APPENDIX A

Glossary and Abbreviations

Acclimation
Gradual physiological adjustment in response to relatively long-term environmental changes.

Acidification
Ocean acidification is the process by which CO_2 is dissolved in seawater resulting in an increase in hydrogen ion (H+) concentration, and a corresponding decrease in the ocean's pH.

Acid Rain
Precipitation which contains sulfate aerosols consisting of sulfuric acid, derived from industrial and other emissions.

Age Class
Individuals in a population of the same age. In Pacific salmonids, an individual of less than one year is referred to a 0+ age class; a fish older than one, but less than two years, is termed a 1+ age class fish, etc.

Adaptation
The evolutionary process, whereby populations become better suited to deal with their physical and biological environments, and therefore to survive and reproduce. It is driven by a host of factors including population diversity (genetic, phenotypic, physiological, and behavioral), inter and intra-specific competition, natural selection, and genetic processes.

Adaptive Trait
Any specific physical, physiological, or behavioral trait of an organism that promotes the likelihood of an organism's survival and reproduction in a particular environment.

Adipose fin
Small fin located composed of fatty tissue on the top-side of a fish between the dorsal and caudal fin.

Adiabatic
Insulated from the surroundings, unable to gain or lose heat from the environment.

Albedo
The fraction of incoming solar radiation that is reflected back to space without being absorbed.

Allele
One of two or more forms of a gene. Sometimes, different alleles can result in different physical or physiological traits. Other times, different alleles will have the same result in the expression of a gene.

Allele Frequency
The relative proportion of all copies of a particular gene variant (allele) among the chromosomes carried by an individual of a population. In population genetics, allele frequencies are used to depict the amount of genetic diversity at the individual, population, and species level.

Alevins
Newly hatched salmon or trout with a visible yolk sac, usually still maturing while still in the redd.

Anadromous
A life history cycle that involves reproducing in freshwater, maturing in marine waters, and returning to freshwater to reproduce.

Anadromous Fraction
The proportion of a heterogeneous *O. mykiss* population that exhibits an anadromous life history, as opposed to the freshwater-resident life history.

Anadromous Waters
Water bodies typically accessible to fish migrating from the ocean, including estuaries, rivers, and lakes.

Anal fin
Fin located on the near the rear, and on the bottom side; used for stability when swimming.

Baseline
A set of reference data sets or analyses use for comparative purposes; it can be based on a reference year or a reference set of standard conditions.

Bayesian
A formal statistical approach in which expert knowledge or beliefs are analyzed together with data. Bayesian methods make explicit use of probability for quantifying uncertainty, and are used in decision making.

Benthic
A habitat or organism found on the stream, lake or ocean bottom.

Biological Diversity
The range of in a range of characteristics within an ecosystem or taxonomic group, including genetic, phenotypic and physiological variability of individuals, and life history strategies, age structure and fecundity of populations.

Bootstrap
A statistical methodology use to quantify the uncertainty associated with estimates obtained from a model. The bootstrap is often based on Monte Carlo resampling of residual form the initial model fit.

Brackish Water
Water that has more salinity than fresh water, but not as much as seawater. It may result from mixing of seawater with fresh water, as in estuaries, or it may occur in brackish fossil aquifers. Technically, brackish water contains between 0.5 and 30 grams of salt per liter—more often expressed as 0.5 to 30 parts per thousand (ppt or ‰). Thus, *brackish* covers a range of salinity regimes and is not a precisely defined condition. By comparison, average, seawater in the world's oceans has a salinity of about 35 ppt.

Brood Stock
Sexually mature individuals used within a hatchery or other controlled environment for breeding purposes.

Carnivore
An organism or species that derives its energy and nutrient requirements from a dies consisting mainly or exclusively of animal tissue, whether through predation or savaging. Animals that depend solely on animal flesh for their nutrient requirements are considered obligate carnivores while those that also consume non-animal food are considered facultative carnivores.

Carrying Capacity
The maximum population of a species that an area or specific ecosystem can support indefinitely without deterioration of the character and quality of the resources. It can also refer to the maximum level of recreational use, in term of numbers of people and type of activity, which can be accommodated before ecological value of the area declines.

Catadromous
A life history cycle that involves reproducing in saltwater, maturing in freshwater, and returning to saltwater to reproduce.

Caudal fin
Tail fin, usually with distinct rays; used principally for propulsion and turning.

Climate
The average prevailing conditions in the atmosphere (air temperature, wind speed and direction, humidity, precipitation, etc.) based upon a series of years.

Coded-wire Tag
Coded-wire tags are small pieces of stainless steel wire that are injected into the snouts of juvenile salmon and steelhead. Each tag is etched with a binary code that identifies its time and place of release.

Coefficient of Variation (CV)
The standard error of a statistic, divided by its point estimate. The CV gives an idea of the precision of an estimate, independent of its magnitude.

Competition
Interaction of individual organisms that occupy or share some part of an ecological niche such that both depend upon the same food source, shelter, or some other resource in the same community; competition may be between individuals of the same or different species.

Cohort
A group of fish generated during the same spawning season, and is part of the same age class.

Confidence Interval (CI)
The probability, based on statistics, that a number will be between and upper and lower bound.

Conspecific
Two or more individuals, populations, or other higher order taxonomic grouping such as a sub-species, are said to be conspecific when they belong to the same species.

Continental Shelf
The underwater shelf of the continent, extending seaward from the shore, with a moderate inclination, to the edge of the continental slope where the inclination increases sharply; water depth varies from 0 to 200 meters.

Demersal
Living in close association with the bottom and generally dependent upon it.

Demographic
Properties of a population such as rate of growth, age structure, sex ratio, number of reproductive individuals, etc.

Density Dependence
In population ecology density-dependence is any population characteristic that varies with the degree of the density of the population.

Density Independence
External factors that influence all individual of a population regardless of population density such as climate.

Dimorphism
Existence within a species of two distinct forms according to color, sex, size, organic structure, etc.

Distinct Population Segment
The smallest division of a taxonomic species that can be protected under the U.S. Endangered Species Act.

Dorsal fin
Located on the top side, generally mid-way along the body, and usually distinct rays; provides stability when swimming.

Ecological niche
The position a species or population its ecosystem. The ecological niche describes how an organism or population responds to the distribution of resources and competitors (*e.g.*, by growing when resources are abundant, and when predators, parasites and pathogens are scarce) and how it in turn alters those same factors (*e.g.*, limiting access to resources by other organisms, acting as a food source for predators and a consumer of prey).

Ecosystem
A biological environment consisting of all the organisms living and interacting in a particular area, as well as all the nonliving, physical components of the environment with which the organisms interact, such as air, soil, water and sunlight.

Ecosystem Functions
Intrinsic ecosystem characteristics related to the set of conditions and processes whereby an ecosystem maintains its integrity. Ecosystem functions include such processes as decomposition, production, nutrient cycling, and fluxes of nutrients and energy.

Ecosystem Services
The benefits that people obtain from functioning ecosystems; they include provisioning services such as food, timber, fiber, fuel and energy, and freshwater; regulating services such as air and water quality, equable climate, control of diseases, pests, and sediment supplies (e.g., beaches, building materials); supporting services such as soil formation, photosynthesis, nutrient cycle; and cultural services such as fulfilling spiritual, religious, and aesthetic needs.

Effective Population Size (N_e)
The number of individuals that contribute offspring to the next generation; generally smaller than the absolute population size (N); a basic parameter in many models in population genetics.

El Niño /La Niña Southern Oscillation
A weather pattern that occurs across the tropical Pacific Ocean roughly every five to seven years. It is characterized by variations in the surface temperature of the tropical eastern Pacific Ocean—warming associated with El Niño and cooling with La Niña. The two variations are coupled: the warm oceanic phase, El Niño, accompanies high air surface pressure in the western Pacific, while the cold phase, La Niña, accompanies low air surface pressure in the western Pacific. ENSO causes extreme weather (such as floods and droughts) in many regions of the world, including the west coast of the United States.

Emigration
Movement of individuals out of a population. With Pacific anadromous salmonids, emigration refers to the movement of juveniles (and also adults) from freshwater to a brackish or marine environment.

Endemic
Species or populations occurring in restricted geographic areas due to the presence of a unique suite of environmental and biological conditions that limit the distribution of the species or population.

Ephemeral Streams
Streams that flow briefly after rainstorms.

Essential Fish Habitat
Waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (16U.S.C. 1802(10)).

Estuary
Estuaries form a transition zone between river environments and ocean environments and are subject to both marine influences, such as tides, waves, and the influx of saline water; and riverine influences, such as flows of fresh water and sediment. The inflow of both seawater and freshwater provide high levels of nutrients in both the water column and sediment, making estuaries among productive natural habitats.

Eutrophication
Enrichment of water by nutrients required for plant growth. The addition of artificial or natural substances, such as nitrates and phosphate through agricultural fertilizer or animal wastes, to an aquatic system. Negative environmental effects include the depletion of oxygen in the water, which induces reductions in specific fish and other animal populations.

Evolutionary Significant Unit
A population (or group of populations) which exhibit two biological characteristics: (1) it is substantially reproductively isolated from other conspecific (of the same taxonomic species) population units; and (2) it represents an important component of the evolutionary legacy of the species.

Evolvability
The potential to generate heritable variation with individuals of a population that can be exploited by natural or artificial selection**.**

Extinction
The disappearance of a species or some other taxonomic group from a region or biota; the precise moment of extinction is generally considered to be the death of the last individual of the species (although the capacity to reproduce and recover may have been lost before that point).
Eutrophication
The process by which a body of water becomes enriched in dissolved mineral nutrients (often phosphorus and nitrogen) that stimulates the growth of aquatic plants, and leads to depletion of dissolved oxygen, and the mortality of oxygen dependent organisms.

Fecundity
The reproductive potential or capacity of an organism or population, usually expressed as the number of eggs or progeny produced during a reproductive cycle. Fecundity usually increases with age and size.

Facultative
The characteristic of being able to adjust to a variety of conditions or circumstances; optional or discretionary.

Fish Ladder
An artificial facility made of a series of steps, with flowing water and pools, to assist fish in swimming up or downstream of a fish passage barrier such as a dam or diversion.

Fitness
The degree that an individual is adapted to or is able to produce progeny in its local environment.

Fry
Juvenile fish that have absorbed their yolk sacs and can emerge from a redd and into deeper water to feed on their own.

Genotype
The genotype of an organism is the inherited genetic code of the individual. Not all individuals with the same genotype look or behave the same way because appearance and behavior are modified by

environmental and developmental conditions. Similarly, not all individual that look alike necessarily have the same genotype.

Genetic Distance
A measure of the difference in allele frequencies between populations. Genetic distance can be used to compare the genetic similarity between different species, such as humans and chimpanzees. Within a species genetic distance can be used to measure the divergence between different sub-species, or populations of the same species.

Gravid
The condition of an individual female carrying ripe eggs, usually with a distended body.

Greenhouse Gas
A gas which is capable of absorbing and emitting infrared light (e.g., water vapor H_20, carbon dioxide $C0_2$, methane CH_4, nitrous oxide N_20, and ozone O_3).

Habitat
The area that is inhabited by a particular species of animal, plant or other type of organisms. It is the natural environment in which an organism lives, or the physical environment that surrounds (influences and is utilized by) a population of a species. The term microhabitat is often used to describe the small-scale physical requirements of a particular organism or population.

Herbivore
An organism that consumes living plants or their parts.

Hydrologic Cycle
The continuous movement of water on, above and below the surface of the Earth, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, runoff, and subsurface flow. Water takes alternative forms of liquid, vapor, and a solid (snow and ice). The hydrologic cycle also involves the exchange of heat energy, which leads to temperature changes. For instance, in the process of evaporation, water takes up energy from the surroundings and cools the environment. Conversely, in the process of condensation, water releases energy to its surroundings, warming the environment.

The water cycle figures significantly in the maintenance of life and ecosystems on Earth. By transferring water from one location to another, the water cycle purifies water, replenishes the land with freshwater, and transports minerals to different parts of the globe. It is also involved in reshaping the geological features of the Earth, through such processes as erosion and sedimentation. The water cycle exerts an influence on climate as well.

Incidental Take
The unintentional take of a listed species as a result of the conduct of an otherwise lawful activity.

Independent population
Any collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time frame are not substantially altered by exchanges of individuals with other populations. For

example, if one independent population were to go extinct, it would not have a significant impact on the 100-year extinction risk experienced by other independent populations.

Indigenous Species
A species occurring naturally in a particular region, and not artificially introduced.

Intermittent Streams
Streams that flow for some, but not all, of the year. Such streams usually receive their waters primarily from surface runoff following storm events.

Interspecific
Interactions, such as competition or predation, between different species.

Interrupted Stream
Stream that flow alternately on and below the surface contemporaneously. Such streams often flow through coarse gravels.

Intraspecific
Interactions, such as competition or predation, between individuals of a single species.

Introgression
The movement of genes from one gene pool to another as a result of hybridization between individuals from genetically distinct populations.

Iteroparous
An organism that has the potential to reproduce more than one during its life cycle. Steelhead are the only members of the Pacific anadromous salmonids (*Oncorhynchus* spp.) that do not die after initial spawning , and may return to the ocean and then return to freshwater to repeat their reproductive phase.

Latent Heat
Heat carried by water, and released when the water vapor condenses to liquid.

Lateral line
A series of sensory receptor arrayed along the sides mid-way between top and bottom of the body; these sensory receptors detect water movement around the fish, allowing it to efficiently navigate currents, detect prey, and swim in coordination with other fish of the same species.

Life Cycle
The successive series of changes through which an organism passes, whether through asexual or sexual reproduction, including breeding, gestation, growth and maturation, and death. This cycle of phases of an individual is also referred to a life history.

Life History Crossover
In Pacific salmonids, the ability of anadromous *O. mykiss to* produce progeny which assume a freshwater reproductive life cycle, and the ability of resident *O. mykiss*, to produce progeny which assume an anadromous reproductive life cycle.

Life History Polymorphism
In Pacific salmonids, the co-occurrence of the anadromous and resident life cycle forms within a population.

Limiting Factor
Any factor that controls a process, such as organism growth or species population size, or distribution. The availability of food, predation pressure, or availability of shelter are examples of natural limiting factors. An example of an anthropogenic limiting factor is set of barriers to migration, which is necessary to complete an organism's life cycle.

Littoral Zone
The zone along the coast the forms the interface between the land and water, and often includes intertidal and near-shore waters.

Mediterranean Climate
The climate is characterized by warm to hot, dry summers and mild to cool, wet winters. Mediterranean climate zones are associated with the five large subtropical high pressure cells of the major oceans. These high pressure cells shift toward the poles in the summer and toward equator in the winter.

Meristics
Measurements of an organism's physical characteristics such as length, scale, spine, fin-ray counts.

Metapopulation
A set of populations that is composed of multiple local populations geographically separated but connected through dispersal and periodic interbreeding. Generally individual populations within such a system have a relatively high probability of local extinction and also recolonization by other populations within the metapopulation. Metapopulations persist as a result of a balance between extinctions of subpopulations and recolonization by others.

Migrate
Travelling of long distances in search of a specific type of habitat to enable an organism to complete some phase of its life cycle; fish such as Pacific anadromous salmonids migrate between their spawning and rearing areas in freshwater habitat the marine environment to feed and grow to maturity.

Mathematical Model
A quantitative description of anything (including processes) that cannot be directly observed, but for which relevant data can be developed, and used to simulate an approximation or estimate of the thing being modeled.

Natural Selection
The process by which the frequency of genetic traits in a population through differential survival and reproduction of individual bearing those traits is determined. Natural selection acts on the phenotype or the observable characteristics of an organism, but the genetic (heritable) basis of any phenotype which gives a reproductive advantage will become more common in a population (see allele frequency). Over time, this process can result in adaptation that adapts populations for a particular ecological niche and may eventually result in the emergence of new species. It is a key mechanism of evolution.

Obligate
The characteristic of being unable able to adjust to a variety of conditions or circumstances; a life history or response to particular environmental conditions without alternative means of responding.

Omnivore
An organism whose diet is broad, including both plant and animal foods; specifically an organism that feeds on more than one trophic level; omnivorous organisms are opportunistic, general feeders not specifically adapted to eat and digest either meat or plant material primarily.

Operculum
The gill cover in bony fishes

Orographic Precipitation
Precipitation induced when air masses pushed by winds are forced up the side of elevated land formations, such as large mountains. The lift of the air up the side of the mountain results in cooling, and ultimately condensation and precipitation.

Otolith
Calcareous concretions in the inner "ear" of lower vertebrates such as fish; the daily accumulation calcareous layers of can be used to determine the age of an organism, and in some cases detect the time spent in waters with different chemical composition (*e.g.*, salt and freshwater).

Pacific Decadal Oscillation (PDO)
A pattern of climate variability that shifts phases on at least an inter-decadal time scale, usually about 20 to 30 years. The PDO is detected as warm or cool surface waters in the Pacific Ocean north of 20° N. During a "warm", or "positive", phase, the west Pacific becomes cool and part of the eastern ocean warms; during a "cool" or "negative" phase, the opposite pattern occurs.

Panmictic Population
A population in which all individuals are potential reproductive partners, that is, there are no restrictions of mating (e.g., genetic or behavioral).

Parameterization
A technique used in constructing models of substituting an unknown feature such as process or limit, with a simplified, but informed estimate of the feature.

Parr
The rearing stage of freshwater salmonids between alevins and smolt that is distinguished by vertical bars or oval spots (parr marks) on the side of the fish.

Pectoral fin
Fin located high up on the sides of deep bodied fish; used for precise movements.

Pelvic fin
Fin located toward the rear of the fish; used for steering and stopping.

Pelagic
Associated with the open sea or at or near the water's surface. Pelagic fish live near the surface or in the water column of coastal, ocean and lake waters, but not on the bottom of the sea or the lake. They are usually agile swimmers with streamlined bodies, capable of sustained cruising on long distance migrations. They can be contrasted with demersal fish which do live on or near the bottom, and reef fish which are associated with coral or volcanic reefs.

pH
A measure of the acidity or basicity of an aqueous solution (generally expresses as the concentration of H+ ions). pH is normally measured in a range of 0-14. Pure water is said to be neutral, with a pH close to 7.0 at 25 ^{0}C (77 ^{0}F). Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline.

Phenotype
Any observable characteristic or trait of an organism such as its morphology (shape and size) developmental pattern, biochemical or physiological properties, and behavior. Phenotypes result from the expression of an organism's genes as well as the influence of environmental factors and the interactions between the two.

Phenotypic Plasticity
The ability of an individual to modify behavioral or other phenotypic characteristics to adjust to differing environmental conditions. In some Pacific salmonids such as steelhead, phenotypic plasticity refers to the ability to adopt either the anadromous or freshwater-resident life cycle, depending on environmental cues or influences.

Photic Zone
The surface layer of water where there is sufficient light for photosynthesis to occur.

Population
A group of interbreeding individuals that have developed a distinct gene pool and that breed in approximately the same place and time.

Population Density
The number of individuals per unit area, or linear distance.

Population Model
A quantitative description of how a population changes over time; population models can take a variety of basic forms, including age/size structured or biomass based, deterministic, or stochastic, density-dependent, or density-independent, spatially structured, or spatially aggregated, equilibrium or nonequilibrium.

Predation
Predation describes a biological interaction a predator feeds on its prey. Predators may or may not kill their prey prior to feeding them, but the act of predation always results in the death of its prey and the eventual absorption of the prey's tissue through consumption. The key characteristic of predation however is the predator's direct impact on the prey population.

Primary Productivity
The production of organic compounds from atmospheric or aquatic carbon dioxide, principally through the process of photosynthesis, with chemosynthesis being much less prevalent. Almost all life on earth is directly or indirectly reliant on primary production. The organisms responsible for primary production form the base of the food chain. In terrestrial ecosystem these are mainly plants; in aquatic ecosystems, algae are primarily responsible.

Radiative Balance
The physical state of a system, such as the earth-atmosphere system, where the incoming and outgoing solar radiation is in equilibrium; greenhouse gases diminish outgoing solar radiation**.**

R-strategists
R-strategists are species characterized by relatively early age of first reproduction, large brood size, numerous progeny, no parental care, and short generations. Populations exhibit exponential growth rate followed by sudden crashes in population size, and tend to live in unpredictable and rapidly changing environments. Pacific anadromous salmonids are an example of an r-strategist species.

Recruitment
The number of fish from a year class reaching a certain age; in fisheries management it is generally the number of fish that grow to a size subject to harvesting.

Redd
A shallow gravel depression excavated by a fish for the purpose of depositing its eggs within the stream channel.

Refugia
Habitats where individuals can avoid predation or environmental stressors such as elevated temperatures, or flood flows.

Relative humidity
The amount of water vapor in the air, compared with complete saturation. If relative humidity is greater than 100%, the vapor will tend to condense to liquid, until 100% is reached.

Salmonids
Fish of the taxonomic family Salmonidae that includes salmon, trout, whitefish, and char.

Seasonal Lagoon
An estuary that becomes separated from the ocean by a sandbar barrier for part of the year.

Sea Level Rise
The rise in average sea level elevation with respect to current terrestrial elevations. Increasing sea level is the result of increasing temperatures causing the thermal expansion of water and the addition of water to the oceans from the melting of mountain glaciers, polar ice caps, and Greenland and Antarctic ice sheets.

Semelparous
Organisms which reproduce only once. The single reproductive event of semelparous organisms is usually large, as well as fatal. An example of a semelparous organism is the Pacific salmon (*Oncorhynchus* spp.), which lives for several years in the ocean before migrating to the freshwater stream of its birth, laying eggs, and dying.

Sink Population
A local population that has a negative growth rate, or a high probability of periodic extinction; it continued persistence is dependent upon immigration from other local populations, or dispersal from more remote populations.

Smolt
A young salmon or steelhead that is undergoing physiological changes in preparation for entering the ocean.

Source Population
A local population that has a sufficiently high growth rate when small to persist even without immigration from other local populations, or dispersal from more remote populations.

Spawning Density
The number of potentially spawning individual in a length of stream, tributary, or some other hydrologic unit.

Steelhead
A rainbow trout (*Oncorhynchus mykiss*) that exhibits an anadromous life cycle.

Stochastic
The state where a system's components are affected by random variability. A stochastic model is a model whose behavior is not fully specified by its form and parameters, but which contains an allowance for unexplained effected represented by random variables.

Stratification
The establishment of distinct layers of temperature or salinity in bodies of water such as an ocean, lake, or estuary, based upon the different density of warm and cold water or saline or freshwater.

Sustainable Fishery
A fishery that does not cause or lead to undesirable changes in the biological and/or economic productivity, biological diversity, ore ecosystem structure and functioning from one human generation to the next.

Taxon
Any named group of organisms at any taxonomic level (*e.g.*, Phylum, Order, Class, Genus, Species, etc.).

Temperature Lapse Rate
The rate of decrease in temperature with altitude in the stationary atmosphere at a given time and location.

Thermocline
A region below the surface layer of the sea or lake, or pool where the temperature gradient increases abruptly (*i.e.*, where temperature decreases rapidly with increasing depth). It is often an ecological barrier, and its oscillations have significant consequences on the distribution of organisms.

Total-Length (TL)
The length of a fish defined as the straight-line distance from the tip of the snout to the tip of the tail (caudal fin) while the fish is lying on its side normally extended.

Triploid
An organism having three sets of chromosomes.

Trophic Level
The position an organism or species occupies in the food chain, or web. A food chain represents a succession of organisms that eat another organism and are, in turn, eaten themselves. The number of energy transfer steps organism is from the start of the chain is a measure of its trophic level. Food chains start at trophic level 1 with primary producer such as plants, move to herbivores level 2, predators at level 3 and typically finish with carnivores or aped predators at level 4 or 5.determined by the number of energy-transfer steps to that level.

Upwelling
An oceanographic phenomenon that involves wind-driven motion of dense, cooler, and usually nutrient-rich water towards the ocean surface, replacing the warmer, usually nutrient-depleted surface water. The increased availability in upwelling regions results in high levels of primary productivity and thus fish growth and abundance. Wind-driven currents are diverted to the right of the winds in the Northern Hemisphere and to the left in the Southern Hemisphere. When surface water transport is occurring away from the coast, surface waters are replaced by deeper, colder, and denser water.

Viable Salmonid Population
An independent population of any Pacific salmonid (genus Oncorhynchus) that has a negligible risk of extinction due to threats from demographic variation (such as population size or sex ratio), local environmental variations, and genetic diversity changes over a 100-year time frame.

Viability Population Parameters
The four measurable characteristics of a viable salmonid population: abundance, growth rate, spatial structure, and diversity (including genetic, phenotypic diversity).

Volitional Fish Passage
The natural movement of fish in response to cues such as natural flow patterns or water temperature, or natural physiological changes in individuals.

Weathering
The physical/chemical processes in which a material is broken down through exposure to the atmospheric conditions (heat, water, etc.)

Young-of-the Year
Fish that are less than a year old (and are in their first year of growth).

Abbreviations

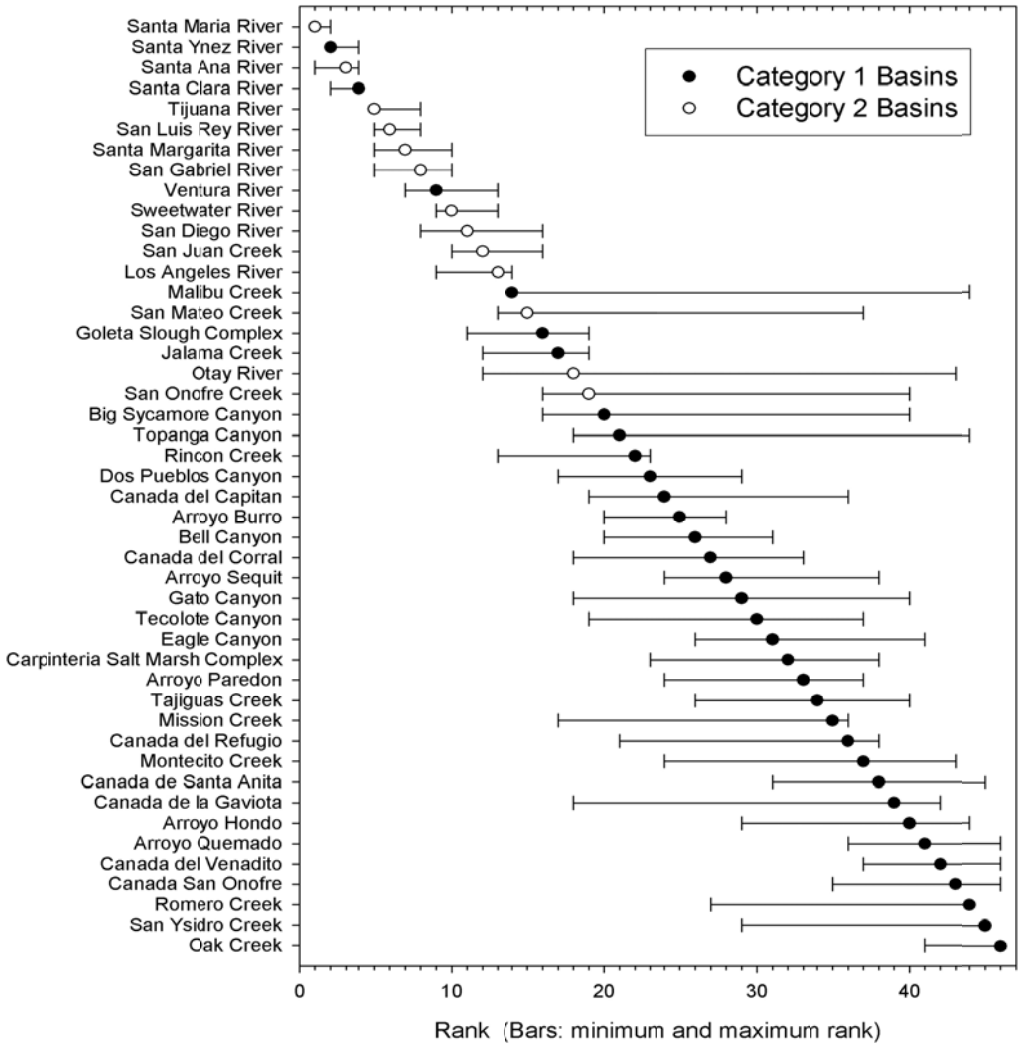
AC	Audubon California
ACOE	Army Corps of Engineers
ACWA	Association of California Water Agencies
AFRP	Anadromous Fish Restoration Program
BIA	Bureau of Indian Affairs
BOR	Bureau of Reclamation
BPG	Biogeographic Population Group
BRT	Biological Review Team
CAMP	Comprehensive Assessment and Monitoring Program
CCC	California Coastal Commission
CCRB	Cachuma Conservation Release Board
CDFG	California Department of Fish and Game
CDF	California Department of Forestry
CDOT	California Department of Transportation
CDPR	California Department of Parks and Recreation
CDMG	California Division of Mines and Geology
CESA	California Endangered Species Act
CI	Confidence Interval
CMARP	Comprehensive Monitoring Assessment and Research Program
CMWD	Casitas Municipal Water District
COMB	Cachuma Operations and Maintenance Board
CSCC	California State Coastal Conservancy
C^0	Centigrade
cm	Centimeters
cm/sec	Centimeters per second
CT	California Trout
CV	Coefficient of Variation
CWT	Coded Wire Tag
DIDSON	Dual-Frequency Identification Sonar
DPS	Distinct Population Segment
DWR	Department of Water Resources
EFH	Essential Fish Habitat
EII	Earth Island Institute
ENSO	El Nino/Southern Oscillation
ESA	Federal Endangered Species Act
ESU	Evolutionarily Significant Unit
FLC	Fallbrook Land Conservancy
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FL	Fork Length
FLC	Fallbrook Land Conservancy
FOLAR	Friends of the Los Angeles River
FOR	Friends of the River
FOSCR	Friends of the Santa Clara River
FOSMR	Friends of the Santa Margarita River

FOVR	Friends of the Ventura River
FRGP	Fisheries Restoration Grant Program
ft/sec	Feet per second
GSDCRCD	Greater San Diego County Resource Conservation District
HCP	Habitat Conservation Plan
IRWMP	Integrated Watershed Management Plan
km/hr	Kilometers per hour
KSW	Keep Sespe Wild
LAC	Los Angeles County
LPFW	Los Padres Forest Watch
m	Meters
mi^2	Square miles
m/sec	Meters per second
mm	Millimeters
MC	Matilija Coalition
MWDSC	Metropolitan Water District of Southern California
MRCD	Mission Resource Conservation District
ORCP	Otay River Conservation Program (WildCoast)
TBD	To Be Determined
TNC	The Nature Conservancy
MOU	Memorandum of Understanding
NGO	Non-Governmental Organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPSPWRO	National Park Service, Pacific Western Regional Office
NRCS	National Resources Conservation Service
OC	Orange County
OVLC	Ojai Valley Land Conservancy
PCSRF	Pacific Coastal Salmon Recovery Fund
PITT	Passive Integrated Responder Tags
ppt	Parts per thousand
PVA	Population Viability Analyses
RC	Riverside County
RFID	Radio Frequency Identification
RM	River Mile
RST	Rotary Screw Trap
RWQCB	Regional Water Quality Control Board
SARWA	Santa Ana River Watershed Alliance
SBC	Santa Barbara County
SBRC	San Bernardino County
SCHR	South Coast Habitat Restoration
SCCWRP	Southern California Coastal Water Research Project
SDBNWR	San Diego Bay National Wildlife Refuge
SDC	San Diego County
SDRPF	San Diego River Park Foundation
SDRVC	San Dieguito River Valley Conservancy
SDSRF	San Diego Surfrider Foundation

SDT	San Diego Trout
SDWA	San Diego Water Authority
SGMRC	San Gabriel Mountains Regional Conservancy
SLRWC	San Luis Rey Watershed Council
SMBRC	Santa Monica Bay Restoration Commission
SMCC	San Mateo Creek Conservancy
SMMC	Santa Monica Mountains Conservancy
SMMRCD	Santa Monica Mountains Resource Conservation District
SWA	Sweetwater Authority
SWMNWR	Sweetwater Marsh National Wildlife Refuge
SWP	State Water Project
SWRCB	State Water Resources Control Board
TBD	To Be Determined
TCFT	Tri-County Fish Team
TL	Total Length
TRAN	Tijuana River Action Network
TRNER	Tijuana River National Estuarine Reserve
TRT	Technical Recovery Team
TU	Trout Unlimited
TWC	The Wildlands Conservancy
USFS	United States Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
USLRRCD	Upper San Luis Rey Resource Conservation District
UWCD	United Water Conservation District
VC	Ventura County
VSP	Viable Salmonid Population
USAF	United States Air Force
USDOT	United States Department of Transportation
USMC	United States Marine Corps

APPENDIX B
Watershed Intrinsic Potential Rankings

Watershed rankings in the Southern California Steelhead DPS.[1] The rankings are based on the amount of potential habitat as in indicator of potential viability. Watersheds are ranked on the single habitat model that is preferred on *a priori* biological grounds. Horizontal bars show the range of ranks (minimum and maximum) for 48 variant biological models (See Boughton *et al*. 2006).



[1] Category 1 Watersheds are watersheds that experience regular winter flows to the ocean and therefore provide access to freshwater spawning areas. Category 2 Watersheds (*i.e.,* all large Watersheds within the southern portion of the Southern California Steelhead DPS, and the Santa Maria River) experience irregular winter flows to the ocean, even in an unimpaired state. Bars indicate the range of ranks (minimum and maximum) for 48 variant models. (See Boughton *et al*. 2006).

APPENDIX C

COMPOSITION OF SOUTHERN CALIFORNIA RECOVERY PLANNING AREA STEELHEAD BPGs

Biogeographic Group	Member Populations (ordered north to south)
Monte Arido Highlands	Santa Maria River, Santa Ynez River, Ventura River, Santa Clara River
Conception Coast[1]	Jalama Creek, Cañada de Santa Anita, Cañada de la Gaviota, Cañada San Onofre, Arroyo Hondo, Arroyo Quemado, Tajiguas Creek, Cañada del Refugio, Cañada del Venadito, Cañada del Corral, Cañada del Capitan, Gato Canyon, Dos Pueblos Canyon, Eagle Canyon, Tecolote Canyon, Bell Canyon, Goleta Slough Complex, Arroyo Burro, Mission Creek, Montecito Creek, Oak Creek, San Ysidro Creek, Romero Creek, Arroyo Paredon, Carpinteria Salt Marsh Complex, Carpinteria Creek, Rincon Creek
Santa Monica Mtns[1]	Big Sycamore Canyon, Arroyo Sequit, Malibu Creek, Topanga Canyon, Solstice
Mojave Rim	Los Angeles River, San Gabriel River, Santa Ana River (multiple subpopulations)
Santa Catalina Gulf Coast	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

[1] Population delineations in these groups may be split too finely if there is significant dispersal of fish among neighboring coastal watersheds. For discussion see Boughton *et al.* 2006.

APPENDIX D

SOUTHERN CALIFORNIA STEELHEAD RECOVERY PLANNING AREA THREATS ASSESSMENT (CAP WORKBOOK) 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 *Oncorhynchus mykiss* populations in the Southern California Coast Steelhead Recovery Planning Area. Hunt & Associates (2008a, 2008b) was tasked with reviewing existing information on *O. mykiss* habitat conditions, assessing the magnitude and extent of threats to *O. mykiss* and their habitats, and developing recovery actions across the Southern California Coast Recovery Planning Area. This document summarizes the methodology used to assess *O. mykiss* threats and sources of threats in Southern California coastal watersheds from the Santa Maria watershed of Santa Barbara County southward to the Tijuana River watershed in San Diego County. Specifically, this document details the use of modified Conservation Action Planning Workbooks to assess watershed and life stage specific threats and threat sources for Southern California Coast *O. mykiss*. CAP workbooks have been developed previously for salmonid threat assessment and recovery planning for southern Oregon and northern California coast coho salmon as well as south-central and southern California steelhead. However, previous *O. mykiss* threat assessment workbooks, described in Kier Associates and National Marine Fisheries Service (2008b), were not inclusive of all watersheds within the Southern California Coast Recovery Planning Area or all available environmental data and information. The CAP workbook analysis results presented in this Recovery Plan builds on information presented in these earlier versions.

Methods

The Conservation Action Planning (CAP) Workbook is a database tool developed by The Nature Conservancy to identify conservation targets, assess existing habitat conditions, and identify management issues for target populations. CAP is a Microsoft Excel-based tool that facilitates the assessment of aquatic habitat quality and human-caused threats to that habitat. 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 (including best professional judgment) information in order to determine what existing conditions are and what healthy targets should look like. Once data are entered, the CAP workbook then links the observed aquatic habitat conditions to watershed conditions, provides a prioritized list of threats, and provides a summary of overall watershed health. The CAP Workbooks can be used to organize and evaluate large amounts of information on current *O. mykiss* habitat conditions and threats in selected watersheds. The Workbook is iterative and should be updated as additional information becomes available.

The CAP Workbook methodology provides a number of useful features in assessing the magnitude and extent of threats to *O. mykiss* and their habitats in that it:

- Incorporates both quantitative and qualitative (*e.g.*, professional judgment) measures of existing habitat conditions;

- Is an objective, consistent tool for tracking changes in the status of each conservation target (i.e., *O. mykiss* life history stage) over time and between watersheds;
- Provides an 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 *O. mykiss* and their habitats;
- Becomes a central repository for documenting and updating knowledge and assumptions about existing conditions; and
- Creates a foundation upon which recovery actions can be tracked and up-dated, based on changing current conditions.

Thirty-four out of 46 coastal watersheds were identified as supporting historical and extant *O. mykiss* populations within the SCS Recovery Area (Boughton *et al.* 2006, Becker *et. al.* 2008, Sleeper 2002, Titus *et al.* 2010, M. Larson, personnel communication 2007-2010). Of the thirty-four coastal watersheds, 26 were selected for threats assessment analysis. A separate CAP Workbook was created for each of the 46 component drainages (Table D-1). Information on existing *O. mykiss* habitat conditions in each watershed was gathered from a broad range of published and unpublished materials, including, peer-reviewed scientific publications, technical reports, federal, state, and local planning documents, EIS/EIRs, 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 in 2007. These sources are listed in the bibliography at the end of this document.

The CAP workbook data base organized data around several basic categories for analysis; these include conservation targets and related key ecological attributes.

Conservation Targets. Specific "conservation targets" for analysis within a CAP workbook must be identified by the user. The conservation targets in this case were *O. mykiss* 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.

Key Ecological Attributes (KEAs). Assessing the "viability" or "health" of a particular conservation target (i.e., life history stage) required 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 *O. mykiss*);
- *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).

Because of the lack of consistent data regarding many key ecological attributes for most of the watersheds,, as well as the lack of established reference values for parameters such as water temperature, the threat assessment utilized the presence threat sources such as physical passage barriers such as dams, extent of surface and groundwater extractions, agricultural and urban development, flood control facilities, mining and quarrying operation, and non-native, invasive species to evaluate threats to steelhead, and the overall condition of individual watersheds. This assessment was used to identify recovery actions which target these threat sources.

The following table provides an inventory of the watersheds for which CAP workbooks were developed, organized by the five Biogeographic Population Groups of the Southern California Steelhead Recovery Planning Area.

Table D-1. Southern California Steelhead Recovery Planning Area Component Biogeographic Population Groups, Watersheds, and Corresponding CAP Workbooks.

BPG	Watershed	CAP Workbook
Monte Arido Highlands	Santa Maria River	Mainstem Santa Maria River
		Cuyama River
		Sisquoc River
	Santa Ynez River	Mainstem Santa Ynez River (lower, middle, and upper)
	Ventura River	Mainstem Ventura River
		Coyote Creek
		Mainstem Matilija Creek
		North Fork Matilija Creek
		San Antonio Creek
	Santa Clara River	Mainstem Santa Clara River
		Santa Paula Creek
		Sespe Creek
		Piru Creek
Conception Coast	Jalama Creek	Jalama Creek
	Canada de Santa Anita	Canada de Santa Anita
	Gaviota Creek	Gaviota Creek
	Arroyo Hondo Creek	Arroyo Hondo Creek
	Tecolote Creek	Tecolote Creek
	Goleta Slough	San Jose, Atascadero, San Pedro & Maria Ygnacio creeks
	Mission Creek	Mission Creek
	Montecito Creek	Montecito Creek
	Carpinteria Creek	Carpinteria Creek
	Rincon Creek	Rincon Creek
Santa Monica Mountains	Big Sycamore Canyon Creek	Big Sycamore Canyon Creek
	Arroyo Sequit	Arroyo Sequit
	Malibu Creek	Malibu Creek
	Las Flores Canyon Creek	Las Flores Canyon Creek
	Topanga Canyon Creek	Topanga Canyon Creek
Mojave Rim	Los Angeles River	Mainstem Los Angeles River
		Arroyo Seco
	San Gabriel River	Mainstem San Gabriel River
		East Fork San Gabriel River
		West Fork San Gabriel River
	Santa Ana River	Mainstem Santa Ana River
		Lytle Creek
		Mill Creek
Santa Catalina Gulf Coast	San Juan River	San Juan River/Trabuco Creek
	San Mateo Creek	San Mateo Creek
	San Onofre Creek	San Onofre Creek
	Santa Margarita River	Santa Margarita River
	San Luis Rey River	San Luis Rey River
	San Dieguito River	San Dieguito River
	San Diego River	San Diego River
	Sweetwater River	Sweetwater River
	Otay River	Otay River
	Tijuana River	Tijuana River

Current Indicators. The range of variation found for each indicator was then subdivided into four somewhat 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. A description of indicators used in the CAP steelhead analyses and the rationale for these indicators is available in Kier Associates and National Marine Fisheries Service (2008). Functionally, however, we assumed that there are essentially two states for an indicator as it relates to the target: 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 Kier Associates and NMFS, 2008b). These landscape-scale metrics were used in this threat assessment to overcome logistical and analytical problems inherent in local-scale metrics of *O. mykiss* habitat quality (*e.g.*, water temperature), that exhibit extreme spatial and temporal variation, which can 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 known to be an important habitat indicator for *O. mykiss*. For the *O. mykiss* fry life stage, turbidity was defined as the "number of days turbidity exceeded 25 NTUs"[1]. Currently, there is little or no systematic and widespread collection of turbidity data in most of the subject watersheds drainages to permit a quantitative assessment of this indicator. 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.

Stresses and Sources of Stress (Threats). An important step in the CAP Workbook assessment, and the purpose of these analyses, is identification of a series of stresses to each *O. mykiss* life history stage. These stresses are basically altered KEAs, *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 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 *O. mykiss* life stages; for example,, 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 then 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

[1] Nephelometric Turbidity Unit.

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.

Summary of Threats. The CAP Workbook ranks the threat sources for each conservation target (*i.e.,* life history stage) 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 *O. mykiss* in the Southern California Coast Steelhead Recovery Planning Area.

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 *O. mykiss*, 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.

The CAP Workbook analysis of Southern California *O. mykiss* prepared by Hunt & Associates was intended to build on those prepared previously by Kier Associates. Hunt & Associates' workbooks are based on review of a large number and broad range of ground-based *O. mykiss* 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 each of the 46 watersheds in the Southern California Coast Steelhead Recovery Planning Area. Kier Associates analyzed 31 of these watersheds, using the GIS-based regional indicators and a small number of point-data measurements (e.g., dissolved oxygen, water temperature, *etc.*). Kier Associates' workbooks are provided in a separate document (Kier Associates and NMFS, 2008b).

Table D-2 compares the results of the two documents for watersheds in the Southern California Coast Steelhead Recovery Planning Area. It should be noted that the difference between a "poor" and "fair" habitat rating and a "good" and "very good" rating was often a matter of professional judgment and may not always represent ecologically important differences in habitat quality. Table D-2 compares the discrepancies between "poor-fair" and "good-very good" categories between the Hunt & Associates and Kier Associates CAP Workbook analyses.

Discrepancies typically could be explained by the type (point-data measurements) and the number of indicators used in the analysis by Kier Associates versus Hunt & Associates. 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.

Further refinement of individual threat severity and threat sources in specific watersheds was conducted for these threat assessments by using information from NOAA staff familiar with these watersheds to override individual assessments.

Table D-2. Assessment of Overall Habitat Conditions for Steelhead in Component Watersheds in the Southern California Coast Steelhead Recovery Planning Area Between Two CAP Workbook Analyses*

WATERSHED	Steelhead Habitat Rating		Reasons for Discrepancy**
	Hunt & Associates	Kier Associates	
Santa Maria River			N/A
Santa Ynez River			fewer number of indicators used in the Kier analyses
Ventura River			fewer number of indicators used in the Kier analyses
Santa Clara River			N/A
Gaviota Creek			fewer number of indicators used in the Kier analyses
Arroyo Hondo			Hunt & Associates rates passage barrier at Highway 101 as severe, but being re-designed for fish passage. Override function used to rate this relatively undisturbed watershed as "good"
Tecolote Creek			fewer number of indicators used in the Kier analyses
Goleta Slough			fewer number of indicators used in the Kier analyses
Mission Creek			fewer number of indicators used in the Kier analyses
Montecito Creek			fewer number of indicators used in the Kier analyses
Carpinteria Creek			fewer number of indicators used in the Kier analyses
Rincon Creek			fewer number of indicators used in the Kier analyses
Big Sycamore Creek			fewer number of indicators used in the Kier analyses
Arroyo Sequit			fewer number of indicators used in the Kier analyses
Malibu Creek			N/A
Las Flores Canyon Creek			N/A
Topanga Canyon Creek			N/A

Los Angeles River			N/A
San Gabriel River			N/A
Santa Ana River			N/A
San Juan/Trabuco Creek			N/A
San Mateo Creek			fewer number of indicators used in the latter analyses
San Onofre Creek			fewer number of indicators used in the latter analyses
Santa Margarita River			fewer number of indicators used in the latter analyses
San Luis Rey River			fewer number of indicators used in the latter analyses
San Dieguito River			fewer number of indicators used in the latter analyses
San Diego River			fewer number of indicators used in the latter analyses
Sweetwater River			fewer number of indicators used in the latter analyses
Otay River			fewer number of indicators used in the latter analyses
Tijuana River			fewer number of indicators used in the latter analyses

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

**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). Many of the watersheds exhibit higher quality habitat conditions in portions of the watershed (particularly in upper tributaries, or publically owned reaches) than the overall ranking indicates; however, conditions for the anadromous form of O. mykiss in these watersheds is generally fair to poor as evidenced by the severely depressed (or in some cases irregular, or non-existent) annual run size of anadromous O. mykiss.*

***Pervasive discrepancies between Hunt & Associates vs. Kier Associates "poor" and "fair" categories here are due to fewer number of indicators used in the latter analyses. Watersheds analyzed only by Hunt & Associates are not shown.*

The full CAP Workbooks, with references, are available upon request to NOAA Fisheries Southwest Regional Office, Long Beach, CA.

APPENDIX E

RECOVERY ACTION COST ESTIMATES FOR STEELHEAD RECOVERY PLANNING

Introduction

The ESA provides that "recovery plans, shall, to the maximum extent practicable . . . incorporate in each plan . . . (iii) . . . estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal." NMFS interim recovery planning guidance (2010) further provides that, "There may be extreme cases in which estimating the date and cost to recovery is not possible due to uncertainty in what actions will need to be taken to recover the species." The precision of any recovery cost estimate is necessarily governed by the specificity of the recovery action, and the availability of information regarding the costs of individual components of that recovery action (labor, materials, logistics, geographic scope and duration, etc.).

As noted in the Recovery Plan, there are many uncertainties regarding the recovery of southern California steelhead, ranging from fundamental biological questions about the ecology of the species, to anticipated changes in climate. The Recovery Plan identifies categories of systemic threat sources within individual watersheds across the DPS but, because of the large number of individual threats (from site-specific activities to general land-use practices), does not provide a detailed assessment of each specific threat, and in many cases calls for further investigations to more clearly characterize and assess threats which are believed to be of particular significance for the conservation of the species (*e.g.*, fish passage barrier inventories, flows restrictions, introduction exotic species, and degradation of estuarine and other habitat types). Because of the uncertainties regarding specific aspects of the life history of steelhead (*e.g.*, relationship between anadromous vs. resident reproductive life history cycles), the Recovery Plan also provides provisional viability, delisting and downlisting criteria, and identifies important research and monitoring needed to better illuminate the biological requirements of the species and thereby better refine the viability, delisting and downlisting criteria, and related recovery actions.

The recovery action tables (Tables 9-4 through 13-10) developed for each BPG within the DPS identify broadly conceived recovery actions for each major threat source in all the core populations (as well as providing a priority ranking for recovery action within each core watershed). These recovery actions are based on the general recovery action descriptions contained in Chapter 8, Summary DPS-Wide Recovery Actions, Table 8.2 (Recovery Action Glossary). However, implementation of the recovery actions will require detailed background studies, and in some cases, engineering and other types of site-specific plans and/or environmental documentation, to further refine the nature, scope and other relevant details of the recovery action. Within the limits of these information constraints, an effort has been made to identify, within an order of magnitude, the estimated cost of the basic types of recovery actions.

Cost Estimation Methodology

The following describes the methods by which cost of individual types of recovery actions were estimated.

NMFS's Southwest Region has utilized a series of assumption tables for costs derived initially from the Southwest Region's *Habitat Restoration Cost References for Salmon Recovery Planning* (Thompson and Pinkerton 2008). These assumption tables have been adjusted to the extent practicable to reflect conditions in southern California, and applied across the DPS.

The "Cost of Doing Business" is estimated on a staff-time basis. When staff is required for review only, the cost is attributed to the initial fiscal year; when implementation is intended, the staff time is annually attributed across the projected duration of the recovery action. All other costs are estimated on a per project, per area, or per distance basis.

Finally the cost estimates provided in the cost assumption tables are the direct costs of implementing each recovery action, and do not reflect indirect costs, or benefits (*e.g.*, benefits to the local economy stemming from restored habitats that support recreational activities, reducing flood hazards, improving water quality, etc.).

Agricultural Development

The costs for implementing a plan to minimize runoff from agricultural activities were derived by estimating the number of river or stream miles running through agriculturally-zoned or agriculturally-designated lands in each BPG using Geographic Information Systems (GIS). After applying a cost per linear mile, project costs were then projected over a twenty-year period. (See Assumptions and Categories Tables 15 and 19.)

Dams and Diversions

The costs to execute recovery actions associated with dams and diversions were calculated using the CalFish.org mapping tool. This tool allows the determination of the number of dams/diversions across the BPG and assigns costs according to passage barrier severity. While this method may be useful for small dams and diversion, the modification or removal of large dams is highly dependent on site-specific conditions and cannot be accurately estimated without extensive technical and planning studies. (Refer to Assumptions and Categories Tables 4 and 5 for cost identities).

Other Passage Barriers

Culvert replacement costs were calculated based on the assumption that a minimum of one culvert would need to be replaced in each identified watershed, or sub-watershed, annually for the first five years of Recovery Plan implementation. (See Assumptions and Categories Table)

Groundwater Management

Groundwater management costs are made based on hiring one staff scientist to assess current groundwater management practices, and identify steps, if necessary, to modify practices to address potential threats. After the first year, the scientist position is dropped to 'Cost of Doing Business". Sediment assessments are initially calculated by stream length and then on a per mile basis. (See Assumptions and Categories Tables 1, 2, and 19.)

Flood Control

The costs for levee and channelization-related recovery actions are estimated by using GIS to perform a dimensional analysis of parameters such as stream length, acreage, etc. Based on these results, costs are assigned on a per mile or per acre basis. As with large dams and diversion, while this method may be useful for facilities, the modification removal of large flood control works is highly dependent on site-specific conditions and cannot be accurately estimated without extensive technical and planning studies. Federal, state and local flood control works, as well as actions such as "minimize herbicide use near levees" are considered to be "Cost of Doing Business". (See Assumptions and Categories, Tables 1, 12 and 13.)

Mining and Quarrying

The cost estimates for aggregate mining operations are made based on hiring one staff biologist to make an initial assessment of current mining practices, and identify steps, if necessary, to modify practices to address potential threats. After the first year, the position is considered to be 'Cost of Doing Business". (See Assumptions and Categories, Tables 1 and 2).

Non-Native Species

Non-native species recovery actions consist of several distinct activities, including assessment, control, education and outreach, as well as development of monitoring programs. The costs for controlling and removing non-native species are derived on a per acre basis and a staff time scenario. The education and outreach costs are based on per program scenarios. The monitoring program costs were based on hiring a biological scientist for one year to develop a monitoring program, and then transitioning that cost into a "Cost of Doing Business" scenario. (See Assumptions and Categories, Tables 2, 17 and 18.)

Urban Development

The costs for recovery actions focused on urban development threat sources were calculated based on the hiring of an Urban Regional Planner under a staff-time scenario for the first year. To assess the adequacy of current land-use planning standards and programs, and to identify step, if necessary, to address potential inadequacies. After the first year, the cost reverts to "Cost of Doing Business". Managing effluents and storm drains were considered to be annual maintenance scenarios and "Cost of Doing Business". (See Assumptions and Categories, Table 1.)

General Planning

The costs associated with reviewing and updating General Plans or Local Coastal Plans, and more focused plans such as transportation, recreation, and water quality plans were all considered to be "Cost of Doing Business". (See Assumptions and Categories, Table 1.)

Wildfires

Public agencies are assumed to be responsible for fuel and equipment required for wildfire planning and management, as is required by the Endangered Species Act for the protection of listed species, including steelhead. Therefore, all costs associated with wildfire planning and management throughout the DPS are considered to be "Cost of Doing Business". (See Assumptions and Categories, Tables 1 and 2.)

Upslope/Upstream Activities

The costs for estuarine restoration recovery actions designed to deal with a variety of upslope/upstream activities were made on a per acre basis using a staff-time scenario. Costs are based on a combination of GIS dimensional analysis to determine currently existing estuarine areas as well as factoring in the percentage of historical estuarine area that still remains. The restoration of coastal estuaries is highly dependent on site-specific conditions and cannot be estimated without extensive technical and planning studies. (See Assumptions and Categories, Tables 2 and 16.)

Regional Cost Estimate Tables: Categories and Assumptions

Table 1. Cost of Doing Business (CDB)	
Action Type	**Cost Representation**
CDB: Enough Staff Available	0
CDB: Inadequate Funding/Staff	0[1]
Over and Above CDB	FTEs[2]

[1]Defer to IRM action where additional FTEs accounted for
[2] See Bureau of Labor Statistics, FTE assumption table (2008) for costs.

Table 2. Staff Time[2]		
Occupation	**Wage[1] ($/hr.)**	**Annual Wage ($/FTE)**
Biologist	33	68030
Biologist Technician	20	40900
Fish and Game Warden	27	56030
Police/Sheriff Patrol Officers	25	52810
Forest Fire Inspectors/ Prevention	18	36400
Forest and Conservation Workers	13	26110
Urban and Regional Planners	30	62400
Physical Scientists (all others)	44	91850

[1] Seasonal
[2] Source: Bureau of Labor Statistics, 2009

Table 3. Groundwater Management[1]	
Action	**Cost ($/gage) & ($/year)**
Installation of State/Private Gage	26136
Installation of USGS Gage	29545
Annual Maintenance of State/Private Gage	7955
Annual Maintenance of USGS Gage	3409

[1] Source: Dem-WRB Streamflow Committee, 2004

Table 4. Fish Passage Improvement ($/Project)[1]				
Stream Crossing	Land Use			
	Forest	Agriculture	Suburban	Urban
Tributary: Total Barrier	63,636	159,090	318,181	556,818
Tributary: Partial/Temporal Barrier	31,818	79,545	159,090	278,409
Stream : Total Barrier	159,090	381,818	556,818	795,454
Stream: Partial/Temporal Barrier	79,545	190,909	278,409	397,727

[1]Source: CDFG 2004 (p. 1-16)

Table 5. Dam Removal[1]	
Dam Height	Cost ($/foot)
< 15'	568,181
>15'	17,045
unknown height: complete barrier	1,022,727
unknown height: partial/temporal/unknown barrier	511,363

[1] Source: CDFG 2004 (p. I.11)

Table 6. Bridge Construction[1]	
Bridge Type	$/sq. ft. of decking
RC Slab	191
RC Box Girder	170
CIP/PS Slab	168
CIP/PS Box Girder	298
PC/PS "I" Girder	231
PC/PS Bulb "T" Girder	239
Average	216

[1]

Source: DOT, 2008.

Table 7. Replacing a Culvert	
New Type of Crossing	Average Cost ($)
Bridge <40ft	51,546
Bridge >40ft	103,093
Bottomless/Open Bottom Arch	193,961
Natural Bottom Pipe Arch	215,776
Box Culvert	248,352

[1]

Source: NMFS 2008, p. 11-15

Table 8a. Road Upgrade/Road Decomissioning[1]	
Location	**Cost ($/mile)**
California	18,104
California	93,279
Table 8b. Road Construction (for relocation purposes)[2]	
Type of Road	**Cost ($/mile)**
Non paved: two directional 12' shared path	175,000
Undivided 2-lane rural road w/ 5' paved shoulders	1,713,000

[1] Source: NMFS 2008, p. 43-44
[2] Source: DOT 2010

Table 9. New Fish Ladder[1]	
Waterway Size	**Cost ($)**
Large	1,022,727
Small	568,181

[1] Source: NMFS 2008, p. 9

Table 10. Culvert Replacement ($/Culvert)[1]				
Size of Waterway	**Road Type**			
	Forest Road	**Minor 2 Lane**	**Major 2 Lane**	**Hwy 4+ Lane**
Small (0-10')	31,976	87,209	174,419	319,767
Medium (10-20')	87,209	220,930	319,767	436,047
Large (20-30')	133,721	267,442	406,977	813,953

[1]Source: NMFS 2008, p. 10

Table 11. Storm Drain Retrofit[1]	
Action	**Cost ($/filter) or ($/program)**
Catch Basin/Filter Installation	98
Annual Maintenance Program	6452

[1]Source: Kosciusko County 2002

Table 12. LWD/Instream Restoration[1*]	
Stream Type	**Cost ($/mile)**
Small, Rocky	68,182
Large, Rocky	159,091

[1]Source: CDFG 2004, p. 1.23 – 1.24
**includes 5 yrs. of monitoring/maintenance and 10% administrative fee*

Table 13. Channel Restoration[1]	
Type	**Cost ($/mile)**
Large scale reach restoration	4,217,623

[1]Source: NMFS 2008, p. 27

Table 14. Riparian Planting			
Materials/Site Accessibility	**Site Preparation Costs ($/acre)[1]**		
	Flat/Light Clearing	**Average Clearing**	**Steep/Heavy Clearing**
Low Cost	17,442	40,698	93,023
Medium Cost	26,163	63,954	110,465
High Cost	46,512	78,488	1,366,279

[1] Source: NMFS 2008, p. 32

Table 15. Bank Stabilization[1]	
Distance From Road (miles)	**Cost ($/foot)**
0.25 - 0.5	284
0.5 - 1	313
1 - 2	341
2 - 3	369
> 3	398

[1]Source: NMFS 2008, p. 38

Table 16. Estuary Restoration[1]	
Project Type	**Cost ($/acre)**
Small: tide gate removal, culvert upgrade, tidal salt marsh restoration	6000
Medium: automated tide gates, culverts, 500 feet of new dikes	67000
Large: automated tide gates, excavation of fill, re-vegetation	20000

[1]Source: Coastal Resources Management Council 2010

Table 17. Education and Outreach Programs[1]	
Type	**Cost ($)**
General Education and Outreach	76,136
Coho Specific Education	55,682

[1] Source: CDFG 2004, p. 1.42

Table 18. Removal of Invasive Plant Species	
Invasive Species	**Cost ($/acre)**
Average	8028

[1]Source: Neil 2002
[2]Source: Bennet 2007 (average cost)
[3]Source: U.S. FWS 2001
[4]Source: Northern California Conservation Center 2010

Table 19. Sediment Assessments[1]	
Location	**Cost ($/mile)**
Average all assessments in CA	1,240

[1]Source: NMFS 2008, p. 61-62

Table 20. BPG: Core 1 and 2 Population Cost Estimates

BPG: Core 1 and 2 Population Cost Estimate

BPG	FY 1-100 Total Costs	Core 1 Populations	Core 1 FY 1-100 Costs	Core 2 Populations	Core 1 + 2 FY 1-100 Costs
Monte Arido	905,765,708	Santa Maria, Santa Clara, Santa Ynez, Ventura	598,092,098	No Core 2 Identified	N/A
Conception Coast	496,776,819	Mission, Carpinteria, Rincon	178,635,055	Goleta & Gaviota	358,983,979
Santa Monica Mountains	125,825,465	Malibu, Topanga	49,591,810	Arroyo Sequit	72,512,230
Mojave Rim	261,428,356	San Gabriel Mainstem	120,068,707	Santa Ana	176,623,694
Santa Catalina Gulf Coast	344,666,136	San Juan, San Luis Rey, San Mateo, Santa Margarita	149,990,421	San Onofre, San Dieguito	262,473,286

Funding Recovery Actions

Many of the recovery actions identified in the recovery action tables are intended to restore basic ecosystem processes and function such as more natural hydrologic conditions, water quality, and riparian and estuarine habitats. These actions will, in many cases, serve to restore multiple native species and associated human uses of these natural resources. As a result, such activities may be eligible for funding from multiple funding sources at the federal, state, and local levels.

Federal funding sources include:

- NOAA/NMFS Restoration Center Community-Based Restoration Program
  NOAA/NMFS Restoration Center Open Rivers Initiative
- NOAA/NMFS Proactive Species of Concern Grant Program
- NOAA National Sea Grant College Program
- NOAA Coastal and Estuarine Land Conservation Program
- NOAA/ACOE/USFWS/EPA/NRCS Estuary Habitat Restoration Program
- EPA Wetlands Protection Grants and Near Coastal Waters Programs
- US. Department of Transportation Highway Bridge Rehabilitation and Replacement Program
- U.S. Fish and Wildlife Service National Coastal Wetlands Conservation Grant Program
- U.S. Fish and Wildlife Service Coastal Program
- U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program
- U.S. Fish and Wildlife Service North American Wetland Conservation Act
- National Resource Conservation Service
- Federal Highway Administration – Road Aquatic Species Passage Funding

State funding sources include:

- California Department of Fish and Game Pacific Coast Salmon Restoration Fund
- California Coastal Conservancy Proposition 84 Funds

- California Coastal Conservancy Southern California Wetlands Recovery Project Community Wetland Restoration Grants
- California Wildlife Conservation Board
- California State and Regional Water Quality Control Board Clean Water Grant Program
- California Integrated Watershed Management Grant Program Proposition 50 Funds
- California Department of Parks and Recreation Habitat Conservation Fund
- CalTrans Environmental Enhancement and Mitigation Program
- U.C. California/NOAA California Sea Grant College Program

In addition to federal and state funding sources, there are also numerous private national, regional and local funding sources for southern California habitat restoration projects, such as:

- National Fish and Wildlife Foundation
- Santa Barbara County Coastal Resource Enhancement Fund
- Santa Monica Bay Restoration Commission Proposition Prop 84 Grant Program
- San Diego Association of County Governments TransNet Environmental Mitigation Program

Many of these grant programs also offer technical assistance, including project planning, design, permitting, monitoring. Additionally, regional personnel with NOAA, California Department of Fish and Game, and the U.S. Fish and Wildlife Service can provide assistance and current information on the status of individual grant programs.

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