

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 CO₂ 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.

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.

Adfluvial Population

A population of fish which migrates between a lake and tributary streams tributary to the lake.

Adiabatic

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

Adipose fin

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

Adjuvant

An agent that modifies the effect of other agents, such as a pesticide. They are sometimes included in pesticides to enhance the effectiveness of the active agent.

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.

Albedo

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

Alevin

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

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.

Allochthonous

Derived from outside a system such as leaves or insects that may fall into a stream.

Alluvial

Deposited by running water.

Alluvium

Material deposited by running water, including the sediments laid down in riverbeds, floodplains, lakes and estuaries.

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.

Anaerobic

Living, growing, or occurring in an environment with no free oxygen.

Anal fin

Fin located near the rear, and on the bottom side of a fish; used for stability when swimming.

Annulus

An annual mark formed on the hard parts of fishes (e.g., scales, bones, otoliths), corresponding to a period of growth.

Autecology

Ecological study of a single organism or a single species.

Autochthonous

Derived from within a system, such as organic matter in a stream resulting from photosynthesis by aquatic plants.

Autotrophic

Making food by photosynthesis or requiring only inorganic chemical for metabolic synthesis.

Baseflow

The portion of a stream discharge derived from natural storage sources such as groundwater, lakes, or groundwater basins that create local surface runoff; the sustained discharge that does not result from direct runoff or from stream regulation, water diversion, or other human activities.

Baseline

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

Bedform roughness

The measure of the irregularity of streambed materials that contributes to the resistance to stream flows. Commonly represented by Mannings roughness coefficient.

Bed-load Sediment

The part of a stream or river's total sediment load moved along the bottom by running waters.

Benthic

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

Biological Diversity

The 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 residuals from the initial model fit.

Brackish Water

Water that contains high concentrations of salts 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.

Braided Stream

Stream that forms an interlacing network of branching and recombining channels separated by branch island or channel bars.

Broodstock

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 diet consisting mainly or exclusively of animal tissue, whether through predation or scavenging. 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 the 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 an extended 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.

Colluvium

Lose deposits of soil and rock moved by gravity; on or below step slopes or cliffs it is referred to as talus.

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 an 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 of a stream or lake 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 individuals 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 with distinct rays; provides stability when swimming.

Ecological niche

The position a species or population in 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 of biomass, 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, natural building materials such as wood); 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.

Embeddedness

The degree to which large particles (e.g., boulders, rubble, gravel) are surrounded or covered by fine sediment, usually measured in classes according to percent of coverage.

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.

Epigenetics

The field of study of the genetic (coding) and non-genetic (non-coding) factors acting upon cells to control selectively the expression of genes that produce development and evolution.

Epigenome

All the epigenetic modifications on the DNA genome and its associated histone proteins.

Escapement

The portion of a run of an anadromous species that is not harvested and escapes to natural or artificial spawning areas.

Essential Fish Habitat

Waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity as defined by 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 the most productive natural habitats.

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.

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 of individuals in 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, niche, 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).

Eyed Egg

A fish egg containing an embryo that has developed to the point where the eyes are visible through the egg membrane.

Facultative

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

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 up to some upper limit.

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.

Fluvial

Pertaining to streams or rivers, or produced by stream action; also migrating between rivers and the ocean.

Fork- Length

Refers to the measurement of a fish from the tip of its snout to the fork in the caudal (tail) fin.

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, developmental, or epigenetic factors. 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 H₂O, carbon dioxide CO₂, methane CH₄, nitrous oxide N₂O, and ozone O₃).

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 derives its principal source of nutrients and energy by consuming 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.

The physiological and behavioral process by which migratory fish assimilate environmental cues to aid their return to their stream of origin as adults.

Imprinting

The physiological and behavioral process by which migratory fish assimilate environmental cues to aid their return to their stream of origin as adults.

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 portion, 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 exhibit surface and sub-surface flow along difference stream reaches 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.

Kelt

A spawned out anadromous fish; it is generally emaciated and weak as a result of its spawning activity.

Latent Heat

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

Lateral line

A series of sensory receptors (formed of a series of pores with hair-like structures) 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 that forms the interface between the land and water, and often includes intertidal and near-shore waters.

Lotic

Pertaining to running water such as river or stream.

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 and 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.

Natal Stream

A stream in which a returning adult fish was originally spawned and reared.

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 modifications in individual organisms that adapt populations for a particular ecological niche and may eventually result in the emergence of new species. It is a key mechanism of evolution.

Non-Point Pollution

Pollution from sources that cannot be defined as discrete points, such as areas of surface mining, construction, or developed agricultural or urbanized areas.

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 hard bony 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 of calcareous layers can be used to determine the age of an organism, and in some cases detect the relative amount of time spent in waters with different chemical composition (*e.g.*, salt and freshwater).

Outmigration

The downstream migration of juvenile fish toward the ocean. See **Emigration**.

Oviparous

Producing eggs that develop outside the females body. Fertilization may occur either inside a female or after the eggs are released by the embryos are given no extra nutrient other than that contained in the original yolk.

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, a part of the eastern ocean warms, while the west Pacific becomes cool; 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 by 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 toward the front of 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 expressed 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 °C (77 °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 working in conjunction with epigenetic factors 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.

Point-Source Pollution

Pollution originating from a confined, discrete source such as a pipe, ditch, oil-well, or factory.

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 in which 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, thus disrupting the radiative balance.

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.

Residualization

The process by which an anadromous steelhead foregoes smoltification and maintains a resident, freshwater life-history.

Riffle

Shallow section of a stream or river with rapid current and surface broken by gravel, rubble, or boulders.

Run

Swiftly flowing stream reach with little surface agitation, and no major flow obstructions.

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.

Sediment

Fragment of rock, soil, and organic matter transported and deposited in beds by wind, water, or other natural phenomena. The term can refer to any size of particles but is often used to indicate only fragments smaller than 6 mm.

Sedimentation

Deposition of material suspended in water or air, usually when the velocity of the transporting medium drops below the level at which the material can be supported and moved.

Sediment Loading

The total sediment in a stream system, whether in suspension (suspended load) or on the bottom (bed load).

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 live 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; its 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.

Smoltification

The suite of physiological, morphological, biochemical, and behavioral changes, including the development of the silvery coloration and tolerance of saltwater, which takes place in salmonid parr as they prepare to migrate downstream to 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 effects 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.

Stream Order

A numerical designation (from 1 to 6 or higher) that designates the relative position of a stream or stream segment in a drainage basin from headwaters to the rivers downstream terminus.

Substrate

Mineral or organic material that forms the bed of a river or stream.

Sustainable Fishery

A fishery that does not cause or lead to undesirable changes in the biological and/or economic productivity, biological diversity, or 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, Sub-species, etc.).

Temperature Lapse Rate

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

Thalweg

A line connecting the deepest parts of a river or stream channel.

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 other organisms and are, in turn, eaten themselves. The number of energy transfer steps 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 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.

Water Table

The irregular surface of contact between the zone of saturation and the zone of aeration; that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere.

Weathering

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

Winter-Run Fish

Anadromous fish that return to freshwater in the autumn or winter, migrating to spawning areas, and then spawn in later winter or spring.

Young-of-the Year

Juvenile fish that are less than a year old (and are in their first year of growth).

Abbreviations

AMCES	AmeriCorps Environmental Stewards
AMBAG	Association of Monterey Bay Area Governments
AC	Audubon California
ACOE	Army Corps of Engineers
ACWA	Association of California Water Agencies
AFRP	Anadromous Fish Restoration Program
AG	Arroyo Grande
ASRA	Arroyo Seco River Alliance
BSLT	Big Sur Land Trust
BIA	Bureau of Indian Affairs (United States)
BLM	Bureau of Land Management (United States)
BMPs	Best Management Practices
BOR	Bureau of Reclamation (United States)
BPG	Biogeographic Population Group
BRT	Biological Review Team
CAWC	California-American Water Company
CCCOM	California Coastal Commission
CCCON	California Coastal Conservancy
CCCORP	California Conservation Corps
CDSOD	California Division Safety of Dams
CDFG	California Department of Fish and Game
CDF&FP	California Department of Forestry and Fire Protection
CDOT	California Department of Transportation
CDPR	California Department of Parks and Recreation
CDMG	California Division of Mines and Geology
CESA	California Endangered Species Act
CNPS	California Native Plant Society
COC	Chemical of Concern
CRPP	California River Parkway Program
CSFPR	California Sport Fishing Protective Association
CSWMB	California State University, Monterey Bay
CT	California Trout
CCSD	Cambria Community Service District
CAWD	Carmel Area Wastewater District
CRA	Carmel River Association
CRLC	Carmel River Lagoon Coalition
CRSA	Carmel River Steelhead Association
CRWC	Carmel River Watershed Conservancy
CRWCO	Carmel River Watershed Council
CVPOA	Carmel Valley Property Owners Association
CCRCDC	Central Coast Resource Conservation and Development Council
CCSE	Central Coast Salmon Enhancement, Inc.
CHEER	Coastal Habitat, Education, and Environmental Restoration
CSLRCD	Coastal San Luis Resource Conservation District
CI	Confidence Interval

CMARP	Comprehensive Monitoring Assessment and Research Program
C ⁰	Centigrade
cm	Centimeters
cm/sec	Centimeters per second
COA	City of Atascadero
COC	City of Carmel
COM	City of Monterey
COMB	City of Morro Bay
COG	City of Gilroy
COPS	City of Paso Robles
COPB	City of Pismo Beach
COS	City of Salinas
CSLO	City of San Luis Obispo
COSM	City of San Miguel
COW	City of Watsonville
CV	Coefficient of Variation
CWT	Coded Wire Tag
DOT	Department of Transportation (United States)
DIDSON	Dual-Frequency Identification Sonar
DPS	Distinct Population Segment
DWR	Department of Water Resources (State of California)
EPA	Environmental Protection Agency (United States)
EFH	Essential Fish Habitat
EII	Earth Island Institute
ENSO	El Nino/Southern Oscillation
ESF	Elkhorn Slough Foundation
ESA	Endangered Species Act (United States)
ESU	Evolutionarily Significant Unit
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FL	Fork Length
FOR	Friends of the River
FRGP	Fisheries Restoration Grant Program
ft/sec	Feet per second
GCWC	Garrapata Creek Watershed Council
HCP	Habitat Conservation Plan
IRWMP	Integrated Regional Watershed Management Plan
km/hr	Kilometers per hour
LPFW	Los Padres Forest Watch
m	Meters
mi ²	Square miles
m/sec	Meters per second
mm	Millimeters
TBD	To Be Determined
TNC	The Nature Conservancy
MC	Monterey County
MCWD	Marina Coast Water District

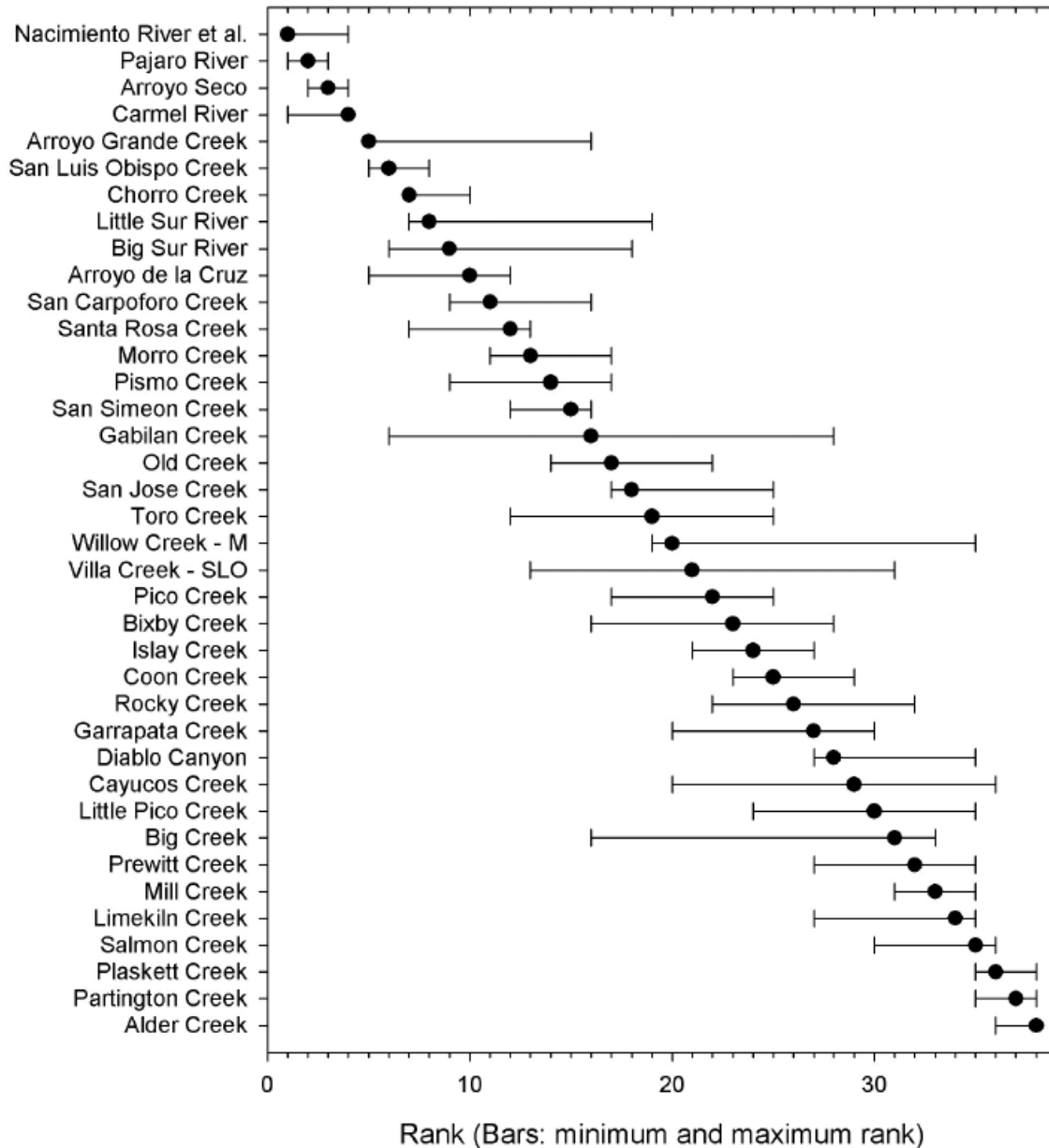
MOU	Memorandum of Understanding
MBMMS	Monterey Bay National Marine Sanctuary
MBSTP	Monterey Bay Salmon and Trout Project
MCPW	Monterey County Public Works Department
MCSA	Monterey County Service Area 50
MCWRA	Monterey County Water Resources Agency
MPWMD	Monterey Peninsula Water Management District
MRPD	Monterey Regional Park District
MCUSA	Monterey County Unified Sportsmen Association
NGO	Non-Governmental Organization
NFWF	National Fish and Wildlife Foundation
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPSPWRO	National Park Service, Pacific Western Regional Office
NRCS	National Resources Conservation Service
PCSRF	Pacific Coastal Salmon Recovery Fund
PITT	Passive Integrated Responder Tags
ppt	Parts per thousand
PBCSD	Pebble Beach Community Services District
PCLF	Planning and Conservation League Foundation
PVA	Population Viability Analyses
RFID	Radio Frequency Identification
RM	River Mile
RST	Rotary Screw Trap
RWQCB	Regional Water Quality Control Board
RCDMC	Resource Conservation District of Monterey County
RCDSC	Resource Conservation District of Santa Cruz County
SBC	San Benito County
SBCWD	San Benito County Water District
SCC	Santa Clara County
SCRC	Santa Cruz County
SCVWD	Santa Clara Valley Water District
SLP	Santa Lucia Preserve
SLOC	Santa Luis Obispo County
SWP	State Water Project
SWRCB	State Water Resources Control Board
TBSLT	The Big Sur Land Trust
TCLT	The Cambria Land Trust
TLCSLOC	The Land Conservancy of San Luis Obispo County
TBD	To Be Determined
TCFT	Tri-County Fish Team
TL	Total Length
TRT	Technical Recovery Team
TU	Trout Unlimited
TWC	The Wildlands Conservancy
TWI	The Watershed Institute (California State University, Monterey Bay)
USLTRCD	Upper Salinas-Las Tablas Resources Conservation District

USWC	Upper Salinas Watershed Coalition
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VWA	Ventana Wilderness Alliance
VSP	Viable Salmonid Population
USA	United States Army (Fort Hunter Liggett)
WCB	Wildlife Conservation Board (State of California)

APPENDIX B

Watershed Intrinsic Potential Rankings

Watershed rankings in the South-Central California Coast Steelhead DPS.¹ These rankings are based on the amount of potential habitat as an 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).



Bars indicate the range of ranks (minimum and maximum) for 48 variant models. (See Boughton *et al.* 2006).

APPENDIX C

COMPOSITION OF SOUTH-CENTRAL CALIFORNIA RECOVERY PLANNING AREA STEELHEAD BPGs

Watersheds identified within each of the four Biogeographic Populations Groups in the South-Central California Coast Steelhead DPS essential components of a recovery DPS. The identified watersheds are based on a combination of factors, including: 1) the amount of potential habitat as an indicator of potential viability, 2) potential diversity of life-history strategies exhibited by populations¹ within the watersheds, and 3) the diversity of habitat types within the watersheds. Additionally, the composition of watersheds addresses the need to ensure survival of a suite of populations within the DPS in the face of natural catastrophic events such as wildfires, droughts, and debris flows, through minimum spatial separation between and redundancy of watersheds/populations within each BPG. 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, 2007).

Biogeographic Group	Member Populations (ordered north to south)
Interior Coast Range	Pajaro River, Gabilan Creek, Arroyo Seco, Upper Salinas Basin.
Carmel Basin	Carmel River
Big Sur Coast ¹	San Jose Creek, Malpaso Creek, Garrapata Creek, Rocky Creek, Bixby Creek, Little Sur River, Big Sur River, Partington Creek, Big Creek, Vicente Creek, Limekiln Creek, Mill Creek, Prewitt Creek, Plaskett Creek, Willow Creek (Monterey Co.), Alder Creek, Villa Creek (Monterey Co.), Salmon Creek.
San Luis Obispo Terrace	San Carpoforo Creek, Arroyo de la Cruz, Little Pico Creek, Pico Creek, San Simeon Creek, Santa Rosa Creek, Villa Creek (SLO Co.), Cayucos Creek, Old Creek, Toro Creek, Morro Creek, Chorro Creek, Los Osos Creek, Islay Creek, Coon Creek, Diablo Canyon, San Luis Obispo Creek, Pismo Creek, Arroyo Grande Creek.

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

SOUTH-CENTRAL CALIFORNIA COAST 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 South-Central California Steelhead Recovery Planning Area. Hunt & Associates 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 South-Central California Recovery Planning Area. This document summarizes the methodology used to assess *O. mykiss* threats and sources of threats in South-Central California coastal watersheds from the Pajaro River in Monterey County south to, but not including the Santa Maria River, in San Luis Obispo 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 south-central 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 (2008), were not inclusive of all watersheds within the South-Central California Recovery Planning Area or all available environmental data and information. The CAP workbook analysis results presented in this recovery plan, therefore, builds on information 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. 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 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.

Twenty-two coastal watersheds, encompassing 46 drainages were identified as supporting historical and extant *O. mykiss* populations within the SCCCS Recovery Area by Boughton *et al.* (2006), and 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 un-published 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.

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. The Workbook is iterative and should be updated as additional information becomes available.

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).

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

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

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, 2008). 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.” 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 input, *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 and directly affect the life-stage, *e.g.*, degraded hydrologic function, increased turbidity, presence of non-native predators, increased substrate embeddedness). Because of the lack of field derived information on specific habitat requirements (*i.e.*, tolerances) and specific habitat conditions, the GIS-based surrogate variables used for the “Multiple Life Stages” conservation target actually are sources of stress, not direct stressors on *O. mykiss* life stages (*e.g.*, increased road density (a source of stress) contributes indirectly to increased turbidity (a direct stressor). The severity (very high, high, medium, or low) and geographic scope (very high, high, medium, and low) of each stress was determined through a review of existing information. The CAP Workbook 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 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 SCCCS 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. However, an important feature of the CAP Workbook methodology is the ability to update the assessment as information becomes available. In the interim, professional judgment must be used to address such gaps until such time as field derived, quantitative data is available.

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

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

Table D-2 compares the results of the two documents for watersheds in the SCCCS Recovery Planning Area. It should be noted that the difference between a “Poor” and “Fair” habitat rating or a “Good” and “Very Good” rating is often a matter of professional judgment and may always not represent important differences in habitat quality. Table D-2 explains 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 certain final assessments.

Table D-2. Variation in Assessments of Overall Habitat Conditions for Steelhead in Component Watersheds in the South-Central California Steelhead Recovery Planning Area Between Two CAP Workbook Analyses*

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

Morro Creek			
Chorro Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability
Los Osos Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability
San Luis Obispo Creek			
Pismo Creek			
Arroyo Grande Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability

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

** 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.

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

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 South-Central California Coast 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 criteria, and identifies important research and monitoring needed to better illuminate the biological requirements of the species and thereby better refine the viability 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 Method

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 South-Central California Coast Steelhead DPS, 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

¹Defer to IRM action where additional FTEs accounted for

²See 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

¹Seasonal

²Source: 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

¹Source: 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

¹Source: CDFG 2004 (p. 1-16)

Table 5. Dam Removal¹	
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

¹Source: CDFG 2004 (p. 1.11)

Table 6. Bridge Construction¹	
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

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

Source: NMFS 2008, p. 11-15

Table 8a. Road Upgrade/Road Decommissioning¹	
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. 43-44² Source: DOT 2010

Table 9. New Fish Ladder¹	
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

¹Source: NMFS 2008, p. 10

Table 11. Storm Drain Retrofit¹	
Action	Cost (\$/filter) or (\$/program)
Catch Basin/Filter Installation	98
Annual Maintenance Program	6452

¹Source: Kosciusko County 2002

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

¹Source: 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

¹Source: 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

¹Source: 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

¹Source: NMFS 2008, p. 38

Table 16. Estuary Restoration¹	
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

¹Source: Coastal Resources Management Council 2010

Table 17. Education and Outreach Programs¹	
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

¹Source: Neil 2002

²Source: Bennet 2007 (average cost)

³Source: U.S. FWS 2001

⁴Source: Northern California Conservation Center 2010

Table 19. Sediment Assessments¹	
Location	Cost (\$/mile)
Average all assessments in CA	1,240

¹Source: NMFS 2008, p. 61-62

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
Interior Coast Range	242,520,445	Pajaro River Salinas River	96,590,000	No Core 2 populations identified	N/A
Carmel River Basin	114,797,765	Carmel River	114,797,765	No Core 2 populations identified	N/A
Big Sur Coast	11,213,090	San Jose Creek Little Sur River Big Sur River	6,860,035	Garrapata Creek Bixby Creek Willow Creek Salmon Creek	4,353,055
San Luis Obispo	195,751,920	San Simeon Creek Santa Rosa Creek Pismo Creek San Luis Obispo Creek Arroyo Grande Creek	80,471,285	San Carpoforo Arroyo de la Cruz Little Pico Creek Pico Creek Morro Creek Morro Bay Estuary (Chorro Creek, Los Osos Creek)	115,280,635

Table 20. BPG: Core 1 and 2 Population Cost Estimates**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 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 South-Central California habitat restoration projects, such as:

- National Fish and Wildlife Foundation

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.

APPENDIX F

Pesticide Application Best Management Practices

Application of pesticides requires site specific assessment, taking into account a variety of factors including the nature and density of the pest to be controlled, the timing, weather and soil conditions, the proximity to water courses, drainage patterns, and the sensitivity of species not targeted for control or elimination through the application of pesticides. Listed below are a number of best management practices and considerations intended to guide the application of pesticides in watersheds supporting anadromous fishes. For up-to-date information on pesticide use in California see California Department of Pesticide Regulation 2012a, 2012b:

- Select the lowest toxicity pesticide necessary to control the targeted species. Research the products by consulting Material Safety Data Sheets, EPA registration documents, or other sources of information that provide ecological toxicity data (e.g. No Observable Effect Concentrations (NOEC), Lethal Concentration 50% (LC50)). Avoid using materials for which such data is unavailable.
- Apply pesticides in a manner that prevents migration from the application area and exposure of listed anadromous fish and their habitat components (e.g., aquatic invertebrates or native riparian plant species).
- Applications within riparian areas (e.g., for invasive plant control) should be made with backpack sprayers, hand-held wands or other devices that give the applicator maximum control of the spraying. If this is not possible, apply the product using the largest droplet size possible to control drift. Have a dedicated observer to monitor for drift of the pesticide.
- Use a non-toxic dye to assist in identifying spray coverage and pesticide drift whenever needed.
- Use a hand-held anemometer or on-site weather station to monitor wind speeds during applications. Do not rely on visual estimation methods.
- Whenever possible, apply pesticides when listed species are not present, and maximize avoidance of reproductive or juvenile life-history stages.
- Avoid indiscriminate drifting of pesticide products into riparian areas or waterways. If applying to properties adjacent to water bodies with anadromous fish, ensure sufficient riparian vegetation is present to serve as a screen against potential drift.
- Utilize aquatic approved formulations of pesticides rather than terrestrial formulations in riparian areas or where pesticide drift into a water body may occur.
- Capture all runoff from areas using higher levels of pesticides (e.g., some agricultural crops, golf courses) and retain the runoff long enough for the pesticides to degrade to safe levels.

- Treat runoff if necessary through aeration or other means. Settle out and
- Use non-chemical control methods (e.g., cleaning orchards of fallen or leftover fruit to prevent overwintering of pests) to minimize pesticide applications.
 - Monitor for pests before spraying to ensure that the application of pesticides is necessary.
 - Avoid adding adjuvants such as surfactants (e.g., R-11, polyoxyethyleneamine (POEA)) or synergists (e.g., piperonyl butoxide (PBO), N-octyl bicycloheptene dicarboximide (NGK 264)) to the pesticides' active ingredients unless toxicity information for these adjuvants is known and they can be safely used. Adjuvants may be more toxic to nontarget organisms such as fish and aquatic invertebrates than the pesticide active ingredient itself.
 - To select the least toxic alternative, research the toxicity of adjuvants in a manner similar to the pesticide active ingredient.
 - Avoid broadcast applications of pesticides to large areas or areas bordering impermeable surfaces. Utilize spot treatments.
 - Promote careful use of granular formulations of pesticides when they are needed, especially by the general public. Pesticide concentrations are often highest immediately downstream of urbanized areas. Replace granular applications with other methods (e.g., spot treatments for weeds, spraying
- retain sediments, if possible, for selected pesticides.
- around the foundation of a building as an insect barrier rather than treating the entire property).
- Avoid the application of pesticides within 48 hours of predicted rain. (This timeframe may vary greatly depending upon the pesticide selected.)
 - Avoid "water-in" granular pesticides to lawn or turf applications if another application type (e.g., spray products) can be utilized. Avoid generating pesticide runoff.
 - Avoid planting or promoting known invasive plants such as Giant Reed (*Arundo donax*), Tamarisk (*Tamarix ramosissima*), Water primrose (*Ludwigia uruguayensis*), Water hyacinth (*Eichhornia* spp.), German ivy (*Senecio mikanioides*), Creeping myrtle or Common periwinkle (*Vinca minor*), Pampas grass (*Cortaderia jubata*), Spanish broom (*Spartium junceum*), etc. that frequently become the target of control programs using herbicides.

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