GUIDE TO THE REFERENCE VALUES USED IN SOUTH-CENTRAL/SOUTHERN CALIFORNIA COAST STEELHEAD CONSERVATION ACTION PLANNING (CAP) WORKBOOKS

PREPARED BY KIER ASSOCIATES AND
NATIONAL MARINE FISHERIES SERVICE

JANUARY 2008

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CONTENTS

INTRODUCTION

The National Marine Fisheries Service (NMFS) is using the Conservation Action Planning (CAP) workbook model to support the development of recovery plans for the South Central California Coast (SCCC) and Southern California Coast (SCC) steelhead trout (*Oncorhynchus mykiss*) Distinct Population Segments (DPS). The workbook is a regional adaptation of a tool used worldwide by The Nature Conservancy (TNC, 2005) and it is similar to a previous application by NMFS for the Southern Oregon/Northern California coastal coho (SONCC) salmon ESU (Kier Associates and NMFS, 2007). NMFS has contracted for this project with Kier Associates scientists to gather regional field and remote sensing data concerning aquatic habitat and upland conditions into a Microsoft Access database to inform a set of 55 CAP workbooks. This effort is intended to provide a broad assessment of SCCC and SCC steelhead freshwater habitat quality and the risk of upland contributions to habitat and water quality impairment.

By using pre-existing data from a variety of sources, and by drawing reference values primarily from the scientific literature, NMFS can provide a tool for governmental agencies and a variety of stakeholders. Programs potentially served by the SCCC and SCC CAP include steelhead recovery plans mandated under the federal and State Endangered Species Acts; implementation of the federal and State Clean Water Acts: the California Salmon, Steelhead Trout, and Anadromous Fisheries Act; California Trout and Steelhead Conservation and Management Planning Act of 1979, California Riparian Habitat Conservation Program; and compliance monitoring required by the Act, National Forest Management Act. The geographic areas of the SCCC and SCC steelhead DPSs encompass four State regional water quality control boards. Improving conditions for steelhead will help these agencies attain their Basin Plan objectives.

The data sources used here include those from the National Marine Fisheries Service (NMFS), California Department of Fish and Game (CDFG), U.S. Forest Service Region 5 (R5), California State Water Resources Control Board (SWRCB), California Department of Forestry and Fire Protection (CDF), U.S. Environmental Protection Agency (EPA), U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS), Resource Conservation Districts (RCDs), Utah State University's (USU) "Bug Lab", Central Coast Salmon Enhancement, Stoecker Ecological, the Southern California Coastal Water Research Project (SCCWRP), as well as other contributors.

The Kier Associates science team previously assisted NMFS by adapting the data from the Klamath Resources Information System (KRIS www.krisweb.com) projects in the SONCC area to support salmon recovery plan development (Kier Associates and NMFS, 2007). The master database developed by Kier Associates in Microsoft Access for the SONCC project has been used to support SCCC and SCC steelhead recovery planning. It captures the data acquired from all of the contributors and is used to compute summary values for a set of automated Excel CAP workbooks.

The purpose of this document is to: 1) provide information on how the CAP has been adapted, 2) present a brief discussion of the reference values used in ranking aquatic and upland conditions relevant to SCCC and SCC steelhead recovery. Some of the reference values are drawn from the general scientific literature, some from specific field investigations and others from the conventions of the agency or entity that provided the data.

HOW THE CAP HAS BEEN ADAPTED

The SCCC and SCC consist of a collection of 55 automated CAP Excel workbooks, one for each steelhead population identified by NMFS (2007d), with some modifications (Figure 1). The analytical tools used in this project for data management were developed under the previous

contract supporting NMFS' southern Oregon and northern California coastal coho salmon recovery plan and include:

1. A customized Microsoft Access database,
2. A set of custom open-source Python computer programs for data preparation, and
3. An adapted Excel CAP workbook.

The Access database stores region-wide data for all indicator- and sources-of-stress data. The data are tagged with spatial coordinates and/or stream names so that SCCC and SCC CAP summary workbooks for sub-basins or other spatial units can be produced.

All indicator and sources-of-stress data for the SCCC and SCC DPS watersheds were entered directly into the Access database rather than into the individual workbooks. For each of the 55 steelhead populations, the Python scripts summarize the Indicator and Source of Stress data contained in the Access database. The scripts then insert these summary values into a separate CAP workbook for each population. This methodology ensures that all 55 workbooks are using the same criteria and protocols.

To ensure transparency, all data in the Access database have been tagged with their source information. These metadata are accessible for each database. The array of results can also be viewed as box plots (see the Readme file on CAP DVD for an explanation of what a boxplot is), so that outliers can be identified and patterns in the data can be easily determined. A summary chart is also generated so that the number of factors used for scores in each of the 55 basins can be reviewed.

What follows is a discussion on the bases for the reference values for aquatic integrity ("Indicators" in CAP terminology) and for "Threats" or "Sources of Stress", CAP terms for upland conditions and the risks for impacting steelhead trout habitat associated with them. Life history stages of steelhead are chosen as conservation "Targets" within the SCCC and SCC CAP areas.

CAUTIONARY NOTE ON USE OF THE KIER ASSOCIATES SCCC AND SCC CAP

Kier Associates' SCCC and SCC CAP project is not the sole source of information upon which NMFS relies for recovery plan development, but it is rather an auxiliary tool. The current exercise is driven only by data sets that cover large geographic areas, because of the limited time and resources available to the project. NMFS is also producing a parallel CAP project for each of the 55 DPS databases being done manually (Hunt, in preparation) based on detailed knowledge, including field reports and small databases that were not practical for integration into the Kier Associates CAP.

There are no data for many Indicators and Sources of Stress that significantly limit steelhead productivity in SCCC and SCC DPS watersheds. Scoring watershed suitability for steelhead based on incomplete data is one source of error that can lead to inaccurate overall characterization. The Kier Associates CAP workbooks come with a separate summary Excel database that provides a chart displaying the number of Indicators that drive CAP scores (Figure 2). Users can, in this way, see at a glance which CAP workbooks are based on rich or sparse data.
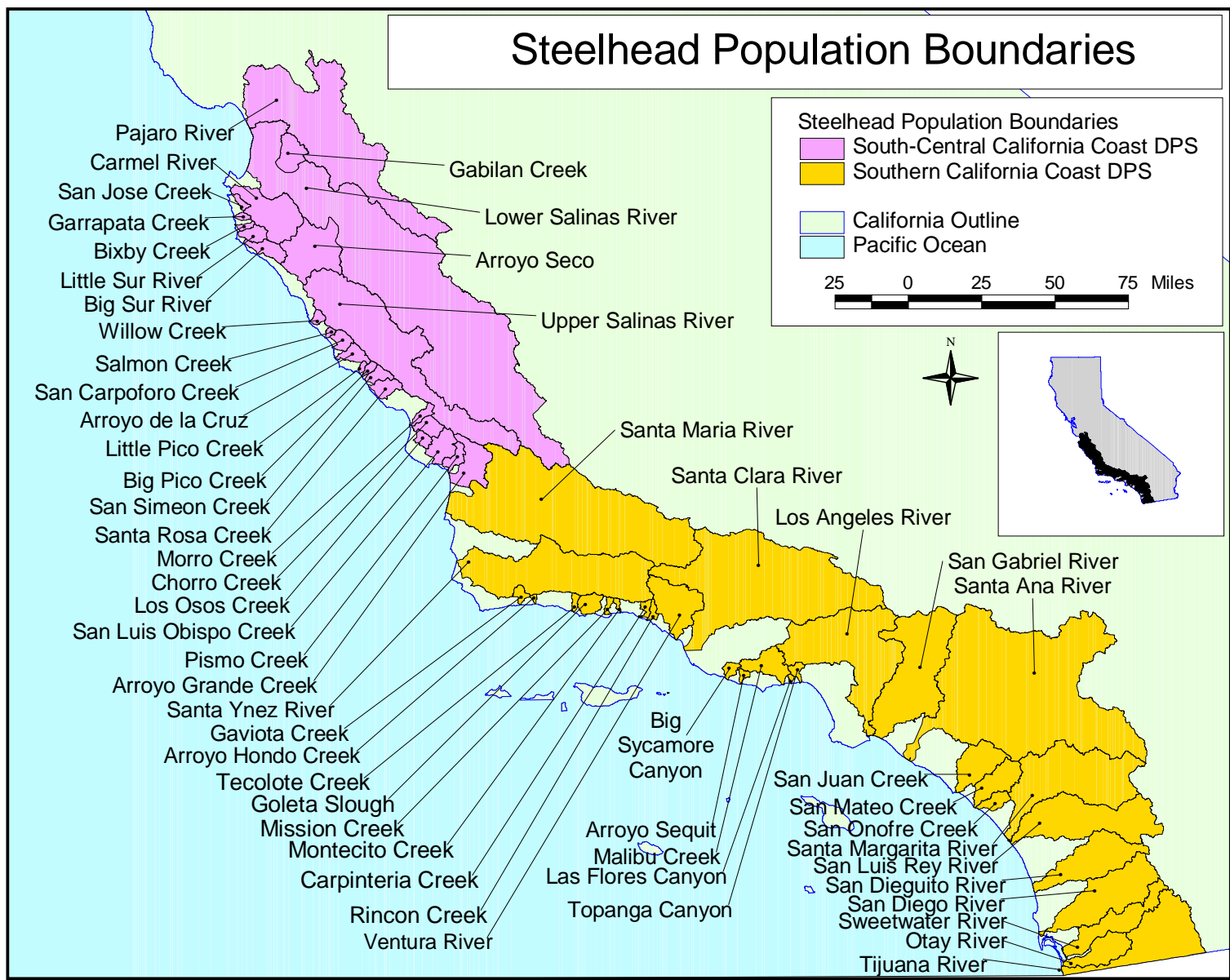
Steelhead Population Boundaries

Steelhead Population Boundaries
- South-Central California Coast DPS
- Southern California Coast DPS

- California Outline
- Pacific Ocean

25 0 25 50 75 Miles

Pajaro River
Carmel River
San Jose Creek
Garrapata Creek
Bixby Creek
Little Sur River
Big Sur River
Willow Creek
Salmon Creek
San Carpoforo Creek
Arroyo de la Cruz
Little Pico Creek
Big Pico Creek
San Simeon Creek
Santa Rosa Creek
Morro Creek
Chorro Creek
Los Osos Creek
San Luis Obispo Creek
Pismo Creek
Arroyo Grande Creek
Santa Ynez River
Gaviota Creek
Arroyo Hondo Creek
Tecolote Creek
Goleta Slough
Mission Creek
Montecito Creek
Carpinteria Creek
Rincon Creek
Ventura River

Gabilan Creek
Lower Salinas River
Arroyo Seco
Upper Salinas River

Santa Maria River
Santa Clara River
Los Angeles River
San Gabriel River
Santa Ana River

Big Sycamore Canyon
Arroyo Sequit
Malibu Creek
Las Flores Canyon
Topanga Canyon

San Juan Creek
San Mateo Creek
San Onofre Creek
Santa Margarita River
San Luis Rey River
San Dieguito River
San Diego River
Sweetwater River
Otay River
Tijuana River

Figure 1. Boundaries of the 55 Steelhead populations in the SCC and SCCC DPS.
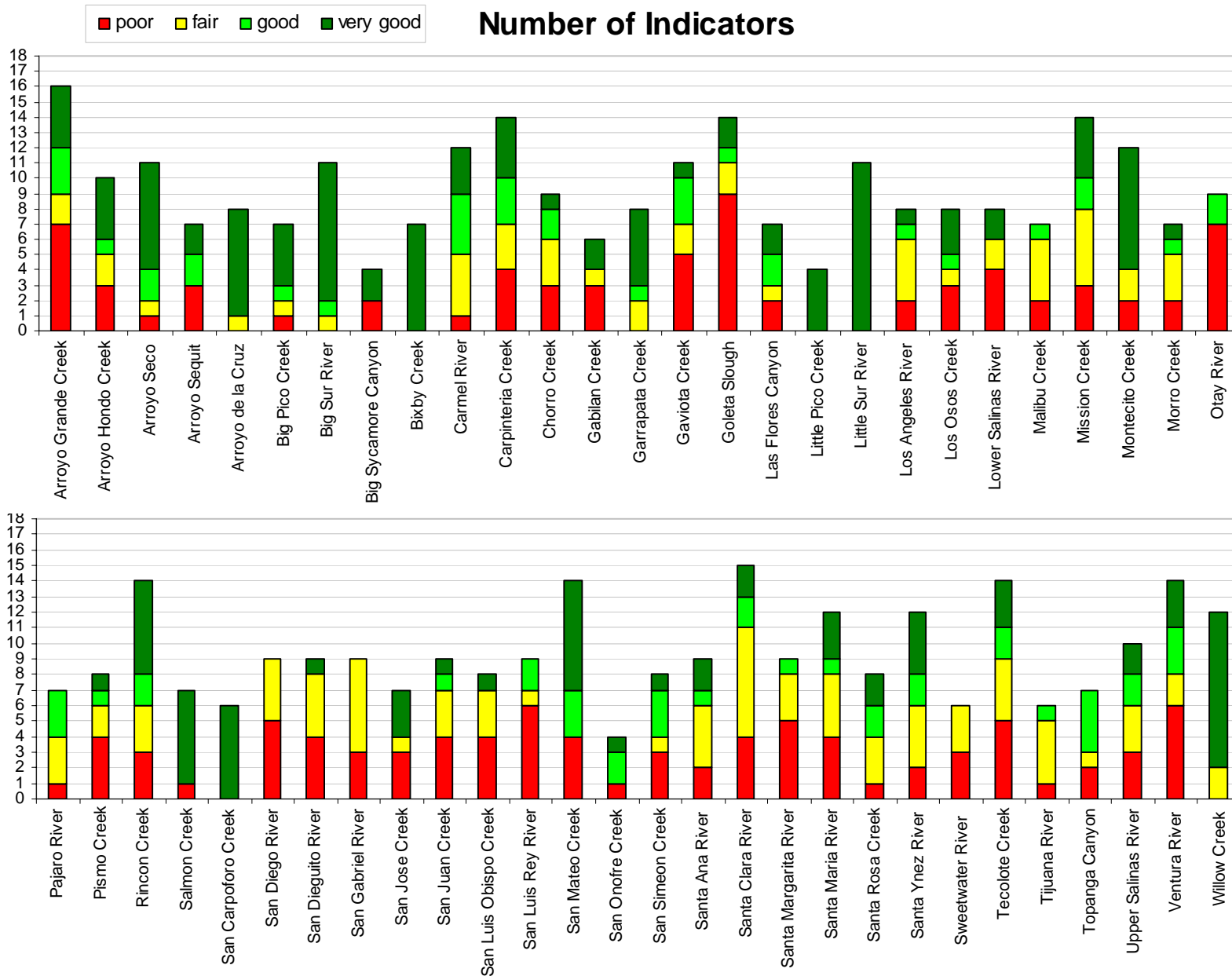
Figure 2. This summary chart shows the number of indicator parameters driving SCCC and SCC CAP scores. Note that some basins are relatively data rich, such as the Santa Clara River (15 indicators), but that some small streams may have as few as four. Colors represent the relative aquatic health based on the reference values described here.

The location and timing of collection of water quality data used in the CAP may make the data of limited utility in analyzing patterns of pollution that affect steelhead trout. Data tend to be collected in very impaired reaches or in waterbodies that are the targets of water quality programs and policies, while relatively less data may be collected in the less impaired streams inhabited by steelhead. Most water quality data comes from discrete samples, rather than from continuous data recorders. As a result sampling may not reflect seasonal extremes and actual worst-case conditions at various sites, skewing results high. The indicators pH, dissolved ammonia, and periphyton have been excluded from the Kier Associates CAP workbooks because these data do not accurately reflect conditions for SCCC and SCC DPS steelhead streams (see details below). Discussion of these parameters remains in the reference paper because these data types can potentially explain nutrient pollution that impacts steelhead.

The Kier Associates CAP workbooks are driven largely by data and associated reference values drawn from scientific literature. NMFS (2007c) staff provided detailed comments on earlier draft Kier Associates CAP workbooks and noted instances where incomplete data lead to mischaracterization of several SCCC and SCC DPS watersheds (complete comments are provided here as Appendix B). Although additional data (gravel extraction, estuarine wetland conditions, and channelization/diking) were added since these earlier draft workbooks, discrepancies still remain. Kier Associates has provided written responses to these comments that lists the following potential explanations for such discrepancies (see Appendix A for complete details):

1. The spatial distribution of the available data
2. The temporal resolution of the available data
3. Reliance on water quality due to data gaps for other indicators
4. Local steelhead adaptations and natural water quality variability
5. Data gaps for critical limiting factors
6. Limitations of large-scale analyses based on remote sensing
7. Internal programming within CAP Excel increases threat ranks in some populations

Therefore, the NMFS CAP workbooks to be generated using more detailed data (Hunt et al., in preparation) should be considered a more accurate reflection of SCCC and SCC DPS stream and watershed conditions than the CAP workbooks discussed here. Once both sets of workbooks are completed, NMFS plans to compare and reconcile the outputs from the two independent threat assessment efforts to create a single threats assessment

REFERENCES FOR CAP AQUATIC INDICATORS

The reference values for aquatic health (Indicators) are based on the best currently available scientific literature, though it needs to be emphasized that much of this literature has been developed on more northern populations of steelhead trout and may not in every case represent the environmental conditions in which the southern (or inland) populations have evolved. Targets represent values characteristic of reference streams, with the long-term objective being to bring impaired streams back to a "natural range of variability" capable of supporting all life history phases of steelhead (Spence et al., 1996; Rieman et al., 1993).

Quantitative data for the SCCC and SCC steelhead habitat are sparse, so water quality data are used as an auxiliary tool to characterize suitability of regional streams for this species. Some types of data described below have been eliminated from final CAP workbooks because of the problems with sampling noted above, however, they are still discussed here because of their potential utility, should water quality management agencies choose to measure them in stream reaches inhabited by steelhead in the future (see Cooperative Monitoring Potential below). Table 1 provides a summary of the Indicators and reference values used in the SCCC and SCC steelhead CAP database.

Table 1. Attributes and Indicators of aquatic habitat suitability for southern California steelhead SCCC and SCC DPS population CAP reference values.

Attribute	Indicators	Poor	Fair	Good	Very Good	E	F	J	S	A
Water Quality	Aquatic Insects (EPT)	<10	10-14	14-17	>17		x	x	x	
Water Quality	Aquatic IBI	<40	40-60	60-80	>80		x	x	x	
Hydrologic Function	Reservoir volume as % of precipitation	>40	10-40	0-10	0	x	x	x	x	x
Barriers	Fish Passage (% of Area Accessible)	<60%	60-80%	80-95%	95-100%		x	x	x	x
Sediment Supply	Embeddedness	>35%	25-35%	20-25%	<20 %	x	x	x		x
Floodplain and Channel Structure	Pool Depths (feet)	<2	2-3	3-3.3	> 3.3		x	x	x	
Floodplain and Channel Structure	Pool Frequency (length)	<35%	35-40%	40-50%	>50		x	x	x	
Floodplain and Channel Structure	Pool Abundance (category)	1-1.99	2-2.99	3-3.99	4		x	x	x	
Barriers	Fish Passage (% of Dry Habitat Types)	>5%	1-5%	<1%	0%	x	x	x	x	
Riparian Forest Conditions	Canopy Cover	<60%	60-70%	70-80%	>80%		x	x	x	
Riparian Forest Conditions	Riparian Condition (% Forest, Wetlands, or Shrub)	<50%	50-70%	70-80%	>80%		x	x	x	x
Estuarine Function	Estuarine Wetland Area (current as percent of historic)	<50%	50-70%	70-80%	>80%		x	x	x	
Water Quality	Water Temperature (MWMT)***	>25	22.5-25	17-22.5	<17		x	x	x	
Water Quality	pH**					x	x	x	x	x
Water Quality	Dissolved Oxygen (max dev. % saturation)	>20 %	14-20 %	10-14 %	<10 %		x	x	x	
Water Quality	Ammonia (% of CCC chronic criterion)**				<10%		x	x	x	
Water Quality	Periphyton (annual max Chl a/m²)**	>150	125-150	100-125	<100		x	x	x	
Water Quality	Total Nitrogen (mg/L)	>1.5	0.8-1.5	0.4-0.8	<0.4		x	x	x	
Water Quality	Total Phosphorus (mg/L)	>0.15	0.06-0.15	0.02-0.06	<0.02		x	x	x	
Floodplain and Channel Structure	Floodplain Connectivity (USFS Judgment)	Impaired	Functioning At-risk		Properly Functioning	x	x	x	x	
Hydrologic Function	Water Quantity/Flow (USFS Judgment)	Altered	Partially Altered		Unaltered	x	x	x	x	
Riparian Forest Conditions	Stream Corridor Vegetation (USFS Judgment)	Impaired	Functioning At-risk		Properly Functioning		x	x	x	
Disease and Predation	[No available data]									

* List of conservation Targets (life stages) that the indicator applies to (E = Egg, F = Fry, J = Juvenile, S = Smolt, A = Adult)

** Data for these indicators were integrated into the Access database but are not included in the final CAP workbooks due to the data's limited temporal and spatial scope

*** No suitable water temperature data were available, so none are included in the Access database, boxplot summary workbook, or individual CAP workbooks

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6

Aquatic Macroinvertebrates: Aquatic macroinvertebrates are an important food source for steelhead trout fry, juveniles and smolts. While availability of aquatic food sources are not generally a natural limiting factor in inland and more southern coastal watersheds (Moore, 1980; Smith and Li, 1983; Rundio and Lindley, In press), aquatic macroinvertebrates are an important tool for evaluating water quality (Barbour et al. 1999), which frequently is a limiting factor due to the extensive land use modifications within many South-Central and Southern California watersheds (Barbour et al. 2007, Keeley 1993, Stephenson and Calcarone 1999).

Aquatic macroinvertebrates often dwell in interstitial spaces between stream cobble and gravel where steelhead eggs are also deposited. Consequently, sediment pollution can decrease macroinvertebrate abundance and diversity and reduce the success of steelhead egg incubation.

The use of aquatic macroinvertebrates in the SCCC and SCC steelhead DPS streams is based on regional studies that have established patterns of diversity and identified reference streams. Ode et al. (2005) were able to analyze hundreds of samples in cooperation with four southern California regional water quality control boards, the U.S. Forest Service, Bureau of Land Management, Environmental Protection Agency, and the Utah State University "Bug Lab" (Figure 2). This enabled a ranking of stream health based on a locally-calibrated index of biotic integrity (IBI). Additional IBI data were obtained from the San Diego Regional Water Quality Control Board.
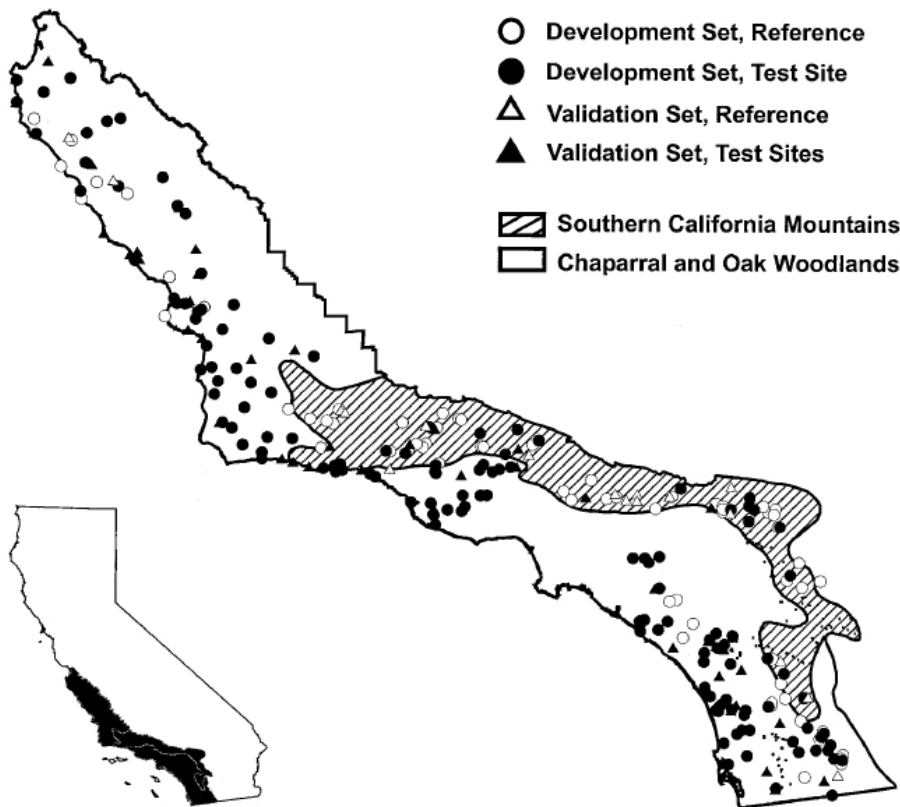

Figure 2. Map from Ode et al. (2005) showing the geographic extent of the southern California sampling area for the aquatic macro-invertebrates that are the basis of the regional IBI.

The IBI ratings for southern California varied slightly between streams in high elevation forested areas and those in lower elevation oak woodland and chaparral (Ode et al., 2005). Since the

7

KIER ASSOCIATES AND NATIONAL MARINE FISHERIES SERVICE: GUIDE TO THE REFERENCE VALUES USED IN THE SOUTH-CENTRAL AND SOUTHERN CALIFORNIA COAST CONSERVATION ACTION PLANNING WORKBOOK

differences are so slight and are not likely to affect CAP scores significantly, the same rating curve is applied to all locations.

Proposed CAP interim reference values for IBI in the SCCC and SCC are: Very Good = >80, Good = 60-80, Fair = 40-60, Poor = <40. Ode et al. (2005) distinguish between Poor and Very Poor (<20), but all waters with scores below 40 are assumed to be unsuited to steelhead survival.

IBI scores are not available for post-2002 "Bug Lab" data points. The Ephemeroptera-Plecoptera-Trichoptera (EPT) Index is, therefore, also used in the CAP. The EPT index is the number of species present in a sample of these pollution-intolerant Orders. EPT reference values from Ode et al. (2005) are used to rate southern California streams.

Proposed CAP interim reference values fore EPT for the SCCC and SCC are: Very Good = >18, Good = 14-17, Fair = 10-14, Poor = <10.

Reservoir Impacts on Hydrology: Highly migratory species such as steelhead depend on connectivity of stream flows to complete the fresh-water phase of their life-cycle. Dams and reservoirs can create major alterations to the hydrology of watersheds and their channel forming and maintenance processes. Such alterations are complex and difficult to quantify. Detailed analyses of reservoir inflows and outflows are beyond the scope of this project, and are likely not possible in all watersheds due to data gaps. Therefore, an alternative system was devised to assess the general effects of dams and reservoirs in watersheds.

For each of the 55 steelhead population watersheds, the total storage volume of reservoirs[1] was calculated as a percent of total annual precipitation volume[2]. While this does not take into account how the dams are operated (e.g. what time of year water is being stored/released, the final destination of impounded water), it does provide a useful approximation of the potential degree of hydrologic alteration attributable to dams/reservoirs.

Proposed CAP interim reference values for reservoir impacts to hydrology for the SCCC and SCC are: Very Good = 0%, Good = 0-10%, Fair = 10- 50%, Poor = >50%.

Fish Passage (Percent of Area Accessible): NMFS (1996a) noted previous work describing impediments to steelhead passage in southern California. Boughton et al. 2005 concluded that "a large majority (68%) of the extirpations of steelhead populations in the 88 coastal watersheds between Monterey Bay and the U.S. Mexico Border are strongly associated with anthropogenic barriers such as dams, flood control structures, and culverts which block access to fish migration to upstream spawning and rearing habitats."

Barriers are well recorded for many southern California streams and accessible in electronic form either as basin-specific datasets (i.e. Stoecker and Stoecker, 2003; CA Coastal Conservancy, 2004; Cachuma RCD and Carpinteria CWA, 2005; Stoecker and Kelley, 2005; Stoecker Ecological, 2005; Love and Stoecker, 2007) or as part of the CDFG Passage Assessment Database (PAD). The PAD

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[1] Reservoir storage volume data obtained from the Dams 2005 GIS dataset assembled from multiple sources by NMFS that included all major dams as well as many smaller dams

[2] Precipitation data were obtained as a GIS dataset from the Oregon Climate Service at Oregon State University, which modeled mean annual precipitation by combining rain gage data with physical rules such as the orographic effect and rain shadows. To obtain annual precipitation volume for a watershed, watershed area was multiplied by average annual precipitation across the watershed.

KIER ASSOCIATES AND NATIONAL MARINE FISHERIES SERVICE: GUIDE TO THE REFERENCE VALUES USED IN THE SOUTH-CENTRAL AND SOUTHERN CALIFORNIA COAST CONSERVATION ACTION PLANNING WORKBOOK

8

also contains information on barrier type, so that defined areas can be differentiated by the particular causes of inaccessibility, such as dams and culverts. The watershed above each total (complete) barrier to fish passage was delineated using GIS software. The indicator reference values in the CAP are based on the percentage of watershed area accessible (i.e, not blocked by total barriers to migration).

The categories of inaccessible area are compared within each steelhead population regarding Sources of Stress as well (see below). Future versions of the CAP could refine this metric to incorporate the quality of blocked habitats, such as percent of stream miles of high potential habitat that are inaccessible due to barriers.

The proposed CAP interim reference values for fish passage (percent of basin accessible) for the SCCC and SCC are: <60% = Poor, 60-80% = Fair, 80-95% = Good, and 95-100% = Very Good

Embeddedness: The degree to which cobbles or gravel at pool tail crests are buried in fine sediment or sand is known as embeddedness, a parameter used routinely in salmonid habitat typing surveys (CDGF, 2004). Pool tail crests are often chosen as locations for steelhead redd construction. Streambed embeddedness at these locations is, therefore, a measure of spawning habitat quality. Female steelhead trout may expend considerably more energy excavating redds, for example, if embeddedness is high. High levels of embeddedness are indicative of high fine sediment supplies, which can resettle after redd construction to smother eggs and decrease egg and alevin survival (Chapman, 1988). Steelhead trout fry and juveniles may also need to hide within the interstitial spaces of a cobbled stream, making embeddedness an inverse index of available cover for steelhead fry and juveniles.

Some southern California habitat typing data includes measurement of embeddedness at locations other than pool tail crests, which is inconsistent with CDFG (2004) protocols. Steelhead are also known to spawn in riffles; therefore, riffle embeddedness scores are included. Since glides, runs and other habitats are not usually selected by steelhead for spawning, embeddedness measurements from these locations are not used in SCCC and SCC CAP scores.

The SCC and SCCC CAP uses habitat typing data from the following sources: Central Coast Salmon Enhancement, Inc. (Close and Smith, 2004) for Arroyo Grande Creek; Stoecker and Conception Coast Project (2002) for Southern Santa Barbara County; Stoecker and Kelley (2005) for the Santa Clara River watershed; and CDFG (2004) for Bear Creek (tributary to Ventura River) and San Mateo Creek. CDFG has surveyed many streams from Santa Cruz, Monterey, and San Luis Obispo Counties, but these data were not available to the SCC and SCCC CAP project.

Various targets for embeddness have been proposed. Armentrout et al. (1998) set targets for embeddedness in volcanic watersheds west of Mt Lassen, in Mill, Deer and Antelope creeks as follows: less than 10% for mainstems, less than 15% for tributaries without highly erodible soils (rhyolite), and less than 20% for tributaries in watersheds with rhyolitic soils. CDFG (2004) rated embeddedness scores of less than 25% as good, while NMFS (1996) rated embeddedness of less than 20% as "properly functioning". NMFS also gave an "at risk" rating of 20-30% and a "not properly functioning" value to embeddedness greater than 30%.

Proposed CAP interim reference values for embeddedness for the SCCC and SCC are: <20% = Very Good, 20-25% = Good, 25-35% = Fair, and >35% = Poor.

Pool Depth: CDFG (2004) habitat typing surveys always capture data on pool depth, which is the best replicable metric for trend monitoring that comes from such surveys. Greater pool depth provides more cover and rearing space for older age (1+ and 2+) steelhead juveniles. Deeper pools also create better shelter for migrating and spawning adults (Bean 2007, Spina 2003, Harrison et al. 2005). Spina et al. (2005) studied use of pools in the lower mainstem of San Luis Obispo Creek in the SCC DPS region and found that:

> "The large, deep pools in the lower main stem probably contribute to steelhead survival, especially that of larger juveniles, based on the relationship between the counts of steelhead and mean pool depth (and area) documented in our study…"

Boughton et al. (2006) noted the significance of pool depth in streams within the SCC and SCCC DPS area:

> "Of notable importance is pool depth. We have occasionally observed distinct summer thermoclines in pools deeper than 2 m, in places such as San Mateo Creek (San Diego Co.), the Santa Margarita River between Fallbrook and Temecula, and in Topanga Creek. In each case the colder bottom water appeared to provide refuge for steelhead and also deter predatory warm-water exotics such as largemouth bass."

Maximum pool depth is partly a function of watershed size and geological formation, but pool depths and volume can be compromised by sediment over-supply or increased peak discharges related to upstream or upslope land management (Montgomery and Buffington, 1993). Barnhart (1986) states that "excessive sediment inputs that fill pools can greatly reduce a stream's capacity to rear steelhead to smolt size." Harrison and Keller (2005) note the importance of boulders in pool formation in steep and confined southern California steelhead streams, although scour was sometimes offset by deposition when high bedload transport of fine sediment was occurring. Bean (2007) noted that sandstone bedrock formations may also create hydraulics that lead to pool formation.

Pool depths of three feet, or one meter, are commonly used as a reference for fully functional salmonid habitat (Overton et al., 1993; USFS, 1998; Bauer and Ralph, 1999; Brown et al., 1994). The California Salmonid Stream Habitat Restoration Manual Third Edition (CDFG, 2004) defines primary pools for 1st and 2nd order streams as having a maximum residual depth of at least two feet, occupying at least half the width of the low flow channel, and being as long as the low flow channel width. For 3rd and 4th order streams, CDFG criterion is a maximum residual depth of at least three feet. Because there are insufficient data to understand the relationship between pool depth and stream size, the CAP does not use different pool depth reference values for streams of different sizes; however it is recognized that larger watersheds, particularly in their headwaters, contain larger and deeper pools controlled by geomorphic factors.

Proposed CAP interim reference values for pool depth for the SCCC and SCC are: Very Good = > 3.3, Good = 3-3.3, Fair = 2-3, Poor = <2.

Pool Frequency: Habitat typing surveys (CDFG, 2004) also provide data on the percentage of stream reaches represented by pools, which are preferred habitat for yearling and older juvenile steelhead. Pool frequency by percent length is preferable to pool frequency by occurrence because the latter may give a false impression of health if there are numerous, shallow, short pools as a result of aggradation. The Washington State Fish and Wildlife Commission (1997) recommend the following pool frequencies by length:

"For streams less than 15 meters wide, the percent pools should be greater than 55%, greater than 40% and greater than 30% for streams with gradients less than 2%, 2-5% and more than 5%, respectively."

California habitat typing surveys are rarely conducted in channels of greater than 2% gradient; therefore, no screen for gradient is used for California SCC and SCCC data. Peterson et al. (1992) used 50% pools as a reference for good salmonid habitat and recognized streams with less than 38% pools by length as impaired. Values from Peterson et al. (1992) are those adapted for use in the SCC and SCCC CAP.

Some habitat surveys for southern California streams (Stoecker and Conception Coast Project, 2002; Stoecker and Kelley, 2005) include aerial reconnaissance for rough approximations of habitat types and lengths, but no aerial data were used in calculating pool frequency in the CAP.

Proposed CAP interim reference values pool frequency for the SCCC and SCC are: Very Good = > 50%, Good = 4-50%, Fair = 35-40%, Poor = <35%.

Pool Abundance: In habitat surveys of small streams in southern Santa Barbara County, Stoecker and Conception Coast Project (2002) estimated relative pool abundance on a five-category scale. These values were converted to a four-category scale for incorporation into the SCCC and SCC CAP.

Proposed CAP interim reference values pool abundance for the SCCC and SCC are: Poor = 1 "Pools scarce or absent" or "Relatively low abundance of pools present", Fair = 2 "Relatively moderate abundance of pools present", Good = 3 "Relatively high abundance of pools present", Very Good = 4 "Relatively high abundance of pools present with multiple 'refuge pools' (greater than 5 feet deep)".

Dry Stream Segments: Habitat typing surveys note reaches of streams that lack surface flow as "dry" (CDFG, 2004). Intermittent stream flow patterns or alternating reaches of surface and non-surface flow can occur naturally in many central and southern California stream systems due to arid climatic conditions (Boughton et al, 2005; Spina et al., 2006). However, loss of surface flow can also be the result of stream diversions, ground water withdrawal or aggradation of the streambed (Kier Associates, 1999; Nielsen et al., 1994). The lack of connectivity of rearing habitats can prevent the movement of juvenile steelhead trout, and thus is used in the CAP as a fish passage indicator.

Surveys of dry habitats using aerial reconnaissance (i.e., Stoecker and Kelley, 2005; Stoecker and Conception Coast Project, 2002) are considered useful for generating CAP scores. The total length of aerial and ground surveys were summed and the dry reaches from both survey types used to calculate percent dry.

Proposed CAP interim reference values dry stream segments for the SCCC and SCC are: > 5% dry = Poor, 1-5% = Fair, <1% = Good, and no dry reaches = Very Good.

Canopy Cover: CDFG (2004) habitat typing surveys measure canopy closure from the middle of streams, which is a good index of shade. Shade is an important influence on water temperature and CDFG (2004) recognizes 80% canopy as optimal for salmon streams. In some reaches of central and southern California streams vegetation may be naturally sparse and large instream boulders or

canyon walls may provide shade and cover. Consequently, standard canopy cover could be low, but adequate cover for steelhead juveniles from boulders may exist.

Proposed CAP interim reference values for canopy cover for the SCCC and SCC are: Very Good = > 80%, 70-80% = Good, 60-70-% = Fair, and <60% = Poor

Riparian Condition: Stream side vegetation and the plant community within the adjacent wet area constitute the riparian zone. Healthy riparian vegetation can help filter nutrients and pollutants, create a cool microclimate over a stream, provide food for aquatic organisms, maintain bank stability and provide hard points around which pools are scoured (Spence et al., 1996). NMFS (1996a) noted that "studies indicate that in Western states, about 80 to 90 percent of the historic riparian habitat has been eliminated." Urbanization and agricultural development have caused major changes in riparian zones of southern California steelhead streams (Boughton et al., 2005, 2006; NMFS 2007a, 2007b)

The National Land Cover Database (NLCD) 2001 (Homer et al., 2004) was used to derive riparian condition score for the CAP. The NLCD does not provide detailed information such as age and species composition (e.g. balance of native vs. non-native species); it just classifies each 30x30 meter pixel as one of 16 land cover types. Three hundred foot (90 m) buffers on each side of streams were applied to the land cover dataset. Final CAP scores are the combined percentage of area within the buffer composed of six feature classes: deciduous forest, evergreen forest, mixed forest, Shrub/Scrub, woody wetlands, or herbaceous emergent wetlands. Proposed reference values are "Very Good" for greater than 80% of the riparian buffer assessed in woodlands or wetlands, whereas less than 50% woodlands and wetlands would constitute "Poor" conditions (Table 1).

Proposed CAP interim reference values riparian condition for the SCCC and SCC are: > 80% = Very Good, 70-80% = Good, 50-70% = Fair, <50% = Poor.

Estuarine Wetland Extent: The importance of coastal lagoons in supporting steelhead life-cycle (rearing, acclimating between the marine and freshwater environments, accessing both marine and freshwater environments) is widely recognized, but many aspects of this habitat feature are not understood in detail. Boughton et al. (2006) state that productivity of SCCC and SCC Evolutionarily Significant Units (ESUs) steelhead streams "depends in part on lagoon size, which is readily measured, but it also depends on primary productivity of the lagoon ecosystem itself, and key driving variables such as the degree of mixing between salt- and freshwater during the summer." NMFS (1996a) estimated "that during the last 200 years, the lower 48 United States have lost approximately 53 percent of all wetlands. Washington and Oregon's wetlands have been estimated to have diminished by one third, while it is estimated that California has experienced a 91 percent loss of its wetland habitat."

Several projects have produced data on SCCC and SCC coastal lagoons:

- The Coastal Commission digitized and geo-referenced boundaries of Southern California coastal wetlands from 1850s Coast and Geodetic Survey maps (T-sheets).
- U.S. Fish and Wildlife Service National Wetland Inventory (NWI) data.
- Southern California Wetlands Mapping Project (SCWMP)

The SCWMP is producing highly detailed maps of current and historic wetlands, but will not finish SCCC and SCC until spring 2008. Pending completion of SCWMP, NMFS (2007e) has compiled an

inventory of original and current estimate of estuarine wetland acreages for each of the 55 populations to be used as a general indicator of the current level of wetland functions for the CAP, based on the assumption that a relatively intact open water and contiguous wetland system will remain productive, while filling or conversion of these areas results in lesser carrying capacity for steelhead. See Appendix C for a complete listing of documents used for the NMFS estuary/wetland assessment.

Proposed CAP interim reference values for the percent of historic estuarine wetland habitat that remains are: Very Good for >80%, Good = 70-80%, Fair = 50-70%, and Poor = <50%.

Temperature: Spence et al. (1996) ranked water temperature as the most important salmonid habitat variable:

> "Stream temperatures influence virtually all aspects of salmonid biology and ecology, affecting development, physiology, and behavior of fish, as well as mediating competitive, predator-prey and disease-host relationships."

There are a number of literature summaries concerning the water temperature requirements of Pacific salmon (McCullough, 1999; Sullivan et al., 2000; U.S. EPA, 2003). The U.S. EPA (2003) *Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards* sets standards by life stage for Pacific salmon species. According to Boughton et al. (2006), the hypothesis that southern California steelhead are adapted to warm water has not been proved conclusively by scientific evidence; "researchers have not found local genetic adaptation in the thermal tolerances of *O. mykiss*." However, there are widespread field data from SCCC and SCC DPS streams where steelhead have been found despite water temperatures considered lethal to more northern stocks.

For example, whereas Sullivan et al. (2000) characterized water temperatures over 25° C as lethal for Pacific salmon species, Spina (2006) found that juvenile steelhead residing in lower Topanga Canyon Creek continued feeding actively despite maximum water temperatures of up to 24.8° C. Conversely, Matthews and Berg (1997) monitored two adjacent pools in Sespe Creek, Ventura County and found that steelhead juveniles left one pool after surface water reached 28.9 C and stratified bottom waters increased to 21.5 C. The adjacent pool had similar surface temperatures (27.9 C) in late August, but retained steelhead juveniles at depth where bottom waters were cooler (mean=18.3 C). Tobias (2006) found that juvenile steelhead favored spring fed habitats in upper Topanga Creek from April-September where water temperatures were cooler, but dispersed in October-December. Questions remain as to what degree fish rely on thermal refugia that result from springs, topographic shading or hyporheic flow (Poole and Berman, 2000).

Boughton et al. (2007) performed a controlled experiment using southern California steelhead trout juveniles in Lion Creek (a tributary to Sespe Creek) that tested whether they grew at a higher rate in warmer water temperatures. They found that, despite increased feeding of steelhead juveniles, fish did not increase growth with increased water temperatures as expected, but Moore (1980) found fish exhibited elevated growth rates.

The complexity of the thermal regime and the lack of adequate data prevented Kier Associates SCC and SCCC CAP workbooks from using stream temperature as an Indicator. Available data were mostly from hand-held temperature spot readings as opposed to data sets from continuous data recorders. Discrete samples are often not in reaches inhabited by steelhead or may be taken during seasons when temperatures are not limiting. Continuous recorder data allow calculation of the duration of stressful conditions for steelhead and suitability for salmonids (U.S. EPA, 2003; Lewis et

KIER ASSOCIATES AND NATIONAL MARINE FISHERIES SERVICE: GUIDE TO THE REFERENCE VALUES USED IN THE SOUTH-CENTRAL AND SOUTHERN CALIFORNIA COAST CONSERVATION ACTION PLANNING WORKBOOK

13

al., 1999; Welsh et al., 2001). Welsh et al. (2001) suggest that the maximum weekly maximum temperature (MWMT) be used as a summary statistic to gauge salmonid stress.

Temperature thresholds in Table 1 are set to reflect findings that steelhead in the region may persist in water temperatures above 25° C (Spina, 2006; 2007). As more water temperature data are collected from steelhead streams in the SCCC and SCC area, tolerance values for steelhead suitability can be refined.

Proposed CAP interim reference values for MWMT for the SCCC and SCC are: < 17 = Very Good, 17-22.5 = Good, 22.5-25 = Fair, >25.0 = Poor.

pH: The pH of water is the standard measure of its acid or alkaline condition and, while high pH can be directly stressful to salmonids, this metric is also useful for unmasking nutrient pollution that can affect steelhead; however, as discussed below, the combination of limited available data and natural geologically-driven variability precluded the use of pH as a CAP indicator.

Both acid (<6.5) or alkaline conditions (>8.5) can cause salmonid stress (Spence et al., 1996), but a pH of over 9.5 is lethal to salmonids (Wilkie and Wood, 1995). Prolonged exposure to pH levels of 8.5 or greater may exhaust the ion exchange capacity at gill membranes and lead to increased alkalinity in the bloodstream of salmonids (Wilkie and Wood 1995). If water temperatures are high (e.g. 25°C), then high pH may also cause conversion of ammonium ions to highly toxic dissolved ammonia (Goldman and Horn, 1983).

Point-source and non-point-source pollution can result in high nutrient concentration in streams, triggering excessive growth of algae and aquatic plants. This photosynthetic activity increases pH as OH- ions go into suspension as part of the associated chemical reactions. Thus, high pH is recognized as limiting water quality and suitability for fish life in water bodies that suffer from nutrient pollution (U.S. EPA, 2001). The Central Coastal (CCRWQCB, 1994), Los Angeles (LARWQCB, 1994), San Diego (SDRWQCB, 1994), and Santa Ana (SARWQCB, 1995) Regional Water Boards set maximum pH standard of 8.5 to maintain beneficial uses, including cold water fish species.

In South-Central and Southern California coastal watersheds pH is strongly influenced by geologic formations (many of which are dominated by poorly consolidated marine sediments which leech calcium carbonate and other alkaline compounds), and are therefore highly variable. For example, in a recent study of feeding habitats of *O. mykiss* (both resident and anadromous) in a South-Central Coast steelhead creek, the pH in two tributaries ranged from 8.6-8.8 and 8.5-8.6 without any apparently adverse affect on the native *O. mykiss* (Rundio 2008 in press). The lower portion of the study area was located within the University of California Landels-Hills Big Creek Reserve, and the upper portion in the Los Padres National Forest Ventana Wilderness Area and not subject to anthropogenic activities which would elevate pH. The reported pH values from this study all exceed the value of 8.5 in the noted by Wilkie and Wood (1995) as causing stress to salmonids. In another study of rearing juvenile steelhead in a Southern California steelhead river pH ranged from 7.7 to 8.0 and the fish exhibited elevated growth rates (Moore 1980). These site-specific studies point up the limitations of using standards derived from more northern or generalized (laboratory) studies of physical parameters for South-Central and Southern California steelhead.

Similar to temperature and dissolved oxygen, available data for pH in the SCCC and SCC are discrete field and laboratory measurements collected at varying times of day at a limited number of

14

KIER ASSOCIATES AND NATIONAL MARINE FISHERIES SERVICE: GUIDE TO THE REFERENCE VALUES USED IN THE SOUTH-CENTRAL AND SOUTHERN CALIFORNIA COAST CONSERVATION ACTION PLANNING WORKBOOK

locations. Due to hourly and seasonal variations in pH, existing samples may not adequately capture worst-case critical conditions. If longer term monitoring of pH in SCCC and SCC steelhead streams included automated probe data that measurements on a continuous basis, statistics like the moving 7-day average of daily maximum could aid greatly in understanding suitability for steelhead and the effects of upstream nutrient pollution.

An examination of available pH data in the SCCC and SCC showed that the combination of limited data and natural geologically-driven variability resulted in pH not being a useful indicator for diagnosing eutrophication. Hence, while the pH data remain in the Access database, they were excluded from the final version of the Kier Associates CAP workbooks.

Dissolved Oxygen (D.O.): Salmonids evolved in cold, oxygen-rich streams. The effects of low D.O. varies according to life history phase. Juvenile salmonid swimming capability diminishes at less than 7 mg/l of D.O. (Reiser and Bjornn, 1979). The egg is the most sensitive of all life stages and the NCRWQCB (2005) recommends 8 mg/l for egg development. A loss of 3 mg/l, however, between surface water and water in the redd is assumed. Therefore, the surface water standard during spawning periods ("SPAWN") is 11 mg/l. Low D.O. can be an indicator of a number of water quality impairments to water quality (e.g. nutrient loading, algal blooms, and elevated water temperatures) and can have a variety of direct adverse impacts on steelhead (Spence et al., 1996). The four Regional Water Board's have slightly varying standards for D.O. (Table 2) to protect steelhead and other cold water fish species.

Table 2. Dissolved oxygen standards from the four water quality control boards in the SCCC and SCC steelhead DPS watershed areas.

Region	D.O. Standard
Central Coast (CCWQCB, 1994)	7.0 mg/L coldwater fish rearing beneficial use ("COLD")
Los Angeles (LARWQCB, 1994)	7.0 mg/L supporting both COLD and spawning ("SPWN") beneficial use
Santa Ana (SARWCB, 1995)	6.0 mg/L for COLD beneficial use
San Diego (SDRWQCB, 1994)	6.0 mg/L for COLD beneficial use

Similar to pH, almost all dissolved oxygen data available for the SCCC and SCC DPS area is from grab samples and locations are likely in reaches recognized as impaired, not necessarily those inhabited by steelhead. Nocturnal and diurnal D.O. in water may fluctuate considerably in nutrient rich waters where photosynthesis is high, with D.O. supersaturated during the day and depressed as plants respire at night. Because grab samples are usually taken during the day, D.O. sags may not be detected. Low saturation during the day can be driven by biological oxygen demand (i.e. dying algae) or sediment oxygen demand. Matthews and Berg (1997) found waters of cold water springs to be naturally low in D.O. in Sespe Creek, an undisturbed SCC steelhead DPS control stream. While the use of automated continuously recording probes would increase the temporal resolution of the data, automated D.O. probes require frequent (i.e. approximately weekly) maintenance to prevent fouling.

Super-saturated D.O. is considered a sign of impairment because it reflects high photosynthetic rates. Consequently, D.O. percent saturation is used in the CAP, with reference values reflecting impairment when conditions indicate either low saturation or super-saturation. Ratings were adjusted after observing the frequency distribution in the draft SCCC and SCC workbooks.

Proposed CAP interim reference values dissolved oxygen (% deviation from saturation) for the SCCC and SCC are: <10% = Very Good, 10-14% = Good, 14-20% = Fair, and > 20% = Poor.

Nitrogen, Phosphorus, and Periphyton Chlorophyll a: Nutrients do not directly affect salmonids, but impact them indirectly by stimulating the growth of algae and aquatic macrophytes to nuisance levels that can adversely impact water quality (dissolved oxygen and pH) in streams as well as reducing living space for rearing juvenile steelhead or in extreme cases restrict the movement of adults. Excessive nutrient concentrations can be caused by point-source discharges such as the direct discharge of treated sewage into coastal rivers and streams, and/or by nonpoint-source discharges such as storm runoff from urban and agricultural areas.

The concentration of nutrients required to cause nuisance levels of periphyton varies widely from one stream to another (U.S. EPA, 2000c; Tetra Tech, 2004). Detailed data analyses are required to determine relationships. Due to uncertainties in nutrient-algal relationships and the complex and variable life history strategies of South-Central and Southern California steelhead, identifying a single reference value or a range of reference values for all streams in the large areas covered by the SCCC and SCC must rely on the exercise of professional judgment; the SCC and SCCC CAP reference values for nutrients (Table 1) are therefore based on a synthesis of the literature presented below.

The San Diego Regional Water Quality Control Board (1994) is the only regional board in Southern California to adopt criteria for nutrient concentrations in Southern California streams, stipulating that:

> "A desired goal in order to prevent plant nuisance in streams and other flowing waters appears to be 0.1 mg/l total P. These values are not to be exceeded more than 10% of the time unless studies of the specific water body in question clearly show that water quality objective changes are permissible and changes are approved by the Regional Board. Analogous threshold values have not been set for nitrogen compounds; however, natural ratios of nitrogen to phosphorus are to be determined by surveillance and monitoring and upheld. If data are lacking, a ratio of N:P = 10:1, on a weight to weight basis shall be used."

U.S. EPA (2000a, 2000b) has provided guidance regarding nutrient criteria (Tables 3,4). Most of the SCC and SCCC are located in the portion of U.S. EPA's Aggregated Ecoregion III (Xeric West), further classified as Level III Sub-Ecoregion 6 (Southern and Central California Chaparral and Oak Woodlands). The highest elevations areas of the SCC are located in the Level III Sub-Ecoregion 8 (Southern California Mountains) of Aggregated Ecoregion II (Western Forested Mountains). Using 25th percentiles, U.S. EPA (2000a) calculated reference conditions for the Level III Sub-Ecoregions in Aggregated Ecoregion II, and Level III Sub-Ecoregions in Aggregated Ecoregion III. EPA also calculated references conditions for the Aggregated Ecoregion II and III as a whole (Table 3) and Sub-Ecoregion 6 (Table 4); there were not enough data for Sub-Ecoregion 8 to adequately analyze.

Tetra Tech (2004) proposed a tiered approach where instead of establishing a single regional standard, three tiers are set:

> Tier I. Impacts unlikely (use is supported)
> Tier II. Probably sustaining (but potentially threatened)
> Tier III. Impacts likely (use is not supported or highly threatened)

Tier II waterbodies then need detailed data analysis to determine site-specific targets. Tetra Tech (2004) also provided draft criteria, presented as preliminary and not intended to be directly used for regulation (Table 5). Tetra Tech (2006), in an update to Tetra Tech (2004) renamed "tiers" as "beneficial use risk categories" and did not include exposure variables such as TP and TN in their recommendations.

Table 3. Reference conditions for nutrient-related parameters for streams in Sub-Ecoregions in Aggregated Ecoregions II and III, and references conditions for Aggregated Ecoregion II and III as a whole. From U.S. EPA (2000a, 2000b).

	Nutrient Ecoregion II		Nutrient Ecoregion III	
Nutrient Parameters	Aggregate Reference Conditions	Range of Level III Sub-Ecoregions Reference Conditions	Aggregate Reference Conditions	Range of Level III Sub-Ecoregions Reference Conditions
Total phosphorus (μg/L)	10.0 μg/L	3.0-32.5 μg/L	21.88 μg/L	10-55 μg/L
Total nitrogen (mg/L)	0.12 mg/L	0.0-0.53 mg/L	0.38 mg/L	0.22-0.90 mg/L
Chlorophyll *a*(μg/L) (Fluorometric method)	1.08 μg/L	0.7-2.95 μg/L	1.78 μg/L	1.78-4.85 μg/L

Table 4. Reference conditions for nutrient-related parameters for streams in Level III Sub-Ecoregion 6 (Southern and Central California Chaparral and Oak Woodlands) that comprises the majority of the SCCC and SCC are located. From U.S. EPA (2000b).

Parameter	No. of Streams N ++	Reported values		25thPercentiles based on all seasons data for the Decade
		Min	Max	P25-all seasons+
TN (mg/L) - calculated	NA	0.075	12.525	0.518
TN (mg/L) - reported	10	0.223	9.95	0.5
TP (μg/L)	23	2.5	3215.5	30

Due to limitations in spatial and temporal resolution, the nitrogen and phosphorous data in the SCCC and SCC steelhead DPS area may not adequately represent steelhead streams. The only source of nitrogen and phosphorus data utilized in the SCCC and SCC CAP is the California's Surface Water Ambient Monitoring Program (SWAMP), including the Central Coast Ambient Monitoring Program. Additional data sources examined but not utilized are:

1) Stein and Yoon (2007) (not sufficiently organized),
2) Monterey Bay National Marine Sanctuary (Conly, 2007) (total nitrogen and total phosphorus could not be calculated),
3) Santa Clara River (AMEC Earth & Environmental, 2006) (geographic coverage too small to justify time required to integrate data),

4) Friends of the Santa Clara River's Santa Clara River Watershed Monitoring Program (Bottorff and Robinson, 2007) (geographic coverage too small to justify time required to integrate data), and

5) Malibu Creek Watershed Monitoring Program (geographic coverage too small to justify time required to integrate data)

Better coordination between entities collecting nutrient related water quality data might provide more useful data for regional analysis, including suitability for steelhead.

There were some periphyton chlorophyll data available from the U.S. EPA's Environmental Monitoring and Assessment Program (EMAP), but the samples were collected during late spring and early summer; thus, they do not represent the peak annual biomass (expected to occur in late summer or early fall) and so cannot be rated according to the rules in Table 1. Hence, these data were included in the Access database but were excluded from the final CAP workbooks.

Table 5. Draft nutrient criteria for protecting the cold water beneficial use in streams. Tetra Tech (2004).

Parameter	Tier I Range	Tier II Range	Tier III Range	Rationale
Exposure variables				
Total Nitrogen (TN) (mg/l)	<0.5	0.5-2.0	>2.0	Background concentrations through modeling; data from Ecoregion 6; stream benthic chlorophyll model
Total Phosphorus (TP) (mg/l)	<0.05	0.05-0.2	>0.2	Background concentrations through modeling; Land-use nutrient relationships from Ecoregion 6; stream benthic chlorophyll model
Response Variables				
Benthic Chlorophyll a (mg/m^2)	<50	50-200	>200	Literature sources; Data from Regional Water Board 6
Planktonic Chlorophyll a (μg/l)	<10	10-20	>30	Literature sources

[1] The criterion continuous concentration (CCC) for ammonia at pH 8.5 and 26°C when early life stages of fish are present is selected as the Tier I/II boundary (value = 0.52 mg/L). Source: U.S. EPA 1999 Update of Ambient Water Quality Criteria for Ammonia.

[2] The criterion maximum concentration (CMC) for ammonia when salmonids are present is 5.62 mg/L at pH 8; because this is higher than the total nitrogen value, the total nitrogen concentration is proposed as the Tier II/III boundary. Source: U.S. EPA 1999 Update of Ambient Water Quality Criteria for Ammonia.

Ammonia: Ammonia is a nitrogen-containing compound that is toxic to fish; the degree of toxicity depends upon ammonia concentration, temperature, pH, and duration of exposure (U.S. EPA 1999). As pH and temperature increase, ammonia converts from ammonium ions to dissolved (unionized) ammonia that is lethal to salmonids at very low levels (e.g. 0.025 mg/l) (U.S. EPA, 1986).

Samples collected in the SCCC and SCC have detected occasional high concentrations in some watersheds (e.g. Santa Clara River, Santa Maria River, San Juan Creek, and Santa Ynez River) and the

State Water Resources Control Board is considering adopting new ammonia standards for the Santa Clara and San Gabriel Rivers.

U.S. EPA (1999) issued ambient water quality criteria for ammonia. The standard stipulates that when fish early life stages are present, the 30-day average concentration of total ammonia nitrogen (in mg N/L) should not exceed the CCC (chronic criterion) listed in a lookup table based on pH and temperature. For example, at pH 9.0 and temperature 26°C, ammonia concentration should not exceed 0.232 mg/L (see U.S. EPA 1999 for a complete table of values).

In an attempt to utilize ammonia standards in the SCCC and SCC CAP, the observed ammonia concentrations were expressed as a percent of the calculated CCC (based on temperature and pH at the time/place of collection of the ammonia sample). For instance, if the observed ammonia concentration is 0.4 mg/L and the CCC is 1.0 mg/L, then the observed is 40% of the CCC. Unfortunately, the spatial and temporal resolution of the data were not sufficient to provide useful comparisons between watersheds (median values for all populations were quite low). Ammonia data remain in the Access database, but were excluded from the boxplots and final CAP workbooks.

Floodplain Connectivity (USFS judgment): During periods of high flows, steelhead survival may depend on access to areas of lower velocity on terraces adjacent to the stream. Riparian forests, large downed trees or other structural elements on the flood plain historically formed areas with slow backwaters where steelhead juveniles and adults could find shelter until flows receded. Levee construction and diking have been used for more than a century to confine stream courses and protect agricultural development on historic floodplains. Velocities inside dikes and levees increase during high flow events and juvenile steelhead may be flushed into the ocean prematurely, limiting their chances of survival. Juvenile or adult steelhead displaced by high flows outside the confines of a diked or levied channel would likely be unable to find their way back to the stream course when flood waters receded and would not likely survive.

There are no data regarding floodplain connectivity that cover the entire SCCC and SCC steelhead DPS area; however, the USFS (2000) Region 5 watershed assessment provided professional judgment ranking of floodplain connectivity for analytical watersheds in several National Forests that overlap with the SCCC and SCC DPS areas (Figure 3). Scores are based on professional judgment, but the staff that did the ranking have extensive experience as professional staff biologists and their criteria are similar to regional standards (e.g. USFS, 1995; Spence et al., 1996). Note that in many cases, the boundaries of the analytical watersheds (Figure 3) for which USFS (2000) provided professional judgment rankings are not the same as the boundaries of the steelhead populations (Figure 1). The USFS analytical watersheds only cover the upper portions of some large river basins such as the Salinas, San Gabriel, Los Angeles, and Santa Ana. In these areas, CAP results must be interpreted cautiously because the USFS judgment indicators pertain only to the more ecologically intact areas of the upper watersheds, not the lowlands that are heavily impacted by urbanization and agricultural land use.

The USFS considers channel condition to be Properly Functioning when more than 80 percent of the low gradient response reaches have floodplain connectivity, while 50-80 percent was considered Partially Functional and less than 50 percent Non-Functional. This three-category system required adaptation to the four-category system use in the CAP.

Proposed CAP interim reference values for floodplain connectivity for the SCCC and SCC are: Fully Functional = Very Good, Functional At Risk = Fair, and Impaired = Poor.

KIER ASSOCIATES AND NATIONAL MARINE FISHERIES SERVICE: GUIDE TO THE REFERENCE VALUES USED IN THE SOUTH-CENTRAL AND SOUTHERN CALIFORNIA COAST CONSERVATION ACTION PLANNING WORKBOOK

19

Water Quantity/Flow Regime (USFS judgment): The USFS (2000) Region 5 watershed assessment provided professional judgment ranking of water quantity and flow regime, according "Unaltered status to streams with unaltered flows, "Partially Altered" status to streams where base flows and peak flows are unaltered but "mid-range discharges may impair aquatic habitat availability and "Altered" to streams with "peak flows and low flows significantly departing from a natural hydrograph" and "resulting in changes to channel morphology Ranking is similar to that described above for floodplain connectivity."

Proposed CAP interim reference values for water quantity/flow regime for the SCCC and SCC are: Fully Functional = Very Good, Partially Functional = Fair, Impaired = Poor.

Stream Corridor Vegetation (USFS judgment): The USFS (2000) Region 5 watershed assessment provided professional judgment ranking of stream corridor vegetation, which they defined as "All streams including the adjacent land that has vegetation that has the potential to directly contribute woody debris to a stream course or meadow system."

USFS (2005) rated >25% disturbance or change as Impaired, 10-25% disturbed as Functioning At-risk, and <10% as Properly Functioning and CAP scores are scaled from these ratings.

Proposed CAP interim reference values for stream corridor vegetation for the SCCC and SCC are: < 10% = Very Good, 10-25% = Fair, and >25% = Poor.
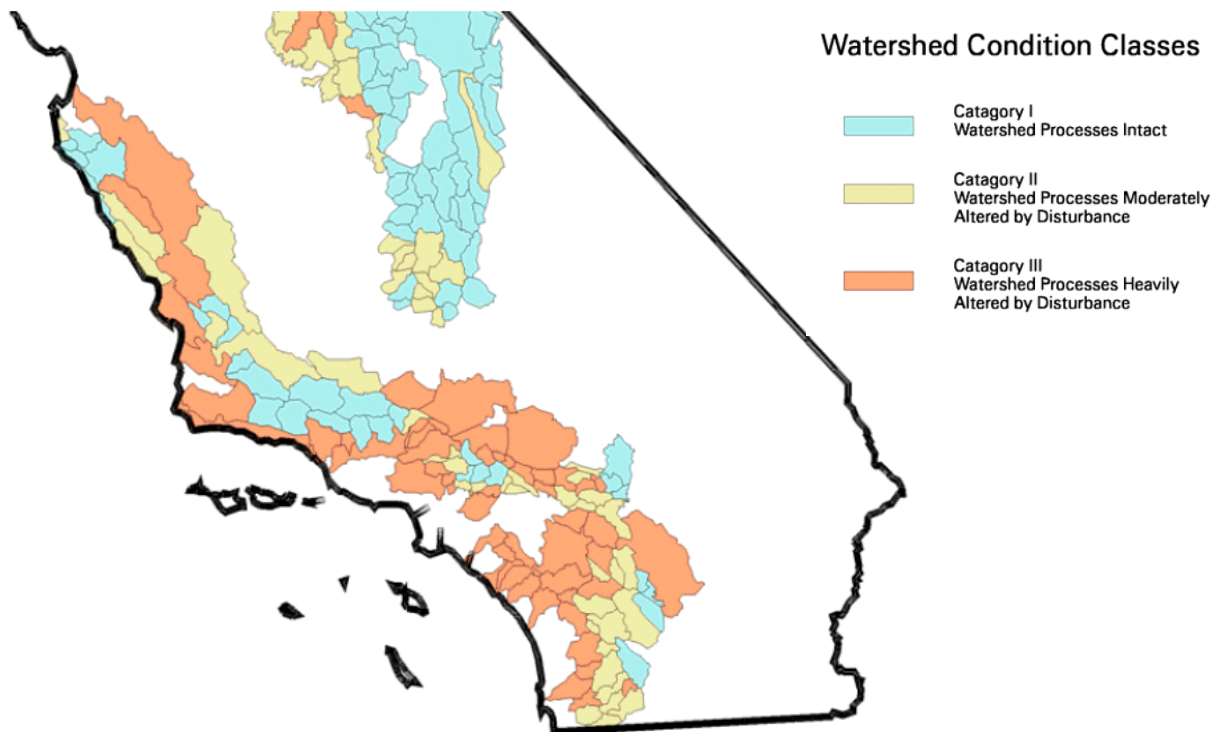

Figure 3. USFS Region 5 watershed analysis ratings for the SCCC and SCC DPS areas. Map is cropped to show only the south-central and southern California area (from Figure 2 in USFS, 2000).

SOURCES OF STRESS

> "Aquatic habitats critical to salmonids are the product of processes acting throughout watersheds and particularly within riparian areas along streams and rivers….Salmonid conservation can be achieved only by maintaining and restoring these processes and their natural rates."   (Spence et al., 1996)

Factors that pose a risk to salmonid habitat are referred to in the CAP as Threats or Sources of Stress. To avoid confusion with a specific regulatory definition of "threats" under the Endangered Species Act, we refer to them here as Sources of Stress. The Source of Stress reference values for the SCCC and SCC CAP presented below are not regulatory targets. They should be considered indices of risk associated with the pattern and extent of watershed disturbance and land use activities. The further the flow regime, range of forest age, the amount of compacted watershed area or exposed soil areas are from the natural range of variability, the greater the likelihood of negative impacts to steelhead trout habitat (Spence et al., 1996). Southern California steelhead studies confirm for example, that there is a high correlation between blockage of fish passage in a watershed and the extirpation of populations within the SCC and SCCC DPS (Boughton et al., 2005).

There are some potentially critical Sources of Stress for which there are no data or for which data are sparse. Other data reflect different methods of survey and are, therefore, not comparable across the region. Table 5 contains a summary of references for Sources of Stress values used to shape summary values in the SCCC and SCC CAP. Table 6 illustrates the Stresses that each Sources of Stress interacts with and Table 7 shows the Stresses that apply to each Target (life-stage).

Table 5. Sources of Stress references used in the SCCC and SCC CAP databases.

Source of Stress	Low	Medium	High	Very High
Dams/Diversions (Hydrologic)(Reservoirs storage as % of precipitation)	0	0-10	10-40	>40
Dams/Diversions (Barriers)(relative % of inaccessible area due to dams)	<25%	25-50%	50-75%	>75%
Roads (Barriers)(relative % of inaccessible area due to roads)	<25%	25-50%	50-75%	>75%
Road Density	<1.6 mi/mi²	1.6-2.5 mi/mi²	2.5-3.0 mi/mi²	>3.0 mi/mi²
Near-Stream Road density (within 90 m of streams)	<0.1 mi/mi²	0.1-0.5 mi/mi²	0.5-1 mi/mi²	>1 mi/mi²
Road Stream Crossings	0	0-1 xings/mi	1-2 xings/mi	>2 xings/mi.
Total Impervious Area (% of watershed area)	<5%	5-10%	10-25%	>25%
Agriculture (% of watershed)	<2%	2-5%	5-10%	>10%
Fire (% watershed burned in last 25 years)	<10%	10-15%	15-20%	>20%
Mining/Gravel Extraction (acres of gravel bar disturbed)	0	0.01-100	100-250	>250
Channelization/Diking	Low	Medium	High	Very High

Table 6. Matrix showing the Stresses that each Sources of Stress interacts with in the SCCC and SCC CAP databases.

Source of Stress	Barriers	Degraded Estuarine Function	Lack of Floodplain and Channel Structure	Altered Hydrologic Function	Degraded Riparian Forest Conditions	Altered Sediment Supply	Impaired Water Quality
Agricultural practices		X	X	X	X	X	X
Channelization/ diking*	X	X	X	X	X	X	X
Dams/Diversions (Barriers)	X						
Dams/Diversions (Hydrologic)		X	X	X	X	X	X
Mining/Gravel Extraction	X	X	X	X	X	X	X
Roads (Barriers)	X						
Roads (Combined)		X	X	X	X	X	X
Urban/Residential /Industrial		X	X	X	X	X	X
Fire (% watershed burned)		X	X	X	X	X	X

Table 7. Matrix showing the Stresses that apply to each Target (life-stage) in the SCCC and SCC CAP databases.

Target	Barriers	Degraded Estuarine Function	Lack of Floodplain and Channel Structure	Altered Hydrologic Function	Degraded Riparian Forest Conditions	Altered Sediment Supply	Impaired Water Quality
Egg				X		X	X
Fry	X		X	X	X	X	X
Juvenile	X	X	X	X	X	X	X
Smolt	X	X	X	X	X	X	X
Adult	X	X	X	X	X	X	X

Dams/Diversions (Hydrologic)

Potential hydrologic impacts due to reservoirs were assessed by calculating the total storage volume of reservoirs in a watershed as a percent of total annual precipitation volume in that watershed. This same metric is also being used as an Indicator, as described above in more detail.

There are currently no available comprehensive region-wide data for diversions or groundwater extractions, so these hydrologic impacts cannot be quantitatively assessed at this time. Because surface diversions and groundwater extractions represent significant Sources of Stress in some watersheds, the metric does not capture the full extent of hydrologic impacts resulting from water developments.

Proposed CAP interim reference values for dams/diversion (hydrologic) for the SCCC and SCC are: Low =0%, Medium = 0-10%, High = 10- 40%, Very High= >40%.

Dams/Diversions (Barriers) and Roads (Barriers)

As noted above in the discussions of Indicators, the statewide Passage Assessment Database (PAD) will be used to calculate the percent of each steelhead populations' watershed that is inaccessible due to complete barriers. The *total percent* of accessible area will be used as the Indicator "Fish Passage (% of Area Accessible)", while the individual *relative* contributions of the dams and roads to that total percent will be used as metrics to quantify the Sources of Stress "Dams/diversions (barriers)" and "Roads (barriers)".

Proposed CAP interim reference values for dams/diversions (barriers) and roads (barriers) for the SCCC and SCC are: < 25% = Low, 25-50% = Medium, 50-75% = High, and 75-100% = Very High.

For example, if 90% of the watershed is accessible (10% inaccessible), the Indicator "Fish Passage (% of Area Accessible)" would rate as Good. If one third (33%) of that inaccessible area is due to roads and two-thirds (67%) is due to dams, then the source of stress rating for Dams/Diversions (Barriers) would be Medium and Roads (Barriers) would both be High.

Road Density: Roads near streams contribute chronic surface erosion and failed road crossings or segments may trigger landslides that contribute catastrophic amounts of sediment to streams (Hagans et al., 1986). Roads also change the flow regime within a watershed, increasing peak flows and decreasing summer base flows (Jones and Grant, 1996). Harr and Nichols (1990) found that sediment from road failures during large storm events could be substantially reduced if abandoned roads were decommissioned, including removing road crossings.

Regional studies from the interior Columbia River basin (USFS, 1996) show that bull trout do not occur in watersheds with more than 1.7 mi/mi^2. The road density ranking system shown in Figure 4 was developed based on the Columbia basin findings. To limit cumulative effects from roads, Armentrout et al. (1998) proposed a limit of 2.5 miles of road per square mile of watershed (mi./mi.^{2}) for watersheds harboring anadromous fish on Lassen National Forest. As part of a Biological Opinion to protect Pacific salmon species, NMFS (1995) required that road mileage be reduced with an emphasis on "road closure, obliteration, and re-vegetation" where road densities exceeded two miles per square mile on USFS and BLM land in the interior Columbia River basin.

NMFS (1996b) provisional guidelines for salmon habitat characterize watersheds with road densities greater than three miles of road per square mile of watershed area (mi/sq mi) as "not properly functioning" while "properly functioning condition" was defined as less than or equal to two miles per square mile, with few or no streamside roads.

Although there are no studies specific to southern California that document relationships between roads and degradation of steelhead streams, the widespread occurrence of erodible sandstone formations in the region make it likely that roads increase sediment supply.

The 2006 TIGER (Topologically Integrated Geographic Encoding and Referencing) data from the U.S. Census Bureau is the best roads data that covers the entire SCCC and SCC region, substantially improved from the 1:100,000 scale year 2000 version of TIGER; its accuracy is sufficient for use in the CAP. These maps tend to better represent roads associated with urban areas and have poorer coverage of rural ranch or logging roads. An assimilation effort to join together all southern

California 1:24,000 scale roads data is needed to improve the accuracy of mapping data used for management decisions.

Proposed CAP interim reference values road density for the SCCC and SCC are: <1.6 mi/sq mi = Low, 1.6-2.5 mi/sq mi = Medium, 2.5-3.0 mi/sq mi = High and >3.0 mi/sq mi = Very High.
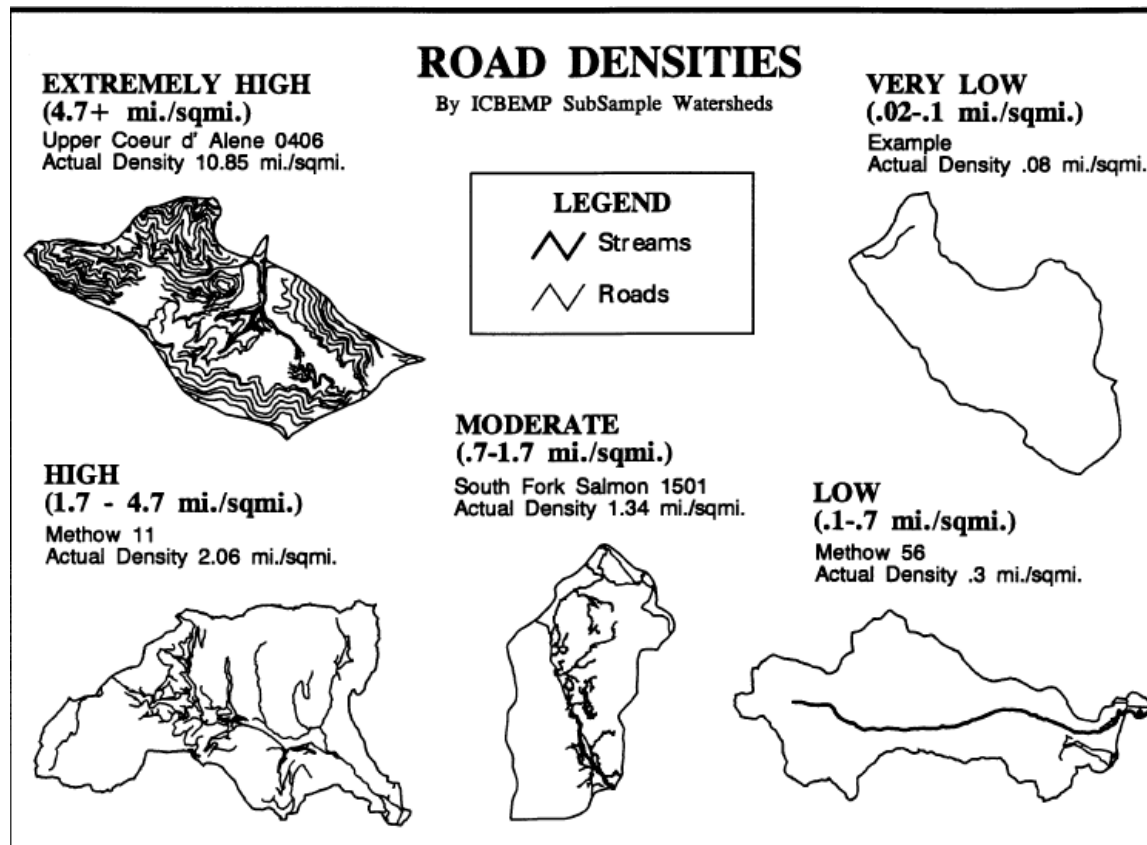

Figure 4. Graphic from Interior Columbia Basin Management Plan (USFS, 1996).

Near-Stream Road Density: Roads constructed within the riparian buffer zone pose the greatest risks to steelhead trout habitat due to loss of shade, decreased large wood recruitment, initiation of mass wasting, and delivery of fine sediment and other pollutants (Spence et al., 1996). Rock revetments are often used to prevent streams from eroding road beds, resulting in channel confinement that can lead to incision of the stream bed.

Near-stream roads were calculated as road miles in the buffer (90 m) per square miles of watershed area. Reference values were derived in the pilot phase of the SONCC CAP project (Kier Associates and NMFS, 2007)

Proposed CAP interim reference values near-stream road density for the SCCC and SCC are: Low = <0.1 mi/sq mi, 0.1-0.5 mi./sq mi. = Medium, 0.5-1 mi/sq mi = High, and >1 mi/sq mi = Very High. .

Road-Stream Crossings: Hagans et al. (1986) found that road crossing failure was the largest source of sediment in northwestern California streams. In southern California, road stream crossings at low elevation also often directly impede fish passage (Stoecker and Conception Coast Project, 2002; Stoecker and Stoecker, 2003; Stoecker and Kelly, 2005; CA Coastal Conservancy,

2004; Cachuma RCD & Carpentaria CWA, 2005; Stoecker Ecological, 2005; Love and Stoecker, 2007). Armentrout et al. (1998) recommended limiting the number of road-stream crossings to reduce cumulative effects damage from major storms to fewer than 1.5 crossings per mile of stream. This reference is used for calculating CAP scores, but a single crossing that blocks access to a refugia or patch of functional steelhead habitat can be a critical limiting factor to an individual population.

Proposed CAP interim reference values for road-stream crossings for the SCCC and SCC are: 0 xings/mi = Low, 0-1 xings/mi = Medium, 1-2 xings/mi = High, and 2 xings/mi = Very High.

Agriculture: Irrigated agriculture and livestock grazing can negatively impact steelhead trout habitat (NMFS, 1996a). The extent of agricultural land use can be assessed using the National Land Cover Database 2001 (Homer et al., 2004). The CAP uses the combination of two land use categories to represent agriculture: Pasture/Hay and Cultivated Crops. The Grassland/Herbaceous category was not used, as there is no way to know whether such lands are grazed. The rating within the CAP is based on the percentage of watershed area that is being used for agricultural activities. These proposed values are based on a frequency distribution of data from the SONCC CAP (Kier Associates and NMFS, 2007).

The proposed reference values for agriculture (as % of watershed area) for the SCCC and SCC CAP are <2% = Low, 2-5% = Medium, 5-10% = High and >10% = Very High.

The percent slope upon which agriculture occurs can alter significantly the degree and the type of impact. For example, avocados trees are often planted on steep terrain and may contribute to surface erosion regionally. On level ground, agricultural activities near streams are typically assumed to have more negative effects on streams than agriculture further away from streams due to the potential for stream channelization, clearing of riparian vegetation, and increased erosion. In the future, more sophisticated GIS analyses that are beyond the current scope of the project could be used to assess these impacts, resulting in a more comprehensive and accurate assessment of agricultural impacts.

The percent of a 90-meter buffer of streams that managed for agriculture was considered for use in the SCCC and SCC CAP, but upon close examination of the data it was discovered that the high-resolution National Hydrologic Dataset (NHD) substantially under-represented streams in major agricultural valleys (especially the Salinas). Consequently, this metric was deemed too unreliable and excluded from the final CAP workbooks (though the data are still included in the Access database).

Total Impervious Area (Urban, Residential & Industrial Development): Urban and suburban developments cause profound changes to natural watershed conditions by altering the terrain, modifying the vegetation and soil characteristics, and introducing pavement, buildings, drainage, and flood control infrastructure (Spence et al., 1996). Reported impacts include increased frequency of flooding and peak flow volumes, decreased base flow, increased sediment loadings, changes in stream morphology, increased organic and inorganic loadings, increased stream temperature, and loss of aquatic/riparian habitat (May et al, 1996).

The magnitude of peak flow and pollution increases with total impervious area (TIA) (e.g. rooftops, streets, parking lots, sidewalks, etc.). Spence et al. (1996) recognized that channel damage from urbanization is clearly recognizable when TIA exceeds 10%. Reduced fish abundance, fish habitat quality and macroinvertebrate diversity occur with TIA levels from 7-12% (Klein, 1979; Shaver et al., 1995). May et al. (1996) showed almost a complete simplification of stream channels as TIA

approached 30% and measured substantially increased levels of toxic stormwater runoff in watersheds with greater than 40% TIA.

The SCCC and SCC CAP use TIA data from the National Land Cover Database 2001 (Homer et al., 2004) as the Source metric for urban, residential and industrial impacts. CAP thresholds for TIA are based on May et al. (1996) and Spence et al. (1996)(Table 5). Figure 5 shows percent impervious by steelhead population.

Proposed CAP interim reference values for total impervious area for the SCCC and SCC are: <5% = Low, 5-10% = Medium, 10-25% = High, and >25% = Very High

Gravel Mining: In-stream sand and gravel mining can have many physical and biological impacts in river and streams (Laird et al. 2000). Gravel extraction can substantially reduce material that would otherwise be available as bedload. The extraction lowers the elevation of the stream bed and headward erosion may occur. Rivers also use bedload to build terraces and focus the energy of the stream, which helps to scour out corner pools in alluvial reaches (McBain and Leopold, 1995). Removing gravel from a stream tends to flatten stream profile both upstream and downstream of the site of extraction, decreasing water depth and exposing the stream to warming (Brown et al., 1998; Pauley et al., 1989; Woodward and Clyde, 1980). Brown et al. (1998) studied Tennessee streams impacted by gravel mining and found that pools decreased, riffles turned to glides, and turbidity during high flows increased.

All of these physical changes have consequences for salmonids and other aquatic biota (Spence et al., 1996). Studies in Alaska and Tennessee found that gravel mining decreased macroinvertebrate and fish biomass and diversity (Woodward-Clyde, 1980; Brown et al., 1998). Channel braiding and reduced depth due to mining can sometimes block salmonid migration (Woodward-Clyde, 1980; Pauley et al., 1989), occasionally even drying up surface flow in mined reaches (Woodward-Clyde, 1980).

Laird et al. (2000) evaluated the effects of gravel mining on north coastal and central coast California streams and concluded that the only way to stop gravel mining impacts to salmonid habitat was to exclude extraction from the river corridor. NMFS (2004) summarizes the effects of gravel mining and provides guidance regarding how NMFS staff should evaluate gravel removal projects. Although effects of gravel mining specifically on SCCC and SCC steelhead populations are not well studied, river processes changes in response to gravel mining are similar regardless of geographic locale.

The California Department of Conservation, Office of Mine Reclamation (OMR) maintains a database of mining operations across the state that includes a variety of information about each mine, including the commodity produced, mining method, acres disturbed, and geographic coordinates. Data are self reported by mine operators and not verified by OMR, so accuracy is unknown; however, the dataset is the only available region-wide information.

The metric selected to represent potential mining impacts to steelhead habitat in the SCC and SCCC CAP was the total acres in each steelhead population disturbed by mines of type "streambed or gravel bar skimming and pitting."

Proposed CAP interim reference values for Mining/Gravel Extraction (acres of gravel bar disturbed) for the SCCC and SCC are: 0 = Low, 0.01-100 = Medium, 100-250 = High, and >250 = Very High.
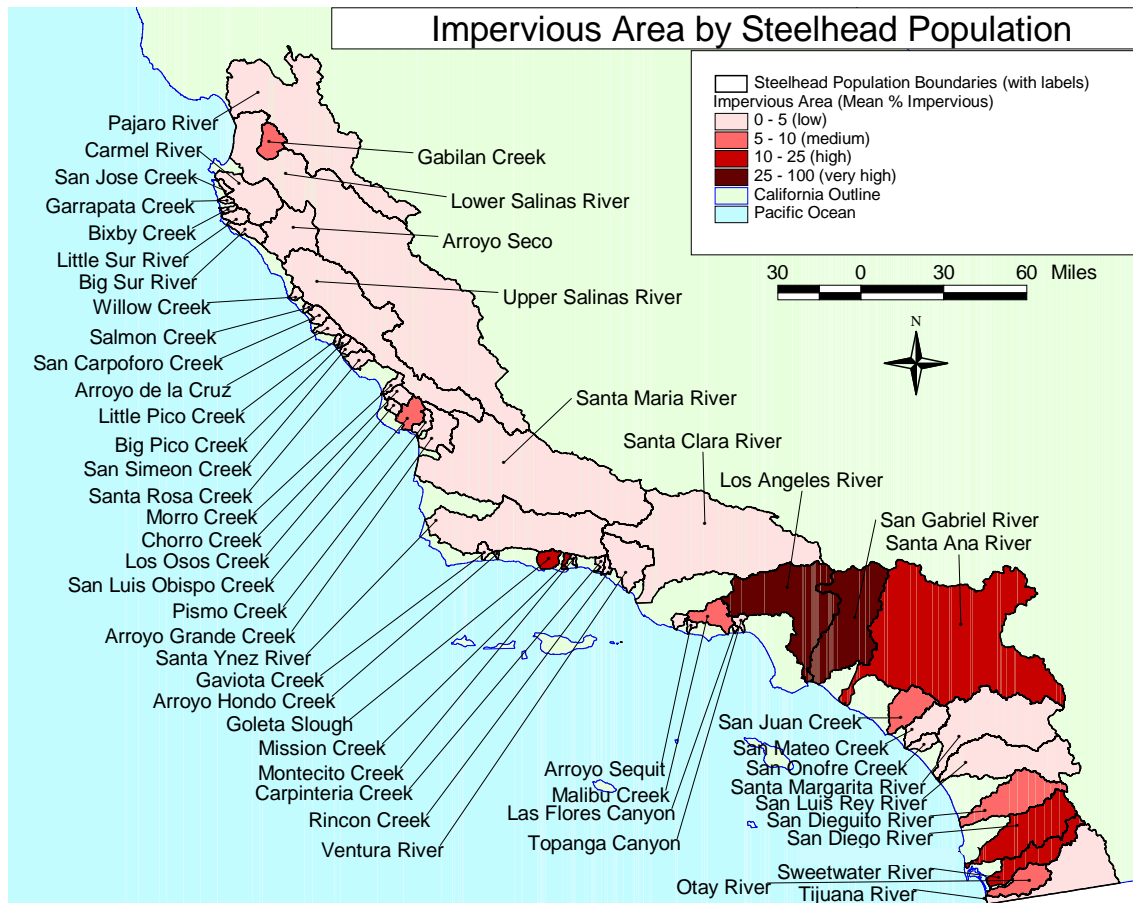
Figure 5. Map showing percent imperviousness for each population in the SCCC and SCC. Data are based on 30x30 meter pixels (Homer et al, 2004), summarized for each Calwater Planning Watershed in the project area using GIS, and then summarized to steelhead population level by aggregating Calwater Planning Watersheds.

Wildfire: Because of the Mediterranean climate of most of the SCCC and SCC DPS geographic area, the fire cycle can be relatively short (<45 years) and intensity of fire high (Sugihara, et al 2006). Boughton et al. (2006) made the following observations regarding fire regimes in the region:

> "The fire regime is the long term pattern of wildfire occurrence for a particular type of ecosystem. It is conveniently characterized in terms of three descriptors (Agee 1993): mean fire size; mean fire return time (the mean time between burnings at a particular point in the landscape); and fire intensity. Fire intensity is typically high in our study area, with wildfires burning the shrubland "canopy" as well as the ground vegetation (grasses and forbs). The shrubs are often highly flammable and burn very hot, removing most of the live vegetation. However, most of the plant species are fire-adapted and resprout or produce seedlings within a year or two after a fire. Some are indeed fire-dependent."

Hotter fires consume organic matter that binds soils, leading to an increase in erosion potential, or in the worst case can volatilize minerals in the soil causing it to become hydrophobic (Wells, 1985). Higgins (1992) noted that soils became hydrophobic in San Mateo Creek after an intense wildfire, depositing more than a foot of sediment in pools surveyed. High recurrence intervals fires in coniferous forests in the SCCC and SCC may cause conversion to chaparral, which can greatly alter hydrologic conditions. Further south, chaparral and coastal stage scrub regimes exposed to repeated

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27

intense fires may be converted to grasslands, resulting in increased potential for chronic sediment yield.

Spina and Tormey (2000) found that sedimentation following fires in the lower Malibu Creek watershed was light. Fire intensity varied, riparian zones and root systems were not destroyed, and rainfall intensity following the fire was low. Florsheim, et al. (1989) reported heavy sedimentation in the north fork of Matilija Creek after the 1985 Wheeler Fire, but rapid flushing of sediments and recovery of the geomorphology of the creek following subsequent rainfall and runoff events. Davis et al. (1988) also reported relative rapid recovery of the riparian zone following the 1985 Wheeler Fire.

Data for fires in the SCC and SCCC DPS geographic area are available from the California Department of Forestry and Fire Protection (CDF) for the years 1950-2006. The dataset is composed of fire perimeters with limited attributes such as year and cause, but does not include information regarding fire intensity. The data do not include the massive fires that occurred in the year 2007, and thus underestimate the extent of area burned. The 2007 fires burned over 750,000 acres[3].

A filter was placed on the fire perimeter data to select for events in only the last 25 years (1981-2006) because of revegetation that would be expected to occur in that period, and the percent of each watershed burned was calculated and rated according to rules in Table 5. This temporal window may need revisiting given the observation of Winter (2000):

> "Observations of post-fire recovery after the Warner Fire, which burned 3,000 acres in 1995, the Ortega Fire, which burned 10,000 acres of the Cleveland National Forest in 1993, and of recovery from the Vail Fire which burned 10,000 acres on the Palomar Ranger District in 1989, indicate that recovery of herbaceous vegetation after fire is rapid and abundant. Cover values of 70% or greater were observed during the spring following the fire, even in areas where the burn intensity was high."

CDF also produces a GIS layer entitled Post-fire Erosion Potential. Since erosion from denuded slopes is the most likely impact to steelhead habitat, post-fire erosion potential could potentially be used in conjunction with the fire perimeter data to obtain a more refined measure of wildfire impacts to steelhead habitat. Post-fire erosion potential was unavailable in a suitable format for inclusion into the SCCC and SCC CAP.

Proposed CAP interim reference values for Fire (% watershed burned) for the SCCC and SCC are: <10% = Low, 10-15%= Medium, 15-20% = High, and >20% = Very High

Channelization/Diking: Channelization and diking alter stream channels by reducing sinuosity and habitat complexity, resulting in the degradation of steelhead rearing and spawning habitat. An overview of the effects of channelization and diking is contained in the section above regarding the indicator Floodplain Connectivity, so will not be repeated here.

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[3] Details from October 28, 2007 LA Times article: Zaca Fire (Santa Barbara/Ventura County): 250,000+ acres; Castaic, Aqua Dulce and Santa Clarita Fires (Northern Los Angeles County): 104,146+ acres; Martin Ranch, Cajon, Grass Valley Slide Fires (San Bernardino County): 14,319+ acres; Santiago, Rosa Fire (Orange County): 27,521+ acres; Witch, Rice, Ammo, Wilcox, Poomacha Fires (Northern San Diego County): 275,018+ acres, Harris Fire (Southern San Diego County): 86,500+ acres.

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28

No suitable existing regional data were available for quantifying the extent of channelization and diking across the SCCC and SCC steelhead DPS area so NMFS staff provided professional judgment values for each of the Kier Associates CAP workbooks. NMFS staff used reports, electronic maps, paper maps and aerial photos to assign a channelization/diking rating (low, medium, high, very high) for each steelhead population. See Appendix B for NMFS notes regarding justifications for channelization/diking ratings.

SCCC AND SCC CAP ONLY ONE TOOL FOR RECOVERY PLANNING

Because data for Indicators and Sources of Stress in the Kier Associates CAP are not comprehensive, NMFS staff is using a more extensive knowledge base to assess threats to steelhead populations and their habitats and is constructing a parallel CAP project based on professional judgment (Hunt, in Preparation). The Kier Associates SCCC and SCC CAP application provided a useful tool to check the array of data regionally to test assumptions and to assess patterns in data across the region using the data management system recently developed for SONCC coho salmon recovery plan support. As regional data are improved, the Kier Associates custom Access database and associated scripts can provide an efficient way to organize and readily update a wide variety of information across a large and diverse landscape. It can provide important insight for NMFS, other agencies, and interested stakeholders regarding steelhead population recovery and abatement of water pollution over time.

COORDINATING DATA COLLECTION AND SHARING CAN DECREASE COSTS AND IMPROVE RESULTS

Although data on streams and watersheds at the southern extent of the steelhead's range in North America in the SCCC and SCC steelhead DPS watersheds are increasing, there are significant data gaps concerning the suitability of freshwater habitat conditions. For example:

- There are no quantitative measures of fine sediment in spawning gravels or pools (McNeil and Ahnell, 1964; Hilton and Lisle, 1992).
- Median stream bed particle size has been used in assessing northern California stream health (Knopp, 1993), but similar data for southern California streams are lacking.
- Turbidity is a widely recognized stressor on salmonids (Sigler et al., 1984; Newcombe and McDonald, 1991), but there are few if any useful turbidity datasets for SCC and SCCC DPS watersheds.
- Southern California steelhead water temperature tolerance has been studied recently (Tobias, 2006; Boughton et al., 2007; Spina, 2007), but continuously (i.e. hourly) recorded temperature data is needed for SCCC and SCC steelhead streams.
- The lack of flow data and information on groundwater pumping and effects on steelhead are also critical gaps.

In the longer term, NMFS should coordinate with water quality agencies to fill these data gaps. Steelhead are recognized as cold water (COLD) beneficial uses of these water bodies under the Clean Water Act and their spawning habitat is afforded similar protection (SPAWN). The SCCC and SCC geographic areas are experiencing high rates of human population growth and development that make water quality preservation challenging. Attention of water quality authorities is often directed toward highly impacted streams suffering from side effects of urbanization, not on those relatively healthy streams that still support steelhead.

KIER ASSOCIATES AND NATIONAL MARINE FISHERIES SERVICE: GUIDE TO THE REFERENCE VALUES USED IN THE SOUTH-CENTRAL AND SOUTHERN CALIFORNIA COAST CONSERVATION ACTION PLANNING WORKBOOK

29

Listing of southern California steelhead under the Endangered Species Act has raised awareness among water quality agencies of the need to direct more attention to protection of these fish. This offers NMFS the opportunity to work cooperatively with Water Board staff to fill critical data gaps regarding suitability of stream habitat for steelhead in the SCCC and SCC regions. Cost efficiency of monitoring can be greatly improved if NMFS staff use water quality data to gauge steelhead habitat trends and water quality staff increase understanding and use of fish data.

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35

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