SOUTH-CENTRAL CALIFORNIA COAST
STEELHEAD RECOVERY PLANNING AREA

CONSERVATION ACTION PLANNING (CAP) WORKBOOKS
THREATS ASSESSMENT

Little Sur River estuary, Monterey County

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South-Central California Coast Recovery Planning Area
Steelhead Threats Assessment Methodology

Introduction. The Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS) contracted with Hunt & Associates Biological Consulting Services to provide technical support in developing Recovery Plans for steelhead (*Oncorhynchus mykiss*) populations in the South-Central California Coast Steelhead Recovery Planning Area and the Southern California Coast Steelhead Recovery Planning Area. Specifically, Hunt & Associates was tasked with reviewing existing information on steelhead habitat conditions, assessing the magnitude and extent of threats to steelhead and their habitats, and developing recovery actions across these two Steelhead Recovery Planning Areas. This document summarizes the results of an assessment of threats and sources of threats to steelhead in the South-Central California Coast Steelhead Recovery Planning Area, which includes coastal steelhead populations from the Pajaro River watershed of Monterey County southward to the Arroyo Grande Creek watershed in southern San Luis Obispo County, California. Recovery action matrices for each watershed in both Steelhead Recovery Planning Areas are provided in separate documents.

Methods. Twenty-two coastal watersheds, encompassing 27 drainages, were selected for threats assessment analysis and recovery planning actions in this Steelhead Recovery Planning Area (see Table 1 in Threats Assessment Summary section). Boughton *et al.* (2006) identified these watersheds as supporting historical and extant steelhead populations. A separate CAP Workbook was established for each of the 27 component drainages analyzed in this Steelhead Recovery Planning Area. Information on existing steelhead habitat conditions in the project area was gathered from a broad range of published and un-published materials, including, peer-reviewed scientific publications, technical reports, federal, state, and local planning documents, EIR/EISs, management plans, passage barrier assessments, habitat evaluations, and field surveys, as well as information provided by NOAA-NMFS staff, and stakeholders and other interested parties at a series of public workshops held throughout both Steelhead Recovery Planning Areas in 2007. These sources are listed in the bibliography in this document.

The Conservation Action Planning (CAP) Workbook is a database developed by The Nature Conservancy to identify conservation targets, assess existing habitat conditions, and identify management issues. The CAP Workbook was used to organize and evaluate the large amount of information on current steelhead habitat conditions and threats to steelhead in these watersheds. The CAP Workbook methodology provides a number of useful features in assessing the magnitude and extent of threats to steelhead and their habitats:

- Use of quantitative and qualitative (*e.g.*, professional judgment) measures of existing habitat conditions;
- Objective, consistent means for tracking changes in the status of each conservation target (steelhead life-history stage) over time;

- Objective, consistent way to compare the status of a specific target between watersheds;
- Overall assessment of a watershed's "health" or viability and objective comparisons to other watersheds;
- Focuses recovery actions by identifying past, current, and potential threats to steelhead and their habitats;
- Central repository for documenting current knowledge and assumptions about existing conditions;
- Continually updated as information on the target's biology and/or existing conditions within watersheds change, and;
- Creates a foundation upon which recovery actions can be tracked and up-dated, based on changing current conditions.

The CAP Workbook process uses available information in an explicit, consistent, and transparent way to assess current habitat conditions. The CAP Workbook allows the user to input quantitative as well as qualitative (professional judgment) information in order to determine what existing conditions are and what healthy targets should look like. The Workbook is iterative and can be updated as additional information becomes available.

CAP Methodology—Conservation Targets. Specific "conservation targets" for analysis are initially identified. The conservation targets in this case are steelhead life-history stages: egg, fry, smolt, and adult. A more general conservation target, "Multiple Life Stages", was also established to allow landscape-scale land use and habitat assessment, based on information derived from GIS-based analysis of entire watersheds (see section below describing relationship between Kier Associates' and Hunt & Associates' CAP Workbook analyses).

CAP Methodology—KEAs. Assessing the "viability" or "health" of a particular conservation life-history stage (target) requires identifying "Key Ecological Attributes" (KEA) for each target. Specific KEAs are aspects of the conservation target's biology or ecology such that if missing or severely degraded, would result in loss of that target over time. KEAs, such as substrate quality, non-native species, food availability, water quality, *etc.*, were identified for each target and measurable indicators, such as turbidity, water temperature, aquatic invertebrate species richness, presence or absence of non-native predators, miles of road/square mile of watershed, *etc.*, were identified in order to characterize existing conditions in the component watersheds. All KEAs were grouped into three categories:

- *Size*: target abundance *(e.g.*, number of adult steelhead);
- *Condition*: a measure of the biological composition, structure, and biotic interactions that characterize the target's occurrence (i.e., generally a local measure of habitat quality or composition), and;
- *Landscape Context*: an assessment of the target's environment (*i.e.*, landscape-scale processes, such as connectivity, accessibility of spawning habitat; hydrology).

CAP Methodology—Current Indicators. The range of variation found in each indicator is subdivided into four more or less subjective, but discrete, categories: "Poor", "Fair", "Good", or "Very Good". The current condition of a specific indicator, taken from a field measurement, literature source, or professional judgment, is assigned to one of these four discrete rating categories (see the description of indicators used in the CAP steelhead analyses and the rationale for these indicators in Kier Associates and National Marine Fisheries Service (2008)). Functionally however, there are essentially two states for the indicator as it relates to the species: 1) "poor-fair", in which the indicator exceeds or minimally meets the requirements for species survival and the population is in danger of extirpation, and 2) "good-very good", where habitat conditions are favorable for species persistence.

The CAP Workbook can use indicators at a local, regional, and landscape-scale. For example, land use indicators, such as density of roads per square mile of watershed, has been widely employed as a landscape-scale metric of watershed "health" for salmonids throughout the western United States (see discussion in Kier Associates and NMFS, 2008). These landscape-scale metrics were used in this assessment to overcome logistical and analytical problems inherent in local-scale metrics of steelhead habitat quality (*e.g.*, water temperature), that exhibit extreme spatial and temporal variation, and can be misleading or lead to misinterpretations.

The goal of establishing measurable indicators in a number of instances was not possible with the current knowledge of existing habitat conditions in the component watersheds. For example, turbidity is an important steelhead habitat indicator. For the steelhead fry life stage, turbidity was defined as the "number of days turbidity exceeded 25 NTUs". Currently, there is little or no systematic and widespread collection of turbidity data in most of the subject watersheds drainages to permit a quantative assessment. In these instances, subjective information, such as observations of mass wasting of slopes, descriptions of point and non-point sediment inputs, *etc.*, were used to qualitatively assess a current condition and rating for this indicator. Because the CAP Workbook analysis is iterative, results can be improved as better quantitative information becomes available.

CAP Methodology—Stresses and Sources of Stress (Threats). An important step in the CAP Workbook assessment is identifying a series of stresses to each steelhead life-history stage. These stresses are basically altered KEAs and directly affect the life-stage, *e.g.*, degraded hydrologic function, increased turbidity, presence of non-native predators, increased substrate embeddedness). Because of the lack of field derived information on specific habitat requirements (tolerances) and specific habitat conditions, the GIS-based surrogate variables used for the "Multiple Life Stages" conservation target actually are sources of stress, not direct stressors on steelhead life stages (*e.g.*, increased road density (a source of stress) contributes indirectly to increased turbidity (a direct stressor). The severity (very high, high, medium, or low) and geographic scope (very high, high, medium, and low) of each stress was determined through a review of existing information. The CAP Workbook assigns an overall stress rank (very high, high, medium, or low) to that stress.

The CAP Workbook automatically inputs the overall rank of each stress into a table that relates the stress to a series of anthropogenic sources of stress (also called Threats) that have been identified by the user as relevant to that watershed (*e.g.*, roads, grazing practices, logging, recreational facilities, agricultural conversion of watershed lands, dams, groundwater extraction, in-channel mining, *etc.*). Each threat is ranked on the basis of its relative "contribution" (very high, high, medium, or low) and "irreversibility" (very high, high, medium, or low) to each stress (*e.g.*, increased turbidity). The CAP Workbook then ranks the threat (source of stress) as "Very High', "High", "Medium", or "Low" and inputs that rank into the next step of the assessment. This process is repeated for each conservation target (egg, fry, juvenile, smolt, and adult), as well as the "Multiple Life Stages" conservation target.

CAP Methodology—Summary of Threats. The CAP Workbook ranks the threat sources for the various conservation targets (life-history stages) from the previous analysis into a "Summary of Threats" table that lists all the threat sources for all life-history stages and assigns a composite "Overall Threat Rank" to each threat source (*e.g.*, dams and surface water diversions), as well as an overall threat rank to that watershed for all threat sources combined. The Workbook derives a second table ("Stress Matrix") that shows the rank of each stress on each life-history stage. The final step in the steelhead CAP assessment is the derivation of a third table entitled, "Overall Viability Summary", that ranks the viability of each life-history stage and KEA category (size, condition, and landscape context) by calculating a composite rank of the current habitat indicators from the "Viability" table of the workbook, as well as an overall "Project Biodiversity Health Rank", which is a measure of watershed "health" based on current habitat conditions. The first and third summary tables proved the most useful in analyzing stresses and sources of stress to steelhead in the South-Central California Coast and Southern California Coast Steelhead Recovery Planning Areas.

Data Gaps. The tables in the CAP Workbooks for the present study have numerous blank cells. Blank cells indicate a lack of available information. Watersheds that have been intensively studied have fewer blank cells than watersheds with few studies. In general, the level of available information on current watersheds conditions relevant to steelhead, with a few notable exceptions, decreased dramatically south of the Santa Monica Mountains (*e.g.*, the Mojave Rim Biogeographic Population Group watersheds and most of the Orange and San Diego county watersheds). However, an important feature of the CAP Workbook methodology is the ability to update the assessment as information becomes available.*

Relationship between CAP Workbook analyses developed by Hunt & Associates and Kier Associates. The CAP Workbooks analyses prepared by Kier Associates are intended to complement, not duplicate, those prepared by Hunt & Associates. During the initial stages of CAP Workbook analyses by Hunt & Associates, it was determined that, in some cases, surrogate indicators covering regional spatial scales and derived from GIS-based watershed analysis, might be useful in overcoming the spatial and temporal problems associated with habitat indicators that rely on point-data measurements, such as water temperature, turbidity, riparian corridor width and composition, *etc.* A separate conservation target category "Multiple Life Stages" was developed for the CAP Workbook analyses that used GIS-based surrogate indicators as input. Surrogate indicators, such as density of roads per square mile of watershed, density of roads within 300 feet of streams per square mile of watershed, human population density, percent of watershed converted to agriculture; percent of watershed converted to impervious surfaces, percent of watershed burned in past 25 years, and others provided a general measure of existing watershed conditions as they affect multiple steelhead life-history stages. For example, road density, especially riparian road density, and percent of watershed as impervious surface, has strong predictive power of general habitat conditions for steelhead because paved surfaces have manifold adverse effects on habitat quality, water quality, and hydrology of streams.

Hunt & Associates' workbooks are based on review of a large number and broad range of ground-based steelhead surveys, habitat and barrier assessments, and other fieldwork, as well as the GIS-based indicators for the "Multiple Life History" target category developed by Kier Associates. Hunt & Associates developed CAP Workbooks for 73 drainages across both Steelhead Recovery Planning Areas (27 in the South-Central California Coast Steelhead ESU and 46 in the Southern California Coast Steelhead Recovery Planning Area). Kier Associates analyzed 54 drainages across both steelhead ESUs (23 in the South-Central California Coast Steelhead Recovery Planning Area and 31 in the Southern California Coast Steelhead Recovery Planning Area), using the GIS-based regional indicators and on a small number of point-data measurements, such as dissolved oxygen, water temperature, *etc.* Kier Associates' workbooks are provided as a separate document (Kier Associates and NMFS, 2008).

Table 1 compares the results of the two documents for watersheds in the South-Central California Coast Steelhead Recovery Planning Area. It should be noted that the difference between a "poor" and "fair" habitat rating or a "good" and "very good" rating is often a matter of professional judgment and may always not represent important differences in habitat quality. Table 1 explains discrepancies between "poor-fair" and "good-very good" categories between the Hunt & Associates and Kier Associates CAP Workbook analyses.

Table 1. Assessment of Overall Habitat Conditions for Steelhead in Component Watersheds in the South-Central California Coast Steelhead Recovery Planning Area Between Two CAP Workbook Analyses*

Watershed	Steelhead Habitat Rating		Reasons for Discrepancy
	Hunt & Associates	Kier Associates	
Pajaro River			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability
Lower Salinas River			

Upper Salinas River			
Carmel River			
San Jose Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability
Garrapata Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability
Bixby Creek			
Little Sur River			
Big Sur River			**Difference in rating floodplain connectivity and number of available indicators used in analysis**
Willow Creek			
Salmon Creek			**Natural barrier (waterfall) in lower reach is limit of anadromy. Kier rates entire watershed as poor on this basis; Hunt & Associates rates only accessible reach.**
San Carpoforo Creek			
Arroyo de la Cruz			
Little Pico Creek			
Pico Creek			**Kier includes point measurements for dissolved oxygen for fry, juvenile, and smolt life stages (rated as "poor"); difference in number of available indicators**
San Simeon Creek			
Santa Rosa Creek			**Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life- history stage viability**
Morro Creek			
Chorro Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability
Los Osos Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability
San Luis Obispo Creek			
Pismo Creek			

Arroyo Grande Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability

***Overall habitat condition rating taken from "Project Biodiversity Health Rank" rating in "Overall Viability Summary" table in Summary section of individual CAP Workbooks (composite rating of habitat conditions for all steelhead life-history stages combined). Watersheds analyzed only by Hunt & Associates are not shown.**

Key: dark green = very good conditions; light green = good conditions; yellow = fair conditions; red = poor conditions.

There are four discrepancies (bolded table entries) that can be explained by the type (point-data measurements) and the lower number of indicators used in each assessment by Kier Associates. This is a consistent difference between Kier Associates' and Hunt & Associates' workbooks. As the number of indicators decreases, the relative weight given to each indicator in the analysis correspondingly increases, and if these indicators are based on point-data measurements, such as water temperature or dissolved oxygen, that exhibit extreme spatial and temporal variation, then different results can be obtained. Aside from these relatively few specific differences, the results of the two assessments closely agree.

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* For NOAA Fisheries Service staff comments on these data gaps see Memo from Mark H. Capelli to Hunt & Associates Re: CAP Threats Workbooks for South-Central California Coast Steelhead Distinct Population Segment, July 18, 2008 (Appendix A); and Memo from Mark H. Capelli and Penny Ruvelas to Kier and Associates Re: CAP Threats Workbooks for South-Central and Southern California Coast Distinct Population Segments, December 7, 2007 (Kier and Associates 2008).

South-Central California Coast Steelhead Recovery Planning Area
CAP Workbooks Threats Assessment Summary

Location and Component Watersheds. The South-Central California Coast Steelhead Recovery Planning Area encompasses four Biogeographic Population Groups (BPGs) identified by the NOAA Fisheries Technical Recovery Team for the South-Central/Southern California Coast Steelhead Recovery Domain (Boughton *et al.* 2007). These BPGs extend from the southern end of the Santa Cruz Mountains southward through the Coast and Interior Coast ranges to the western end of the Transverse Range, and includes portions of Santa Clara, Santa Cruz, Monterey, San Benito, and San Luis Obispo counties. The component watersheds of the four BPGs analyzed in this document using the CAP analyses are listed in Table 1.

Table 1. Component BPGs, Watersheds, and Corresponding CAP Workbooks for the South-Central California Coast Steelhead Recovery Planning Area.

Biogeographic Population Group	Watershed (North to South)	CAP Workbook
Interior Coast Range	Pajaro River	Main stem Pajaro River
		Uvas Creek
	Lower Salinas Basin	Main stem Salinas River
		Gabilan Creek
		Arroyo Seco
	Upper Salinas Basin	San Antonio River
		Nacimiento River
Carmel River Basin	Carmel River	Carmel River
Big Sur Coast	San Jose Creek	San Jose Creek
	Garrapata Creek	Garrapata Creek
	Bixby Creek	Bixby Creek
	Little Sur River	Little Sur River
	Big Sur River	Big Sur River
	Willow Creek	Willow Creek
	Salmon Creek	Salmon Creek
San Luis Obispo Terrace	San Carpoforo Creek	San Carpoforo Creek
	Arroyo de la Cruz	Arroyo de la Cruz
	Little Pico Creek	Little Pico Creek
	Pico Creek	Pico Creek
	San Simeon Creek	San Simeon Creek
	Santa Rosa Creek	Santa Rosa Creek
	Morro Creek	Morro Creek
	Morro Bay Estuary	Chorro Creek
		Los Osos Creek
	San Luis Obispo Creek	San Luis Obispo Creek
	Pismo Creek	Pismo Creek
	Arroyo Grande Creek	Arroyo Grande Creek

Land Use. The type and intensity of land use varies widely across the South-Central California Coast Steelhead Recovery Planning Area. The amount of public ownership of these watersheds, which includes lands managed by the U.S. Forest Service, Bureau of Land Management, California Department of Parks and Recreation, local parks departments, and other public agencies, varies from nearly 100% to 0% of the individual watersheds. In general, the Big Sur Coast BPG watersheds have the greatest amount of land in public ownership. However, ownership is not always a predictor of watershed health for steelhead. For example, the San Carpoforo, Arroyo de la Cruz and Little Pico Creek watersheds have almost no land within their boundaries under public ownership yet provide some of the highest quality steelhead spawning and rearing habitat of any watersheds in this Steelhead Recovery Planning Area. The Big Sur River, Arroyo Seco, San Antonio River, and Nacimiento River watersheds, with more than half their areas under public ownership, are impacted to varying degrees by passage barriers, recreational, and water management issues.

The majority of land in all of the component watersheds across this Steelhead Recovery Planning Area is open space (78% to 100% of total watershed area). However, the spatial configuration and intensity of land use within these watersheds is what determines the type and magnitude of impacts to steelhead. A relatively small amount of urban or agricultural development can have disproportionately large impacts on instream, riparian, and estuarine habitat conditions for steelhead. The typical pattern of urban and agricultural development concentrates on the flatter portions of a watershed, typically within the floodplain and usually along the main stem of the drainage and one or more tributaries, thereby magnifying potential impacts to steelhead even if the vast majority of the watershed remains undeveloped.

Although agricultural conversion of watershed lands in this Steelhead Recovery Planning Area is small, averaging less than 4% of total watershed area (range = 0% to 19%), agricultural practices are important sources of threats to steelhead. Agriculture situated on the floodplain and flanking the main stem of the drainage frequently leads to loss or degradation of the riparian corridor and frequently channelization. Habitat impairments stemming from agricultural development may range from increased water temperature, incision of the streambed and loss of structural complexity and instream refugia (meanders, pools, undercut banks, *etc.*), increased sedimentation, turbidity, and substrate embeddedness, and nutrient loading.

Urban and suburban development in the watersheds in this Steelhead Recovery Planning Area also is generally low, averaging 2.8% of total watershed area (range = 0% to 16%). However, population density varies widely between watersheds (Fig. 1; Table 2). High population densities occur in the northernmost watersheds in this Steelhead Recovery Planning Area, along the main stem of the Salinas River, in the lower Carmel Basin BPG, and in the southern watersheds in the San Luis Obispo Terrace BPG. Coastal watersheds in the center of the Steelhead Recovery Planning Area (Big Sur Coast and northern San Luis Obispo Terrace BPGs) have very low population densities or are effectively uninhabited (Fig. 1; Table 2).

Table 2. Human population density of component watersheds in the South-Central California Coast Steelhead Recovery Planning Area (data from CDFFP Census 2000 block data (migrated), 2003).

Watershed (north to south)	Human Population Density (# / square mile)
Interior Coast Range BPG	
Pajaro River	170
Gabilan Creek	993
Arroyo Seco	3
Salinas River main stem (Salinas Valley)	79
San Antonio River and Nacimiento River combined	6
Carmel River Basin BPG	
Carmel River	70
Big Sur Coast BPG	
San Jose Creek	15
Garrapata Creek	6
Bixby Creek	4
Little Sur River	2
Big Sur River	2
Willow Creek	2
Salmon Creek	< 1
San Luis Obispo Terrace BPG	
San Carpoforo Creek	< 1
Arroyo de la Cruz	< 1
Little Pico Creek	0
Pico Creek	24
San Simeon Creek	19
Santa Rosa Creek	90
Morro, Los Osos, and Chorro creeks combined	324
San Luis Obispo Creek	606
Pismo Creek	160
Arroyo Grande Creek	297

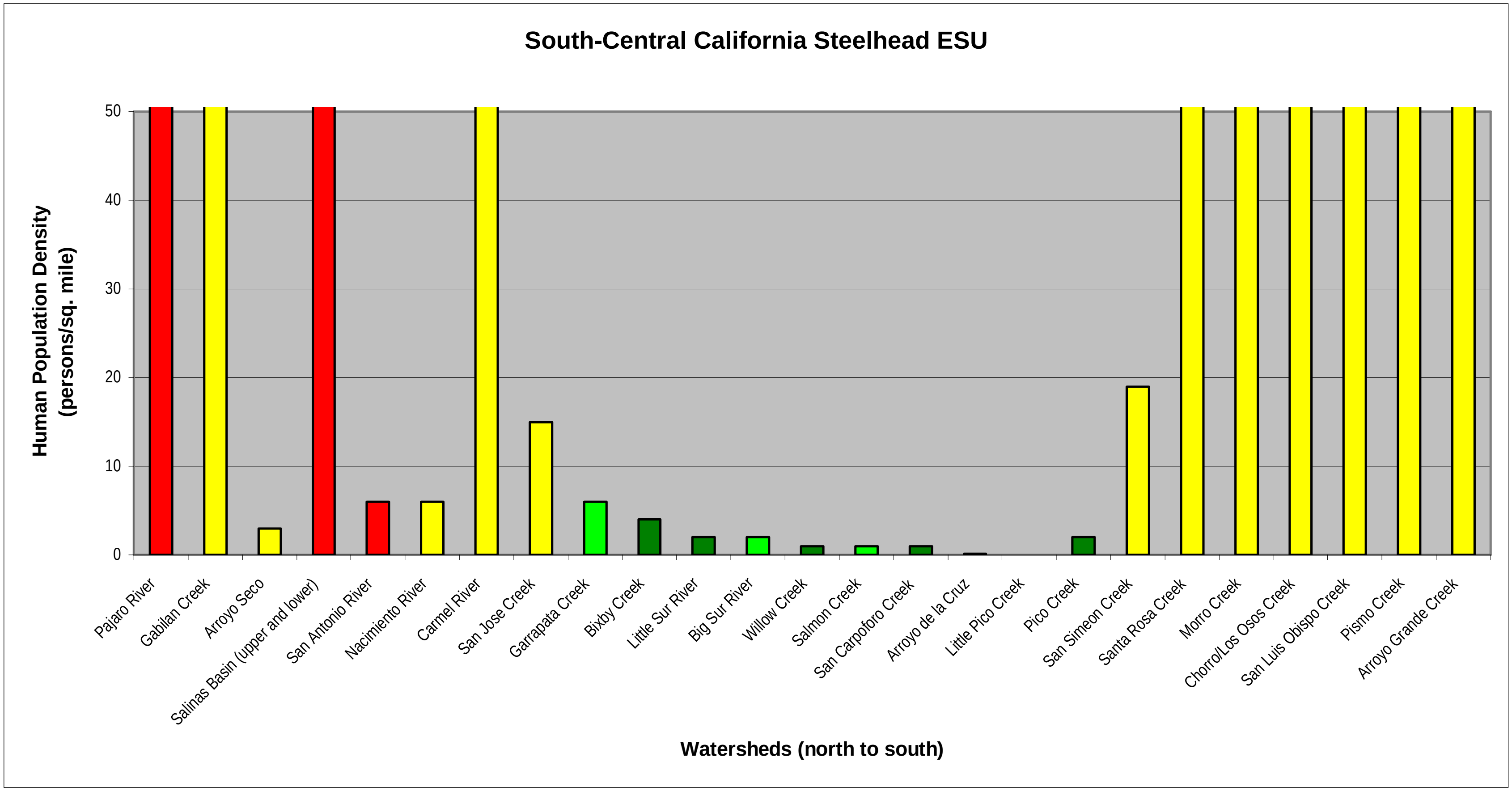

Figure 1. Habitat conditions and human population density in component watersheds of the South-Central California Coast Steelhead Recovery Planning Area (histogram color code is same as for indicator ratings in individual BPG summaries; densities are listed in Table 2).

Threats. Each of the watersheds in the South-Central California Coast Steelhead Recovery Planning Area is impacted by a variety of anthropogenic factors, but the most frequent source of threats arises from agricultural and urban development, specifically water management activities. Dams, surface water diversions, groundwater extraction are common across this Steelhead Recovery Planning Area, especially on the larger rivers, such as the Pajaro, Salinas (and tributaries), and Carmel Rivers, some of which contain multiple major dams. Five of the 23 watersheds listed in Table 1 are sub-watersheds that depend on the main stem of the river to maintain connectivity to the estuary and ocean. Loss of surface flows or other passage impediments along the main stem of the river indirectly degrades these tributaries as spawning and rearing habitat even if the tributaries themselves remain undisturbed. Re-establishing or maintaining connections between the ocean and upper watersheds expands access to historically important spawning and rearing habitats, and significantly improve habitat conditions in these watersheds for steelhead, as well as the existing populations of native rainbow trout that currently are isolated above dams and reservoirs.

Urban and agricultural conversion of floodplain lands flanking the main stem of these rivers and creeks typically requires levees or other structures to protect these lands from flooding. The urban and agricultural reaches of all of the watersheds in this Steelhead Recovery Planning Area have been subjected to some degree of channelization and/or levee construction with the resulting loss or degradation of the riparian corridor and/or streambed. Habitat impairments for steelhead may range from increased water temperature, incision of the streambed and loss of structural complexity and instream refugia (meanders, pools, undercut banks, *etc.*), complete loss of bed and bank habitat, increased sedimentation, turbidity, and substrate embeddedness, and nutrient loading.

Estuaries are used by steelhead as rearing areas for juveniles and smolt as well as staging areas for smolt acclimating to saline conditions in preparation for entering the ocean and adults acclimating to freshwater in preparation for spawning. Loss and/or degradation of estuarine habitats varied widely across this Steelhead Recovery Planning Area, averaging about 70% loss in the Interior Coast Range BPG, 33% loss in the Carmel Basin BPG; 15% loss in the Big Sur Coast BPG (almost wholly associated with 98% loss of the San Jose Creek estuary), and; about 43% loss in the San Luis Obispo Terrace BPG. Losses in the latter BPG were concentrated in the southern watersheds (Table 3).

Table 3. Estuarine habitat loss in component watersheds in the South-Central California Coast Steelhead Recovery Planning Area.

Watershed (north to south)	Remaining Estuarine Habitat as Percentage of Historic Habitat
Interior Coast Range BPG	
Pajaro River	50
Gabilan Creek	9*
Arroyo Seco	9*
Salinas River main stem	9
San Antonio River	9*
Nacimiento River	9*

Carmel River Basin BPG	
Carmel River	67
Big Sur Coast BPG	
San Jose Creek	2
Garrapata Creek	100
Bixby Creek	100
Little Sur River	100
Big Sur River	100
Willow Creek	90
Salmon Creek	100
San Luis Obispo Terrace BPG	
San Carpoforo Creek	80
Arroyo de la Cruz	80
Little Pico Creek	100
Pico Creek	62
San Simeon Creek	50
Santa Rosa Creek	62
Morro Creek	0
Chorro and Los Osos creeks	83
San Luis Obispo Creek	61
Pismo Creek	30
Arroyo Grande Creek	20

* tributary of Salinas River; loss is shared by all contributing sub-watersheds

Summary. In general, the overall "health" of a particular watershed for steelhead is directly related to human population density (Fig. 1). The exception is the large tributaries of the Salinas River. Despite very low population densities and agricultural activity, degraded conditions for steelhead in the Arroyo Seco, San Antonio River, and Nacimiento River watersheds are the result of surface and groundwater management practices designed to serve agricultural and other types of development within and outside these watersheds.

Dams and other surface water diversions and excessive groundwater extraction are the most pervasive sources of threats to steelhead in this Steelhead Recovery Planning Area. The Big Sur Coast BPG (with the exception of its northernmost watershed, San Jose Creek) and the northern watersheds in the San Luis Obispo Terrace BPG, offer the best existing conditions for steelhead.

Table 4. Severe and Very Severe Sources of Threats to Steelhead in the South-Central California Coast Steelhead Recovery Planning Area.

Threat Source	Biogeographic Population Group			
	Interior Coast Range	Carmel Basin	Big Sur Coast	San Luis Obispo Terrace
Dams and Surface Water Diversions	X	X	X	X
Groundwater Extraction	X	X	X	X
Levees and/or	X	X		X

Channelization				
Urban Development	X	X		X
Roads	X		X	X
Other Passage Barriers		X	X	X
Agricultural Effluent	X		X	X
Agricultural Development	X			X
Recreational Facilities	X			X
Flood Control	X			X
Logging			X	
Urban Wastewater Effluent				X
Non-Native Species	X			

*** These are the "severe" (yellow) and "very severe" (red) threat sources taken from the top five threat sources identified by the CAP Workbook analyses. See individual BPG Threat Summaries for additional information.**

The individual threat sources listed in Table 4 are not mutually exclusive threat sources and they can create a number of primary and secondary sources of threats to steelhead. For example, dam construction as a result of urban or agricultural development in a watershed not only creates passage barriers to spawning and rearing habitat and negatively affects the natural hydrograph of the affected drainages, recreational development of reservoirs for fishing and camping can impact steelhead by introducing non-native predators and/or competitors (*e.g.*, largemouth bass, crayfish, western mosquito fish) as well as promoting foot traffic within the active channels of contributing streams that can directly affect redds.

A widespread trend observed in this Steelhead Recovery Planning Area is severe to very severe degradation of habitat conditions along the main stem of impaired watersheds, while the upper main stem and tributaries retain relatively high habitat values for steelhead. This is particularly evident in the Pajaro and Salinas watersheds in the Interior Coast Range BGP, the Carmel River watershed in the Carmel River Basin BPG, and Arroyo Grande Creek watershed in the San Luis Obispo Terrace BPG. Because the main stem of these drainages is the conduit that connects upstream steelhead spawning and rearing habitat with the ocean, recovery actions in watersheds impaired in this manner should focus on reducing the severity of anthropogenic impacts along the main stem (resulting from encroachment into riparian areas and related flood control activities) in order to promote connectivity between the ocean and upstream spawning and rearing habitats. Additionally, degraded estuarine conditions stemming from filling, artificial sandbar manipulation, and both point and non-point waste discharges should be further evaluated and addressed as part of any recovery strategy for this Steelhead Recovery Planning Area (see Threats Summaries and Recovery Action Matrices for individual Biogeographic Population Groups for more specific recovery actions).

Threats Assessment for the Interior Coast Range Biogeographic Population Group

Location and Physical Characteristics. The Interior Coast Range Biogeographic Population Group (BPG) region is the largest of the four BPG regions in the South-Central Coast Steelhead Recovery Planning Area and includes the east-facing (interior) slopes of the Central Coast Range (Santa Lucia Mountains) and the west-facing slopes of the Inner Coast Range (Diablo, Gabilan, Caliente, and Temblor ranges). This region extends 180 miles across the entire length of the South-Central Coast California Steelhead Recovery Planning Area and includes portions of Santa Clara, San Benito, Monterey, and San Luis Obispo counties. The Interior Coast Range BPG region consists of two major watersheds, the Pajaro River and Salinas River, which empty into the Pacific Ocean at Monterey Bay. The Pajaro River watershed includes the Uvas Creek sub-watershed. The Salinas River watershed is very large, covering over 2.8 million acres (4,426 square miles) and contains two major sub-basins: the Lower Salinas sub-basin, which includes the Gabilan Creek and Arroyo Seco watersheds, and the Upper Salinas sub-basin, which includes the San Antonio River and Nacimiento River watersheds (Fig. 1; Table 1).

Tectonic activity associated with the northwest-trending San Andreas Fault has created a parallel series of northwest to southeast-trending basins and ranges in this part of California. The main stem of the Salinas River runs through the center of most of this BPG and two major tributaries, the San Antonio and Nacimiento rivers are unusual in that they flow southward for most of their length before their confluence with the Salinas River, which flows northwest (Fig. 1).

Average annual precipitation in this region is relatively low (Table 1) and shows high spatial variability. In general, the higher elevations get more moisture, but because of the "rain shadow" effect created by the coastal slope of the Central Coast Range, the eastern half of the Interior Coast Range BPG receives significantly less precipitation than the western half. The upper reaches of the Pajaro River watershed extend into the redwood coniferous forests of the Santa Cruz Mountains and receive significantly more rainfall than do other portions of the Interior Coast Range BPG. Although the highly dissected terrain contributes to a very large total stream length in this region (7,773 miles), the majority of drainages exhibit seasonal surface flow or have extensive seasonal reaches because of highly variable patterns of precipitation.

Land Use. Table 1 summarizes land use and population density in this region. Although human population density is relatively low for the region as a whole, about 100 persons per square mile, population centers, such as Atascadero, Paso Robles, and Salinas, are growing rapidly and are surrounded by large tracts of semi-developed rural land. Most of the land in the Pajaro River watershed, along the main stem of the Salinas River (Salinas Valley), and throughout the eastern half of the region, is privately owned. Public ownership of land is concentrated in the Los Padres National Forest lands and military reservations, such as Fort Hunter-Liggett and Camp Roberts, situated in the western portions of the Interior Coast Range BPG. Additionally, several rivers have been evaluated for consideration as Federally-designated Wild and Scenic Rivers: Arroyo Seco and Tassajara Creek, tributaries to the Salinas River within the Los Padres National Forest.

Agriculture (row crop and orchard cultivation and livestock ranching), are important land uses that directly or indirectly affects watershed processes throughout this region. A major consequence of agricultural activity in this region is reservoir development and operation. There are at least 37 dams on watersheds in this region that are large enough to be regulated by the California Department of Water Resources and/or Department of Defense (Fig. 1 shows nine of the more significant dams). These dams are owned and operated by federal, state, public utility, local government, or private interests for irrigation, flood control and storm water management, recreation, municipal water supply, hydroelectric power generation, fire protection, farm ponds, or a combination of these purposes. The largest reservoirs in this region, San Antonio Lake (San Antonio River), Lake Nacimiento (Nacimiento River), and Santa Margarita Lake (Upper Salinas River main stem), receive extensive recreational use.

Table 1. Physical and Land Use Characteristics of Watersheds in the Interior Coast Range BPG.

Physical Characteristics				Land Use				
Watershed	**Area (acres/miles^2)[1]**	**Stream Length[2] (miles)**	**Average Annual Rainfall[3] (in.)**	**Human Population[4]**	**Public Ownership***	**Urban Area[5]**	Agriculture/ **Barren[5]**	**Open Space[5]**
Pajaro River	838,776/1,311	1,843	16.9	222,235	7%	4%	14%	83%
Gabilan Creek	(99,929)/(156)	(247)	(18.9)	(154,907)	(0%)	---	---	---
Arroyo Seco	(196,430)/(307)	(477)	(18.5)	(920)	(58%)	---	---	---
Lower Salinas Basin	1,255,902/1,962	2,598	16.5	266,449	14%	3%	19%	78%
Upper Salinas Basin	1,576,869/2,464	3,332	16.4	82,805	24%	1%	4%	94%
San Antonio River and Nacimiento River combined	(456,758)/(714)	(1,030)	(17.4)	(4,598)	(55%)	---	---	---
Total/Average	**3,671,547/5,737****	**7,773****	**17.4**	**571,489****	**15%****	**3%**	**12%**	**85%**

Sources: 1. CDFFP CalWater 2.2 Watershed delineation, 1999 (www.ca.nrcs.usda.gov/features/calwater/)
2. CDFG 1:1,000,000 Routed stream network, 2003 (www.calfish.org/)
3. USGS Hydrologic landscape regions of the U.S., 2003 (1 km grid cells)
4. CDFFP Census 2000 block data (migrated), 2003
5. CDFFP Multi-source land cover data (v02_2), 2002 (100 m grid cells) (http://frap.cdf.ca.gov/data/frapgisdata/select.asp)

* National Forest Lands and Military Reservations; does not include State and County Parks (http://old.casil.ucdavis.edu/casil/gis.ca.gov/teale/govtowna/)
** Total or average for Pajaro River watershed (including Uvas Creek sub-watershed), Lower Salinas Basin (including Gabilan Creek and Arroyo Seco sub-watersheds), and Upper Salinas Basin (including San Antonio River and Nacimiento River sub-watersheds)

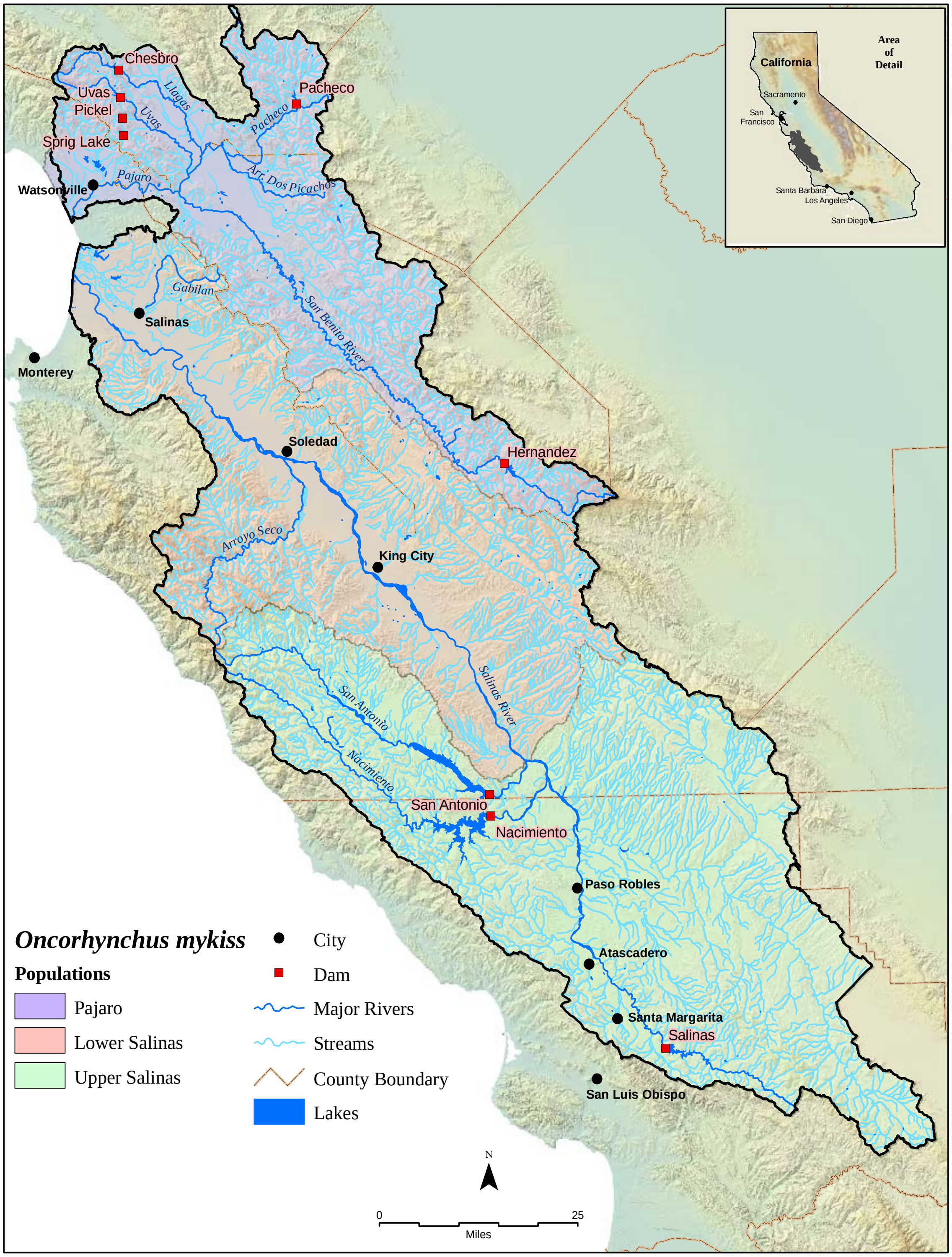

Figure 1. The Interior Coast Range Biogeographic Population Group region. Seven steelhead populations/watersheds were analyzed in this region: two in the Pajaro River watershed; three in the Lower Salinas Basin, and two in the Upper Salinas Basin.

Current Watershed Conditions. The relative ratings of current habitat and land use conditions used to assess the suitability of watersheds to support steelhead in the Interior Coast Range BPG are presented in Figure 2. Because of the amount of relevant information available at the time of this analysis, the number of indicators varied widely between watersheds, from five for the San Antonio River watershed to 35 indicators each for the Pajaro and Salinas river main stems.

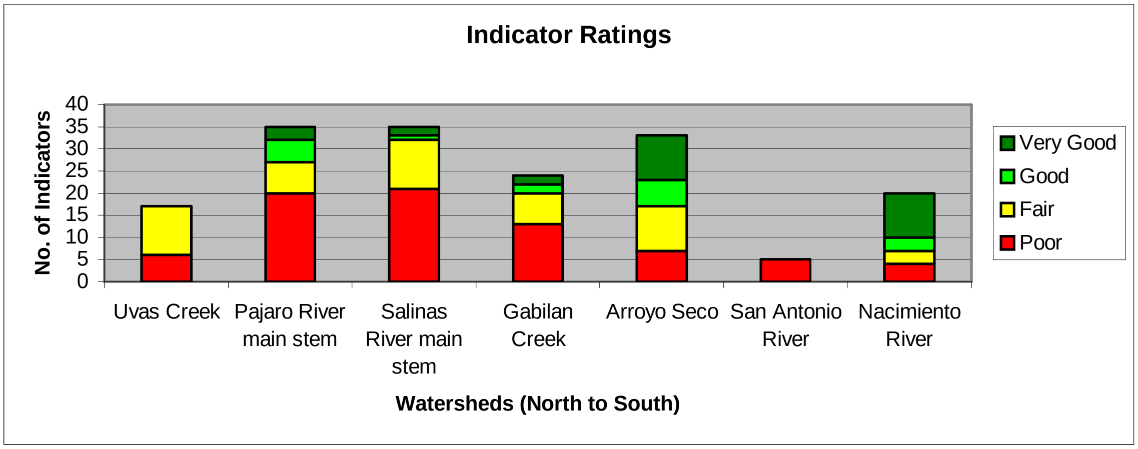

Fig. 2. Relative frequency of indicator ratings for watersheds in the Interior Coast Range BPG. Indicators are rated as "Very Good", "Good", ***etc.*****, based on the current condition of landscape, habitat, or population variables. Although the amount of available information (the number of indicators) varies between watersheds, the relative ranking of indicators provides a general picture of existing habitat and land use conditions across the BPG (see individual CAP Workbooks for details).**

The CAP Workbook analyses rated overall habitat conditions for steelhead as "Fair" in the Uvas Creek, Gabilan Creek, Arroyo Seco, and Nacimiento River watersheds, and "Poor" in the Pajaro River, Salinas River, and San Antonio River watersheds. Each of the watersheds included in this BPG are subject to one or more instream, riparian, or upland land use conditions that pose significant threats to steelhead. In general, habitat quality for steelhead declines in a downstream direction through each of these watersheds. The upper watersheds are in relatively good condition; the main stems are in fair to very poor condition. The major concern in this BPG is that the main stems of the two primary drainages in this region, the Pajaro and Salinas rivers, are severely impaired for steelhead by multiple, intensive anthropogenic activities related to agriculture, recreation, and residential development (see Threats discussion below). The main stems of these rivers provide the conduits that connect the ocean, estuary, and upper watershed habitats needed by steelhead to complete their life cycle. In other instances, major tributary watersheds, such as Arroyo Seco and the upper reaches of the San Antonio and Nacimiento rivers, provide generally good to excellent habitat for salmonids, but receive low ratings because they are highly constrained by passage barriers along their lower reaches (dams) or by passage barriers along the main stem of the Salinas River (seasonally dry stream reaches).

Threats and Sources of Threats. A variable number of threats were used in the CAP Workbooks to determine threat status for the Interior Coast Range BPG watersheds, ranging from seven in the Nacimiento River and San Antonio River watersheds to 16 in the Salinas River main stem (Fig. 3). The level of threat severity is generally very high in all watersheds in this BPG, but especially in Uvas Creek and along the main stems of the Pajaro River and Lower Salinas River (Fig. 3).

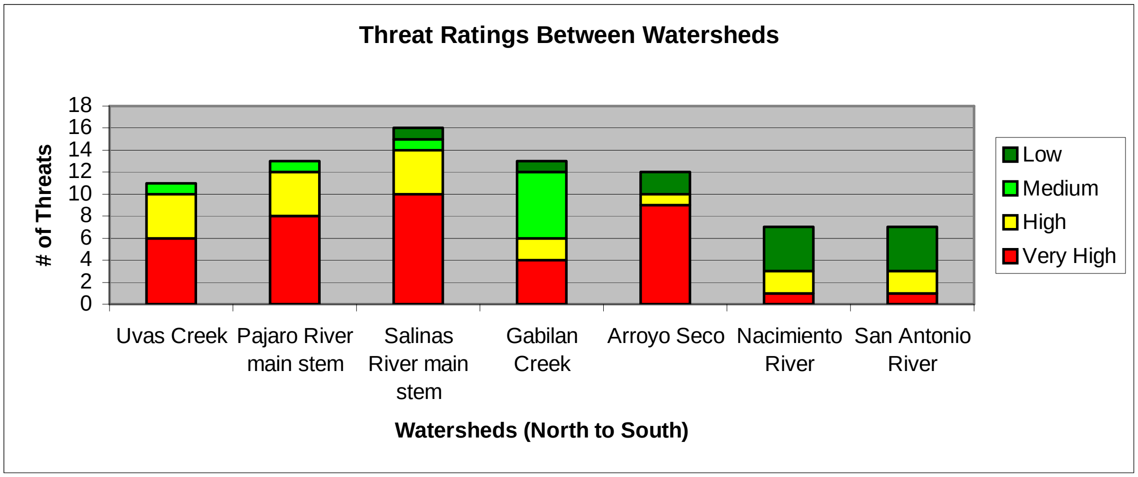

Fig. 3. Relative frequency of threat ratings in watersheds in the Interior Coast Range BPG, as identified by the CAP Workbook analyses. The sources, number, and severity of threats varies between watersheds, but watersheds in the Pajaro River and lower Salinas River watersheds are subject to more severe threats than those in the upper Salinas River watershed.

Ten anthropogenic activities ranked as the top five sources of stress to steelhead viability in this BPG (Table 2). These sources are not mutually exclusive and can be collapsed into the following general threat categories:

- barriers to upstream and downstream movement (roads, dams, groundwater extraction, sand and gravel mining);
- agricultural conversion of floodplain habitats, and;
- recreational facilities.

A pervasive threat to steelhead throughout the Interior Coast Range BPG watersheds is barriers to upstream and downstream passage either in the form of dams and surface water diversions or excessive groundwater extraction that creates and maintains dry stream reaches. As noted previously, there are at least 37 regulated dams on drainages in this watershed. Although there is only one dam on the main stem of the Salinas River, located more than 125 miles from its mouth, the intervening main stem is a major barrier to steelhead passage because extensive reaches routinely go dry in the summer and fall. Dams have isolated native rainbow trout populations in the upper San Antonio and Nacimiento River watersheds that otherwise would be anadromous. The reservoirs created by dams create suitable habitat conditions for several species of non-native fishes and bullfrogs that may affect one or more life-history stages of steelhead directly (predation) or indirectly (competition for food). Non-native crayfish, snails, fishes, bullfrogs, and even fishes native to California, but not native to the Interior Coast Range BPG, are problems in particular watersheds. Water management activities are closely related to agricultural conversion of watershed lands. This type of land conversion can increase sedimentation, embeddedness, and turbidity, degrade instream substrates, increase nutrient loading, change riparian canopy cover, and alter the natural hydrograph of the drainages.

Anthropogenic activities can produce manifold threats to steelhead. For example, dam construction and groundwater extraction for irrigation and municipal use is directly related to the magnitude of agricultural and urban conversion of floodplain habitats in the Pajaro River and Salinas River watersheds. A consequence of reservoir construction in this BPG is recreation, which generates its own series of impacts, ranging from the purposeful or unintentional introduction of non-native steelhead predators/competitors that have become a severe threat in the Arroyo Seco, San Antonio River, and Nacimiento River watersheds, to off-road vehicle damage to instream and riparian habitats that occurs in the lower portions of Arroyo Seco and the main stem of the Salinas River. Another consequence of agricultural and/or urban encroachment onto the floodplains of the Uvas Creek, Pajaro River main stem, Gabilan Creek, and Salinas River main stem is the need to construct levees or otherwise channelize to protect floodplain development. These structures, in turn, require maintenance by flood control agencies which disturbs riparian canopy cover, creates conditions suitable for invasive, non-native plants, and damages instream habitats.

Table 2. The top five sources of stress, ranked in order of frequency of occurrence and severity, in the component watersheds of the Interior Coast Range BPG. The Gabilan Creek and Arroyo Seco watersheds also are severely affected by other passage barriers, such as in-channel mining and culverts/road crossings (see CAP Workbooks for individual watersheds for further information).

Sources of Threats	**Component Watersheds (north to south)**						
	Uvas Creek	Pajaro River main stem	Salinas River main stem	Gabilan Creek	Arroyo Seco	San Antonio River	Naci-miento River
Dams and Surface Water Diversions							
Groundwater Extraction							
Agricultural Development							
Recreational Facilities							
Levees and Channelization							
Non-Native Species							
Urban Development							
Flood Control							
Agricultural Effluent							
Roads							

Other Passage Barriers							

Key: Threat cell colors represent threat severity, as determined by the CAP Workbook analyses:
Red = Very High threat   Yellow = High threat
Light green = Medium threat   Dark green = Low threat

Summary. Dams and water diversions (including groundwater extractions) on the major rivers of the Interior Coast Range BPG (Salinas and Pajaro Rivers) have had the most severe adverse impacts on the steelhead populations in this BPG, cutting off access to upstream spawning and rearing habitats and reducing both the magnitude and duration of flows, as well as altering the timing, necessary for immigration of adults and emigration of juveniles.

Agricultural activities (including agricultural effluents) have also significantly impacted steelhead habitats through encroachment into the riparian corridor and degradation of water quality. In addition to levees and channelization, and related flood control activities, particularly in the Pajaro River system, have degraded steelhead habitat, as have instream mining operations in the Salinas River.

Estuarine habitat loss is also a significant threat source to steelhead populations in the Interior Coast Range BPG because, despite its enormous geographic size, the major watersheds in this BPG share a single estuarine complex, which has been substantially altered by a variety of agricultural and urban developments. Today, the mouths of the Pajaro River and the Salinas River at the Pacific Ocean are less than a mile from each other and form separate estuaries, but historically, the lower reaches of these drainages meandered across a broad coastal plain to create a single estuarine complex that extended from Watsonville in the north to Marina in the south. Less than 50% of the Pajaro River estuary remains extant and the Salinas River estuary has been reduced in size by over 91%. Consequently, steelhead populations in widely separated tributaries of the Salinas River, such as Arroyo Seco and the San Antonio and Nacimiento Rivers, are subject to equally severe impacts from loss of these estuarine habitats.

Fire frequency in the Interior Coast Range BPG is relatively low compared to other BPGs further south such as the Big Sur Coast BPG. Wildland fires are not a currently a significant threat source to steelhead in the Pajaro River, Gabilan Creek, and lower Salinas River watersheds. However, wildfires may but pose a moderate to severe threats in the Arroyo Seco and upper Salinas River drainages, where 15% and 27% of the watershed has burned within the past 25 years, respectively. Here, increased road density allowing increased access to many parts of the watershed, and increased population density in fire-prone areas has increased fire frequency potential. Increased fire frequency can increase slope erosion and sediment input to streams, resulting in long-term changes to substrate texture and embeddedness, water quality (*e.g.*, turbidity), and water temperature (loss of riparian canopy cover).

Despite widespread and varied habitat degradation to the coastal and middle main stems of all these watersheds, native rainbow trout populations still inhabit the relatively high-quality habitat that survive upstream of the dams in this region, and small numbers of steelhead attempt to enter and spawn in each of the watersheds of the Interior Coast Range BPG when flow conditions are suitable.

Restoring conditions for steelhead passage, spawning, and/or rearing in these watersheds will require multiple, long-term, measures related to water management, recreation, and fish passage past large dams. Impediments to fish passage stemming from the construction and operation of dams and groundwater extractions (*e.g.*, the main stem of the Pajaro River and the Salinas River), modification of channel morphology and adjacent riparian habitats through flood control activities, instream activities such as sand and gravel mining, loss of estuarine functions as a result of filling, and point and non-point waste discharges from agricultural and other anthropogenic activities should be further evaluated and addressed.

The threat sources discussed in this section are the focus of a variety of recovery actions to address specific stresses on steelhead viability associated with these threats. Spatial and temporal data acquired on specific indicators associated with sources of threats or stresses, such as water temperature, pH, nutrients, *etc.*, are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigations in order to refine the primary recovery actions or to target additional recovery actions as part of any recovery strategy for the Interior Coast Range BPG (see the Recovery Action Matrices for more specific recovery actions).

ATTACHMENT. SUMMARY TABLES FOR STRESSES AND THREATS, STRESS MATRIX, AND OVERALL VIABILITY SUMMARY FOR THE INTERIOR COAST RANGE BPG

Threats Assessment for the Carmel River Basin Biogeographic Population Group

Location and Physical Characteristics. The Carmel River Basin Biogeographic Population Group (BPG) region is one of the smallest of the four BPG regions; the main axis of the watershed is just 28 miles long. In contrast, the main axis of the neighboring Interior Coast Range BPG region is over 180 miles long. The Carmel River Basin BPG region drains the eastern slopes of the northern portions of the Santa Lucia Range and the western slopes of the Sierra de Salinas in northwestern Monterey County. It empties into the Pacific Ocean at Carmel Bay, just south of the Monterey Peninsula. This BPG region shares some physical characteristics with the Interior Coast Range BPG region, such as general northwest-southeast watershed orientation, landform evolution largely controlled by tectonic activity associated with the San Andreas Fault, and a highly dissected watershed. There are seven major perennial tributaries to the Carmel River (Fig. 1).

Average annual precipitation in this region is relatively low (Table 1) and shows high spatial variability. In general, the coastal regions and higher elevations receive higher amounts of precipitation. The Carmel River watershed is relatively steep and most of the tributaries are naturally perennial.

Land Use. Table 1 summarizes land use and population density in this region. Human population density is moderately high and concentrated in the lower and middle portions of the Carmel Valley, and includes the towns of Carmel and Carmel Valley. Population density averages 70 persons per square mile of watershed. Although less than 4% of the watershed is classified as urban, well over 50% of the watershed is privately-owned and the Carmel Valley, through which the main stem flows, is surrounded by extensive areas of ranches and rural land use. Less than 1% of the watershed is under cultivation. There are three dams in the Carmel River watershed: the Black Rock Creek on the Black Rock Creek tributary was constructed in 1925 and is used for recreational purposes, the San Clemente Dam, located at stream mile 18.5 at the confluence of San Clemente Creek and the main stem, was constructed in 1921, and the Los Padres Dam, located at stream mile 24.8, was constructed in 1949. The San Clemente and Los Padres dams are used for municipal and agricultural water supply. These dams are privately-owned and are regulated by the California Department of Water Resources. Los Padres National Forest lands cover about 31% of the watershed. Additionally, a portion of the lower watershed is owned and managed by the Monterey Peninsula Regional Park District.

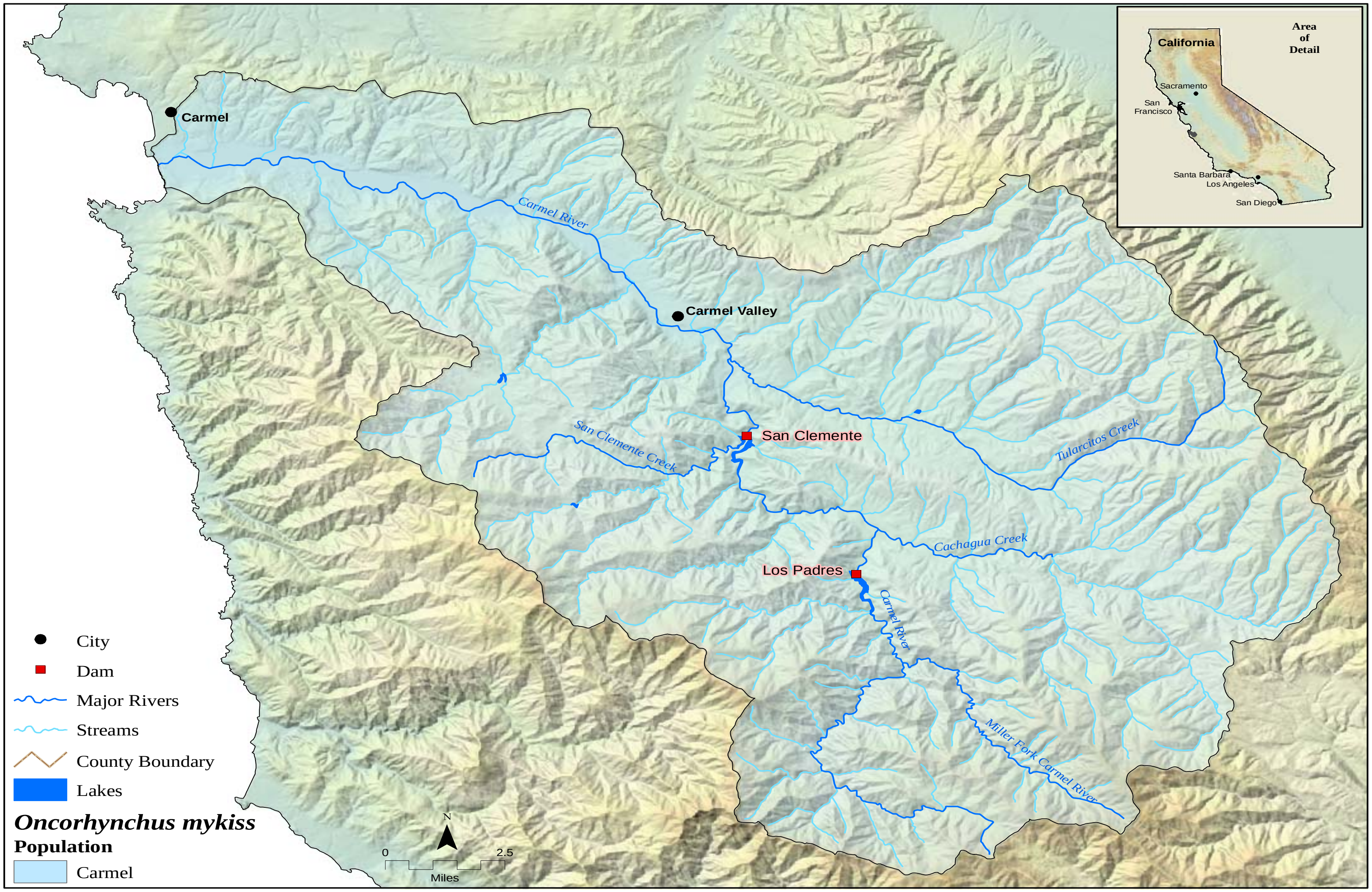

Figure 1. The Carmel Basin Biogeographic Population Group region. This BPG consists of a single watershed, the Carmel River.

Table 1. Physical and Land Use Characteristics of Watersheds in the Carmel River Basin BPG.

Physical Characteristics				Land Use				
Watershed	**Area (acres/miles^2)[1]**	**Stream Length[2] (miles)**	**Average Annual Rainfall[3] (in.)**	**Human Population[4]**	**Public Ownership***	**Urban Area[5]**	Agriculture/ **Barren[5]**	**Open Space[5]**
Carmel River	162,286/254	248	19.8	17,692	31%	4%	0.6%	95%

Sources: 1. CDFFP CalWater 2.2 Watershed delineation, 1999
6. CDFG 1:1,000,000 Routed stream network, 2003
7. USGS Hydrologic landscape regions of the U.S., 2003 (1 km grid cells)
8. CDFFP Census 2000 block data (migrated), 2003
9. CDFFP Multi-source land cover data (v02_2), 2002 (100 m grid cells)
* National Forest Lands and Military Reservations; does not include State and County Parks.

Current Watershed Conditions. The current condition of habitat and land use indicators used to assess the health of the Carmel River watershed for steelhead is depicted in Figure 2. Information was available to rate 30 indicators.

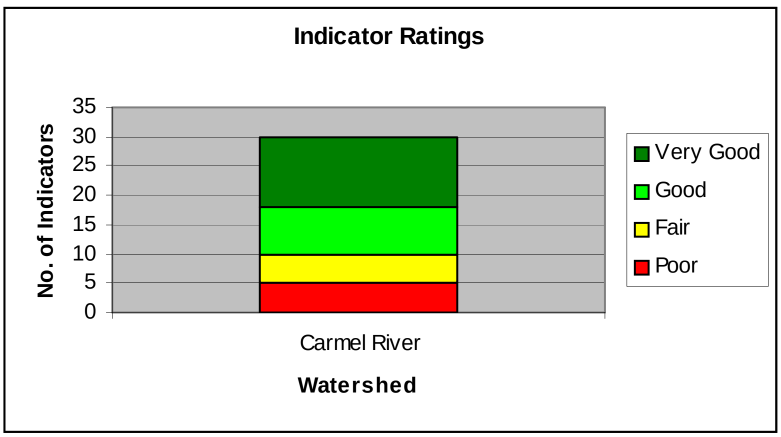

Fig. 2. Relative frequency of indicator ratings for the Carmel River Basin BPG. Indicators are rated as "Very Good", "Good", *etc.*, based on the current condition of landscape, habitat, or population variables. The relative ranking of indicators provides a general picture of existing habitat and land use conditions across the watershed (see Carmel River CAP Workbook for details).

The CAP Workbook analyses rated overall habitat conditions for steelhead in the Carmel River watershed as "Fair. Approximately 33% of the indicators were impaired (fair condition) or severely impaired (poor condition) and these indicators repeatedly focused on lack of surface flows in the main stem caused by water management activities (dams and surface water diversions) and excessive pumping of groundwater. The main stem contains suitable spawning habitat and functions as the conduit connecting the ocean and estuary to even more extensive spawning habitat in the upper watershed. The San Clemente and the Los Padres dams impede steelhead access to spawning and rearing habitat in at least 50% of the watershed. Native rainbow trout populations persist in the main stem and most of the tributaries above these structures.

Another feature of the Carmel River watershed that received low ratings was the estuary. While the existing estuary has undergone substantial restoration and still contains valuable rearing habitat for steelhead, at least 33% of the original estuary has been eliminated due to encroachment from residential development, transportation corridors (Highway 1), and recreational development (Carmel Beach State Park).

Threats and Sources of Threats. Although information was gathered on 30 habitat and land use indicators (Fig. 2), the underlying threat sources that determined the poor to very poor condition of approximately one-third of those indicators repeatedly pointed to a limited number of anthropogenic causes (Fig. 3):

- passage barriers caused by excessive surface and groundwater diversions;
- passage barriers caused by dams;
- loss or degradation of spawning substrates below San Clemente Dam due to water management practices;
- urban development and associated levee construction that has significantly reduced estuarine habitats and constricted the lower floodplain of the river, and;
- artificial breaching of the estuary sandbar to alleviate flooding of adjacent residential development.

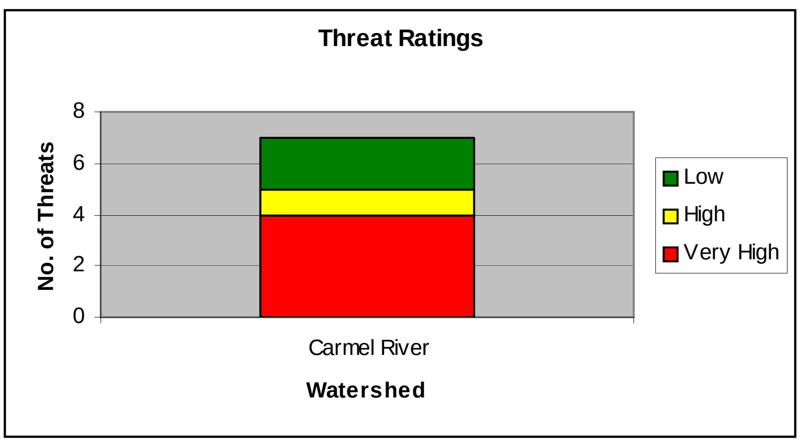

Fig. 3. Relative frequency of threats to steelhead habitat in the Carmel River Basin BPG.

A pervasive threat to steelhead throughout the Carmel River are impediments to upstream and downstream fish passage either in the form of dams and surface water diversions or excessive groundwater extraction that creates and maintains dry stream reaches (Table 2). Several miles of the main stem of the river below San Clemente Dam, which would otherwise have perennial surface flows, frequently dry up or are reduced to isolated pools by late spring and early summer due to the combination of reduced runoff and surface and subsurface water withdrawals. Spawning habitat in the main stem below San Clemente Dam has been damaged by water releases from the dam, contributing to increasing sedimentation, bank erosion, and increased substrate embeddedness and turbidity. A sandbar forms during the summer and fall each year at the river mouth; however, the pattern of sandbar formation and breaching has been artificially modified by both surface and groundwater extractions that delay natural breaching, or artificial breaching for flood control, which causes premature draining of the estuary.

Table 2. The top sources of threats in the Carmel River Basin BPG (See CAP Workbook for details).

Threat Sources	Rating
Dams and Surface Water Diversions	Red
Groundwater Extraction	Red
Urban development	Red
Levees and Channelization	Red
Other Passage Barriers	Yellow
Recreational Facilities (*)	Yellow

(*) Artificial breaching of the sandbar at the mouth of the lagoon and associated recreational activities rank as the sixth most serious threat source to steelhead in this watershed and is included here because implementing specific recovery action recommendations can substantially reduce the magnitude of this threat.

Key: Threat cell colors correspond to the threat rating from CAP Workbook:
Red = Very High threat
Yellow = High threat

Summary. Dams and diversions (including groundwater extractions) on the Carmel River have had the most severe adverse impacts on the steelhead populations of the Carmel Basin BPG, reducing access to upstream spawning and rearing habitats and reducing both the magnitude and duration of flows, as well as altering the timing, necessary for immigration of adults and emigration of juveniles.

Urban and agricultural developments within the watershed are also a significant threat to the viability of steelhead habitats. For example, residential development around the estuary, and along some reaches of the lower main stem, has encroached on and degraded estuarine and riparian habitats. Generally, road density, population density, and fire frequency are relatively low, though these may be expected to increase in the future.

Because the main stem of the Carmel River is the conduit that connects upstream steelhead spawning and rearing habitat with the ocean, recovery actions in this watershed should focus on reducing the severity of anthropogenic impacts stemming from the construction and operation of dams *(e.g.*, San Clemente and Los Padres Dams) and groundwater extractions along the main stem in order to promote connectivity between the ocean and estuarine habitats, as well as main stem spawning and rearing habitat. Additionally, degraded estuarine conditions stemming from filling, artificial sandbar manipulation, and both point and non-point waste discharges, should be further evaluated and addressed.

The threat sources discussed in this section are the focus of a variety of recovery actions to address specific stresses on steelhead viability associated with these threats. Spatial and temporal data acquired on specific indicators associated with sources of threats or stresses, such as water temperature, pH, nutrients, *etc.*, are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigations in order to refine the primary recovery actions or to target additional recovery actions as part of any recovery strategy for the Carmel River BPG (see Recovery Action Matrices for more specific recovery actions).

ATTACHMENT. SUMMARY TABLES FOR STRESSES AND THREATS, STRESS MATRIX, AND OVERALL VIABILITY SUMMARY FOR THE CARMEL RIVER BASIN BPG

Threats Assessment for the
Big Sur Coast Biogeographic Population Group

Location and Physical Characteristics. The Big Sur Coast BPG consists of seven small watersheds that drain the steep coastal slopes of the northern Santa Lucia Range. This region extends approximately 60 miles along a sparsely populated section of coastal Monterey County from the Monterey Peninsula southward almost to the San Luis Obispo County line. From north to south, these watersheds are: San Jose Creek, Garrapata Creek, Bixby Creek, Little Sur River, Big Sur River, Willow Creek, and Salmon Creek (Fig. 1). The Big Sur Coast BPG resembles the Conception Coast BPG in Santa Barbara County and the Santa Monica Mountains BPG in Ventura and Los Angeles counties in that its component watersheds are, with one or two exceptions, small, steep, and have small total stream lengths. Although average annual precipitation shows little spatial variation across the component watersheds (Table 1), total seasonal rainfall in this region is highly variable from year to year, depending on the intensity and duration of Pacific storms. In general, the higher elevations receive greater amounts of precipitation, and persistent spring and summer fog is characteristic of this region. All of the watercourses in this BPG are perennial.

Land Use. The Big Sur Coast BPG region supports, by far, the lowest total human population of any of the nine regions and is highly buffered from urban areas by extensive undeveloped open space and rural lands. Average human population density averages about 4 persons per square mile of watershed land (Table 1). The closest population centers are the small towns of Carmel near the north end and Cambria near the south end of the region. There are no major cities or towns within this BPG. There is a strong gradient of increasing public ownership of watershed lands, from less than 1% in the San Jose Creek watershed in the north to over 98% in the Salmon Creek watershed in the south. Most of the federal lands are in the Los Padres National Forest. Small acreages of National Recreation Area lands occur along the immediate coast. The Los Padres National Forest encompasses several federally designated wilderness areas, such as Ventana and Silver Peak Wilderness Areas. Additionally, the Big Sur River, including the North and South Forks, is a federally designated Wild River. There are several State and County parks along the coast in this region, but some of the larger state parks, such as Andrew Molera and Pfeiffer-Big Sur in the Big Sur River watershed, extend well into some of the component watersheds. Urban and agricultural conversion of land in these watersheds lands is correspondingly low, with the overwhelming majority of watershed lands being open space (Table 1). There are no major dams on watersheds in this region, though there are seasonal dams on some of the drainages that can affect steelhead, particularly the instream movement of juveniles.

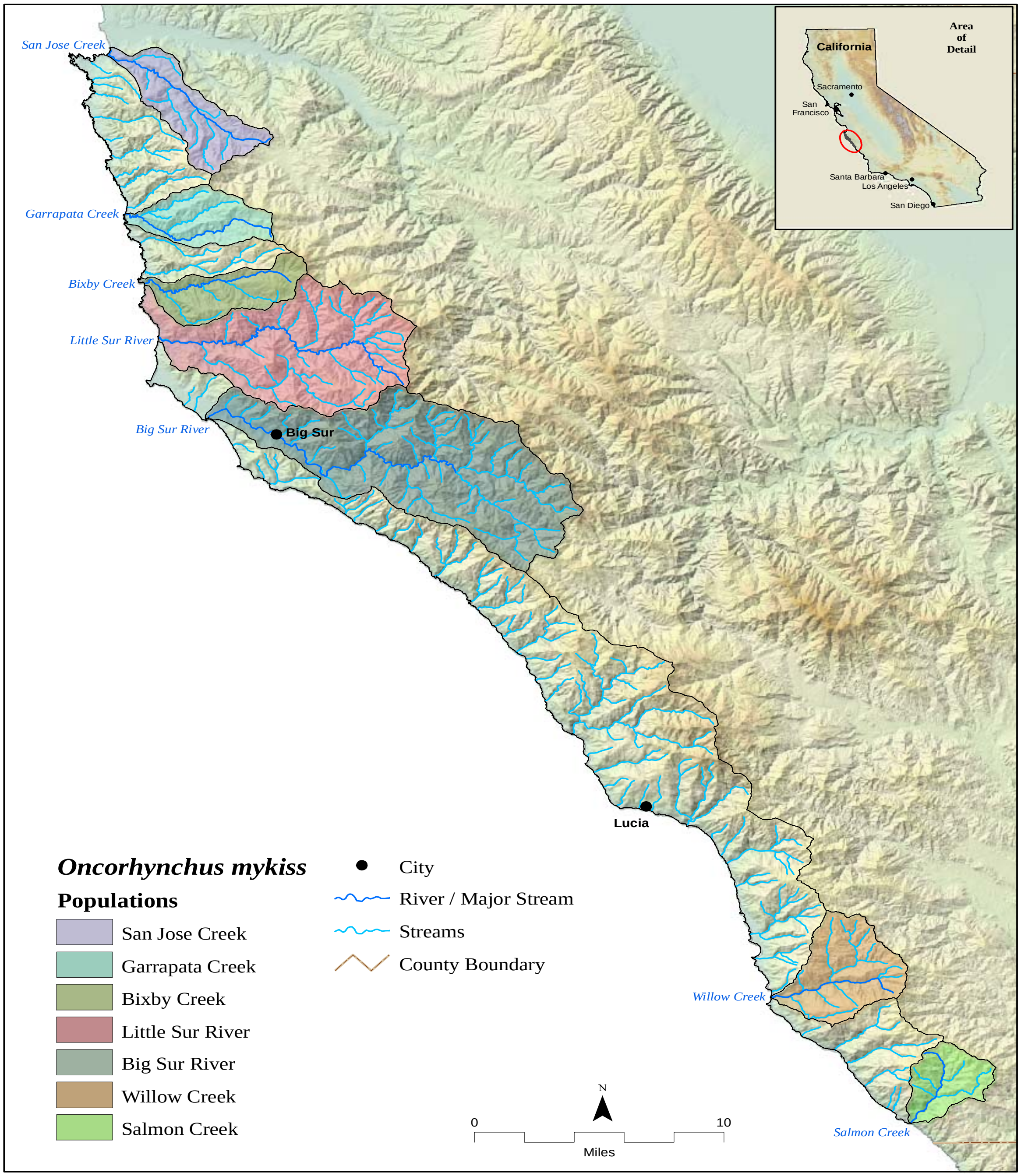

Figure 1. The Big Sur Coast Biogeographic Population Group region. Seven steelhead populations/watersheds were analyzed in this region.

Table 1. Physical and Land Use Characteristics of Watersheds in the Big Sur Coast BPG.

Physical Characteristics				Land Use				
Watershed	**Area (acres/miles²)[1]**	**Stream Length[2] (miles)**	**Average Annual Rainfall[3] (in.)**	**Human Population[4]**	**Public Ownership***	**Urban Area[5]**	**Agriculture/ Barren[5]**	**Open Space[5]**
San Jose Creek	8,826/14	23	20.3	213	0.1%	0.2%	0.1%	> 99%
Garrapata Creek	6,925/11	16	20.5	63	12%**	0%	0%	100%
Bixby Creek	7,218/11	15	20.8	44	27%	0%	0%	100%
Little Sur River	26,541/41	64	20.8	70	63%	0.2%	< 0.1%	> 99%
Big Sur River	37,374/58	92	20.8	142	86%	0.7%	< 0.1%	> 99%
Willow Creek	10,412/16	26	18.5	35	95%	0%	0%	100%
Salmon Creek	5,406/8	12	19.5	6	98%	0%	0%	100%
Total/Average	**102,702/159**	**248**	**20.2**	**573**	**54%**	**< 0.2%**	**< 0.1%**	**> 99%**

Sources: 1. CDFFP CalWater 2.2 Watershed delineation, 1999
10. CDFG 1:1,000,000 Routed stream network, 2003
11. USGS Hydrologic landscape regions of the U.S., 2003 (1-km grid cells)
12. CDFFP Census 2000 block data (migrated), 2003
13. CDFFP Multi-source land cover data (v02_2), 2002 (100 m grid cells)
* National Forest Lands and State Recreation Areas; does not include State and County Parks.
** 68% of the watershed is owned by the State, Land Trust, or has conservation easement restrictions on land use.

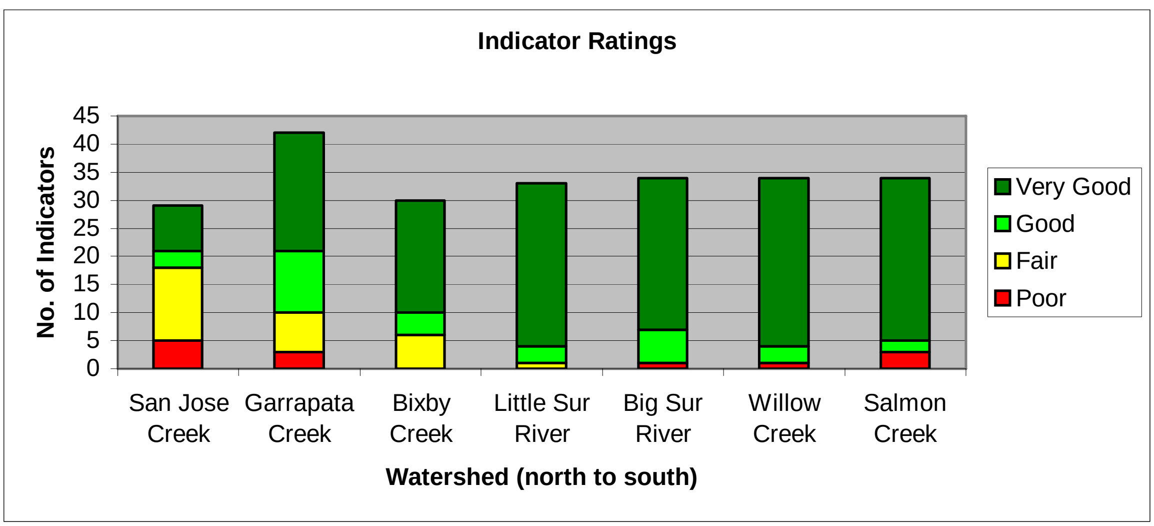

Fig. 2. Relative frequency of indicator ratings for watersheds in the Big Sur Coast BPG. Indicators are rated according to the current condition of landscape, habitat, or population variables. The relative ranking of indicators within and across watersheds provides a general picture of existing habitat and land use conditions within the BPG region (see CAP Workbooks for individual watersheds for details).

Current Watershed Conditions. The relative ratings of current habitat and land use conditions used to assess the viability of watersheds to support steelhead in the Big Sur Coast BPG are presented in Figure 2. The number of indicators varied from 30 for the San Jose Creek watershed to 42 indicators for the Garrapata Creek watershed.

Instream, riparian, and upland habitat conditions in the watersheds in this region are, collectively, rated the highest of any of the BPG regions by the CAP Workbook analyses. The CAP Workbooks rated overall habitat conditions for steelhead in the San Jose Creek watershed as "Fair", "Good" in the Garrapata Creek, Big Sur River, and Salmon Creek watersheds, and "Very Good" in the Bixby Creek, Little Sur River, and Willow Creek watersheds. Land use activities that affect these conditions are most pronounced in watersheds that are mostly under private ownership: the San Jose Creek, Garrapata Creek, and Bixby Creek watersheds are degraded by groundwater and surface water diversions, elevated sedimentation from old logging roads, and road crossings, respectively. Big Sur River and Salmon Creek have natural barriers that block steelhead passage to the middle and upper portions of the watershed. Increased fire frequency in the Big Sur Creek and Salmon Creek watersheds was rated as a severe threat to steelhead because of potential sedimentation and other impacts to instream and riparian habitats. In general, however, the six watersheds south of the San Jose Creek watershed provide excellent spawning and rearing habitat for steelhead.

Threats and Sources of Threats. The number of threats affecting various watersheds in this region is very low compared to other BPG regions, ranging from three in the Bixby Creek watershed to eleven in the San Jose Creek watershed (Fig. 3). The low number of threats reflects low human population density and land use impacts in this region. Aside from the San Jose Creek watershed, the most pervasive threats to watersheds here come from roads as a source of sedimentation and natural barriers to steelhead passage in the form of landslides, waterfalls, and log jams, and fire. On-going restoration and revegetation of eroded slopes and disused logging roads and removal of log jams in the Garrapata Creek watershed will, in time, reduce or eliminate these threat sources and significantly improve habitat conditions for steelhead. Land use activities in the mostly privately-owned San Jose Creek watershed pose a number of problems for steelhead. Surface water diversions and groundwater extraction in the main stem of San Jose Creek produce severe to very severe impairments of instream habitat quality and quantity related to passage barriers (dry stream reaches), degraded water quality caused by sediment inputs and other non-point pollution arising from high road density, and depleted food resources for steelhead.

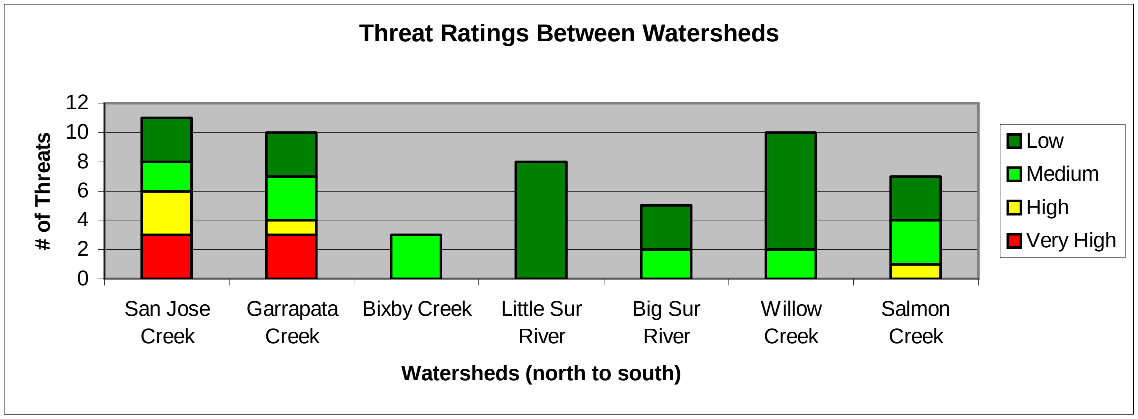

Fig. 3. Relative frequency of threat ratings in watersheds of the Big Sur Coast BPG, as determined by the CAP Workbook analyses. The sources, number, and severity of threats varies between watersheds, but in general, steelhead populations in most of the watersheds in this BPG region are subject to only a few, relatively minor threats.

The only significant threat to steelhead persistence in the Salmon Creek watershed is the large waterfall that forms the natural limit of anadromy only two miles above the mouth of the creek. The main stem of Salmon Creek between the ocean and the Highway 1 culvert provides excellent spawning and rearing habitat for steelhead (though the culvert is an impediment to upstream fish passage under low-flow conditions).

Ten anthropogenic activities ranked as the top five sources of stress to steelhead viability in the Big Sur Coast BPG, however, CAP Workbook Analysis of the Bixby Creek watershed produced only three threats (Table 2). The severity of these threats compared to similar threat levels in other BPGs in the South-Central Coast Steelhead Recovery Planning Area is generally low. These ten threat sources can be grouped into the following categories:

- passage barriers caused by culverts and road crossings and natural barriers, such as waterfalls, landslides, and log jams;
- passage barriers caused by excessive groundwater extraction and surface water diversions (San Jose Creek watershed only), and;
- sedimentation and non-point pollution caused by moderate road density, including active and abandoned logging roads.

Table 2. The top five sources of threats in the component watersheds of the Big Sur Coast BPG (see CAP Workbooks for individual watersheds for details). Only three medium-severity threat sources were identified for the relatively undeveloped Bixby Creek watershed.

Threat Sources	**Component Watershed (north to south)**						
	San Jose Creek	Garrapata Creek	Bixby Creek	Little Sur River*	Big Sur River	Willow Creek	Salmon Creek
Other Passage Barriers	Yellow	Red	Light green	Dark green	Dark green	Dark green	Light green
Roads		Red	Light green	Dark green	Dark green	Light green	Light green
Non-Point Pollution	Red	Red	Light green	Dark green		Dark green	Dark green
Natural Barriers		Yellow		Dark green	Light green		Yellow
Groundwater Extraction	Red			Dark green		Dark green	
Recreational Facilities					Light green	Light green	
Wildfires					Dark green		Light green
Dams and Surface Water Diversions	Red						
Logging	Yellow						
Non-Native Species		Light green					

Key: Threat cell colors represent threat rating from CAP Workbook:
Red = Very High threat
Yellow = High threat
Light green = Medium threat
Dark green = Low threat

*Wildfires were not identified during the CAP Workbook analyses as one of the top five threats in these watersheds, but recent fires in coastal watersheds in 2008 could result in significant impacts to steelhead habitats.

Summary. The Big Sur Coast BPG contains the some of the least altered steelhead watersheds within any of the four BPGs in the South-Central California Coast Steelhead Recovery Planning Area. In particular, the Bixby Creek, Little Sur River, Big Sur River, Willow Creek, and Salmon Creek watersheds are some of the best preserved watersheds. With the exception of the San Jose Creek and Garrapata Creek watersheds, the majority of threats in the watersheds in this BPG were rated as low. Only three medium-severity threat sources were identified for the relatively undeveloped Bixby Creek watersheds. However, these conditions could change in the future because some of these watersheds are largely under private ownership, are all traversed by Highway 1, and all support low to moderate intensity livestock ranching operations.

Increased residential and recreational development within these watersheds, including higher road densities, could significantly alter natural fire regimes in the Big Sur Coast BPG by allowing human access to greater portions of the component watersheds. Increased fire frequency can increase slope erosion and sediment input to streams, resulting in long-term changes to substrate texture and embeddedness, water quality (*e.g.*, turbidity), and water temperature (loss of riparian canopy cover).

Improving one or a few of the moderate threats that are adversely affecting steelhead habitat in the Bixby Creek, Little Sur River, Big Sur River, Willow Creek, and Salmon Creek watersheds, such as road crossings and erosion control, could reduce further or eliminate threats to the viability of steelhead habitats in these watersheds. Recovery actions to address the severe to very severe sedimentation impacts from existing and abandoned roads and fish passage impediments in the San Jose Creek and Garrapata Creek watersheds will require multiple, long-term, measures related to water management and upper watershed land use practices, including agricultural and residential development and related road development. Additionally, the restoration of the San Jose estuary, which has been largely eliminated as a result of the construction of Highway 1, will require removal of fill and replacement of the existing culvert with a free-spanning road crossing and should be further evaluated and addressed.

The threat sources discussed in this section should be the focus of a variety of recovery actions to address specific stresses on steelhead viability associated with these threats. Spatial and temporal data acquired on specific indicators associated with sources of threats or stresses, such as water temperature, pH, nutrients, *etc.*, are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigations in order to refine the primary recovery actions or to target additional recovery actions as part of any recovery strategy for the Big Sur Coast BPG (see Recovery Action Matrices for more specific recovery actions).

ATTACHMENT. SUMMARY TABLES FOR STRESSES AND THREATS, STRESS MATRIX, AND OVERALL VIABILITY SUMMARY FOR THE BIG SUR COAST BPG

Threats Assessment for the
San Luis Obispo Terrace Biogeographic Population Group

Location and Physical Characteristics. The San Luis Obispo Terrace BPG region extends about 75 miles to include the extreme SW corner of Monterey County and almost the entire length of coastal San Luis Obispo County. It consists of eleven small to moderate-size watersheds that drain the steep coastal slopes of the southern half of the Santa Lucia Range. The San Luis Obispo Terrace BPG is almost conterminous with the Big Sur Coast BPG and the upper watersheds resemble the latter physiographically but, because the spine of the Santa Lucia Range veers inland in this region, the lower portions of the watersheds in the San Luis Obispo Terrace BPG are relatively flat and cut across coastal terraces before entering the Pacific Ocean. From north to south, 12 watersheds are included in this BPG: San Carpoforo Creek, Arroyo de la Cruz, Little Pico Creek, Big Pico Creek, San Simeon Creek, Santa Rosa Creek, Morro Creek, Chorro Creek (Morro Bay), Los Osos Creek (Morro Bay), San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek. (Fig. 1). The Morro Bay steelhead population region (Fig. 1) includes the separate watersheds of Morro Creek, which empties into the Pacific Ocean north of Morro Bay, and Chorro and Los Osos creeks, which, along with several smaller drainages, empty into Morro Bay, forming an extensive estuarine wetland (Fig. 1). Separate CAP Workbooks were prepared for Morro, Chorro, and Los Osos creeks.

Watersheds in the San Luis Obispo BPG vary in size by over an order of magnitude, from less than 5,300 acres in the Little Pico Creek watershed to almost 100,000 acres in the Arroyo Grande Creek watershed. Average annual precipitation shows some spatial variation across the component watersheds and total seasonal rainfall in this region is highly variable from year to year, depending on the intensity and duration of Pacific storms. In general, the higher elevations receive greater amounts of precipitation, and persistent spring and summer coastal fog is characteristic of this region. All of the watercourses in this BPG are perennial (though some reaches may be seasonally reduced to isolated pools, particularly during low rainfall years).

Table 1. Physical and Land Use Characteristics of Watersheds in the San Luis Obispo Terrace BPG.

Physical Characteristics				Land Use				
Watershed (North to South)	**Area (acres/miles^2)[1]**	**Stream Length[2] (miles)**	**Average Annual Rainfall[3] (in.)**	**Human Population[4]**	**Public Ownership****	**Urban Area[5]**	**Agriculture/ Barren[5]**	**Open Space[5]**
San Carpoforo Creek	29,316/46	64	19.7	38	30%	0.1%	0.1%	> 99%
Arroyo de la Cruz	27,774/43	65	19.4	5	0.1%	0.2%	0.2%	> 99%
Little Pico Creek	5,229/8	13	18.1	0	0%	0%	0.2%	> 99%
Big Pico Creek	9,687/15	29	18.1	367	0.3%	1%	< 0.1%	99%
San Simeon Creek	22,247/35	57	17.8	681	0.1%	1%	1%	98%
Santa Rosa Creek	31,484/49	81	17.2	4,403	1%	5%	3%	92%
Morro Bay (*)	65,993/103	127	18.8	33,389	17%	10%	6%	84%
San Luis	55,554/87	98	18.9	52,731	2%	16%	6%	78%

Obispo Creek								
Pismo Creek	25,355/40	49	18.4	6,385	0.1%	6%	9%	85%
Arroyo Grande Creek	97,873/153	175	18.0	45,378	20%	7%	9%	84%
Total/Average	**370,512/579**	**758**	**18.4**	**143,377**	**7%**	**5%**	**3%**	**92%**

Sources: 1. CDFFP CalWater 2.2 Watershed delineation, 1999
14. CDFG 1:1,000,000 Routed stream network, 2003
15. USGS Hydrologic landscape regions of the U.S., 2003 (1 km grid cells)
16. CDFFP Census 2000 block data (migrated), 2003
17. CDFFP Multi-source land cover data (v02_2), 2002 (100 m grid cells)
* "Morro Bay" include statistics for the Morro Creek, Chorro Creek, and the Los Osos Creek watersheds, combined (see Fig. 1).
** National Forest and BLM lands, Wilderness Areas, Military Reservations, State and County Parks.

Land Use. Despite a relatively low total human population density, the San Luis Obispo Terrace BPG has over 2.5 times the population density of any BPG in the South-Central Steelhead DPS, averaging about 248 persons per square mile of watershed. Population density increases dramatically south of the San Simeon Creek watershed such that over 99% of the total population in the San Luis Obispo Terrace BPG is concentrated in the seven southern watersheds: Santa Rosa Creek, Morro Creek, Chorro Creek (Morro Bay), Los Osos Creek (Morro Bay), San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek. The San Carpoforo Creek, Arroyo de la Cruz, Little Pico Creek, Big Pico Creek, and San Simeon Creek watersheds are practically undeveloped (though there are ranching and agricultural activities in the Big Pico Creek watershed), or have very low population densities and, in this respect, they most resemble the central and southern Big Sur Coast BPG watersheds. The Los Padres National Forest encompasses a federally designated wilderness area: the Santa Lucia Wilderness Area within the San Luis Obispo Creek and Arroyo Grande Creek watersheds (Table 1).

The strong increasing gradient in population density towards the southern portions of this BPG is reflected in land use changes, such as increasing agricultural conversion of watershed lands and urbanized areas, including small cities, such as Morro Bay, San Luis Obispo, Grover Beach, Pismo Beach, Shell Beach, and Arroyo Grande, increasing private ownership of land, and correspondingly lower amounts of open space (Table 1). The coastal terraces of the southern watersheds receive high recreational and urban use. There are four major reservoirs in this region: a privately-owned dam on a tributary of San Luis Obispo Creek, Lopez Dam on the main stem and Terminal Dam on a tributary of Arroyo Grande Creek, and Chorro Dam on Chorro Creek. The reservoirs created by these structures are used as municipal water supplies, agricultural irrigation, and recreation.

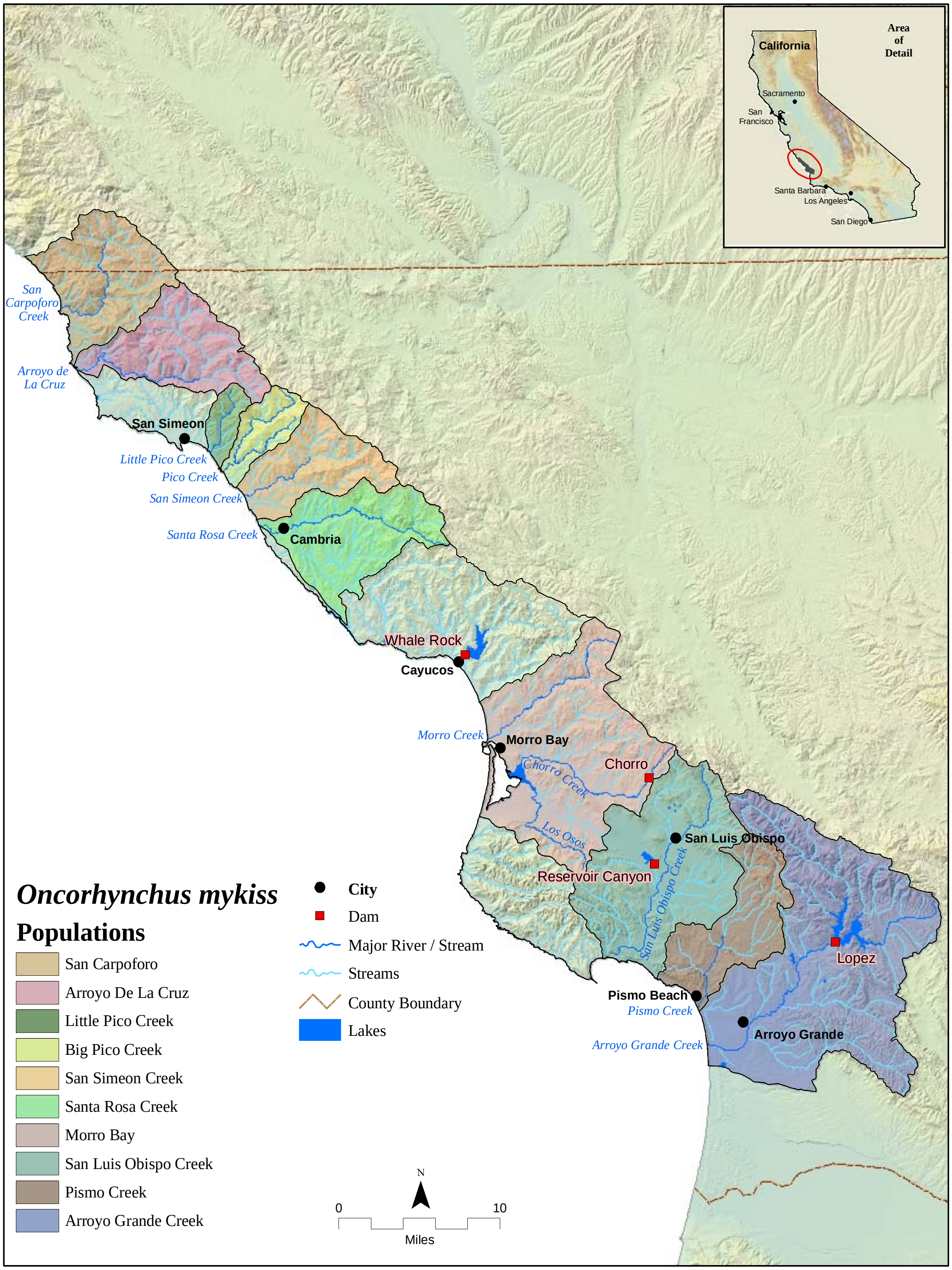

Figure 1. The San Luis Obispo Terrace Biogeographic Population Group region. Twelve steelhead populations/watersheds were analyzed in this region, including three in the Morro Bay watershed.

Current Watershed Conditions. The relative ratings of current habitat and land use conditions used to assess the suitability of watersheds to support steelhead in the San Luis Obispo Terrace BPG are presented in Figure 2. The number of indicators varied widely between watersheds from 16 for the Pismo Creek watershed to 45 indicators for the Arroyo de la Cruz watershed.

There is a dramatic shift in the steelhead habitat quality in watersheds south of the Pico Creek watershed, reflecting increasing land use changes associated with higher human population densities. Although mostly or entirely privately owned, the northernmost watersheds in this BPG, the San Carpoforo, Arroyo de la Cruz, Little Pico, and Pico creeks, are relatively pristine and resemble the southernmost of the Big Sur Coast watersheds (Little Sur, Big Sur, Willow, and Salmon creeks) in this respect. The CAP Workbook analyses rated overall habitat conditions for steelhead as "Very Good" or "Good" in the four northernmost watersheds, and "Fair" in the seven watersheds in the central and southern portions of this BPG.

Threats and Sources of Threats. Various numbers of threats were used in the CAP Workbooks to determine threat status in individual watersheds in this region, ranging from 7 in the Pico Creek watershed to 16 in the San Carpoforo Creek, San Luis Obispo Creek, and Arroyo Grande Creek watersheds (Fig. 3). However, all or most of the "threats" identified in the four northern watersheds (San Carpoforo, Arroyo de la Cruz, Little Pico, and Pico) are rated as low severity. In fact, near-natural conditions identified here reflect the prevailing very low-intensity land use in these watersheds. Pico Creek has a single threat rated as "high": extensive reaches of the main stem and North Fork frequently go dry in summer and pose fish passage impediments to juveniles and smolt. This condition is natural, but can be exacerbated by groundwater extraction and surface water diversions.

Although the San Simeon Creek watershed has a relatively low human population density (about 19 persons/square mile) and less than 1.4% of the watershed has been converted to row crop agriculture, most of the agricultural conversion has occurred within the narrow floodplain of San Simeon Creek, thereby exacerbating land use impacts. The stream and riparian corridor are subject to a number of severe to very severe threats related to land use: groundwater extraction, severe stream incision caused by confinement of the active channel due to floodplain encroachment from agriculture, ranch houses, and the main road through the watershed. Wastewater treatment facilities near the San Simeon Creek estuary and a proposed desalination plant have the potential to adversely affect the lower stream reaches and estuary through direct or indirect effluent discharges. Development of recreational facilities (San Simeon State Park) at the mouth of the creek and the placement of the Highway 1 bridge abutments has eliminated 50% of the estuary.

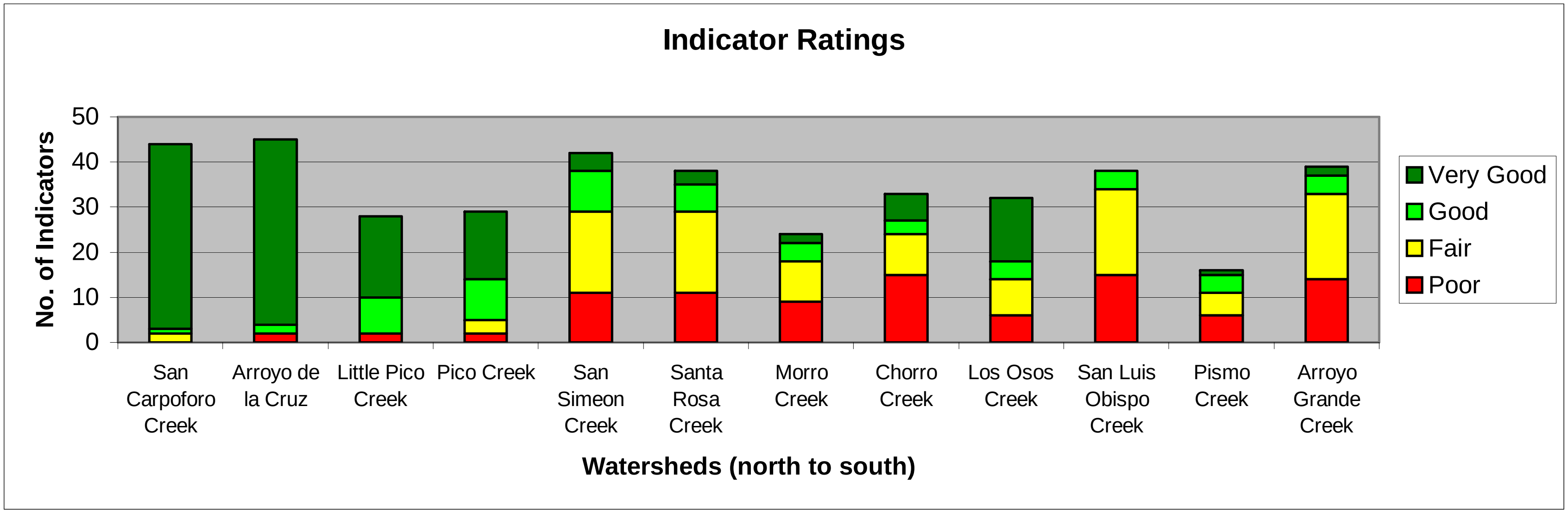

Figure 2. Relative frequency of indicator ratings for watersheds in the San Luis Obispo Terrace BPG. Indicators are rated as "Very Good", "Good", *etc.*, based on the current condition of landscape, habitat, or population variables. Although the amount of available information (the number of indicators) varies between watersheds, the relative ranking of indicators provides a general picture of existing habitat and land use conditions across the BPG (see individual CAP Workbooks for details).

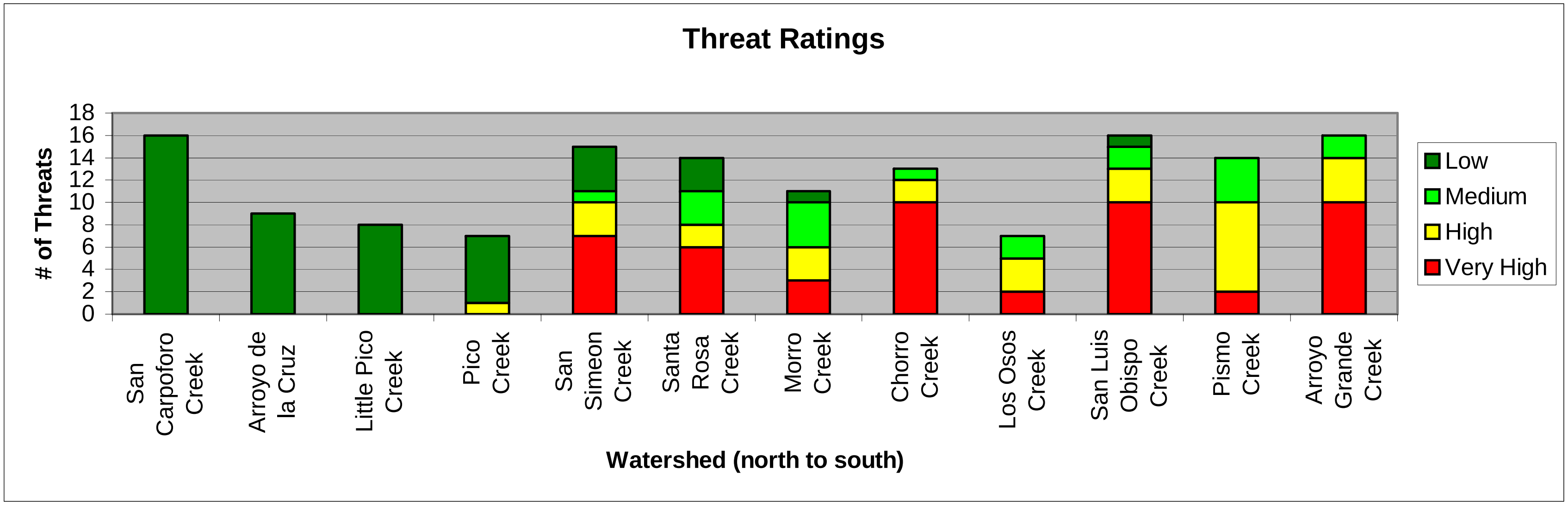

Figure 3. Relative frequency of threat ratings to steelhead habitat in watersheds in the San Luis Obispo Terrace BPG, as determined by CAP Workbook analyses. The sources, number, and severity of threats vary between watersheds and there is a dramatic increase in overall severity of threats to steelhead in watersheds south of the Pico Creek watershed.

Fourteen anthropogenic activities ranked as the top five sources of threats to steelhead viability in this BPG (Table 2). These sources are not mutually exclusive and can be grouped into a few general threat categories related to the land use. Although open space is by far the dominant land use within all of the watersheds in this BPG region, with less than 10% of any watershed converted to agricultural production, watersheds south of the San Simeon Creek watershed share a common pattern of urban and agricultural development that largely determines the pervasive lower quality of steelhead habitat in their drainages. These watersheds are primarily under private ownership, with land use activities concentrated along the narrow, coastal terrace floodplains, which magnify impacts to instream and riparian habitats. Recurring sources of threats to instream and riparian habitats here include: agricultural conversion of floodplain lands, increased density of roads and placement of roads in or near the riparian corridor, and the development of towns and cities on the floodplains, frequently at or near the estuaries of these watersheds. Increased sedimentation and substrate embeddedness, excessive groundwater extraction, culverts and road crossings as passage barriers, recreational facilities, non-point pollution from runoff from roads as well as nutrient and coliform bacteria loading from agricultural and wastewater treatment effluents, and channelization are important sources of threats to steelhead.

Dams and surface water diversions on Morro Creek, Chorro Creek, San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek serve agricultural, urban, and recreational purposes and have significantly altered natural sediment and hydrological processes in these watersheds. Dams also have isolated native rainbow trout in the upper watersheds of these drainages that otherwise would be anadromous. The reservoirs behind these dams create suitable habitat conditions for several species of non-native fishes and bullfrogs that may affect one or more life-history stages of steelhead directly (predation) or indirectly (competition for food). Non-native crayfish, fishes, and bullfrogs are particular problems in these watersheds.

The Pico Creek, San Simeon Creek, Santa Rosa Creek, Morro Creek, San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek estuaries have lost between 50% and 80% of their former size as a result of development of recreational facilities (State and County parks), Highway 1 bridge construction, and/or agricultural or urban development.

Fires are a minor source of disturbance in the northern watersheds of this BPG where less than 4% of watershed lands have burned in the past 25 years, but between 18% and 44% of the Morro Creek, Chorro Creek, Los Osos Creek, San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek watersheds have burned in this same time. Sedimentation and increased substrate embeddedness as a result of elevated slope erosion stemming from overgrazing and agricultural developments are significant habitat stressors in these watersheds. Increased road density and human population density in these fire-prone watersheds has increased fire frequency.

Table 2. The top five sources of threats in component watersheds of the San Luis Obispo Terrace BPG. Threat sources are ranked in order of frequency of occurrence and severity (see CAP Workbook for details).

Threat Sources	Component Watersheds (north to south)											
	San Carpoforo Creek (*)	Arroyo de la Cruz (*)	Little Pico Creek (*)	Pico Creek	San Simeon Creek	Santa Rosa Creek	Morro Creek	Chorro Creek	Los Osos Creek	SLO Creek	Pismo Creek	Arroyo Grande Creek
Agricultural Development												
Groundwater Extraction												
Dams and Surface Water Diversions												
Levees and Channelization												
Other Passage Barriers												
Urban Development												
Roads												
Recreational Facilities												
Channel and/or Estuary Maintenance												
Non-Point Pollution												
Natural Barriers												
Urban Effluents												
Agricultural Effluents												
Livestock Farming and Ranching												

Key: Threat cell colors represent threat rating from CAP Workbook:
Red = Very High threat Light green = Medium threat
Yellow = High threat Dark green = Low threat

Summary. The watersheds in the San Luis Obispo Terrace BPG exhibit the widest range of steelhead habitats conditions within the South-Central California Coast Steelhead Recovery Planning Area. The San Carpoforo Creek, Arroyo de la Cruz Creek, Little Pico Creek, and Pico Creek watersheds contain the best preserved and protected steelhead streams in any of the four BPGs within the South-Central California Coast Steelhead Recovery Planning Area. Although threats to these streams are currently low, conditions could change in the future because they are largely under private ownership, are all traversed by Highway 1, and support low to moderate intensity livestock ranching operations. San Luis Obispo Creek Pismo Creek, and Arroyo Grande Creek exhibit the highest number and severity of sources of threats to steelhead habitats within this BPG.

As a result of the substantial increase in human population density and related development pressures in the southern portion of the San Luis Obispo Terrace BPG, recovery actions should be focused in the watersheds south of the community of San Simeon (though efforts to ensure continued protection of the more northern watersheds are also important). Recovery actions in these watersheds should concentrate on reducing the severity of anthropogenic impacts from water diversions and groundwater extractions and related agricultural and urban development, which adversely impact steelhead rearing habitat; minimizing erosion and sedimentation caused by upslope developments (including roads, overgrazing, and agricultural and urban development); removing impediments to fish passage along the main stems and tributaries of affected drainages in order to facilitate connectivity between the ocean and estuaries and the upstream steelhead spawning and rearing habitats; and restoring channel morphology and riparian habitats affected by urban and agricultural floodplain encroachment and related flood control activities. Additionally, degraded estuarine conditions stemming from filling, artificial sandbar manipulation, and both point and non-point waste discharges should be further evaluated and addressed.

The threat sources discussed in this section should be the focus of a variety of recovery actions to address specific stresses on steelhead viability associated with these threats. Spatial and temporal data acquired on specific indicators associated with sources of threats or stresses, such as water temperature, pH, nutrients, etc., are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigations in order to refine the primary recovery actions or to target additional recovery actions as part of any recovery strategy for the San Luis Obispo Terrace BPG (see Recovery Action Matrices for more specific recovery actions).

ATTACHMENT. SUMMARY TABLES FOR STRESSES AND THREATS, STRESS MATRIX, AND OVERALL VIABILITY SUMMARY FOR THE SAN LUIS OBISPO TERRACE BPG

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APPENDIX A

NOAA FISHERIES SERVICE STAFF COMMENTS

July 18, 2008

TO: Hunt & Associates Biological Consultants

FROM: Mark H. Capelli, South-Central and Southern California Steelhead Recovery Coordinator

RE: CAP Threats Workbooks for South-Central California Coast Steelhead Distinct Population Segment (2008)

The NOAA Fisheries Service staff has reviewed the 27 CAP Threats Workbooks for the South-Central California Coast Steelhead Distinct Population Segment and is providing the following comments as a supplement to the final the CAP Workbooks; these comments also reflect previous comments on CAP Threats Workbooks previously prepared by Kier and Associates (2008); see memo from Mark Capelli and Penny Ruvelas to Kier and Associates (December 7, 2007) in Kier and Associates “Guide to the Reference Values used in South-Central/Southern California Coast Steelhead Conservation (CAP) Workbooks” (January 2008).

The principal task of the CAP Threats Workbooks was to capture broad-scale threats to steelhead habitats (fire, roads, dams, agricultural practices, mining, etc.) organized around individual watersheds. The CAP Workbooks are based on a large number and broad range of ground-based steelhead surveys, habitat and barrier assessments, and other field work on these threats, as well as the GIS-based indicators for “Multiple Life History” targets developed by Kier and Associates (January 2008). For a majority of the watersheds, the CAP Workbook’s overall results (“Threats Across Targets/Overall Threat Rank”) comport with the evaluations of the NOAA Staff based upon their familiarity with individual watersheds. As with the Kier and Associates CAP Workbook threats assessment, however, there is some discrepancy between the CAP Workbook results and the assessment of NOAA Fisheries Service staff.

Several factors account for these discrepancies. Most pervasive is the varied spatial and temporal distribution of individual threats or stresses in many watersheds (particularly large watersheds). Without breaking up individual watersheds into component sub-basins, and sometimes reach specific areas, and analyzing the threats and stresses over an extended period of time, relative to the whole watershed, it is difficult, if not impossible to accurately express the level of threat in a single over-all ranking (even for individual threats or stresses) for an entire watershed. Another contributing factor is the disparity of available data (and sometimes the complete lack of data) on relevant threats or stresses within watersheds. This unevenness of data can bias the ranking of an individual threats/stresses, as well as the overall threat ranking for an individual watershed. Finally, there is the issue of using appropriate reference values for individual indicators. A majority of the habitat and ecological studies for *O. mykiss* have been conducted in the northern portion of the species range and may not be applicable in South-Central California. This factor is further complicated by the naturally wide variability (both spatially and temporally) of environmental conditions in South-Central California steelhead watersheds. We have provided more specific comments and documentation (*e.g.*, Berg and Matthews 1997, Spina 2006, Boughton, *et al.* 2007, Rundio and Lindley *in press)* on this factor in our previous comments on the Kier and Associates' "Guide to Reference Values Used in South-Central/Southern California Coast Steelhead Conservation Action Planning (CAP) Workbooks" (January 2008). Given the dearth of *in situ* studies and the naturally wide variability in habitat conditions in South-Central California it is not practical at this time to generate alternative numerical values of various indicators, or generally adjust rules for their application (though we have suggested in the case of pH and temperature an alternative range of values which is more appropriate to the natural variability in the southern portion of the species range).

Despite the inherent challenges and limitations in accurately characterizing threats and stresses to listed steelhead in South-Central California, the CAP Workbooks provides a useful tool, particularly in tracking over time, a large and growing body of information on the threats and stresses to steelhead in South-Central California coastal watersheds.

The following specific comments address the individual Overall Threat Rank for Threat Sources, arranged alphabetically by the CAP Workbook watersheds/populations. For additional comments see memo from Mark Capelli and Penny Ruvelas to Kier and Associates (December 7, 2007) in Kier and Associates "Guide to the Reference Values used in South-Central/Southern California Coast Steelhead Conservation (CAP) Workbooks" (January 2008).
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ARROYO DE LA CRUZ

Threat Sources

Note: Arroyo de la Cruz Creek is one of two relatively unimpaired watersheds which can serve as a reference watershed south of San Francisco.

ARROYO GRANDE CREEK

Threat Sources

Urban Development: Commercial and residential development in the lower reaches of the watershed (*e.g.*, City of Arroyo Grande) has encroached on the riparian corridor, elevated erosion and sedimentation, and altered the lower river hydrology.

Flood Control: Portions of lower reaches have been confined by earthen dikes (with natural channel bottom and some riparian vegetation), but periodic flood control maintenance activities following major storm events disrupt remaining natural channel morphology and native riparian vegetation.

Agricultural Effluents: Agriculture on adjacent lands in the lower reaches has contributed elevated levels of fine sediments and degraded spawning and rearing habitats.

ARROYO SECO

Threat Sources

Flood Control: No significant portions of this watershed have been channelized; however periodic flood control maintenance activities in the lower reaches to protect roads and other structures following major storm events disrupt natural channel morphology and native riparian vegetation.

Other Passage Barriers: A number of road crossings in the lower reaches impede fish passage under some flow conditions.

BIG SUR RIVER

Threat Sources

Recreational Activities: Recreational facilities in the lower reaches and related recreational activities encroach upon the riparian corridor.

Wildfires: Recent wildfires in the region have elevated the rate of erosion and sedimentation in the watershed.

Dams and Surface Water Diversions: Small seasonal recreational dams are constructed in the lower reaches on both public and private holdings, concentrating recreational activities and potentially impeding the instream movement of fish.

Logging: Past logging activities have had a legacy effect on the watershed, changing the composition of the vegetative cover and modifying the erosion and sedimentation rates, and watershed hydrology.

BIXBY CREEK

Threat Sources

Recreational Activities: Recreational facilities and related recreational activities have encroached upon the estuary.

Logging: Past logging activities have had a legacy effect on the watershed, changing the composition of the vegetative cover and modifying the erosion and sedimentation rates, and creek hydrology.

CARMEL RIVER

Threat Sources

Other Passage Barriers: Roads in the lower reaches with culverts create impediments to fish passage, *e.g.*, Sleepy Hollow Ford.

CHORRO CREEK

Threat Sources

Other Passage Barriers: Road and utility crossings block or impede fish passage under some flow conditions.

GABILAN CREEK

Threat Sources

Dams and Surface Water Diversions: Water diversion weirs along stream have impeded fish passage under some flow conditions.

Non-Native Species: A variety of non-native species of plants and animals have colonized the lower reaches.

GARAPATA CREEK

Threat Sources

Logging: Past logging activities have had a legacy effect on the watershed, changing the composition of the vegetative cover and modifying erosion and sedimentation rates, and watershed hydrology.

LITTLE PICO CREEK

Agricultural Development**:** Cattle grazing on steep slopes have reduced vegetative cover and increased erosion and sedimentation in the watershed.

LITTLE SUR RIVER

Threat Sources

Recreational Activities: Recreational facilities in the upper reaches include a Boy Scout Camp seasonal dam which potentially impedes fish migration.

Wildfires: Recent wildfires in the region have elevated the rate of erosion and sedimentation in nearby watersheds and pose potential threats to additional watersheds.

Dams and Surface Water Diversions: Water rights pending for diversions from the lagoon pose a threat to rearing juveniles, or smolts emigrating out of the system in the spring.

Logging: Logging: Past logging activities have had a legacy effect on the watershed, changing the composition of the vegetative cover and modifying the erosion and sedimentation rates, and watershed hydrology.

LOS OSOS CREEK

Threat Sources

Levees and Channelization: No significant portion of this watershed has been channelized, though portions have been confined by adjacent developments.

Urban Development: Expanding residential development in Los Osos and Baywood Park has altered erosion and sedimentation rates and hydrology within the watershed.

LOWER SALINAS RIVER

Threat Sources

Agricultural Development: Extensive agricultural development of the flood plain has removed large tracts of native riparian vegetation, and confined the main stem channel, reducing channel habitat complexity.

Non-Native Species: A variety of non-native species of fish, amphibians, and plants have colonized the lower reaches below the two major upstream reservoirs (which serve as a refugia for non-native species of fish and amphibians).

Urban Development: Portions of the middle reaches haven been encroached upon by industrial, commercial and residential development which periodically necessitates flood control maintenance activities to protect structures, disrupting natural channel morphology and native riparian vegetation.

Agricultural Effluent: Run-off from irrigated agricultural fields has adversely affected water quality in the lower main stem and estuary.

MORRO CREEK

Threat Sources

Levees and channelization: Portions of this watershed have been channelized and the mouth has been relocated from the Morro Bay Estuary to a separate mouth north of the Morro Bay Estuary.

PAJARO

Threat Sources

Flood Control: Flood control maintenance activities in the channelized reaches in Watsonville, (and Uvas and Llagas Creeks) have significantly altered natural channel morphology and native riparian vegetation.

PICO CREEK

Threat Sources

Agricultural Development**:** Cattle grazing on steep slopes have reduced vegetative cover and increased erosion and sedimentation in the watershed.

PISMO CREEK

Threat Sources

Levees and Channelization: Portions of this watershed in the lower reaches have been channelized or confined between levees.

Other Passage Barriers: Road and utility crossings impede fish passage under some flow conditions.

Flood Control: Periodic flood control maintenance activities in the lower channelized reaches have significantly altered natural channel morphology and native riparian vegetation.

SALMON CREEK

Wildfires: Recent wildfires in the region have elevated the rate of erosion and sedimentation in the watershed.

Logging: Past logging activities have had a legacy effect on the watershed, changing the composition of the vegetative cover and modifying the erosion and sedimentation rates, and creek hydrology.

SAN CARPOFORO CREEK

Threat Sources

Note: San Carpoforo Creek is one of two relatively unimpaired watersheds which can serve as a reference watershed south of San Francisco.

SAN JOSE CREEK

Threat Sources

Natural Barriers: A number of log-jams have created impediments to fish passage in the upper reaches.

SAN LUIS OBISPO CREEK

Threat Sources

Other Passage Barriers: Steelhead can access most of the watershed, though transportation facilities may impede fish passage under certain circumstances.

Urban Development: Portions of the creek which runs through the City of San Luis Obispo have been channelized and the riparian corridor reduced or eliminated.

SAN SIMEON CREEK

Threat Sources

Urban Effluents: Wastewater treatment facilities adjacent to the lower reaches have the potential to adversely affect water quality, particularly in the estuary.

SANTA ROSA CREEK

Threat Sources

Recreational Facilities: Recreational facilities and related recreational activities have encroached on and reduced the habitat complexity of the estuary.

Flood Control: Periodic flood control maintenance activities to protect structures and adjacent roads in the lower and middle reaches disturb channel morphology and native riparian vegetation.

Urban Effluents: Wastewater treatment facilities adjacent to the lower reaches have the potential to adversely affect water quality, particularly in the estuary.

UPPER SALINAS RIVER (SAN ANTONIO AND NACIMIENTO RIVERS)

Threat Sources

Levees and channelization: Some channelization has occurred in the lower reaches immediately below the San Antonio and Nacimiento Dams, but levees are generally set back from the active channel.

UVAS CREEK

Threat Sources

Levees and Channelization: Portions of the lower reaches been partially channelized (though the channel bottom has remained unlined), disturbing the natural channel morphology and native riparian vegetation.

Flood Control: Periodic flood control maintenance activities following major storms have disturbed natural channel morphology and native riparian vegetation.

WILLOW CREEK

Threat Sources

Wildfires: Recent wildfires in the region have elevated the rate of erosion and sedimentation in the watershed.

Logging: Past logging activities have had a legacy effect on the watershed, changing the composition of the vegetative cover and modifying the erosion and sedimentation rates, and creek hydrology.