez pers. comm.).

Restoration Opportunities

Addressing passage barriers in the Mission Creek basin to provide steelhead access to high quality habitat is the highest priority restoration need in the basin. Passage barriers identified in Stoecker *et al.* (2002) are listed in Table 44 and labeled in Figure 12. A discussion of barrier modification projects is provided below.

Table 44. Mission Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
903-01	Mission	Concrete channelization from Chapala St. to UPRR crossing	Partial	Stoecker *et al.* 2002
903-02	Mission	Concrete channelization from Castillo Bridge to u/s of Arrellaga Bridge	Total	Stoecker *et al.* 2002
903-03	Mission	Grade control structure d/s of Pedegosa St. Bridge	Partial	Stoecker *et al.* 2002
903-04	Mission	Grade control structure under Pedegosa St. Bridge	Partial	Stoecker *et al.* 2002
903-05	Mission	Concrete channelization d/s of Mission St. to Los Olivos St.	Total	Stoecker *et al.* 2002
903-08	Mission	Mission Canyon Rd. crossing #1 bridge and apron	Partial	Stoecker *et al.* 2002
903-09	Mission	Bridge and apron d/s of Hwy 192 Bridge	Total	Stoecker *et al.* 2002
903-10	Mission	Mission Canyon Rd. #2 bridge and apron	Partial	Stoecker *et al.* 2002

Table 44, continued

ID	Stream	Description	Type	Source
903-11	Mission	Pipe crossing/grade control structure	Total	Stoecker *et al.* 2002
903-12	Mission	Old Mission Dam	Total	Stoecker *et al.* 2002
903-13	Mission	Debris basin dam	Total	Stoecker *et al.* 2002
903-14	Mission	Stone dam	Partial	Stoecker *et al.* 2002
904-01	Rattlesnake	Pipe crossing and grade control structure	Partial	Stoecker *et al.* 2002
904-02	Rattlesnake	Riprap channelization	Total	Stoecker *et al.* 2002
904-03	Rattlesnake	Bridge and apron	Total	Stoecker *et al.* 2002
904-04	Rattlesnake	Diversion dam	Partial	Stoecker *et al.* 2002
904-05	Rattlesnake	Aerial pipe blockage	Total	Stoecker *et al.* 2002
904-06	Rattlesnake	Las Canoas Rd. Bridge and apron	Total	Stoecker *et al.* 2002
904-07	Rattlesnake	Debris basin dam	Total	Stoecker *et al.* 2002
904-08	Rattlesnake	Old Mission Dam	Total	Stoecker *et al.* 2002

The 2002 assessment report for the Conception Coast recommended high priority fish passage improvements in the channelized sections of Mission Creek (Barriers 903-01, 903-02, and 903-05) (Stoecker *et al.* 2002). As noted above, modification to improve passage through the lower creek is planned. Additional priority passage projects include reestablishing access to the productive Rattlesnake Creek by modifying total barriers, and also modifying total barriers in upper Mission Creek (M. Stoecker pers. comm.).

Carpinteria Creek

Steelhead Resources

Historical steelhead observations on Carpinteria Creek have been noted since the 1930s (Stoecker *et al.* 2002). The creek was surveyed in 1994 and 1995 when multiple *O. mykiss* year classes (indicating reproduction) were observed (Cardenas 1995; DFG 1994b). In 2004, a steelhead habitat and population study noted 3.4 miles of "high quality steelhead habitat" in upper Carpinteria Creek and an *O. mykiss* population of "perhaps 2,000 to 5,000" (ECI 2004). An additional 2.3 miles of high quality habitat were identified in Gobernador Creek.

Causes of Decline

Numerous passage barriers on Carpinteria Creek and its principle tributary Gobernador Creek precluded steelhead access to the majority of high quality habitat in the basin until recent years, when coordinated efforts led to the removal of several key barriers. Three significant barriers on mainstem Carpinteria Creek and one in Gobernador Creek remain, although plans have been developed to remove the last Gobernador Creek barrier. Plans also are being developed for removal of an obsolete debris dam on upper Carpinteria Creek as well as a downstream road crossing (M. Gomez pers. comm.; M. Stoecker pers. comm.).

Conservation Activities

The City of Carpinteria modified a minor temporal passage barrier on lower Carpinteria Creek near Highway 101 in 2004. The Community Environmental Council, Stoecker Ecological, and South Coast Habitat Restoration have coordinated the removal of multiple passage barriers in the Carpinteria Creek watershed. In 2008, a private road crossing barrier downstream from Highway 192 on Carpinteria Creek and three concrete road crossings, one on Carpinteria Creek and two on Gobernador Creek, were removed and two were replaced with freespan bridges. A debris basin dam in upper Gobernador Creek also was modified for fish passage.

The Agricultural Commissioner has managed the eradication of *Arundo donax* from the Carpinteria Creek watershed since 2005. Eradication is expected in November of 2010, after which the project will enter its monitoring phase (M. Gomez pers. comm.).

Restoration Opportunities
Addressing the remaining passage barriers in Carpinteria Creek is the highest priority restoration need in the basin. Other recommended restoration projects include bank stabilization and vegetation management.

Passage barriers in the Carpinteria Creek watershed identified in a 2002 barrier assessment for watersheds of southern Santa Barbara County (Stoecker *et al*. 2002) are listed in Table 45 and labeled in Figure 12. Barrier modification projects are discussed below.

Table 45. Carpinteria Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
922-01	Carpinteria	Gaging weir	Partial	Stoecker *et al*. 2002
922-02	Carpinteria	Two bridges and channelization	Total/Partial	Stoecker *et al*. 2002
922-03	Carpinteria	Debris basin dam	Total	Stoecker *et al*. 2002
922-04	Carpinteria	Seasonal diversion dam	Partial	Stoecker *et al*. 2002
923-01	Gobernador	Culvert stream crossing	Total	Stoecker *et al*. 2002

A USGS gaging weir on Carpinteria Creek (Barrier 922-01) was not considered a significant passage barrier during surveying in 2002, but has become more perched and created difficulties for fish passage (M. Stoecker pers. comm.), The severity of the barrier is expected to worsen due to erosion at the site during high flow events (M. Gomez pers. comm.). Two bridge crossings (Barrier 922-02) also create passage barriers. The lower crossing is a channelized reach and forms a total barrier, while the upper crossing includes a concrete apron that acts as a partial barrier (M. Stoecker pers. comm.). Modification of these barriers is considered a high priority as high quality habitat exists upstream.

A debris basin dam on Carpinteria Creek (Barrier 922-03) is a total barrier (Stoecker *et al*. 2002). Removal of this barrier is considered a high priority restoration action for the watershed. The Santa Barbara County Flood Control district has received funding assistance from DFG to address this barrier (M. Gomez pers. comm.).

A seasonal diversion dam on Carpinteria Creek (Barrier 922-04) creates a partial passage barrier when in place. The 2002 barrier assessment recommended working with landowners to ensure fish passage during critical migration periods (Stoecker *et al*. 2002).

A culvert stream crossing on Gobernador Creek (Barrier 923-01) is a total migration barrier and the last remaining anthropogenic barrier. Modification of this crossing is considered the highest priority restoration action for the watershed and will restore steelhead access from the ocean to the watershed's natural limit of anadromy (M. Stoecker pers. comm.). Designs for a freespan bridge at this site are nearly complete, and the project is dependent on funding. Work on the project likely will begin in 2011, pending a final access agreement from the adjacent landowner (M. Stoecker pers. comm.; M. Gomez pers. comm.).

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Figure 11. Anchor and other important watersheds of northern Santa Barbara County, California

Figure 12. Anchor and other important watersheds of southern Santa Barbara County, California

Chapter 6. Ventura County

As shown in Table 46, three of Ventura County's four historical steelhead watersheds continue to support *O. mykiss* reproduction, though the anadromous life history form is severely suppressed. Very small numbers of steelhead have been observed in the Ventura and Santa Clara rivers, and the Rincon Creek observations likely consist of progeny of stream-maturing (*i.e.*, "resident") individuals, as the Highway 101 crossing of the creek constitutes a total passage barrier.

Table 46. Ventura County Watersheds Screening by *O. mykiss* Population

Watershed	*O. mykiss* population?
Rincon	Y
Ventura River	Y
Santa Clara River	Y
Big Sycamore Canyon	N

Available data and supplemental information were used to estimate rearing habitat in watersheds hosting *O. mykiss* populations, as shown in Table 47. The results indicate that the Ventura and Santa Clara River basins (Figures 13 and 14, respectively) contain the vast majority of the county's steelhead resources.

Table 47. Ventura County Watersheds Screening by Habitat

		Habitat (stream miles)	
Watershed	**Area (sq.mi.)**	**Total[1]**	**Available[2]**
Rincon	14.7	4.8	0.0
Ventura	225.8	44.5	14.4
Santa Clara	1625.8	86.5	38.7

Notes

[1]Includes all habitat located downstream from natural limits of anadromy

[2]Excludes habitat located upstream from impassible anthropogenic barriers

In particular, Santa Clara River watershed has extensive available habitat. The Ventura River watershed currently accounts for about one quarter of the available habitat in the region, and that proportion would increase with removal of Matilija Dam, which is currently in the planning phase. To further characterize the habitat resources of the various mainstem and tributary streams of the Ventura and Santa Clara rivers, we reviewed available information and interviewed knowledgeable individuals. The results of our estimation of available rearing habitat by stream are presented in Table 48.

Table 48. Ventura County Anchor Watershed Habitat by Stream

Watershed	Mainstem/Tributary	Habitat (stream miles) Total[1]	Available[2]
Ventura		**44.5**	**14.4**
	Ventura	4.1	4.1
	Coyote	3.8	0.0
	Santa Ana	2.3	0.0
	San Antonio	5.9	5.9
	Ojai	0.0	0.0
	Gridley Canyon	0.4	0.0
	Matilija	7.3	0.0
	North Fork Matilija	8.0	4.3
	Bear	3.3	0.0
	Murrietta Canyon	2.0	0.0
	Upper N. Fork Matilija	4.1	0.0
	Upper N. Fork Matilija tributary	0.8	0.0
	Old Man Canyon	2.3	0.0
Santa Clara		**86.5**	**38.7**
	Santa Clara	0.0	0.0
	Santa Paula	2.9	0.0
	Sisar	5.9	0.0
	East Fork Sisar	0.4	0.0
	East Fork Santa Paula	0.0	0.0
	Willard Canyon	0.0	0.0
	Sespe	17.1	17.1
	Coldwater Canyon	0.0	0.0
	West Fork Sespe	0.1	0.1
	Alder	0.4	0.4
	Park	1.4	1.4
	Timber	0.9	0.9
	Bear Canyon	0.2	0.2
	Trout	1.0	1.0
	Piedra Blanca	2.8	2.8
	Lion Canyon	3.0	3.0
	Howard	1.0	1.0
	Rose Valley	0.4	0.4
	Rock	1.0	1.0
	Tule	2.3	2.3
	Potrero John	2.6	2.6
	Munson	1.0	1.0
	Chorro Grande Canyon	0.7	0.7
	Ladybug	0.4	0.4
	Cherry	1.4	1.4
	Abadi	0.0	0.0
	Pole	0.0	0.0
	Hopper Canyon	0.9	0.9
	Toms Canyon	0.0	0.0

Table 48, continued

Watershed	Mainstem/Tributary	Habitat (stream miles) Total[1]	Available[2]
Santa Clara (cont.)			
	Piru	18.4	0
	Agua Blanca	14.0	0
	Fish	6.2	0

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

Within the two anchor watersheds of Ventura County, we identified 12 streams (of 45 candidates) that appear to account for the majority of the high value rearing habitat.

Anchor Watersheds

Ventura River

Steelhead Resources

The Ventura River supported one of southern California's larger steelhead populations historically, although construction of Matilija Dam in the upper watershed in the late 1940s blocked access to large amounts of previously available habitat. A 1946 issue of the California Fish and Game Journal notes, "The Division of Fish and Game reports large and consistent runs into [the] Ventura…" (DFG 1946a).

In the past, steelhead may have spawned and reared throughout the Ventura River and its principal tributary, Matilija Creek. The California Fish and Game Journal from 1938 states about the Ventura River, "This is a trout stream right down to the ocean" (DFG 1938). The historical distribution of habitat was characterized in 1946, when DFG staff stated, "It is our belief that 48 percent of the adult steelhead spawn in the ten miles below the Matilija dam site…" (DFG 1946b). The document also states regarding the area affected by the dam, "This area comprises one of the best spawning grounds of the entire river system, and the distance above the dam represents approximately twelve miles of spawning area or one-half of the entire stream area of the Matilija-Ventura section" (DFG 1946b). Staff from DFG proposed in 1947 that during a dry year about two miles of the lower Ventura River was suitable for spawning that could support a run of about 1,000 individuals (DFG 1947).

After Matilija Dam construction, the *O. mykiss* population in the upper watershed could be characterized as resident. A 1979 U.S. Forest Service survey report states about Matilija Creek, "Good summer holding water exists, high potential for excellent 'large' RBT fishery" (Moore 1980a).

Prior to the construction of Casitas Dam on Coyote Creek in 1959, this tributary also provided habitat resources: "[Coyote Creek] remains as one of the principal remaining suitable spawning tributaries for the Ventura River steelhead run" (DFG 1951a). A 1980 survey notes the presence of high quality habitat in Coyote and Santa Ana creeks upstream of Casitas Dam (Moore 1980a).

Steelhead population estimates for the Ventura River from 2006 and 2007 found *O. mykiss* abundance to be "zero or near zero" in the reaches downstream of Robles Diversion Dam, "intermediate" in the reaches above the diversion dam, reflecting high densities in the lower portion of North Fork Matilija Creek, and highest upstream of Matilija Dam (Payne 2008).

Substantial high quality rearing habitat in the Ventura River watershed exists upstream of the Matilija Dam in the Matilija Creek mainstem as well as its tributaries Upper North Fork Matilija, Murietta Canyon, and Old Man Canyon creeks and is currently inaccessible to steelhead. San Antonio Creek currently provides the largest quantity of available rearing habitat (DFG 1999; Entrix 2003; Payne 2007), and spawning habitat in the tributary is considered near ideal for steelhead (S. Lewis pers. comm.). High quality rearing habitat also is found in North Fork Matilija Creek and its tributary Bear Creek, though operations at the Ojai Quarry near the mouth of North Fork Matilija Creek have recently created passage problems for steelhead (Jenkin 2010a).

Causes of Decline

Construction of Matilija Dam barred steelhead access to an estimated 37 percent of historical habitat and degraded habitat downstream by reducing flows and altering sediment transport. Multiple agencies are collaborating to develop plans to remove the dam and restore downstream reaches to pre-dam conditions.

The Robles Diversion Dam is located at about stream mile 14.5 and was constructed in 1958 without fish passage provisions. A fish passage facility was installed in 2004. Bypass flows at Robles were set forth in a biological opinion for the fish passage facility. Casitas Municipal Water District is in a multiple-year process of evaluating Robles Diversion Dam flows for consistency between water supply and habitat objectives (S. Lewis pers. comm.).

The reach of the Ventura River from approximately 0.75 miles downstream of the Robles Diversion Dam to approximately 0.5 miles above the confluence with San Antonio Creek goes dry very quickly following storms "in most normal and all dry years" (Payne 2008, p. 17) due to natural porosity of the streambed (S. Lewis pers. comm.). Depending on the water year type, smolts may be unable to outmigrate past the dry reach and may spend an additional year rearing in the stream, or in some cases may perish (S. Lewis pers. comm.). Over 100 smolts died in 2009 due to being stranded in drying of pools downstream from the Robles Diversion Dam (S. Lewis pers. comm.).

A 2006 landslide at the Ojai Quarry created an impassible boulder barrier in the lower North Fork Matilija Creek (Payne 2008), preventing steelhead access to several miles of high quality rearing habitat. A consultant observed two adult steelhead sustaining injuries while making failed attempts to pass the boulder barrier in March of 2010 (Jenkin 2010a).

Erosion control, particularly downstream from the San Antonio Creek confluence, is another critical restoration issue for the Ventura River system. According to NMFS staff, elevated fine sediment deposition has dramatically altered habitat, decreasing the potential steelhead production (M. Capelli pers. comm.). Additionally, rearing habitat in San Antonio Creek appears is in need of improvement—while the creek provides abundant spawning gravels, it lacks complex pool habitat (S. Lewis pers. comm.).

Conservation Activities

The Matilija Dam Ecosystem Restoration Project, which is being developed to restore access to historical steelhead habitat and improve habitat conditions in the Ventura River system, includes multiple components, most important of which is the removal of the Matilija Dam. Dam removal is in an advanced state of planning and has been estimated to cost $130 million. The project may occur in 2011 or 2012, according to staff from the Army Corps of Engineers (Biasotti 2007). The project will include a high-flow sediment bypass at Robles Diversion Dam to accommodate the increased sediment supply to the river following removal of the Matilija Dam and installation of a high flow fishway (Tetra Tech 2009).

The Trust for Public Land began developing a lower Ventura River parkway plan to limit encroachment into the river corridor. The parkway plan involves preserving lands within the Ventura River's 100-year floodplain between Foster County Park and Emma Wood State Beach. The Ventura Hillsides Conservancy, a local land trust, has since become the lead organization for the project. The Ventura Hillsides Conservancy has acquired three small parcels of land in the lower Ventura River since 2003 and is in the process of purchasing nine acres in the Ventura River estuary near the Main Street Bridge (Clerici 2010).

Casitas Municipal Water District staff recently completed habitat surveys in the Ventura River mainstem, lower North Fork Matilija Creek, and San Antonio Creek with the objective of characterizing habitat and identifying specific restoration needs. The reports will likely be released in 2011 (S. Lewis pers. comm.). In addition, as part of an ongoing study of bypass flows at Robles Diversion Dam, the Casitas Municipal Water District has conducted annual counts of upstream migrating adults and emigrating smolts since 2006.

An invasive plant removal project was implemented in 2007 to remove giant reeds (presumably *Arundo donax*) in the floodplains of the Ventura River from upstream of the Highway 150 bridge to the Matilija Creek confluence and in floodplain areas of Matilija Creek. A fish passage barrier on Lion Creek, a tributary to San Antonio Creek, was removed in 2010. Other important conservation actions include the recent expansion of angling restrictions upstream of Robles Diversion Dam (S. Lewis pers. comm.).

Restoration Opportunities

The dominant restoration issues in the Ventura River system are Matilija Dam removal, Robles Diversion Dam bypass flows, and habitat quality in the lower river. Resource agency priorities for restoration in the watershed are consistent with addressing these issues. A 2009 article notes, "…future NMFS priorities within the Ventura River mainstem and joining tributaries include partnering with entities to (1) balance water-management needs and properly functioning living space for juvenile steelhead, (2) return lost habitat to steelhead, and (3) remediate the effects of human-made structures on the migration of this endangered species" (Spina and Capelli 2009).

San Antonio Creek currently provides a substantial portion of available rearing habitat in the Ventura River basin. With removal of the Matilija Dam still in the planning phase, improving the quality of rearing habitat in lower San Antonio Creek is a critical near-term restoration need (S. Lewis pers. comm.). Specific projects might include installing structures to create pool habitat and improving hydraulic conditions.

A review of passage barriers was performed using the PAD and other sources. Key passage barriers in the Ventura River system are listed in Table 49 and labeled in Figure 13.

Table 49. Ventura River Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
933-02	Ventura	OVSD pipeline at Hwy 150	Partial	Entrix 2003
933-03	Ventura	Robles Dam and downstream weir	Partial	Entrix 2003
934-01	Coyote	Camp Chaffee Rd. crossing	Partial	PAD
934-02	Coyote	Casitas Dam	Total	PAD
941-00	San Antonio	Bike trail crossing	Partial	Entrix 2003
941-01	San Antonio	Hwy 33 Culvert	Partial	PAD
941-02	San Antonio	Old Creek Rd. crossing	Partial	Entrix 2003
941-03	San Antonio	Fraser St. crossing	Partial	Entrix 2003
941-04	San Antonio	Creek Rd., Camp Comfort	Partial	Entrix 2003
941-05	San Antonio	private rd. crossing	Partial	Entrix 2003
941-06	San Antonio	crossing above 10 mile curve	Partial	Entrix 2003
941-08	San Antonio	Hwy 150 Bridge	Partial	PAD
941-09	San Antonio	Grand Ave. Bridge	Partial	PAD
941-10	San Antonio	Debris Basin	Total	PAD
941-11	San Antonio	Diversion Dam	Total	PAD
950-01	Matilija	USGS gaging station	Partial	Entrix 2003
950-02	Matilija	Matilija Dam	Total	Payne 2003
948-00	North Fork Matilija	Ojai Quarry boulder barrier	Total	Payne 2008
948-01	North Fork Matilija	Lower Wheeler Campground crossing	Total	Payne 2003
948-02	North Fork Matilija	Upper Wheeler Campground crossing	Partial	Payne 2003
948-03	North Fork Matilija	Hwy 33 culvert	Total	Payne 2003
949-01	Bear	Lower Wheeler Campground crossing	Partial	Payne 2003
949-02	Bear	Upper Wheeler Campground crossing	Partial	Payne 2003

A pipeline on the Ventura River (Barrier 933-02) was identified as a low-flow barrier in a 2003 watershed assessment (Entrix 2003). It does not pose a significant barrier to migrating steelhead and is not considered a priority for restoration. As noted above, passage improvements to the Robles Diversion Dam (Barrier 933-03) will be made following further investigations into modification options. This is considered a priority restoration project for the watershed.

A partial barrier on Coyote Creek at the Camp Chaffee Road crossing (Barrier 934-01) is not considered a priority for restoration as no habitat exists between the crossing and Casitas Dam (Barrier 934-02). A project to modify a bike trail crossing on lower San Antonio Creek (Barrier 941-00) is in the planning phase. The crossing clogs with debris that can be quickly removed and does not pose a significant barrier to fish passage (S. Lewis pers. comm.).

A consultant's report (Entrix 2003) identified multiple low-flow barriers on San Antonio Creek (Barriers 941-01 to 941-09). These barriers do not pose significant passage problems for steelhead and should not be considered high priority for restoration (S. Lewis pers. comm.). The upper limit of steelhead habitat in San Antonio Creek occurs at the Soule Park Golf Course, above which flows become intermittent during most years. A total passage barrier at the golf course that was identified in the 2003 Entrix report blew out during storms in 2005 (S. Lewis pers. comm.). Two total passage barriers on San Antonio Creek, consisting of a debris basin and a diversion dam (Barriers 941-10 and 941-11), are located upstream from the upper limit of suitable habitat and are not considered priorities for restoration.

As noted above, removal of the Matilija Dam (Barrier 950-02) is in the planning phase and is considered the highest priority restoration project in the Ventura River watershed. Passage past the USGS gaging station (Barrier 950-01) on Matilija Creek is not considered a priority at this time, as flow dynamics will drastically change following removal of the Matilija Dam.

On North Fork Matilija Creek, a boulder barrier at the Ojai Quarry (Barrier 948-00) blocks access to the majority of the rearing habitat in the basin. The landowner is working with NMFS to improve fish passage at this site (S. Lewis pers. comm.). This is considered a priority passage project. A consultant's report (Entrix 2003) noted the presence of another total barrier at the Lower Wheeler Campground crossing on North Fork Matilija Creek (Barrier 948-01). The barrier consists of an Arizona crossing with significant (approximately 15 vertical feet) downstream downcutting (P. Jenkin pers. comm.). This barrier should be considered a high priority for removal due to the presence of high quality habitat upstream on North Fork Matilija Creek and its tributary Bear Creek.

Santa Clara River

Steelhead Resources

The Santa Clara River appears to have supported a large steelhead population historically, although the run size is difficult to estimate. A 1946 issue of the DFG journal relays, "The Division of Fish and Game reports large and consistent [steelhead] runs into Ventura and Santa Clara rivers…" (DFG 1946b). Based on run size estimates for Matilija Creek and comparison of habitat information between Matilija Creek and the Santa Clara River watershed, one researcher projected a run of about 9,000 individuals (Moore 1980b). While the assessment report characterized the estimate as "reasonable" and "conservative," it should not be viewed as definitive.

By 1974 the run had declined sufficiently for DFG staff to state, "…there is no fishery to speak of in the [Santa Clara] river now" although it notes that "…there are some [steelhead] now that come up during large flows" (DFG 1974). A 1982-1984 study similarly indicated that a small number of adult steelhead spawned in the Santa Clara system and that the watershed supported smolt production (DFG 1985). A 1998 report summarizing the results of five years of fish passage monitoring at the Vern Freeman Diversion noted that the 414 smolts captured in 1997 likely comprised "nearly all of the outmigrant steelhead" (Entrix 1998). According to NMFS, less than ten adult steelhead were observed during the period from 1994 to 2000 (NMFS 2000).

Much of the historical steelhead production in the Santa Clara River watershed appears to have occurred in the Sepse Creek basin, which remains in relatively good conditions due in large part to its location in the Los Padres National Forest. In 1994, USFS staff determined that the Sespe Creek watershed was the highest priority of the 12 "anadromous fish watersheds on the Forest" (USFS 1997). A 2005 assessment of the Santa Clara system states, "The greatest number of trout observed in the Santa Clara River watershed were in the Sespe Creek drainage…and the Sespe had the highest relative abundance of trout" (Stoecker and Kelley 2005). In particular, the portion of Sespe Creek between Alder and Tar creeks has been deemed "excellent" rainbow trout habitat (USFS 1993). Regarding the Sespe Creek basin, a USFS watershed analysis notes, "The most suitable spawning areas are the riffles of the mid to upper section of the Sespe, Lion, and Tule Creek…" (USFS 1997). Recent studies suggests that Piedra Blanca, Timber, and Howard creeks also offer substantial spawning and rearing habitat resources (Stoecker and Kelley 2005).

Additional habitat exists in the Santa Paula Creek basin. A 2005 assessment of the Santa Clara River watershed states, "Santa Paula Creek contained the most productive habitat in the study area for salmonids" (Stoecker and Kelley 2005). In particular, the Sisar Creek tributary can support *O. mykiss*. A 1979 survey report of the lower section found "…good summer holding water, abundant food, adequate cover, suitable water temps…" (Moore 1980a). Similarly, a 1992 report states, "Sisar Creek has generally good trout habitat including adequate spawning areas" (DFG 1999). The 2005 Santa Clara River assessment found, "Sisar Creek accounts for 84% of the trout observed in the Santa Paula Creek drainage" (Stoecker and Kelley 2005).

Causes of Decline

Water diversions appear to have been impacting Santa Clara River steelhead populations for many decades. Notes from 1947 state, "Below the intake the stream goes dry as all of the water is diverted… There are many small sand diversion dams across the stream and when the steelhead start running there is sufficient flow to wash out these diversions. It is difficult for the young steelhead returning" (DFG 1951b). A report from 1951 states, "The lower reaches of the Ventura and Santa Clara Rivers are of secondary importance as a means of access by which steelhead trout migrate upstream from the ocean to headwaters tributaries. With increased water development and reduced runoff to the oceans, these runs will unfortunately continue to diminish in size and importance" (DFG 1951b).

The Santa Clara River system includes an important water supply feature, the Vern Freeman Diversion Dam, which was constructed in 1991 at about stream mile ten. A fishway was provided at the facility that became operational in 1991. The 2005 Santa Clara River assessment states, "While conditions are poor for spawning and sub-optimal for rearing in most reaches, the mainstem [Santa Clara] is a critical corridor for upstream and downstream steelhead movement" (Stoecker and Kelley 2005). Specifically, bypass flows at the diversion dam can affect migration opportunities.

Santa Paula Creek was blocked near the mouth by a failed Army Corp fishway structure that was damaged during severe flooding that occurred in January and February of 2005. The Harvey Diversion Dam and fishway near the confluence with Mud Creek and the grade control structures at the Highway 150 crossing near the confluence of Sisar Creek also failed after the 2005 floods. These barriers block all usable habitat in Santa Paula Creek and its tributary, Sisar Creek (Stoecker and Kelley 2005). The 2005 Santa Clara River watershed assessment notes, "…the entire [Santa Paula] drainage is effectively inaccessible to steelhead…" due in part to damage to fishways (Stoecker and Kelley 2005).

The Army Corps recently repaired the fishway on lower Santa Paula Creek and studies are being conducted to design a new fish passage structure, but the sub-basin remains inaccessible due to barriers at the Harvey Diversion Dam and Highway 150 (S. Howard pers. comm.). The 2005 watershed assessment states, "Even prior to the destructive flows of 2005, the fishway at Harvey Dam was reported to have significant problems with substrate accumulation in the fishway and ineffective fish passage…Even if the facilities are rebuilt in a similar configuration, steelhead passage at this site will continue to be questionable due to the inherent problems associated with fishway operations and debris blockage during steelhead migration flows" (Stoecker and Kelley 2005, p.168).

The 2005 flooding also caused severe channel incision and bank erosion in the lower reaches of Santa Paula Creek (Stillwater Sciences 2007). The flood control channel on lower Santa Paula Creek frequently clogs with sediment. The Army Corps excavated the channel in 2010, but sedimentation likely will continue to be a problem in the future (S. Howard pers. comm.). Several passage barriers also were noted on Sisar Creek in the 2005 assessment (Stoecker and Kelley 2005).

Based on research by the USFS in Sespe Creek in 1994, Sespe Creek habitat was found to be limited "…by availability of oversummering habitat" (USFS 1994). In a subsequent journal article, the authors noted that seeps likely were essential to *O. mykiss* survival during the summer months for their capacity to create temperature refugia in pools (Matthews and Berg 1997).

When a migration corridor is not present downstream of the Vern Freeman Diversion Dam, smolts are trapped at the dam and released into the Santa Clara estuary. A portion of the inflows to the estuary consists of treated wastewater from the City of Ventura's sewage treatment plant. The additional discharge results in more frequent breaching of the lagoon due to artificially high levels of water. Fish kills associated with lagoon breaching have been observed in recent years. In September 2010, six juvenile steelhead died due stranding following the sudden breach of the lagoon (Jenkin 2010b).

Conservation Activities

An analysis to determine minimum flow requirements for steelhead passage on the lower Santa Clara River was performed in 2006. The resulting report presented the following findings:

1) "Model-based predictions suggest a minimum flow of 800 cfs is required to provide a depth of 0.6 ft continually across 10 ft of channel, from the SCR estuary to Santa Paula Creek; flow of 500 cfs is needed to provide the same depth and width of flow from Santa Paula to Sespe Creek; and 700 cfs would be needed between Sespe Creek and Piru Creek.

2) … The results indicate that once natural flows in the mainstem near Piru exceed several hundred cfs, the lower reaches should have little difficulty meeting the minimum depth

criteria. In addition, passage flows along the mainstem SCR should exist everywhere at the same time due to the hydrologic regime of the SCR.

3) … total annual runoff (or rainfall conditions), should control the number of passage opportunities in a given year…

4) …The greatest reduction to the number of potential passage opportunities due to water diversions has occurred during the average water years. In general, migratory steelhead would have had many more potential opportunities in the past to access the upstream tributaries during average and wet years, and few if any during the dry years" (Harrison *et al.* 2006, pp. 22-23).

The Department of Fish and Game commissioned the Santa Paula Creek Watershed Planning Project in 2007. The project included the preparation of steelhead habitat and population, hydrology, and geomorphology assessments, with the objective of improving fish passage in Santa Paula Creek while maintaining existing diversion rights.

On-going discussions and studies are focused on migration flows at the Vern Freeman Diversion Dam. In 2008, NMFS and United Water Conservation District appointed an independent panel of engineers and biologists to evaluate passage at the dam and develop proposed alternatives to the existing fish passage structure. A conceptual design report was published in September 2010, in which recommendations were made to conduct further analysis of the feasibility of four fish passage alternatives identified in the report, as well as a dam removal option (VFDFPP 2010).

Passage at the Vern Freeman facility should be developed through a collaborative process between United Water Conservation District, resources agencies, and other interested stakeholders. Completion of the associated studies will facilitate this process. The United Water Conservation District is planning a smolt bypass flow study for 2011, which will entail radio tagging smolts to assess migration rates downstream of the Vern Freeman Diversion Dam to the ocean. The results of this study will inform development of a smolt bypass flow plan for the diversion (S. Howard pers. comm.).

Restoration Opportunities

Stoecker and Kelley (2005) state, "Ensuring effective steelhead migration upstream and downstream on the mainstem of the Santa Clara River is essential for recovery of the steelhead population. In fact, effective mainstem migration is necessary for the anadromous steelhead population regardless of other actions taken because without access to the principal steelhead spawning and rearing tributaries all other recovery actions would have little or no effect on the recovery of steelhead" (Stoecker and Kelley 2005, p. 117). Their assessment identified "improved fish passage at the Vern Freeman Diversion Dam" as the number one priority in the Santa Clara River watershed (Stoecker and Kelley 2005, p. 5). In addition, Stoecker and Kelley (2005) recommend that an "independent fish passage feasibility study" include "removal of the current Freeman Diversion Dam" and assessment of alternative diversion options.

Passage improvements in the flood control channel and fishway, Harvey Diversion Dam facility, and the Highway 150 bridge site in the Santa Paula Creek basin also were identified as critical projects for the Santa Clara River basin (Stoecker and Kelley 2005). In lower Sespe Creek, passage at Fillmore Irrigation District's seasonal diversion dam (at the old Mulholland Dam site) should be evaluated and operations modified as necessary.

Stoecker and Kelley (2005) recommend "implementation of dedicated fish passage flows for the mainstem of the Santa Clara River and those reaches on Santa Paula Creek, Sespe Creek, and Piru Creek downstream of Harvey Diversion Dam, Fillmore Irrigation Diversion, and Santa Felicia Dam respectively" (Stoecker and Kelley 2005, p. 6). With adequate steelhead passage upstream from Vern Freeman Diversion Dam provided in the future, steelhead migration into spawning and rearing habitat (*e.g.*, in Santa Paula, Sespe, and Hopper creeks) will be dependent on adequate bypass flows and modification of passage barriers (M. Stoecker pers. comm.).

In a 2008 biological opinion for the operation of Santa Felicia Dam on Piru Creek, NMFS provided steelhead restoration measures to be implemented as conditions of relicensing. United Water Conservation District is working with NMFS in the development of study plans that are required in the biological opinion (S. Howard pers. comm.). A bypass flow plan developed in cooperation between United Water Conservation District and NMFS has been finalized and will be implemented in the near future. The objective of the new flow regime will be to support migration and provide essential habitat functions for steelhead below Santa Felicia Dam.

A review of passage barriers in the Santa Clara River watershed was performed using the PAD and other sources. Key barriers are listed in Table 50 and labeled in Figure 14. A discussion of barrier modification projects is provided below.

Table 50. Santa Clara River Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
955-01	Santa Clara	Vern Freeman Dam	Total	Stoecker 2005
959-01	Santa Paula	Concrete flood control channel	Partial	Stoecker 2005
959-02	Santa Paula	Army Corps Fishway	Total	Stoecker 2005
959-03	Santa Paula	Harvey Dam	Total	Stoecker 2005
959-04	Santa Paula	Hwy 150 grade control structure	Total	Stoecker 2005
961-01	Sisar	Hwy 150 grade control structure	Partial	Stoecker 2005
961-02	Sisar	Private road crossing	Total	Stoecker 2005
961-03	Sisar	Private road crossing	Partial	Stoecker 2005
1932-01	East Fork Sisar	Bridge crossing	Total	Stoecker 2005

Fish passage is expected to be improved at the Vern Freeman Diversion Dam site (Barrier 955-01) following the completion of studies into restoration options and the implementation of a preferred alternative.

The U.S. Army Corps of Engineers-designed concrete flood control channel and fishway on Santa Paula Creek (Barriers 959-01 and 959-02, respectively) continue to present significant passage problems for steelhead. The fishway was severely damaged in 2005. Until redesign and modification are completed, the channel is likely to continue to clog with debris and the fishway will remain ineffective (Stoecker and Kelley 2005). The Army Corps is collaborating with resource agencies to restore passage at the fishway (S. Howard pers. comm.).

The Harvey Diversion Dam on Santa Paula Creek (Barrier 959-03) is owned by Canyon Irrigation. The Santa Paula Creek Watershed Planning Project report states, "...all channel infrastructure and channel modifications should be designed to retain or improve coarse sediment connectivity" (Stillwater 2007, p. 47). The report cites the most incised reaches in the creek associated with constructed features as downstream from the Highway 150 bridge and the Harvey Diversion Dam. Projects to remove or redesign these structures are deemed "priority actions." The report also notes, "...the highest priority action for [the Santa Paula Creek watershed] is to explore alternative water-diversion opportunities at or upstream of the site of the current Harvey Diversion Dam" (Stillwater 2007, p. 49).

The Santa Paula Creek Watershed Project report notes, "...the redesign of the Highway 150 bridge drop structures is currently under consideration by the California Department of Transportation" (Stillwater 2007). While there is support for improving passage at the Highway 150 crossings on Santa Paula and Sisar creeks (Barriers 959-04 and 961-01), repair of these structures remains a critical restoration need for the Santa Clara River watershed steelhead population (S. Howard pers. comm.).

Two private road crossing on Sisar Creek (Barriers 961-02 and 961-03) were identified as important passage barriers in the 2005 watershed assessment (Stoecker and Kelley 2005). The report recommended obtaining permission from the landowner to survey the crossings and identify options for modification.

A bridge crossing on East Fork Sisar Creek (Barrier 1932-01) was identified as a total passage barrier in the 2005 watershed assessment. The report recommended working with the landowner to install a wider span bridge that would improve substrate mobility and allow passage following the flushing of debris.

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Figure 13. Ventura River watershed, Ventura County, California

Figure 14. Santa Clara River watershed, Ventura County, California

Chapter 7. Los Angeles County

Our review of available information indicates that steelhead/rainbow trout occurred in eight Los Angeles County watersheds historically, and recent documentation of *O. mykiss* is available for five of these drainages (Table 51). While the Los Angeles and San Gabriel rivers support populations of resident *O. mykiss* in their headwaters, they were not included in our comparison of habitat data for anchor watershed consideration, as restoring steelhead runs to these areas is improbable given the large scale hydrologic modifications in the lower portions of these watersheds. Steelhead/rainbow trout resources of the San Gabriel River watershed (Figure 16) are discussed in Chapter 10 of this report and the Los Angeles River watershed is discussed in the Appendix.

Table 51. Los Angeles County Watersheds Screening by *O. mykiss* Population

Watershed	***O. mykiss* population?**
Arroyo Sequit	Y
Zuma Canyon	N
Solstice Canyon	N
Malibu	Y
Las Flores Canyon	N
Topanga Canyon	Y
Los Angeles River	Y*
San Gabriel River	Y*

Notes
*Does not support anadromy, but supports resident *O. mykiss* in the headwaters.

Available data and supplemental information were used to estimate rearing habitat in Los Angeles County watersheds hosting *O. mykiss* populations, as shown in Table 52. Our analysis indicates that restoration in the Malibu Creek watershed (Figure 15) offers the best potential for increasing steelhead abundance in the region. There is significant stakeholder interest in restoring steelhead habitat in Malibu Creek, and studies to modify passage barriers in the watershed, most importantly including removing Rindge Dam in the lower mainstem, are ongoing. Malibu Creek is considered the anchor watershed of Los Angeles County in the following discussion.

Table 52. Los Angeles County Watersheds Screening by Habitat

		Habitat (stream miles)	
Watershed	**Area (sq.mi.)**	**Total[1]**	**Available[2]**
Arroyo Sequit	10.9	4.6	4.6
Malibu	109.6	25.9	3.0
Topanga Canyon	19.7	3.8	3.8

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

To further refine the areas containing important rearing habitat resources, the mainstem and tributaries of the Malibu Creek watershed were examined, as shown in Table 53. Various aspects of steelhead resources in the basin are described below.

Table 53. Los Angeles County Anchor Watershed Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available[2]**
Malibu		**25.9**	**3.0**
	Malibu	9.5	3.0
	Cold	4.7	0.0
	Dark Canyon	1.3	0.0
	Las Virgenes	8.6	0.0
	Liberty Canyon	1.8	0.0

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

Anchor Watersheds

Malibu Creek

Steelhead Resources

Malibu Creek is an historical steelhead stream, although a dam (alternately referred to as "Malibu" or "Rindge") constructed in the 1920s at about stream mile three has restricted access to the majority of the suitable habitat in the watershed. Rainbow trout appear to have been extirpated from the upper watershed (Stoltz 1979).

A 1969 survey report states, "Steelhead have apparently been making runs into Malibu Creek in recent years and will probably continue to do so if water quality and flow are maintained" (DFG 1969). According to a 1973 DFG report, Malibu Creek and the Ventura River supported the only consistent southern California steelhead runs at the time (DFG 1973).

In 1989, consultants surveyed Malibu Creek between the mouth and Century Dam (RM 8.3) as well as a tributary, Cold Creek. The survey noted "rearing habitat concentrations" in ten reaches throughout the study segment of mainstem Malibu Creek (Entrix 1989). A related report notes, "Since 65 percent of the available rearing habitat in Malibu Creek is currently inaccessible to juvenile steelhead, then at least a three-fold increase in the juvenile stream-rearing population would result by providing passage for adults over Rindge Dam" (Keegan 1990). Notes from a 1992 meeting indicate DFG staff's opinion that addressing passage issues in Malibu Creek "…can open up approximately 86% of the total potential spawning habitat of the system" (DFG 1992).

Surveys conducted between 2005 and 2009 indicate the consistent presence of steelhead trout in the lower three miles of Malibu Creek (Dagit and Abramson 2007; Dagit *et al.* 2009). Seasonal use of the Malibu Creek lagoon by steelhead also has been recently documented (Moffatt & Nichol 2005).

Beginning in 2006, fishkills due to undetermined causes have severely diminished the Malibu Creek steelhead population. A steelhead monitoring report notes, "In May 2006, 245 steelhead were observed in Malibu Creek, including over 60 young of the year… Starting in July 2006, a yellow color variation of steelhead was observed… Trout were also observed…looking stressed, swimming slowly with their mouths agape. By September 2006, only nine steelhead trout were observed in Malibu Creek, and the decline of other species, including crayfish, carp and catfish was also noted" (Dagit and Abramson 2007, p. 5).

Causes of Decline

Rindge Dam precludes steelhead access to the majority of the high quality habitat in the Malibu Creek watershed. In the early 1990s, Cal Trout, the Izaak Walton League, and DFG expected funding to construct a borgemon lift to provide passage at Rindge Dam (Woelfel 1991), but the project was not implemented. Numerous passage barriers also have been noted upstream of Rindge Dam on mainstem Malibu Creek and the tributaries Las Virgenes and Cold creeks.

Regarding the three mile anadromous portion of Malibu Creek, a 2007 monitoring report states, "…Malibu Creek supports flourishing populations of numerous invasive aquatic species (crayfish, carp, largemouth bass, catfish, *etc.*), has poor water quality and a limited benthic invertebrate community… [T]he impacts of these…factors has reached a threshold where it is more difficult for steelhead to survive successfully (Dagit and Abramson 2007, p. 7). The invasion of New Zealand mudsnail, first documented in Malibu Creek in 2005, poses a significant threat to the steelhead population (Abramson *et al.* 2009).

During 2006 snorkel surveys of Malibu Creek, researchers noticed "yellow" individuals in the *O. mykiss* population. Over the course of about four months the entire *O. mykiss* population, estimated at about 250 individuals, and all other fish in Malibu Creek between Rindge Dam and Malibu Lagoon, died (Dagit and Abramson 2007). Investigators have not conclusively determined the cause of the die-off (Orton pers. comm.; Dagit, Adams, and Drill 2009), although based on anecdotal evidence from other stream systems with instances of trout "yellowing," a likely explanation is prolonged exposure to excessive water temperature. A 2009 investigation concluded that while thermal stress alone did not likely cause the die-off, it was likely an important contributing factor (Dagit, Adams, and Drill 2009).

Recolonization of *O. mykiss* following the die-off was minimal in 2007, with only two adult steelhead observed, but the population appeared to rebound in 2008, when several anadromous adults and over 2,200 young of year were observed (Dagit, Adams, and Drill 2009). A die-off similar to the 2006 event occurred again in 2009. The cause of the die-off is currently being investigated by the Resource Conservation District of the Santa Monica Mountains and others.

Malibu Creek and lagoon are listed as impaired by nutrients by EPA and the State Water Control Resources Board. A nutrient TMDL for the basin was developed in 2003. The Santa Monica Bay Restoration Commission prepared a restoration plan for the Santa Monica Bay in 1995, and released an updated plan in 2008. Regarding Malibu Creek, the 2008 plan notes, "Potential sources of nutrient loading include runoff from residential and commercial areas, runoff associated with agriculture and livestock, treated wastewater discharges, septic system, groundwater, aerial deposition, etc…. One key piece of missing information is the potential impact from septic discharges on the water quality of the Malibu Creek and Lagoon through groundwater movement in the Malibu Civic Center area" (SMBRC 2008, p. 15).

Conservation Activities

Multiple stakeholders are involved with the conservation and restoration of the Malibu Creek steelhead population. Numerous organizations recently collaborated on an extensive habitat typing and fish passage inventory for 13 watersheds of the Santa Monica Mountains, including Malibu Creek. The subsequent report identifies limiting factors and recommended restoration actions for the Malibu Creek steelhead population (California Trout 2006). Heal the Bay produced a steelhead habitat quality and passage barrier report for Malibu Creek in 2005. The report includes prioritized recommendations for barrier removal projects in the Malibu Creek basin (Abramson and Grimmer 2005). The report notes that a failed "Texas crossing" in Malibu Creek State Park was removed in 2005.

The U.S. Army Corps of Engineers and California State Parks is conducting the Malibu Creek Environmental Restoration Study, which focuses on the feasibility of removing Rindge Dam. According to a 2008 article, removing the dam would involve the relocation of 780,000 cubic yards of impounded sediment, with project cost estimates ranging from 31 to 72 million dollars (Damavandi 2008).

The Resource Conservation District of the Santa Monica Mountains has conducted annual monitoring of the Malibu Creek steelhead population since 2005, and is working to identify the source of the recent fishkills (Dagit and Abramson 2007). In addition, the Santa Monica Bay Restoration Commission and Santa Monica Baykeeper are collaborating on strategies to eradicate the New Zealand mudsnail from the Malibu Creek basin and have conducted annual mudsnail monitoring surveys since 2006 (Abramson *et al.* 2009).

In October 2010 the California Coastal Commission approved a lagoon restoration plan for Malibu Creek prepared by California State Parks and the Santa Monica Bay Restoration Commission in 2005. The project will enhance water circulation and increase the salt marsh area and involves re-contouring of the lagoon, sediment removal, and bank revegetation (Moffatt & Nichol 2005). Construction on the project is expected to begin in summer of 2011.

A 156-acre development proposed for the watershed would include substantial grading for homes and roads and is opposed by a number of organizations concerned with the creek and its watershed lands. Environmental review and permitting of the proposed project are ongoing at the time of publication of this report.

Restoration Opportunities

Passage barriers, water supply, and water quality have been identified as key issues for steelhead restoration in the Malibu Creek watershed (DFG 1980b; Abramson and Grimmer 2005; Dagit and Abramson 2007). Determining and addressing the cause of the fishkills in lower Malibu Creek also is considered a high priority. With the proposed removal of Rindge Dam, passage barrier projects in the upper mainstem Malibu Creek and tributaries would become priorities, particularly in Las Virgenes and Cold creeks (Abramson and Grimmer

2005). Additional restoration priorities in the watershed include reducing nutrient levels in Malibu Creek and decreasing sedimentation in the lower mainstem and lagoon (SMBRC 2008).

A review of passage barriers in the Malibu Creek watershed was conducted using the PAD and other sources. Notable barriers are listed in Table 54 and labeled in Figure 15. A discussion of recommended barrier modification projects is provided below.

Table 54. Malibu Creek Watershed Key Passage Barriers

ID	Stream	Description	Type	Source
1065-01	Malibu	Pipeline utility crossing	Partial	PAD
1065-02	Malibu	Rindge Dam	Total	HTB 2005
1065-03	Malibu	Stream gage concrete apron	Partial	PAD
1065-05	Malibu	Century Dam	Total	HTB 2005
1065-06	Malibu	Malibu Lake Club dam	Total	PAD
1066-01	Cold	Piuma Rd. culvert	Total	HTB 2005
1066-02	Cold	Malibu Meadows Rd. crossing	Partial	HTB 2005
1066-03	Cold	Crater Camp crossing	Total	HTB 2005
1066-04	Cold	Cold Canyon Rd. culvert	Total	HTB 2005
941-06	Las Virgenes	Las Virgenes Creek/ Crags Rd. double culvert	Total	HTB 2005
941-07	Las Virgenes	White Oak Farms dam	Total	HTB 2005
941-08	Las Virgenes	Lost Hills Rd. box culvert	Total	HTB 2005
941-09	Las Virgenes	Meadow Creek Lane drop structure	Total	HTB 2005
941-10	Las Virgenes	Agoura Rd. crossing	Total	HTB 2005

The PAD indicates that a pipeline utility crossing on lower Malibu Creek (Barrier 1065-01) creates a low flow barrier (DFG 1989 as cited in PAD). This barrier was not identified as a high priority for modification in recent publications and is not considered a passage impediment (Abramson and Grimmer 2005; California Trout 2006).

Modifying or removing Rindge Dam on Malibu Creek (Barrier 1065-02) for fish passage would provide steelhead access to high quality habitat in mainstem Malibu Creek up to the Century Lake Dam and in Cold and Las Virgenes creeks. Modification of this barrier is the highest restoration priority in the watershed (Abramson and Grimmer 2005; California Trout 2006).

The PAD indicates that the Los Angeles County stream gage concrete apron (Barrier 1065-03) on Malibu Creek creates a partial barrier. This barrier was not identified as a high priority for modification in recent publications (Abramson and Grimmer 2005; California Trout 2006).

A 2005 barrier assessment report notes that Century Dam on Malibu Creek (Barrier 1065-05) is a total passage barrier, preventing steelhead access to approximately 1.9 miles of high quality habitat upstream from the dam (Abramson and Grimmer 2005). In addition, the report notes that Century Dam prevents natural sediment replenishment downstream, impacting steelhead habitat. The report recommends removing the dam and restoring the stream channel as one of ten high priority barrier modification projects in the Malibu Creek watershed.

The Malibu Lake Club Dam on upper Malibu Creek (Barrier 1065-06) is a total barrier to fish passage (Edmonson 2002 as cited in the PAD). No action is recommended currently for this barrier due to the lack of steelhead habitat upstream.

The Piuma Road culvert on Cold Creek (Barrier 1066-01) prevents steelhead from accessing the majority of the tributary's suitable habitat. The 2005 barrier assessment report recommends replacing the culvert with a free span bridge as one of ten high priority barrier modification projects in the Malibu Creek watershed (Abramson and Grimmer 2005).

The 2005 barrier assessment report notes that the Malibu Meadows Road crossing on Cold Creek (Barrier 1066-02) creates a significant partial passage barrier. It recommends removing the concrete bottom and reinforcing the piers to improve fish passage at this site as one of ten high priority barrier modification projects in the Malibu Creek watershed (Abramson and Grimmer 2005).

The 2005 barrier assessment report notes that the Crater Camp crossing on Cold Creek (Barrier 1066-03) prevents steelhead access to approximately 1.3 miles of good quality habitat on the Cold Creek tributary Dark Canyon Creek and recommends replacing the crossing with a free span natural bottom bridge as one of ten high priority barrier modification projects in the Malibu Creek watershed (Abramson and Grimmer 2005). The report also indicates that high quality habitat is present on the Cold Creek mainstem upstream of this barrier.

The 2005 barrier assessment report recommends replacing the Cold Canyon Road culvert on Cold Creek (Barrier 1066-04) with a bottomless culvert or free span bridge at Cold Canyon Road as one of ten high priority barrier modification projects in the Malibu Creek watershed (Abramson and Grimmer 2005). The report indicates that high quality habitat is present on the Cold Creek mainstem upstream of this barrier.

The Crags Road double culvert on Las Virgenes Creek (Barrier 941-06) is a total barrier, barring steelhead access to all usable habitat in the tributary. The 2005 barrier assessment report recommends replacing the culvert with a free span bridge to provide steelhead access up to the dam at White Oak Farm (Barrier 941-07) (Abramson and Grimmer 2005). The report also recommends lowering the height of the dam at White Oaks Farm to allow passage (Abramson and Grimmer 2005).

The Lost Hills Road box culvert on Las Virgenes Creek (Barrier 941-07) is a total passage barrier. The 2005 barrier assessment report recommends modifying the culvert by creating a low flow channel for fish passage or by replacing it with a wider bridge or bottomless culvert (Abramson and Grimmer 2005).

The Meadow Creek Lane drop structure on Las Virgenes Creek (Barrier 941-09) is a total passage barrier (Abramson and Grimmer 2005). The 2005 barrier assessment report also notes "severe undercutting" at this site, and recommends replacing the structure and restoring the stream channel to "reduce the massive downstream bank scour" and provide fish passage (Abramson and Grimmer 2005).

Other Important Watersheds

A 2007 steelhead monitoring report for Malibu Creek states "If Malibu Creek, the largest, potentially most suitable watershed [in the Santa Monica Mountains region], is rendered unsuitable due to anthropogenic influences, then restoration actions must be directed in one of two ways. The impairments must be addressed and reduced to levels suitable for steelhead, and protection and enhancement of other potential steelhead habitats must also take priority" (Dagit and Abramson 2007, p. 7).

The Arroyo Sequit and Topanga Canyon Creek watersheds (Figure 15) each contain several miles of available habitat and likely play an important role in the maintenance of the region's steelhead resources despite their relatively smaller sizes, particularly prior to completion of major restoration projects in Malibu Creek. Multiple *O. mykiss* year classes have been observed consistently in Topanga Creek, and Arroyo Sequit may provide an important refugia, at least in some years (Dagit and Abramson 2007).

To further refine the areas containing important steelhead habitat, the mainstems and tributaries of the Arroyo Sequit and Topanga Canyon watersheds were examined, as shown in Table 55. Various aspects of steelhead habitat within these two watersheds are described below.

Table 55. Los Angeles County Important Watersheds Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available**
Arroyo Sequit		**4.6**	**4.6**
	Arroyo Sequit	3.3	3.3
	West Fork Arroyo Sequit	0.8	0.8
	East Fork Arroyo Sequit	0.5	0.5
Topanga Canyon		**3.8**	**3.8**
	Topanga Canyon	3.8	3.8

Notes
[1]Includes all habitat located downstream from natural limits of anadromy

Arroyo Sequit

Steelhead Resources

A 1979 survey of Arroyo Sequit found *O. mykiss* and the resulting report stated, "Historically, small steelhead runs have been reported in this area" (DFG 1980). Surveys of Arroyo Sequit in 1989-1990 again noted steelhead (Keegan 1990). Observations made in Arroyo Sequit between 1980 and 2000 indicate the presence of multiple *O. mykiss* age classes, albeit in low numbers, and observations made between 2000 and 2005 indicate the consistent presence of adult *O. mykiss*, also in low numbers (Dagit *et al.* 2005). Steelhead have been observed in both the mainstem and East Fork Arroyo Sequit. A 2007 steelhead monitoring report for Arroyo Sequit notes, "When surface flows are sufficient and the connection to the ocean is established and maintained, then anadromous trout take advantage of the opportunity to enter Arroyo Sequit" (Dagit and Abramson 2007, p. 7).

A 2005 steelhead distribution report for the Santa Monica Bay region describes steelhead habitat in Arroyo Sequit as follows: "…much of the lagoon and lower creek have been modified over the years with fill materials, in-stream road crossings and bank hardening to protect the campground. Despite these impacts causing sedimentation in the lower reaches, which cause the creek to dry up for much of the year, remnant pools upstream continue to support both juvenile and adult steelhead" (Dagit *et al.* 2005). A 2006 report on steelhead habitat in streams of the Santa Monica Mountains notes that steelhead are "commonly found" in Arroyo Sequit and identified the stream "as one of top three watersheds [of the Santa Monica Mountains] where future restoration efforts should be focused" (California Trout 2006).

Causes of Decline

The 1990 survey report found that streamflow was limiting to fish habitat, particularly with respect to migration. According to the researcher, "A moderate increase in streamflow would result in suitable rearing habitat…" (Keegan 1990a). According to DFG staff, "…future upstream water demands and construction should be reviewed to insure that riparian and aquatic habitats are maintained" (DFG 1980).

Passage problems also have been noted as limiting to the steelhead population. A 2007 steelhead monitoring report for Arroyo Sequit characterizes the passage constraints in the basin as follows:

> "Passage opportunities at Arroyo Sequit are limited in two ways. First by the limited amount of time there is a passable thalweg and ocean connection, and second, due to the numerous upstream passable barriers located at the top of the lagoon (in-stream road crossing), a sediment bulge upstream that causes the creek to flow sub-surface much of the time, and an additional in-stream road crossing located at the upper end of the campground… While there is an estimated five miles of creek potentially suitable to support steelhead, the lack of opportunity to move within the system, combined with the exposed and easily accessible locations of the pools within the State Park indicates that even if steelhead are able to enter the creek, they are still quite vulnerable to predation (both natural and human)" (Dagit and Abramson 2007, pp. 29, 65).

Conservation Activities

A 2007 steelhead monitoring report for Arroyo Sequit notes that California State Parks and Heal the Bay were in the process of acquiring funding to implement several fish passage projects in the watershed, including two instream road crossings at group campgrounds along the mainstem Arroyo Sequit and a check dam further upstream, and to oversee a lagoon restoration project (Dagit and Abramson 2007). Restoration work at these sites is slated to begin in 2012. The proposed project will replace the Arizona crossings located 0.10 miles and 0.75 miles upstream from the ocean on mainstem Arroyo Sequit with two free span bridges designed for 100-year storm events and will notch a small check dam constructed of native stream cobble and concrete located 1.0 mile upstream from the ocean on the mainstem (J. King pers. comm.).

Restoration Opportunities

A 2007 steelhead monitoring report for Arroyo Sequit states, "While the overall conditions within the watershed remains suitable for supporting steelhead, it appears that the significant migration and passage limitations are taking their toll. Several upstream developments are being proposed that might also degrade the habitat for steelhead by armoring or channelizing sections of the creek running through private property upstream of the park boundary. A coordinated effort to integrate protection for the stream reaches and remove all barriers in order to preserve the opportunity for steelhead re-establishment is critical" (Dagit and Abramson 2007, p. 65).

Passage barriers in the Arroyo Sequit watershed identified in the Santa Monica Mountains Steelhead Habitat Assessment (California Trout 2006) are listed in Table 56 and labeled in Figure 15. A discussion of recommended barrier modification projects is provided below.

Table 56. Arroyo Sequit Watershed Key passage Barriers

ID	Stream	Description	Type	Source
1060-01	Arroyo Sequit	State Park Arizona crossing	Partial	California Trout 2006
1060-02	Arroyo Sequit	Upper campground crossing	Partial	California Trout 2006
1060-03	Arroyo Sequit	Abandoned check dam	Partial	California Trout 2006
1060-04	Arroyo Sequit	Mullholland Rd. crossing	Partial	California Trout 2006
1060-05	Arroyo Sequit	Concrete grade control structure	Partial	California Trout 2006
1062-01	E. Fork Arroyo Sequit	Concrete wall and dam	Total	California Trout 2006

The 2006 assessment report identified high priority barrier removal projects in Arroyo Sequit including removing the instream road crossings in the lower and upper state park campground (Barriers 1060-01 and 1060-02), and replacing the Mulholland highway culvert (Barrier 1060-04) to facilitate passage to the upper watershed (California Trout 2006).

The lower campground crossing on mainstem Arroyo Sequit (Barrier 1060-01) is considered the keystone fish migration barrier for the Arroyo Sequit watershed. The concrete Arizona crossing creates a substantial impediment to steelhead migration during low to moderate stream flows, and is the primary cause of scour occurring in the channel immediately downstream. Replacement of this crossing with a free-span bridge is scheduled for 2012 (J. King pers. comm.).

The upper group campground Arizona crossing (Barrier 1060-02) is located approximately 0.75 miles upstream of the ocean on Arroyo Sequit. It is believed that both the upper and lower campground crossings limit steelhead passage over about 95 percent of the flow range. The upper concrete crossing has experienced substantial downstream channel erosion. Replacement of this crossing with a free-span bridge is scheduled for 2012. The project proposes to realign the current location of the crossing to a more suitable place approximately 15 feet upstream of its existing alignment (J. King pers. comm.).

An abandoned check dam located approximately one mile upstream from the mouth of Arroyo Sequit (Barrier 1060-03) currently prevents upstream migration of juvenile fish during low flow conditions. Larger fish can pass the dam during most flows. In 2010, the dam will be notched at least one foot to provide access to all size and age classes of steelhead (J. King pers. comm.).

On East Fork Arroyo Sequit, a total barrier formed by a concrete wall and dam (Barrier 1062-01) is not considered a priority for restoration, as a natural waterfall immediately downstream likely constitutes the upper limit of anadromy in the stream (California Trout 2006).

Topanga Canyon Creek

Steelhead Resources

Topanga Canyon Creek historically has supported steelhead in years of sufficient rainfall. A 1974 DFG letter states, "A small population of trout manages to survive in…Topanga Canyon Creek. In years of good rainfall, and good water conditions, some steelhead are reported…, and it is probable that some of these successfully spawn" (DFG 1974). A 1975 study of southern California fishes notes, "…a small but persistent run [of steelhead] still enters Malibu and Topanga canyon…" (Swift 1975).

The *O. mykiss* population in Topanga Canyon Creek has been monitored annually since 2001. The resulting reports indicate continuing reproduction, access by spawning steelhead, and smolt production (Dagit *et al.* 2007). A 2007 steelhead monitoring report for Malibu Creek notes that although the Topanga Canyon Creek watershed is about one-third of the area of the Malibu Creek watershed, "…the numbers of locations where trout were observed is three times higher for Topanga than for Malibu, and over two times as many pools are consistently found with steelhead" (Dagit and Abramson 2007, p. 55). The report notes that successful *O. mykiss* reproduction can be attributed in part to "…overall good to excellent water quality, habitat quality, benthic macro-invertebrate diversity, and lack of invasive aquatic species" (Dagit and Abramson 2007, p. 56). The role of groundwater, seeps and springs has been studied, revealing that these year-round water sources are directly correlated to distribution of steelhead (Tobias 2006).

Causes of Decline

Migration opportunities into the Topanga Canyon Creek watershed have been found to be limited due to large sediment deposits at the mouth (Dagit *et al.* 2003; California Trout 2006; Dagit *et al.* 2009). Constricted flow at the Highway 1 Bridge also has been noted to limit migration opportunities (California Trout 2006).

Conservation Activities

Steelhead population monitoring has been conducted in Topanga Canyon Creek since 2001, and a preliminary watershed assessment for the basin was prepared in 2003 based on two years of monthly snorkel surveys and stream habitat evaluation (Dagit *et al.* 2003). The watershed assessment report identified limiting factors to the Topanga Creek steelhead population and included recommended restoration projects and studies to guide management of the basin.

A steelhead tagging program commenced in 2008 to improve understanding of growth and reproduction dynamics in the Topanga Canyon Creek watershed, and a major passage barrier in lower Topanga Canyon Creek, the Rodeo Grounds berm, was removed in fall of 2008

(Dagit *et al.* 2009). The density of *O. mykiss* in the Topanga Canyon Creek watershed has increased since 2001 (Dagit *et al.* 2009).

A 2009 report notes that restoration projects under consideration for funding in Topanga Canyon Creek include lagoon restoration at Topanga Beach and channel restoration and road stabilization in the Topanga Narrows, along a section of State Highway 27, and along a section of Topanga Canyon Boulevard (Dagit *et al.* 2009).

Restoration Opportunities

Due to the aridity of the Topanga Canyon Creek watershed researchers have noted the importance of conserving instream flows, particularly in the dry season (DFG 1980b). A 2008 survey report notes, "Given that the steelhead trout population in Topanga is continuing to expand to occupy all available habitat, it is critical that continued efforts are made to improve passage opportunities and maintain a healthy habitat within Topanga Creek in order to ensure the survival of these fishes in this region" (Dagit *et al.* 2009, p. 39).

The Santa Monica Mountains Steelhead Habitat Assessment (CalTrout 2006) and a recent monitoring report by Dagit, Reagan, and Tobias (2007) identify priority restoration projects and management needs for the Topanga Canyon Creek watershed, including:

1) restoration of Topanga Lagoon to its historical condition
2) restoring the natural bank and creek channel in the Narrows
3) stabilizing landslides in the lower watershed
4) maintaining suitable water quality
5) preventing introduction of exotic invasive aquatic species
6) addressing private development and road alignment encroachments in the upper watershed

A review of the PAD and other sources was made determine the location and status of passage barriers in Topanga Canyon Creek. An important barrier is listed in Table 57 and labeled in Figure 15.

Table 57. Topanga Canyon Creek Watershed Key Passage Barrier

ID	Stream	Description	Type	Source
1071-01	Topanga Canyon	Pacific Coast Hwy Bridge	Partial	California Trout 2006

The 2006 habitat assessment notes that a plan has been developed to excavate the fill material from the Topanga Canyon Creek lagoon and replace the Pacific Coast Highway Bridge (Barrier 1071-01) to improve flow dynamics at the mouth. Restoration of the lagoon is currently under consideration for funding (Dagit *et al.* 2009).

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Figure 15. Anchor and other important watersheds of Los Angeles County, California

Figure 16. Important *O. mykiss* habitat in the San Gabriel Mountains, California

Chapter 8. Orange County

According to our review, three coastal Orange County watersheds provided habitat for steelhead historically (Table 58), and documentation of recent *O. mykiss* presence is available for two of these drainages. Although the Santa Ana River supports a small population of resident *O. mykiss* in its headwaters, it was not included in our comparison of habitat data for anchor watershed consideration, as restoring steelhead runs to this basin in the near-term is improbable given the large scale hydrologic modifications in the lower portions of the watershed. Steelhead/rainbow trout resources of the Santa Ana River watershed (Figure 16) are discussed in Chapter 10 of this report.

Table 58. Orange County Watersheds Screening by *O. mykiss* Population

Watershed	*O. mykiss* population?
Santa Ana	Y*
San Diego	N
San Juan	Y

Notes:
*Does not support anadromy, but supports resident *O. mykiss* in the headwaters.

Our analysis indicates that restoration in the San Juan River watershed (Figure 17) offers the best potential for increasing steelhead abundance in the county. Available data and supplemental information were used to estimate rearing habitat in the San Juan River, as shown in Table 59.

Table 59. Orange County Watersheds Screening by Habitat

		Habitat (stream miles)	
Watershed	Area (sq.mi.)	Total[1]	Available[2]
San Juan	176.9	2.4	0.0

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

To further refine the areas containing suitable rearing habitat, the mainstem and tributaries in the San Juan River watershed were examined, as shown in Table 60. Various aspects of steelhead habitat within the anchor watershed are described below.

Table 60. Orange County Anchor Watershed Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available[2]**
San Juan		**2.4**	**0.0**
	San Juan	1.0	0.0
	Arroyo Trabuco	0.9	0.0
	Falls Canyon	0.5	0.0

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

Anchor Watersheds

San Juan Creek

Steelhead Resources

Historically, San Juan Creek supported steelhead during years of good rainfall. Consistent steelhead runs were documented through the late 1940s (Hubb 1946, as cited in CDM 2007). According to a DFG staff account, steelhead runs were not seen after 1969 (Woelfel 1991). In several years since the year 2000, adult in-migrants have been observed in lower San Juan Creek attempting to ascend the stream to spawn, but have failed due to significant migration barriers.

When streamflow allows, habitat occurs in upper San Juan Creek and in the upper portion of Arroyo Trabuco. Based on surveys in 2002 staff from NMFS concluded, "…the amount and quality of habitat in the San Juan Creek and Trabuco Creek watersheds is capable of supporting steelhead…" (NMFS 2004). A 2008 report on the San Juan Creek watershed notes, "If accessible, the upper watershed has suitable rearing/spawning habitat and adequate flow, although not year round, to support steelhead migration. Despite the lack of flow in the upper reaches during the dry season, wetted pools remain in tact [sic] and can act as holding ponds until the onset of the wet season" (Katagi 2008 p. 4).

Causes of Decline

A 2007 San Juan Creek watershed management plan states, "Specific factors on Trabuco Creek and San Juan Creek that negatively impact the habitat or conditions needed for Steelhead survival, growth, or reproduction include low or reduced flows in some sections due to groundwater pumping and creek diversions (with associated water temperature increases), water quality degradation from a variety of sources, invasive plant communities (such as Arundo and alyssum), competition with non-native fish, predation by non-native predators (such as bullfrog), stream channelization and other forms of alterations, manmade and natural barriers, siltation of spawning habitat, degradation of riparian plant communities that provide cover, and temperature regulation of the stream" (CDM 2007, p. 3-34).

Significant migration barriers in the lower watershed, such as the Metrolink drop structure and the I-5/Camino Capistrano crossing on Arroyo Trabuco, and a 30-foot drop near a railroad bridge on San Juan Creek have prevented steelhead from accessing spawning and rearing habitat upstream. A 2006 DFG report found "one, perhaps two" dams constituting total passage barriers in San Juan Creek (DFG 2006). Two Arizona crossings with culverts on San Juan Creek at Casper's Park and on Rancho Mission Viejo property have become fish passage barriers. Scouring occurs downstream from the culverts, creating impassable jumps for fish (G. Sutherland pers. comm.).

The 2002 watershed management plan found "phenomenal degrees of erosion damage" in the previous 20 years in the lower reaches of Arroyo Trabuco (USACE 2002). The 2007 plan noted riverine and riparian habitat impacts from channel downcutting and other erosion problems, as well as poor water quality. According to the plan, the San Juan Creek lagoon "…is highly impacted by sediment loading…" (CDM 2007, p. 5-41). During surveys conducted in 2006, "rapid growth of arundo and other invasive plant species" were observed in the middle and lower reaches of San Juan Creek (Katagi 2008). In recent years, largemouth bass, a non-native predatory species, also has been observed in pools in the lower watershed (G. Sutherland pers. comm.).

Feasibility studies are being conducted in the San Juan Creek estuary for the development of a desalination plant. Implementation could result in the further reduction of surface flow in the lower reaches of stream, impairing habitat and reducing migration opportunities (G. Sutherland pers. comm.).

Conservation Activities

Multiple stakeholders collaborated in the preparation of the San Juan and Trabuco Creeks Steelhead Recovery Watershed Management Plan (CDM 2007), which characterizes existing habitat conditions and identifies and prioritizes recommended projects for steelhead recovery in the watershed.

Designs have been completed for a fishway to allow passage on Trabuco Creek past 800 feet of concrete channel and a drop structure that runs under Camino Capistrano, I-5 and Rancho Viejo Road, identified in the 2007 plan as a high priority project (CDM 2007). The project includes creating a side channel with a series of resting pools along the section of Trabuco Creek that runs beneath I-5 (G. Sutherland pers. comm.). The City of San Juan Capistrano and Orange County also have coordinated *Arundo* removal projects on San Juan Creek (G. Sutherland pers. comm.).

Restoration Opportunities

The 2007 watershed management plan for San Juan Creek and Arroyo Trabuco recommends the following high priority actions to restore steelhead resources in the basin: Remove migration barriers; develop minimum in-stream flow requirements to facilitate migration and improve habitat; enhance habitat to ensure steelhead survival during a range of flow conditions; eliminate invasive fish and plant species in the lower watershed, such as largemouth bass and *Arundo*; and enhance lagoon habitat (CDM 2007).

A 2008 report notes, "The upper portions of the watershed are relatively healthy and will be vital to steelhead recovery efforts. The upper reaches of San Juan Creek have not been impacted by urban development, while the lower portion of the watershed has been affected by the growth along the Interstate 5 corridor and San Juan Capistrano. Additionally, invasive plant and animal species do not appear to have migrated to the upper reaches of the watershed" (Katagi 2008, p. 4).

Key passage barriers in the San Juan Creek watershed are listed in Table 61 and labeled in Figure 17. A discussion of barrier modification projects is provided below.

Table 61. San Juan Creek Watershed Key Passage Barriers

Barrier ID	Watershed	Stream	Description	Type	Source
1169-02	San Juan	San Juan	Railroad crossing	Total	CDM 2007
1169-03	San Juan	San Juan	Arizona crossing at Rancho Viejo	Total	G. Sutherland pers. comm.
1169-04	San Juan	San Juan	Arizona crossing at Casper's Park	Total	G. Sutherland pers. comm.
1170-01	San Juan	Arroyo Trabuco	Metrolink Drop Structure	Total	CDM 2007
1170-03	San Juan	Arroyo Trabuco	Interstate 5/Camino Capistrano Grade Control Structure and Channel	Total	CDM 2007

Modification of the structures in lower San Juan Creek and Arroyo Trabuco (Barriers 1169-02, 1170-01, and 1170-03) is the highest priority restoration need in the watershed, as they constitute total passage barriers and are located downstream from all suitable rearing habitat in the basin.

Modification of the Arizona crossings on upper San Juan Creek (Barriers 1169-03 and 1169-04) also is recommended due to the high quality habitat that exists upstream. Landowners at Rancho Viejo plan to replace the crossing on the property (Barrier 1169-03) as part of a larger plan for development in the area, however a start date has not yet been determined. DFG has indicated interest in funding and constructing a temporary fish passage structure at the site, but owners of the ranch have not agreed at this time (G. Sutherland pers. comm.).

References

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Woelfel, D.G. 1991. The Restoration of San Mateo Creek: A feasibility Study for a Southern California Steelhead Fishery. Master's Thesis. California State University, Fullerton.

Personal Communications

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Chapter 9. San Diego County

Our review of available information indicates that San Diego County has eight watersheds with evidence of steelhead presence historically (Table 62). Although *O. mykiss* has recently been documented in only two of these watersheds, San Mateo Creek and the San Luis Rey River, we also advanced San Onofre Creek and the Santa Margarita River to analysis for anchor watershed consideration as they are minimally developed and located on the Camp Pendleton Marine Corps Base, offering important opportunities for steelhead recovery in these basins.

Table 62. San Diego County Watersheds Screening by *O. mykiss* Population

Watershed	*O. mykiss* population?
San Mateo	Y
San Onofre	N*
Santa Margarita	N*
San Luis Rey	Y
San Dieguito	N
Sweetwater	N
Otay	N
Tijuana	N

Notes
*Advanced to habitat screening due to possible future steelhead use.

Available data and supplemental information were used to estimate rearing habitat in four San Diego County watersheds, as shown in Table 63. Our analysis shows that the San Margarita River watershed contains the majority of the region's available habitat, and substantial additional habitat is available in San Mateo and San Onofre creeks. The San Mateo Creek and Santa Margarita River watersheds (Figure 17) are considered the anchor watersheds for San Diego County. As San Onofre Creek has supported steelhead historically and offers substantial habitat resources, this watershed is considered important. While the San Luis Rey River did not contain sufficient habitat resources to be included as an anchor watershed, the presence of a reproducing population of *O. mykiss* in the upper basin has important implications for steelhead recovery in the watershed and the region. A description of steelhead resources in the San Onofre Creek and San Luis Rey River watersheds (Figure 17) is presented in the "Other Important Watersheds" section below.

Table 63. San Diego County Watersheds Screening by Habitat

		Habitat (stream miles)	
Watershed	**Area (sq.mi.)**	**Total[1]**	**Available[2]**
San Mateo	133.5	11.5	11.5
San Onofre	42.7	4.9	4.9
Santa Margarita	741.0	31.6	31.6
San Luis Rey	559.3	13.65	0.0

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

To further refine the areas containing important rearing habitat resources, mainstems and tributaries in the San Diego County anchor watersheds were examined, as shown in Table 64. Various aspects of steelhead habitat within the anchor watersheds are described below.

Table 64. San Diego County Anchor Watersheds Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available[2]**
San Mateo		**11.5**	**11.5**
	San Mateo	9.0	9.0
	Devil Canyon	2.5	2.5
Santa Margarita		**31.6**	**31.6**
	Santa Margarita	18.0	18.0
	De Luz	6.2	6.2
	Sandia Canyon	2.9	2.9
	Rainbow	3.1	3.1
	Stone	1.3	1.3

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

Within the two anchor watersheds of San Diego County, we identified two streams (of seven candidates) that appear to account for the majority of the high value rearing habitat.

Anchor Watersheds

San Mateo

Steelhead Resources
San Mateo Creek may have supported a substantial steelhead run historically, at least in some years. A USFS report relays historical reports of steelhead in the Devil Canyon Creek tributary by fishermen from the 1920s and 1930s (Knight 1998). A memo from 1939 describes the steelhead resources of San Mateo Creek:

> "Reports from many sources indicate that there has been a heavy run of steelhead spawners in this stream every year. Number of fish running seems to be in the thousands with a reported length of from 18 to 24 inches… Spawners have been seen in the stream 12 miles from mouth 4 days after a storm."
>
> "The live water area for this year seems to be that part of the stream for eight miles above the first 12, the lagoon and one tributary, Blue Water canyon… The total available spawning area of the stream and its tributaries is about 25 miles or more…" (DFG 1939).

According to an issue of the DFG journal from 1946, "[DFG warden E.H.] Glidden states that trout weighing up to about 20 pounds run far up the San Mateo, and that he has personally observed the runs in San Mateo and San Onofre creeks for 20 years" (DFG

1946). Based on surveys of San Mateo Creek in 1950 DFG staff observed, "I believe the present resident population of [rainbow trout] is sufficient to reproduce the carrying potential of this stream whenever water conditions improve, and "…it is very likely from all reports that an ample steelhead population migrates considerable distance upstream…" (DFG 1952).

Staff from USFS surveyed Camp Pendleton creeks in 1995 and 1996 and stated, "…San Mateo Creek provide[s] a corridor to upstream habitat off-Base. Spawning and rearing habitat occurs on San Mateo Creek and Devils Canyon within the Cleveland National Forest… Historically, SMC may have been one of the most important steelhead spawning streams on the south coast" (Knight 1998).

Staff from DFG collected *O. mykiss* in the San Mateo Creek watershed in 1999 and observed the population for several years. According a to subsequent paper, "The discovery… represents the first multiple record account of trout in the creek in over 50 years" (DFG 2004). A 2004 paper notes, "Genetic and age analysis on specimens collected in 1999 and 2000 established that…successful, resident reproduction occurred in [Devil's Canyon Creek] in 2000" (DFG 2004). Tissue samples from San Mateo Creek *O. mykiss* were analyzed and the resulting report indicates that the fish "are clearly not [of hatchery ancestry]" (Girman and Garza 2006).

Causes of Decline

Woelfel (1991) examined the San Mateo Creek system and concluded that several factors led to the decline of steelhead runs. "These include increased groundwater removal along the lower section of the creek, increased erosion resulting from military training activities (especially fires caused by the training activities) and the loss of riparian vegetation, the diking of the creek... In addition, the introduced green sunfish (*Lepomis cyanellus*) probably eliminated the residual steelhead population from the spawning area of the creek" (Woelfel 1991, p. ii). Anecdotal evidence presented in Woelfel (1991) also suggests that the creek experiences lower baseflow and longer periods with no flow than historically, though causes are not ascribed. Woelfel's research also infers that decreased lagoon size, providing less habitat area, has been a factor in the decline of the steelhead fishery.

A description of the San Mateo Creek watershed notes, "…concentrated pumping near the creek has lowered the water table below the creek channel and has dried up reaches of the creek that in the past had flow part of the year. Reduced stream flow in San Mateo Creek also hinders or eliminates steelhead migrations. Excessive pumping can also trap adult and smolt steelhead in upstream pools by eliminating the flows necessary for the fish to return to the sea" (SCC 2001). A draft assessment for San Mateo Creek steelhead prepared in 2001 noted impacts from off-highway vehicles in the Wildomar area, non-native plants, and erosion of trails in the San Mateo Wilderness as having negative effects on aquatic habitat (USFS 2001).

In 2004 DFG staff noted, "The higher water temperature [in San Mateo Creek than in Devil Canyon Creek] and presence of non-native fish species likely contributed to the extirpation of adult trout on SMC in 2000" (DFG 2004). Recently, natural processes exacerbated by land and water use activities in the lower reaches of San Mateo Creek have prevented the sandbar at the mouth from breaching, precluding possible steelhead migration in and out of the basin. Continued sediment deposition at the mouth in the vicinity of the railroad crossing and associated establishment of vegetation on the sandbar has stabilized the structure, significantly reducing the likelihood of breaching by flood events.

Conservation Activities

In 2000, state funds were made available for the implementation of a steelhead restoration project in San Mateo Creek. The multi-year restoration project includes numerous stakeholders, including Trout Unlimited and DFG, and involves a habitat assessment of the basin and development of a long-term watershed management plan. A draft steelhead assessment for San Mateo Creek prepared in 2001 by USFS included a list of priority restoration recommendations for the basin. The Department of Fish and Game began efforts to remove non-native fish from the basin in 2003, and a non-native vegetation removal project also was implemented by volunteer groups.

Restoration Opportunities

Studies conducted in the last decade suggest that critical restoration needs in the San Mateo Creek basin consist of reducing groundwater withdrawal in the lower basin, improving passage opportunities between the mouth and habitat in Devil's Canyon Creek, bank stabilization, erosion control, and exotic fish and vegetation control.

A memo addressing conservation of the steelhead population in San Mateo Creek recommended habitat restoration, removal of exotic fish, and evaluation of groundwater use and lagoon management (DFG 1999). The 2001 assessment recommendations included exotic species control, improved off-road vehicle management, and erosion control on roads and trails to reduce impacts on steelhead (USFS 2001).

A Camp Pendleton biologist noted in 2010 that priority restoration projects in the basin should include controlling invasive fish species in the lagoon and upland portions of San Mateo Creek and installing exclusion fencing at the lagoon and I-5 bridge on San Mateo Creek to prevent human use and resulting impacts. The biologist also notes that the railroad crossing replacement project offers an opportunity to address habitat and passage concerns in the lower reach of the creek (M. Rouse pers. comm.).

The NMFS 2009 draft steelhead recovery plan recommends the following priority actions in San Mateo Creek:

Develop and implement a groundwater monitoring program

Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures

Develop and implement a watershed-wide sediment management plan

Conducting a watershed-wide fish passage barrier assessment

A review of passage barriers in the San Mateo Creek basin was conducted using the PAD and other sources. Key barriers are listed in Table 65 and labeled in Figure 17. A discussion of barrier modification projects is provided below.

Table 65. San Mateo Creek Watershed Key Passage Barriers

Barrier ID	Watershed	Stream	Description	Type	Source
1173-02	San Mateo	San Mateo	Sandbar with vegetation	Partial	CEMAR
1173-03	San Mateo	San Mateo	Arizona crossing	Partial	PAD
1173-04	San Mateo	San Mateo	Arizona crossing	Partial	PAD

As noted above, the sandbar at the mouth of San Mateo Creek (Barrier 1173-02) has built up over several years and its stability been increased by establishing vegetation. Unnaturally low stream flows in the lower reaches of San Mateo Creek in combination with the increasing stability and size of the sandbar significantly reduce the likelihood that natural processes will breach the sandbar, and steelhead migration to and from the basin will continue to be prevented. While modification of natural features is not recommended for other watersheds in the study area of this report, it may be appropriate in this case. We propose an examination of the likelihood of natural breaching of the sandbar at the San Mateo Creek mouth, and implementation of a breaching program to allow migration in at least some years. This action should be coupled with the provision of migration flows in the lower basin.

The PAD notes the presence of two Arizona crossings on San Mateo Creek (Barriers 1173-03 and 1173-04) that create passage problems for steelhead during low flows (DFG 2002 as cited in the PAD). These passage barriers should be evaluated in the context of a larger restoration plan for the San Mateo basin that includes the provision of instream flows for steelhead habitat and migration. If these barriers hinder migration under suggested improved flow conditions, modification options should be developed.

Santa Margarita River

Steelhead Resources

A memo from 1949 notes, "…a few steelhead are known to enter the river on wet years and run upstream to slightly above the Fallbrook area" (DFG 1949). However, in 1947 DFG staff stated, "A constant flow is present in the section opposite Fallbrook but summer temperatures and shifting sand bottom make it unsuitable for trout" (DFG 1947). Steelhead also apparently used the tributary DeLuz Creek and its tributary Fern Creek historically (Knight 1998). A fish distribution study of the Santa Margarita watershed conducted between 1997 and 1999 found that "…steelhead, stickleback, and lamprey…have been extirpated since at least the 1940s" (Warburton 2000).

Staff from USFS conducted habitat surveys on creeks in Camp Pendleton in 1995 and 1996, including mainstem Santa Margarita River. The resulting report states, "The Santa Margarita River...provide[s] a corridor to upstream habitat off-Base" (Knight 1998, p. 1). It adds, "[The Santa Margarita River] contained the least quantity and quality of steelhead habitat" (Knight 1998, p. 92). According to a 2003 NMFS report, the Santa Margarita River does not offer spawning habitat downstream from O'Neill Dam (NMFS 2003).

A consulting biologist's report from 1991 notes the presence of perennial water and suitable substrate in the DeLuz Creek tributary Roblar Creek, stating, "[Roblar Creek] may have suitable conditions to support steelhead..." (Higgins 1991, p. 19). Staff from USFS conducted habitat surveys on creeks in Camp Pendleton in 1995 and 1996, and observed "small amounts" of spawning habitat on Roblar Creek (Knight 1998). The 2000 fish distribution report states, "Steelhead habitat for rearing is present at several sites in the drainage; upper De Luz Creek from about the De Luz School upstream to the upper limit of accessible flow, about 11-12km; Sandia Creek from its mouth in the river upstream about 4-5km; Rainbow Creek in its lower about 5km; Stone Creek for about 2km up from the mouth; and the main river from about the De Luz Ford on the Base to the top of the gorge, about 32km" (Warburton 2000, p. 21).

A 2009 report regarding modification of the O'Neill diversion weir on the Santa Margarita River states, "NMFS believes that this watershed was historically inhabited by steelhead, and because steelhead have recently been found in other streams near the Santa Margarita River (*e.g.*, San Juan Creek, San Mateo Creek, and the San Luis Rey River) it is possible that steelhead will attempt to enter the Santa Margarita River during the winter and spring when rainstorms and increased wet season flows occur" (USBR 2009, p. 2). Also in 2009, a fisherman reported catching silvery (likely smolting) *O. mykiss* in Santa Margarita Creek (M. Rouse pers. comm.).

Causes of Decline

The 1998 USFS report on habitat resources of Camp Pendleton provides the following explanation for the loss of steelhead from streams running through the military base, including the Santa Margarita River:

> "An extended dry cycle from the mid 1940's through the late 1970's, and concurrent urban and agricultural growth in the lower alluvial valleys of the Santa Margarita River, San Mateo and San Onofre creeks, overtaxed the groundwater resources of these streams. There were extended periods in the mid 1950's, when stream flows were insufficient to reach the ocean during the historical wet months February through April. This severely limited the opportunity for upstream and downstream migration of adult and juvenile steelhead. Landlocked steelhead were likely extirpated due to competition, increased fishing pressure, disease, and/or predation following plants of hatchery trout for put and take fisheries, and the introduction of exotic predatory game fish" (Knight 1998, p. 1)

The Vail Lake Dam on Temecula Creek was constructed without provisions for minimum bypass flows. The 2000 fish distribution report states, "Upstream of the gorge the stream dries for too long or is inaccessible behind Lake Vail. The main Temecula Creek down to the top of the gorge was probably a major rearing and spawning area for steelhead before 1900" (Warburton 2000, p. 22). A 2002 monitoring plan for the Santa Margarita River states, "Water management in the watershed has resulted in lowered groundwater levels and an associated reduction in the quantity of groundwater that resurfaces at the gorge. With the exception of the record flood in 1993, downstream releases from Vail Reservoir are promptly removed by groundwater pumps below the dam. These hydrologic modifications have diminished river base flows and groundwater levels that support aquatic and riparian species" (White 2002, p. 8).

The 2002 monitoring plan report notes a lack of late season base flow in the mainstem Santa Margarita River due to reservoir operations and decreased groundwater recharge and higher late season base flows in tributary streams due to increased irrigation and impermeable surfaces. The tributary streams were found to contribute high inputs of sediment to the mainstem (White 2002).

A 2008 urban runoff management report for the Santa Margarita basin notes degraded water quality in the Santa Margarita River due to various pollutants, most notably nutrients and sediment. Other pollutants of concern included "dissolved minerals (iron, manganese, sulfates, and total dissolved solids), bacteria (fecal coliform), heavy metals (total copper), and pesticides" (CSDLUEG 2008, p. iii).

Conservation Activities

The Bureau of Reclamation conducted a series of studies between 2002 and 2009 to develop a conjunctive water use project for the Santa Margarita basin. The project is focused on enhancing groundwater supplies in aquifers within Camp Pendleton, and involves increasing storage at O'Neill Reservoir, increasing winter surface withdrawals from the Santa Margarita River while decreasing dry-season withdrawals, and providing year-round instream flows of three to nine cubic feet per second downstream from the dam (Stetson Engineers 2007; USBR 2009). A 2009 report regarding modification of the O'Neill diversion weir notes, "Other potential project elements involve instream water retention structures, reclaimed wastewater, off-stream storage, and recharge of other groundwater basins on the base" (USBR 2009 p.1). Increased instream flows will likely create opportunities for steelhead migration into Santa Margarita River.

The 2009 report notes that steelhead restoration in the watershed is one consideration of the conjunctive use project, including a fish passage element at the O'Neill diversion weir (USBR 2009). Large quantities of sediment have accumulated upstream and downstream of the diversion, creating a significant barrier to migration. The 2009 USBR report describes potential modifications to the weir for fish passage.

Restoration Opportunities

Restoration of steelhead resources in the Santa Margarita River basin is dependent upon restoring critical migration flows in the lower reaches of the mainstem to allow steelhead access to tributary habitat. This likely will entail increasing winter storage of surface flows by improving capacity at O'Neill Reservoir and creating off-stream storage areas, decreasing groundwater pumping, and altering the location and timing of diversions. Other important restoration actions include identifying and addressing upstream sediment sources, identifying and addressing sources of nutrient runoff, and improving pool habitat in the lower mainstem.

A key passage barrier in the Santa Margarita River is listed in Table 66 and labeled in Figure 17. Modification of this barrier is discussed below.

Table 66. Santa Margarita River Watershed Key Passage Barriers

Barrier ID	Watershed	Stream	Description	Type	Source
1186-01	Santa Margarita	Santa Margarita	O'Neill diversion weir	Partial	USBR 2009

A 2009 Bureau of Reclamation report notes problematic sediment deposition and vegetation growth within the channel upstream and downstream from the O'Neill diversion weir on the mainstem Santa Margarita River (Barrier 1186-01), and lack of flow in the channel downstream from the weir in summer months (USBR 2009). Designs for a fishway are in the preliminary planning phase. Effective passage at the site will entail management of the large quantities of sediment delivered from upstream to avoid clogging of the fishway. The report recommends establishing a general operating plan for the diversion that considers water diversion requirements, sediment management, and fish passage goals prior to designing a fishway.

Other Important Watersheds

The San Onofre Creek watershed is considered important as a steelhead resource in that it has supported steelhead historically, offers substantial rearing habitat, and is contained within the boundaries of Camp Pendleton. The San Luis Rey River watershed was identified as important to increasing steelhead production in San Diego County based on the presence of high quality habitat and a reproducing *O. mykiss* population (in a section of the stream located upstream from impassible anthropogenic barriers). To further refine recommendations to support steelhead restoration in these systems, we reviewed information regarding habitat in mainstem reaches and tributaries as shown in Table 67. Information regarding the steelhead resources of these streams is provided in the following.

Table 67. San Diego County Other Important Watersheds Habitat by Stream

		Habitat (stream miles)	
Watershed	**Mainstem/Tributary**	**Total[1]**	**Available[2]**
San Onofre		**4.9**	**4.9**
	San Onofre	4.2	4.2
	San Onofre Canyon (Middle Fork)	0.7	0.7
San Luis Rey		**13.7**	**0.0**
	Pauma	5.0	0.0
	Doane	0.1	0.0
	Cedar	7.7	0.0

Notes
[1]Includes all habitat located downstream from natural limits of anadromy
[2]Excludes habitat located upstream from impassible anthropogenic barriers

San Onofre

Steelhead Resources

According to an issue of the DFG journal from 1946, a DFG warden observed steelhead runs in San Onofre Creek over a period of 20 years (DFG 1946b). The San Onofre Creek lagoon was surveyed in 1950 and juvenile steelhead were observed (DFG 1979). A 1998 USFS report on steelhead resources of streams within Camp Pendleton Marine Corps Base notes that San Onofre Creek "historically had a run of reproducing steelhead through the early 1950's" and adds, "Steelhead were listed as possibly being native to the lower 1.6 km including the lagoon" (Knight 1998, p. 34).

Staff from USFS conducted habitat surveys in mainstem San Onofre Creek, South Fork San Onofre Creek, and San Onofre Canyon Creek (also called "Middle Fork") in 1995 and 1996. The resulting report notes, "The largest area of steelhead habitat on the [Camp Pendleton] Base occurs within Middle Fork [San Onofre Creek]" (Knight 1998, p. 95).

As part of a steelhead distribution study, NMFS staff collected information on San Onofre Creek. The resulting 2005 report notes that the creek is dry, and therefore incapable of supporting *O. mykiss* (NMFS 2005). According to a naturalist and long-time resident, suitable steelhead habitat is available in the upper reaches of the creek and in the lagoon (A. Greenwood pers. comm.).

San Onofre Creek lies completely within the bounds of Camp Pendleton. According to a Camp Pendleton biologist, San Onofre Creek is in an "impact area" where military uses preclude stream surveys. The biologist described the condition of the San Onofre lagoon in 2010 as "very good" (M. Rouse pers. comm.).

Causes of Decline

The 1998 USFS report on habitat resources of Camp Pendleton notes that the decline of steelhead resources in San Onofre Creek is related to the same factors impacting the San Mateo Creek and Santa Margarita River drainages, namely a prolonged drought between 1940 and 1970 and increased water development that depleted the basin's groundwater resources and reduced surface flow (Knight 1998). The report notes, "historical flow on [San Onofre Creek] was similar to [the Santa Maria River] and [San Mateo Creek]. A comparison of the two gages on [San Onofre Creek] (11046200 and 11046250) showed that median surface flow was zero for the twenty-one years (1946-1967) that flow was recorded. After 1967, flow data was only recorded for nine months in 1989 and was zero. Between the two gages, surface flow decreased, likely becoming subsurface due to the sandy soils and groundwater pumping" (Knight 1998, p. 18). San Onofre Creek is used as a potable water source for the military base (Knight 1998).

Stream surveys conducted in San Onofre Creek noted lack of streambank vegetation, lack of riparian canopy cover, and lack of flow in the lower and middle mainstem. In the wetted reaches of the mainstem, pool habitat, instream cover, and spawning gravels were noted to be absent (Knight 1998).

Conservation Activities

The limited development and low intensity land use in the San Onofre Creek watershed offers an important opportunity to protect and enhance steelhead resources. It is largely on this basis that the watershed is identified as important in this report. However, current information regarding restoration goals for the basin was not available at the time of production of this report. A biological assessment for the Camp Pendleton Base was in preparation in 2009 (M. Rouse pers. comm.).

Restoration Opportunities

The 1998 USFS habitat report notes, "The primary concern for SOC would be to promote adult migration and juvenile emigration through the lower river... The effectiveness of a migratory corridor leading to habitat on and off Base could be enhanced by the conservation of existing native riparian habitat" (Knight 1998, p. 95). Information contained in the biological assessment being prepared for the Camp Pendleton Base report will clarify current restoration needs for the San Onofre Creek basin.

San Luis Rey River

Steelhead Resources

Multiple *O. mykiss* observations exist for the San Luis Rey River system, although very little information is available regarding abundance. A 1998 study relays accounts by Native Americans that a steelhead run existed in the upper San Luis Rey River prior to construction of Henshaw Dam (Knight 1998, p. 19). A 1946 reference states, "[Rainbow trout] is abundant in the streams rising in Smith [Palomar] Mountain and emptying in to the San Luis Rey River" (DFG 1946b). Another 1946 reference notes, "Live section near Pala often contains a few large trout washed downstream from tributaries but few trout in general" (DFG 1946c). A 1947 summary of stream surveys characterizes the San Luis Rey River as having 11 miles of "trout water" (DFG 1947).

A 2010 assessment report for the San Luis Rey River watershed characterizes historical steelhead habitat in the San Luis Rey River as follows:

> "The SLR River at the Henshaw Dam site was a perennially flowing river with minimum monthly summer flows of 1.4 cfs…The majority of these flows were most likely the result of the numerous tributaries flowing into the river in the western portion of the sub-basin. Historically, the mainstem and most likely the West Fork SLR River, contained large areas of year round flows and supported trout populations of original ocean decent" (Kajtaniak and Downie 2010).

Department of Fish and Game biologists observed an adult steelhead approximately 21-24 inches in length in the San Luis Rey River near Oceanside in May 2007 but the subsequent survey report notes, "[The] reach lacked any possible spawning areas" (DFG 2007). Consulting biologists observed two adult *O. mykiss* in the tributary Gomez Creek in September 2005. A 15-inch individual was examined, but ancestry was undetermined (Dudek 2005).

A 2010 watershed assessment report for the San Luis Rey River notes that the highest quality habitat in the San Luis Rey River basin currently occurs in the northern sub-basin, defined in the report as the area including all tributaries within "the watershed area immediately north of the SLR River from Rice Canyon, approximately one mile east of Interstate 15 (RM 20), to just upstream of the Escondido Canal Diversion (RM 40)" (Kajtaniak and Downie 2010). Within this sub-basin, the report notes historical observations of steelhead in Pauma, Gomez, Pala, Agua Tibia, and Frey creeks. A reproducing *O. mykiss* population currently exists above significant passage barriers in Pauma Creek and its tributaries Doane and Cedar creeks (Kajtaniak and Downie 2010).

A 1946 survey report notes "fair" natural propagation and a largely self-sustaining population in Pauma Creek. It states, "This is one of the best natural trout streams in San Diego County" (DFG 1946d). A 2008 stream inventory report for Pauma Creek notes the presence of "numerous rainbow trout of all age classes" in two reaches of the stream within the Cleveland National Forest, stating "Some large, deep pools easily contained more than

20 trout per pool" (DFG 2008, p. 6). A 1947 DFG survey report notes "poor" natural propagation in Doane Creek and states, "This stream is generally too small in size to support many trout" (DFG 1947b).

Causes of Decline
The construction of Henshaw Dam in the upper San Luis Rey River and the Escondido Canal Diversion Dam ten miles downstream significantly altered the basin's hydrology. All flows are diverted from the Escondido Canal, drying the river downstream from the diversion and barring steelhead access to the basin in most years. Lack of flows have impacted riparian habitat and increased erosion, and spawning habitat has been greatly diminished due to the dams preventing spawning gravels from being deposited downstream. Passage barriers preclude possible outmigration of individuals from the reproducing population of *O. mykiss* currently found in Pauma Creek and tributary streams.

Conservation Activities
As noted above, a comprehensive assessment of the San Luis Rey River watershed was prepared by DFG staff in 2010, and the findings will be used to inform restoration planning for the watershed. Numerous stakeholders in the watershed are involved in discussions regarding restoring the basin's steelhead resources.

Restoration Opportunities
Key recommendations in the 2010 watershed assessment include: conducting studies to determine minimum bypass flow releases from Lake Henshaw and the Escondido diversion that will support steelhead migration and improve instream habitat conditions; modifying fish passage barriers within the mainstem San Luis Rey River and northern sub-basin to facilitate passage; enhancing pool habitat and instream cover; improving spawning habitat in selected areas; working with landowners to reduce impacts of diversions on habitat; identifying and addressing erosion sources; eradicating *Arundo* and other invasive plant species from the basin; and installing livestock exclusionary fencing to decrease stream bank erosion (Kajtaniak and Downie 2010).

Key passage barriers in the San Luis Rey watershed are listed in Table 68 and labeled in Figure 17. A discussion of passage barrier modification projects is provided below.

Table 68. San Luis Rey River Watershed Key Passage Barriers

Barrier ID	**Watershed**	**Stream**	**Description**	**Type**	**Source**
1216-01	San Luis Rey	Pauma	Hwy 76 crossing	Total	DFG 2008
1216-02	San Luis Rey	Pauma	Concrete wall	Total	DFG 2008
1219-01	San Luis Rey	Doane	Weir barrier	Total	DFG

The Highway 76 Bridge crossing on Pauma Creek (Barrier 1216-02) is a total barrier to inmigration and outmigration. The 2010 DFG watershed assessment recommends modification of this barrier (Kajtaniak and Downie 2010). The report also recommends modification of a concrete dam on Pauma Creek (Barrier 1216-03) located approximately 2.4 miles upstream of the Highway 76 barrier and a weir on Doane Creek (Barrier 1219-01).

A 2008 DFG Pauma Creek survey report provided a recommendation to "design and engineer pool enhancement structures to increase the number of pools in the lower end of the canyon and, if necessary, periodically throughout the corridor between the canyon and the SLR River. This is a long, open stretch of Pauma Creek (approximately 2.75 miles) that steelhead/trout would need to migrate through and resting pools may be needed during migration" (DFG 2008, p. 8).

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Figure 17. Anchor and other important watersheds of southern Orange and Northern San Diego Counties, California

Chapter 10. Other Habitat Resources

Our review of available information revealed numerous locations in the southern portion of the study area where habitat exists but where major hydrologic modifications currently preclude anadromous *O. mykiss* reproduction. In some watersheds, this habitat is the only suitable spawning and rearing habitat, while in others habitat exists downstream from the total passage barriers as well. The majority of this isolated historical spawning and rearing habitat occurs in the upper portions of larger watersheds in the southern study region and has been protected from human development by virtue of being located within National Forest lands. Most of these areas continue to support populations of stream-maturing (*i.e.*, resident) *O. mykiss*.

While the current study has focused on conserving and restoring available habitat and habitat that may become available with implementation of barrier modifications, we recommend a program that addresses *O. mykiss* resources (*i.e.*, habitat and populations) upstream from barriers unlikely to be removed or modified for passage. This program would formalize and expand ongoing efforts by CDFG and NMFS in three important aspects. First, the program should characterize *O. mykiss* populations upstream from barriers in terms of distribution, abundance, and genetics. Secondly, the program should establish Endangered Species Act status of the populations. Finally, the program should develop and implement a conservation/restoration plan for associated habitat.

A 2007 report on population genetics of *O. mykiss* in the Santa Ynez River notes "Genetic studies in coastal California report that resident and anadromous forms from the same river are generally more similar than the same form in adjacent drainages and are generally descended from coastal steelhead lineages" (Garza and Clemento 2007). A number of recent studies have demonstrated that isolated populations of *O. mykiss* can produce smolts that survive the marine environment and return to their natal drainages as spawning adults (Thrower and Joyce 2004; Hayes *et al.* 2004; Thrower *et al.* 2008). It follows from these findings that the potential exists to use "landlocked" *O. mykiss* populations as sources when it is determined that transplantation or other supplementation methods should be applied to re-establish or increase anadromous populations. This management approach typically would be expected when previously inaccessible habitat is made accessible (to "jump start" a run), or when low-level population concerns indicate that additional genetic resources should be introduced into a population.[9] Detailed distribution, abundance, and genetic information is necessary in such cases to avoid harm to source populations and populations targeted for restoration.

Research performed through the first (characterization) phase of the proposed program should be used to establish upstream populations as part of the associated downstream distinct population segment or as the basis for creating a new grouping that receives ESA review and, presumably, listing status. *Oncorhynchus mykiss* populations upstream from total passage barriers unlikely to be removed or modified now appear to be in a legal limbo that

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[9] An analogous situation currently occurs in the Russian River drainage, where NMFS, DFG, the Sonoma County Water Agency, and others are conducting a coho salmon broodstock program. Coho salmon populations from outside the watershed are being used to increase the number of breeding opportunities.

does not afford the protection opportunities necessary to advance conservation and restoration.

Lastly, to advance species conservation goals we recommend a coordinated program to identify important habitat resources, identify restoration actions, and establish stakeholder groups to carry out rehabilitation of habitat. As much of the area supporting isolated *O. mykiss* populations is in public ownership, few institutional hurdles would be expected for such a program. Where restoration involves private lands, additional outreach will be necessary to gain access and develop restoration projects.

Several important above-barrier habitat areas are reviewed briefly below. The areas described here should not be viewed as comprising all important habitat upstream from total barriers, however, as additional research will be necessary to complete this characterization. Insufficient information was found to allow mapping rearing habitat in the streams discussed below. We have not attempted to provide detailed recommendations regarding most important streams and restoration actions for these watersheds.

Santa Maria
For a discussion of steelhead resources in the anadromous portion of the Santa Maria River drainage (Figure 11), please refer to Chapter 5.

While the Cuyama River, tributary to the Santa Maria River, does not appear to have provided a large quantity of historical steelhead habitat due to sub-basin's aridity, a number of tributary streams, including Alamo, Reyes, and Beartrap creeks, contain high quality perennial habitat. These areas were isolated from the Santa Maria River (and the ocean) by construction of Twitchell Dam in the 1950s. Recent surveys conducted by NMFS staff in Reyes and Beartrap creeks found excellent habitat and reproducing *O. mykiss* populations (M. Stoecker pers. comm.).

Santa Ynez
For a discussion of steelhead resources in the anadromous portion of the Santa Ynez River drainage (Figure 12), please refer to Chapter 5.

The construction of Gibraltar, Juncal, and Bradbury dams between 1920 and 1950 blocked access to nearly 70 percent of the historical steelhead spawning and rearing habitat in the Santa Ynez River watershed. Resident *O. mykiss* continue to use habitat in many tributaries to Lake Cachuma (formed by Bradbury Dam). Potentially important tributaries to the reservoir include Cachuma, Tequepis Canyon, and Santa Cruz (and tributary) creeks. Streams tributary to Gibralter Reservoir with potential rearing habitat resources include Gidney, Indian, Buckhorn, Blue Canyon, Escondido Canyon, Fox, and Alder creeks. The upstream-most portion of the Santa Ynez River and several tributaries feed Jameson Lake (formed by Juncal Dam). Notable streams include North Fork Juncal and Steelhead creeks. Investigation of Santa Ynez tributaries should include assessment of habitat damage related to the 2007 Zaca fire.

Santa Clara
For a discussion of steelhead resources in the anadromous portion of the Santa Clara River drainage (Figure 14), please refer to Chapter 6.

Prior to construction of the Santa Felicia and Pyramid dams on Piru Creek in 1954 and 1970, respectively, steelhead accessed high quality habitat in upper mainstem Piru Creek up to about the Snowy Creek confluence as well as numerous tributaries, including Agua Blanca, Fish, Buck and Snowy creeks. Recent observations indicate the continued presence of stream-maturing (*i.e.*, resident) *O. mykiss* in mainstem Piru Creek between Santa Felicia and Pyramid dams and in interspersed pools between Pyramid Lake and the Lockwood Creek confluence (Stoecker and Kelley 2005; Girman and Garza 2006; B. Yin pers. comm.). The Lake Piru tributaries Fish and Agua Blanca creeks, the Pyramid Lake tributaries Buck and Snowy creeks, and the upper Piru Creek tributary Mutau Creek also support resident rainbow trout populations (B. Yin pers. comm.). Staff from DFG recently characterized Piru Creek as a "pristine system"(C. McKibbin pers. comm.).

San Gabriel River

The San Gabriel River is channelized throughout its lower 30 miles and dammed in two locations near the mouth of San Gabriel Canyon. Morris Dam, located approximately 2.7 miles upstream from the mouth of the canyon, was constructed in 1934 and San Gabriel Dam, located approximately six miles upstream from San Gabriel Dam, was completed in 1939. Cogswell Dam is located at approximately stream mile nine on the West Fork San Gabriel River. The San Gabriel River continues to support stream-maturing trout populations in numerous locations in its headwater region (Figure 16). High quality perennial habitat supporting *O. mykiss* has been noted in the San Gabriel River immediately downstream from Morris Dam and the tributary Fish Canyon Creek, in the West Fork San Gabriel River downstream from Cogswell Dam and in the Cogswell Reservoir tributary Devil's Canyon Creek. The Iron, Fish, and Prairie forks of the San Gabriel River upstream from San Gabriel Reservoir also support *O. mykiss* (B. Yin pers. comm.).

Santa Ana

At 2,650 square miles, the Santa Ana River watershed is larger than any more southerly basin in California, including the Tijuana River watershed. In its lower 24 miles, downstream from the entrance to Santa Ana Canyon, the river is channelized. Prado Dam is located at about stream mile 31, near where the river enters Santa Ana Canyon. While the lower drainage is highly urbanized, headwaters areas in the eastern San Gabriel Mountains and the San Bernardino Mountains (Figure 16) historically provided suitable habitat for steelhead/rainbow trout.

Historical observations of rainbow trout exist for various Santa Ana River tributaries within the San Bernardino Mountains including West Fork City Creek, Mill Creek, Falls Creek, Bear Creek, and the South Fork Santa Ana River. Many of the headwaters tributaries of the Santa Ana River system were stocked historically, making determination of native *O. mykiss* distribution problematic. Rainbow trout have been observed in Lytle Creek historically, and habitat exists currently due in part to management of the water supply infrastructure located on the creek. Habitat in the mainstem Santa Ana River downstream from the Bear Creek diversion is maintained by bypass flows, and surveys conducted in the reach downstream from the diversion between 2005 and 2007 found multiple *O. mykiss* age classes (PBS&J 2008).

Habitat in the reach downstream from Big Bear Lake is dependent upon reservoir releases. Recent observations indicate the presence of a self-sustaining *O. mykiss* population in Mountain Home Creek, a tributary to Mill Creek (Leidy *et al*. 2001). *Oncorhynchus mykiss* also has been observed in Deer Creek, which enters Santa Ana River just upstream from the Bear Creek diversion, and Fish Creek, a headwater tributary upstream from the South Fork Santa Ana River (B. Yin pers. comm.).

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Discussion

In an earlier steelhead distribution study, we found that populations of steelhead and rainbow trout continue to occur in the majority of the watersheds in the historical range south of the Golden Gate (Becker and Reining 2008). Other measures present a bleaker picture of the species' status, however. First, abundance clearly is a fraction of its historical average largely due to habitat loss (although population size estimates are rare and involve potentially problematic assumptions). In particular, the steelhead spawning runs of many streams either do not exist or now include very few individuals. Secondly, habitat resources consistently demonstrate substantially lower quantity and quality than were observed during surveys in the 1940s and 1950s. Water supply facilities and operations, transportation infrastructure, and channelization projects have had especially profound effects on habitat availability.

While ongoing efforts by the restoration community are producing inspiring results throughout the region south of San Francisco, the continuing perilous condition of steelhead suggests that a well-reasoned, comprehensive program to protect the best steelhead resources and alleviate continuing threats be developed as quickly as possible. This report responds to the need, given limitations on funding, expertise, political will, and agency and non-governmental organization staff time, to focus on a finite set of restoration actions in a bounded group of watersheds and streams. The authors consider the recommendations presented here to constitute a "triage" plan for steelhead watersheds between San Francisco and the United States/Mexico border "focused on securing the relatively healthy areas, followed by expanding these areas" (Doppelt *et al.* 1993, pp. 33-34).

This study analyzed rearing habitat related information in order to identify the most important steelhead resources. In our previous examination of San Francisco Estuary watersheds (Becker *et al.* 2007), we were comfortable comparing habitat (measured in stream miles) across the region. We modified our approach in the current study, as we were aware of striking differences between the amount of suitable habitat in watersheds in the northern portion of the study area compared to the southern region. Rather than compare "apples to oranges," we elected to compare watersheds and streams within specific counties where climatic conditions (especially rainfall) were less likely to vary greatly within the focus area.

The watersheds reviewed in this report contain stream reaches and/or estuarine areas with the increasingly rare conditions that allow juvenile steelhead to survive during the extended dry season experienced in the region. Also, since ocean survival of steelhead smolts is highly related to their size at out-migration, streams that can produce high juvenile growth rates are arguably the most important. We suggest, therefore, that the primary focus of restoration activities should be to protect and enhance existing stream reaches with cold water and adequate food supply, and to connect them with the ocean during key migration and movement periods.

This report recommends various watersheds be considered "anchor" watersheds, and within these watersheds identifies a number of "essential" mainstem and tributary streams. We also ascribe "important" status to watersheds and streams that demonstrate lower levels of production potential but, for various reasons described in the report, should receive attention and funding support. As shown in Table 69, of 142 watersheds in the study area known to have supported steelhead historically, 96 (~68 percent) demonstrate evidence of recent use or other compelling reasons for consideration as anchor watersheds. We designated 25 anchor watersheds, representing about 26 percent of the historical steelhead basins and about 18 percent of the screened basins. Across the study area, an additional 17 watersheds were considered non-anchor but otherwise important.

Table 69. Anchor and Other Important Watersheds Evaluation Summary

County	Historical Steelhead	Anchor Screening[1]	Anchor	Other Important
All Counties	**142**	**96**	**25**	**17**
San Mateo	22	12	2	1
Santa Cruz	16	15	6	1
Monterey	25	17	4	2
San Luis Obispo	24	18	5	2
Santa Barbara	32	21	2	5
Ventura	4	3	2	0
Los Angeles	8	4	1	3
Orange	3	2	1	1
San Diego	8	4	2	2

Notes
[1]Watersheds currently supporting *O. mykiss* populations or possessing outstanding potential for restoration.

We suggest that focusing steelhead restoration resources on the anchor watersheds will lead to a highly effective use of available funding. However, we also emphasize our support for stream restoration in general including in other, typically smaller watersheds of the study area (especially the Other Important Watersheds). Achieving viable steelhead populations in a large number of geographically dispersed creeks will produce the greatest probability of long-term regional population stability.

Within the anchor watersheds, we evaluated mainstem and tributary streams in order to further refine restoration recommendations to a relatively small group of streams containing the extensive habitat resources. Table 70 provides a summary of the results, and shows the total number of streams within each county's anchor watersheds evaluated for essential stream status (column 2), the number of essential streams in each county (column 3), and the proportion of available habitat contained in essential streams to all available habitat (in anchor and non-anchor watersheds) in each county (column 4).

Table 70. Essential Stream Evaluation Summary

County	Anchor Watershed mainstem/tributaries	Essential Streams	Essential Stream available habitat/total available habitat (%)
All counties	**395**	**88**	
San Mateo	35	8	56
Santa Cruz	121	23	63
Monterey	81	16	55
San Luis Obispo	35	13	57
Santa Barbara	63	9	52
Ventura	45	12	68[1]
Los Angeles	5	1	26[2]
Orange	3	2	0[3]
San Diego	7	4	74

Notes
[1]86 percent with Matilija Dam removal
[2]76 percent with Rindge Dam, keystone barriers removals/modifications
[3]Greater than 90 percent after keystone barriers modifications

According to our analysis, 88 of the 395 anchor watershed steelhead streams (~22 percent) represent the vast majority of the available rearing habitat resources in the study area. On a county-by-county basis, the essential streams contain between about 52 and 90 percent of available habitat. In our earlier study of habitat resources in tributaries to the San Francisco Estuary, we found that 18 of 54 anchor watershed mainstems and tributaries (~33 percent) contained more than 50 percent of the region's available rearing habitat (Becker et al. 2007). Thus, the current study finds the potential to tighten restoration focus to a greater degree while encompassing a substantially greater proportion of the available rearing habitat.

For the anchor watersheds, essential streams, and other important streams we used available information to characterize factors limiting steelhead production, the status of ongoing conservation efforts, and future restoration needs. Consistent with our experience in the San Francisco Estuary, the Eel River, and elsewhere, we found important restoration projects centered on three basic areas: passage barriers, instream flow provision for all phases of the steelhead life history, and channel and riparian enhancement. Throughout the study area, intensive land and water resources use has produced overwhelming impacts on the stream environment of at least a portion of the watershed. While many headwater areas continue to support rearing, most mainstem migration corridors and habitat refugia no longer support steelhead life history tactics adequately due to physical alterations. The San Gabriel River system epitomizes these conditions.

Our study placed particular emphasis on barrier removals and modifications to provide a scientific basis for capital spending priorities. In many instances, we could not make or cite prioritization recommendations as barriers had not been assessed for severity. We encourage spending in the anchor watersheds to apply the standardized, powerful assessment tools currently available to remaining un-surveyed barriers. Also, we found the Passage Assessment Database (PAD) to provide a valuable resource for barrier information, and recommend continuing efforts to update the PAD as an authoritative barrier reference.

Passage barrier modifications are a critical component of an overall program to restore access to habitat in the region, but should be approached cautiously. Dam removal science and engineering are complex and relatively recent disciplines, practiced by a selected group. Poorly designed projects have the potential to waste money, reduce public support for restoration, and injure habitat and property. We greatly appreciate the visionary funders and agency staff who understand the need for high-quality design prior to undertaking important passage barriers projects, as well as the added implementation cost to maximize habitat benefits and provide long-term channel stability.

The study area has several high-profile dam removal projects in various stages of planning. In particular, the Carmel River (San Clemente Dam), the Ventura River (Matilija Dam), and Malibu Creek (Rindge Dam), will require major dam removal projects to allow access to the bulk of the historical habitat. Important barrier modifications also should be pursued in the tributaries of Malibu Creek. Ongoing efforts to improve passage at the Santa Clara River's Vern Freeman facility combined with passage projects in Santa Paula and Sespe creeks have the potential to increase production from this important system. An unusual passage project affecting the sandbar at the mouth of San Mateo Creek (San Diego County) may be necessary to create migration opportunities (see Chapter 9).

Channel and riparian work recommended in this report also must be thoughtfully developed. In particular, we noted a lack of applied geomorphic studies throughout the region that identify and rank erosion control and other channel improvement projects. In these instances we were only able to recommend further study. Channel and riparian enhancement opportunities also are severely limited by access to private property and by stream setback policy and enforcement. While it is beyond the scope of the current report to propose policy changes, we acknowledge that anchor watershed restoration cannot be completed without the cooperation of local jurisdictions and private landowners in protecting and restoring stream corridors. We recommend establishing stakeholder groups in each watershed where coordination is lacking currently to advance restoration and build support.

Regarding flows, we recommend that a comprehensive program to connect the high quality spawning and rearing habitats of the anchor watersheds should be undertaken. Rearing steelhead may migrate away from habitats of declining quality (*e.g.*, due to declining spring baseflow) and require hydrologic connectivity between these areas and other habitat refugia. Recent research also finds that steelhead juveniles move upstream under certain circumstances, suggesting that adequate flows must be maintained between estuarine and upstream habitats throughout the year (Hayes *et al.* unpublished manuscript).

Several anchor watersheds have long migration corridors between suitable spawning and rearing habitat and the ocean where existing conditions appear to limit potential production. The Carmel, Santa Maria, Ventura, and Santa Clara rivers are important examples of watersheds suffering from poor passage conditions due to flow considerations in the lower watershed. More commonly, habitat quality is reduced by the cumulative effect of water diversions. Instream flows are being analyzed in a number of important watersheds of the study area including San Gregorio Creek, Pajaro River tributaries, and the Big Sur and Santa Maria rivers. Significant gaging, analysis, and modification of diversion practices will be necessary in many of the essential streams to allow for successful restoration.

In the following, we put forward a list of *selected* critical planning and implementation features of an overall program for the anchor watersheds. Our goal is to stimulate a discussion regarding the prioritization of projects, studies, and policies necessary to achieve steelhead restoration in the region as a whole.

- Complete a study of the Pescadero Creek lagoon that determines causes of lowered ecological function and recommends fixes. This process is underway with support from the Coastal Conservancy and has the potential to increase steelhead production dramatically. This effort is notable due to the watershed's size and habitat quality, and its corresponding potential to contribute more to the region's steelhead abundance than possibly any other study area stream system.

- Assist stakeholders including the County of Santa Cruz, the Santa Cruz RCD, and others in efforts to prioritize and implement erosion control projects in the mainstem San Lorenzo River and in key tributaries. This watershed historically had the largest steelhead run in the study area and can host a large, reproductively independent steelhead population with the potential to help "seed" the populations of nearby watersheds.

- Remove San Clemente, Matilija, and Rindge dams. Each of these sites has sufficient political support, potential habitat gains, and advanced planning work completed to justify high-cost decommissioning projects.

- Use the results of the ongoing instream flow study of the Santa Maria River to inform reoperation of the Bureau of Reclamation's Twitchell Reservoir (on the Cuyama River) for migration related releases. Sufficient high quality, protected steelhead habitat exists in the Sisquoc River basin to justify expenditures to improve adult in-migration opportunities and smolt out-migration success in the Santa Maria River between the lower Sisquoc and the ocean.

- Improve lower Ventura River habitat. Carrying out a suite of actions involving instream flows and riverine and riparian corridor protections will diversify the watershed habitat resources and improve the chances of successfully restoring the Matilija Creek run.

- Complete analysis and implementation of water resources of the lower Santa Clara River system. Managing the water supply facilities and controlling groundwater withdrawal with respect to steelhead migration could revitalize the Sespe Creek population, a major regional resource.

While an active stakeholder group is advancing each of the activities listed above, the Santa Maria River study project should be accompanied by investment in capacity building in this watershed wherein representatives of resources agencies, the Bureau of Reclamation, the U.S. Forest Service, county and local governments, water users, and citizens groups are convened to address restoration related issues. Similar processes should be established or expanded in several anchor and other important watersheds described in this report, including Arroyo Seco and the Little Sur River in Monterey County, Arroyo de la Cruz and

San Carpoforo Creek in San Luis Obispo County, Jalama and Gaviota creeks in Santa Barbara County, and San Mateo Creek in San Diego County. The experiences of those involved in salmonid restoration in coastal California and beyond clearly indicate the necessity of stakeholder involvement for successfully implementing the often complex, costly, and time-consuming projects that watershed-based approaches entail.

This report has not attempted to produce cost estimates for the various projects and programs recommended to rehabilitate the streams of the anchor watersheds. In most cases, necessary information is lacking and must be developed through conceptual design efforts for specific barrier modifications or stream enhancement projects. Clearly, though, the budget to implement actions envisioned here (and to monitor and adaptively manage the associated, long-term restoration processes) represents a daunting sum. It also is apparent that funds for steelhead restoration will remain extremely limited into the foreseeable future.

For this reason, we are compelled to conclude this report with an opinion regarding financing steelhead restoration activities. We believe the most promising and equitable funding approach is to establish a fee for the ecological services provided by streams (*e.g.*, water supply, public trust resources, stormwater discharge, *etc.*). This approach could generate substantial, stable revenue to support restoration at the required scale. Ideally, funds would be administered by a conservation district accountable to the ratepayers. Such a program has the potential to raise stakeholder awareness of impacts to streams (decreasing future restoration costs), increase public involvement, and accomplish watershed-wide goals such as maintaining adequate flows and intact stream corridors.

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