Southern Steelhead Resources Evaluation

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

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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

[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

[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

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[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 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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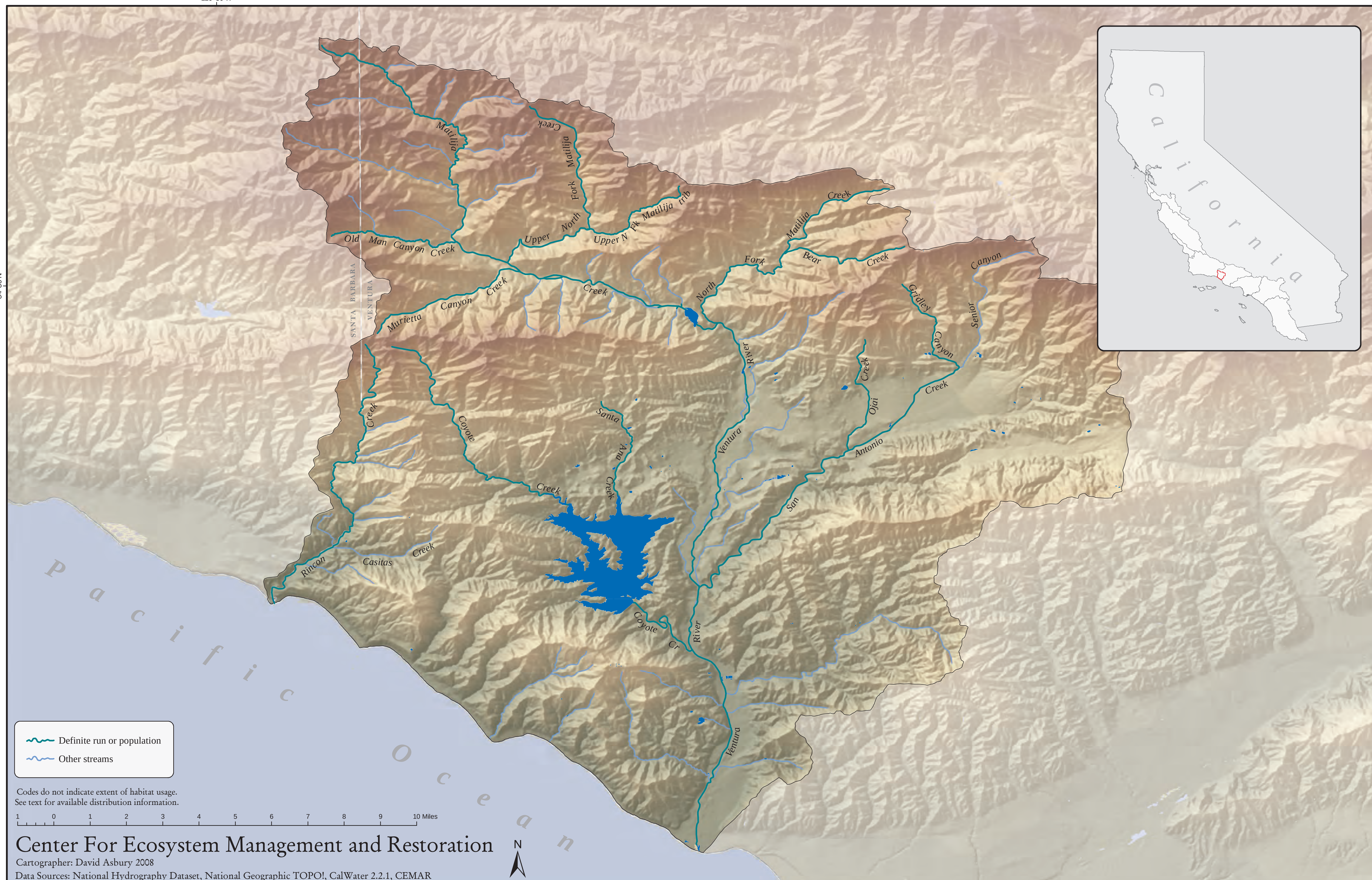
Figure 22. Historical status of *Oncorhynchus mykiss* in coastal streams of northern Ventura County, California



Center For Ecosystem Management and Restoration

Cartographer: David Asbury 2008

Data Sources: National Hydrography Dataset, National Geographic TOPO!, CalWater 2.2.1, CEMAR

Figure 23. Current status of *Oncorhynchus mykiss* in coastal streams of northern Ventura County, California