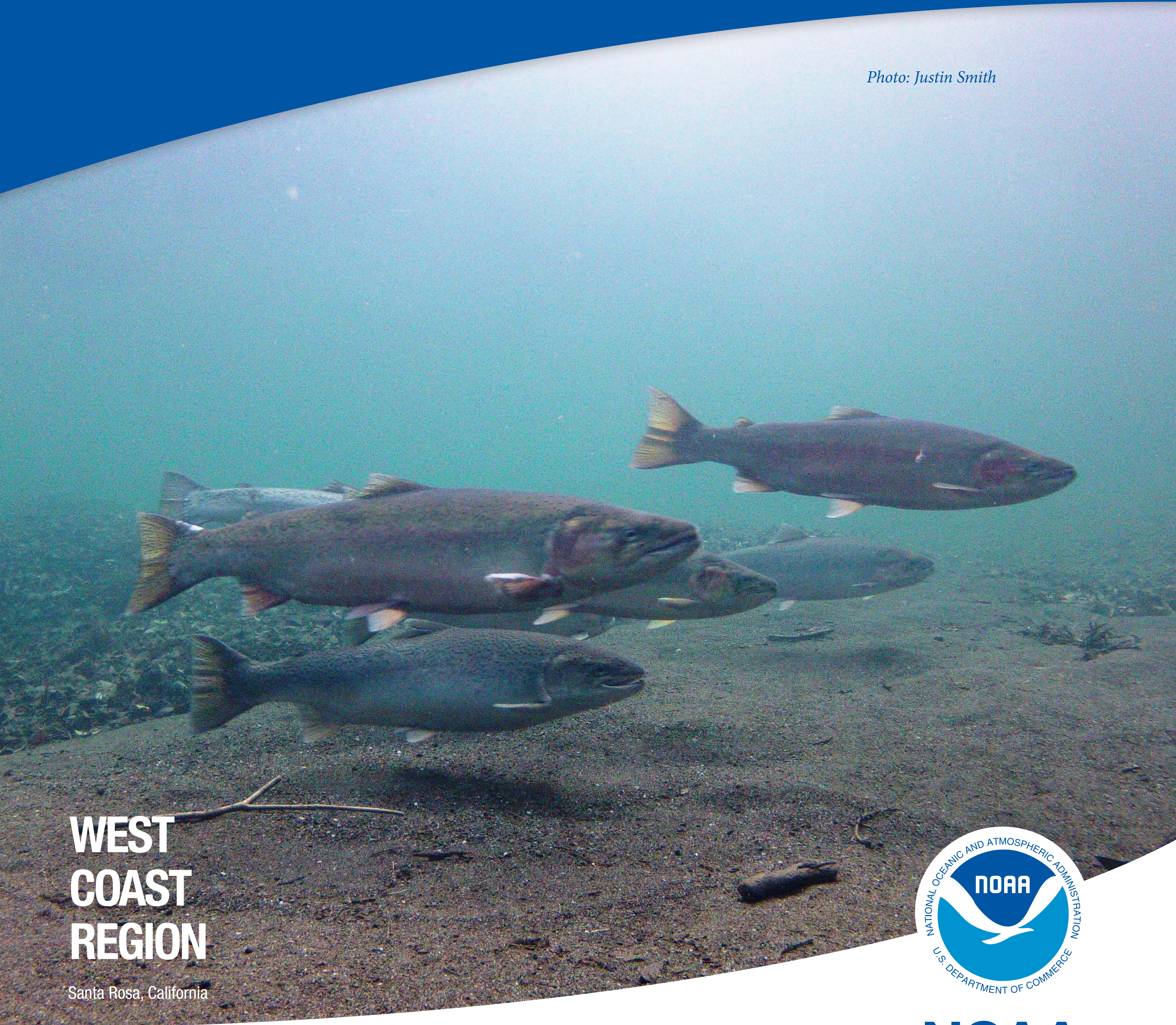
Final Coastal Multispecies Recovery Plan

October 2016

- California Coastal Chinook Salmon
- Northern California Steelhead
- Central California Coast Steelhead



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WEST COAST REGION

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EXECUTIVE SUMMARY

The California Coastal Multispecies Recovery Plan was developed for three salmon and steelhead species: the California Coastal (CC) Chinook salmon Evolutionarily Significant Unit (ESU), and the Northern California (NC) and Central California Coast (CCC) steelhead Distinct Population Segments (DPS). Between 1997 and 2000, NOAA's National Marine Fisheries Service (NMFS) listed the CCC steelhead DPS (1997), the CC Chinook ESU (1999), and the NC steelhead DPS (2000), as threatened under the Federal Endangered Species Act (ESA) due to the precipitous and ongoing declines in their populations. Under the ESA, a recovery plan (which is a non-regulatory document) must be developed and implemented for each threatened or endangered species. The purpose of a recovery plan is to provide a framework for the conservation and survival of the listed species [ESA section 4(f)(1)] that focuses and prioritizes threat abatement and restoration actions necessary to recover, and eventually delist, a species.

GEOGRAPHIC SETTING AND BIOLOGICAL FOUNDATION OF THIS RECOVERY PLAN

This recovery plan was developed by the NMFS North Central Coastal Office (NCCO) recovery team with assistance from staff in the North Coast Office (NCO); both offices are located within the California Coastal Office of NMFS' West Coast Region (WCR). This plan covers the geographic area of approximately 8 million acres along California's central coast that extends from the Redwood Creek watershed in Humboldt County, south to the Aptos Creek watershed in Santa Cruz County, including the San Francisco Bay Estuary and its tributaries (except for the Sacramento-San Joaquin rivers) and Humboldt Bay and its tributaries. The diverse geographic setting includes redwood and oak forestlands, rural working forests and agricultural lands, as well as the highly urbanized areas surrounding San Francisco Bay.

The biological setting and foundation for the plan were provided in two technical memoranda prepared by a group of experts and fishery scientists (The Technical Recovery Team or TRT) led by the NMFS Southwest Fisheries Science Center. These memoranda describe each of the species' historical population structure and biological viability and also describe the environmental and biological settings necessary to reduce the risk of extinction. For each species, individual populations were classified as functionally independent, potentially independent or dependent populations, and the populations were grouped into Diversity Strata, which are geographically distinct areas with similar environmental conditions. Functionally independent populations are larger populations that are likely to persist over a 100-year time scale in isolation and without the influence of migrants from neighboring populations. Potentially independent populations, as those likely to persist over a 100-year time scale but are influenced by immigration from neighboring populations, and dependent populations are those likely to go extinct within a 100-year time period in isolation and rely on immigration from neighboring populations to persist.

The TRT developed biological viability criteria for the three levels of biological organization (i.e., populations, Diversity Strata, ESU/DPS), important for the long term persistence of salmon and steelhead. These criteria involve a minimum number of populations achieving viability and populations, not required to achieve viability, but that demonstrate occupancy and distribution patterns to suggest sufficient connectivity within and between populations.

The TRT determined the CC Chinook salmon ESU was historically comprised of 38 populations (32 fall run and 6 spring run) distributed among four Diversity Strata. Of the 32 fall run populations, 15 were considered functionally or potentially independent, and the remaining were considered dependent populations. All six of the spring-run populations in the ESU were considered functionally independent, but all are now considered extinct. For the NC steelhead DPS, the TRT identified a total of 40 historically independent populations (18 functionally and 22 potentially independent) and 10 summer run populations (all functionally independent). The NC steelhead DPS winter run populations were delineated among five Diversity Strata, and the summer run populations were split into two Diversity Strata. For the CCC steelhead DPS, the TRT identified a total of 37 independent winter run populations (10 functionally independent and 27 potentially independent) distributed across five Diversity Strata.

Not all populations are needed for, or capable of supporting, recovery in the ESU or DPS. The recovery team evaluated quantitative and qualitative information provided by a large suite of stakeholders regarding current presence or absence of Chinook salmon and steelhead, habitat suitability, threats likely affecting habitat suitability and current protective efforts ongoing in the watershed. Using this assessment, the recovery team selected populations from each species and Diversity Stratum that will be essential for their recovery; these are termed essential populations. The remaining populations are expected to play a supporting, although important, role in recovery; these are termed supporting populations. In nearly all cases, essential populations consist of independent populations expected to meet a low risk of extinction, while supporting populations are dependent populations and independent populations expected to meet a moderate risk of extinction. Spawner abundance numeric targets were established for each essential and supporting population, for each Diversity Strata, and for the ESU and DPS.

CHINOOK SALMON AND STEELHEAD LIFE CYCLE

Chinook salmon and steelhead are anadromous (ocean-going) fish and return from the ocean to the streams where they were born to spawn and die. This cycle of life takes them from freshwater to tidal zones to the ocean and back again in as few as three years. Each transition into a new habitat is associated with a different life stage. Salmon and steelhead begin as eggs in stream gravels where their parents spawned, they then emerge from the gravels up into the stream flow as juveniles where they will stay for a few months (some Chinook salmon) or a few years (steelhead) before beginning their downstream migration to the ocean as smolts. As adults, one to three years usually are spent in the ocean (depending on the species) before they return to the stream where they were born to spawn. Unlike Chinook salmon (and coho salmon), steelhead are iteroparous, meaning some adults do not die after spawning but instead return to the ocean and repeat the adult portion of their lifecycle one or more times.

Juvenile Chinook salmon and steelhead need cool and clean water that flows unimpaired and unconstrained from the headwaters to the ocean. The suitability of a river or stream to provide the necessary habitats for Chinook salmon or steelhead survival at each life stage is critical to their persistence. This means streams must have: (1) clean loose gravels free of fine sediment; needed for spawning and egg development; (2) adequate pools and natural instream cover for juveniles; (3) connected alcoves and off-channel habitats for juveniles to survive winter flows; (4) clean cool water; and (5) unimpaired passage to and from the ocean. Coastal estuaries, or lagoons, play an equally important role in the life history of Chinook salmon and steelhead because they serve as transitional habitat between life in freshwater and marine environments. Properly functioning estuaries provide highly productive feeding opportunities where rapid growth occurs and where they can acclimate to saltwater prior to entering the ocean; this is particularly important during the smolt life stage for both species.

Assessment and Prioritization

The more impaired a watershed, the less likely juvenile Chinook salmon and steelhead will survive to reach the ocean and return as adults to spawn. The suitability of habitats to provide for salmon and steelhead survival across life stages, and ultimately abundant populations, is inexorably linked to factors that impair these habitats or diminish their ability to support these species (*e.g.*, threats). We evaluated numerous habitat conditions as well as natural and anthropogenic threats to their habitat and survival. Using two different analyses, the NCCO recovery team evaluated these conditions based on the best available information. The larger independent populations were analyzed using the Nature Conservancy Conservation Action Planning (CAP)[1] analysis; these populations are the essential populations. The dependent populations and independent populations expected to achieve a moderate extinction risk were analyzed at the Diversity Stratum scale (not population level) using an abbreviated CAP protocol called the rapid assessment; these are the supporting populations. The rapid assessments utilized a subset of the factors analyzed in the full CAP protocol.

[1] CAP is an Excel-based user-defined tool with specific protocols to organize a project, assess conditions and threats, and identify strategies. See Chapter 4, Methods for more information.

CURRENT STATUS

Low survival of juveniles in freshwater, in combination with poor ocean conditions, has led to the precipitous declines of Chinook salmon and steelhead populations throughout the central and northern California coastal areas. Recent status reviews for these species concluded that the CC Chinook salmon ESU and both the NC and CCC steelhead DPSs remained threatened (NMFS 2016a; NMFS 2016b; Williams *et al.* 2016) . Estimates by researchers and agencies indicate Chinook salmon and steelhead have declined substantially in coastal populations of central and northern California over the past 70 years.

Long time-series of adult return data are extremely scarce and for most populations only estimates based on best professional judgement are available. For steelhead, populations most impacted over the last 70 years are those surrounding San Francisco Bay.

Based on our evaluation of current habitat conditions and ongoing and future threats, we conclude that all life stages of Chinook salmon and steelhead are impaired by degraded habitat conditions. These impairments are due to a lack of complexity and shelter formed by instream wood, high sediment loads, lack of refugia during winter, low summer flows, reduced quality and extent of coastal estuaries and lagoons, and reduced access to historic spawning and rearing habitat. The major sources of these impairments are roads, water diversions and impoundments, logging, residential and commercial development, severe weather patterns, and channel modification. Comparing results across the ESU and DPSs, patterns emerged. For CC Chinook salmon and NC steelhead, conditions and threats tend to worsen from south to north. This spatial difference is largely attributed to historic effects of intensive logging practices on the availability of instream large wood, reduced habitat complexity and shelter, and sediment generated from poor road construction throughout the northern coastal forests of Humboldt and Mendocino counties. For the CCC steelhead DPS, conditions are more degraded in the Santa Cruz Mountain and San Francisco Bay Diversity Stratum populations.

TURNING THE PLAN INTO ACTION

Threat abatement and restoration recommendations (recovery actions) were developed site-specifically and for the ESU/DPS, Diversity Stratum, and population (watershed). Actions described in the plan are prioritized as: (1) Priority 1 is an action that must be taken to prevent extinction or to identify those actions necessary to prevent extinction; (2) Priority 2 is an action that must be taken to prevent a significant decline in population numbers, habitat quality, or other significant negative impacts short of extinction; and (3) Priority 3 actions are all other actions necessary to provide for full recovery of the species.

Unlike many other recovery planning efforts in the western United States, few Federal or State lands are available to aid in the recovery this species. The majority of lands in the recovery domain for this plan (approximately 83%) are in private ownership. The primary mechanism for Chinook salmon and steelhead protection on forestlands is California's Forest Practice Rules, while the primary mechanisms of protection from other land uses are more indirect and associated with State regulations, county ordinances, etc. Developing and nurturing partnerships with private landowners, concerned citizens, various State and Federal agencies, and non-governmental organizations is essential. Furthermore, creating incentives and expanding public/private partnerships for restoration and improving land and water use practices are critical for the recovery of the CC Chinook salmon ESU and the NC and CCC steelhead DPSs.

To track progress towards recovery, we must develop and implement a comprehensive monitoring program that will provide the necessary data to inform species status and trends as well as the five federal listing factors and associated threats. For this, we will rely primarily on the California Coastal Monitoring Plan (CMP), which is a statewide program developed by the California Department of Fish and Wildlife (CDFW) and NMFS to standardize monitoring of coastal populations of anadromous native salmonids and inform recovery, conservation, and management. Currently, the CDFW and NMFS are in the process of developing protocols for measuring habitat conditions in both freshwater and estuarine environments. Dedicated funding necessary to expand and refine the CMP will be critical.

The Price Tag of Clean Water and Flowing Streams

Healthy salmon and steelhead populations provide significant economic benefits. Entire communities, businesses, jobs and even cultures have been built around the salmon and steelhead of California. Similarly, many communities, businesses and jobs have been lost as wild populations have steadily declined. In other words, unhealthy salmon and steelhead populations signify lost economic opportunities and an unhealthy environment. Investments in watershed restoration projects can promote the economy through the employment of workers, contractors, and consultants, and the expenditure of wages and restoration dollars for the purchase of goods and services. Such investments also provide opportunities for enhanced education and ways of connecting (or reconnecting) younger generations with nature. In addition, viable salmonid populations provide ongoing direct and indirect economic benefits as a resource for fishing, recreation, and tourist-related activities. Every dollar spent on salmon and steelhead recovery will promote local, State, Federal, and tribal economies, and should be viewed as an investment with both societal (*e.g.*, healthy ecosystems and clean rivers where we and our children can swim and play) and economic returns.

Recovering Salmon

The plight of salmonid species is inexorably tied to the story of the changing landscape. Many naturalists, fishermen and biologists across Europe, Eastern Pacific and North America have monitored salmonids and chronicled their decline and extinctions. NMFS alone cannot shift the trajectory of Chinook salmon and steelhead from their continued decline towards recovery. Their recovery will require a united community forming alliances and strategically implementing recovery actions to this single purpose. Salmon survival will depend on us not regarding "…*this inhabitant of the waters with something like annoyance*" (Fearing 1876), but embracing a paradigm that we can live, work and use the land and water compatibly with the needs of the larger ecological community, including fish.

NMFS estimates recovery of the CC Chinook salmon ESU and the NC and CCC steelhead DPSs would take 50 to 100 years. Although the cost for their recovery will be a significant amount of money, it is important to note the cost for recovery of each species will bring many ancillary benefits to the public as well as other species. Once implemented, many of the identified recovery actions described in this plan will also provide direct benefits towards the recovery of other salmon populations throughout coastal California and vice versa.[2] Therefore, costs of salmonid recovery will be shared among species within the recovery domain.

> *"…restoring salmon runs will require reshaping our relationship to the landscape, guided by the humility to admit that we do not know how to manufacture, let alone manage, a natural ecosystem…"*
>
> *David Montgomery 2003*

[2] In 2012 and 2014, the NMFS NCCO and NCO finalized the recovery plans for the Central California Coastal (CCC) coho salmon and Southern Oregon Northern California Coast (SONCC) coho salmon ESUs. Both of these ESUs overlap with CC Chinook and either the NC steelhead or CCC steelhead DPSs. This plan includes recovery actions at the three spatial scales that will ultimately benefit all salmonid species present within these populations and similarly, actions identified in the CCC and SONCC coho salmon plans will benefit CC Chinook and either NC or CCC steelhead populations.

COASTAL MULTISPECIES PLAN

- Volume I: Recovery Plan: Chapters 1 - 8
- Volume II: California Coastal (CC) Chinook Salmon Evolutionarily Significant Unit (ESU)
- Volume III: Northern California (NC) Steelhead Distinct Population Segment (DPS)
- Volume IV: Central California Coast (CCC) Steelhead Distinct Population Segment
- Volume V: Appendices

The recovery plan is organized into five volumes. Volume I details general information on recovery planning, methods, results, actions, criteria, and implementation. Volumes II, III and IV describe CC Chinook, and NC and CCC steelhead, respectively. These volumes describe which essential and supporting populations were selected for recovery, general trends in conditions and threats, priorities for the ESU/DPS, climate change implications, factors leading to decline, status of conservation/protective efforts, recovery actions and delisting criteria. For each population, information is provided on watershed setting, habitat and threat results, and actions required for the populations' recovery. Volume V contains the appendices which include: (1) a discussion of marine and estuarine condition and threats; (2) climate change scenarios; (3) the foundational document on population viability developed by the Technical Recovery Team (TRT) (Spence *et al.* 2008 and 2012); (4) reports detailing how current conditions and future threats were analyzed; (5) a description of attributes produced by the stream summary application; (6) protocols used to estimate costs and ESU/DPS and population level recovery action cost estimates ; (7) intrinsic potential updates; and (8) prioritization of populations for restoration and focus.

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COASTAL MULTISPECIES PLAN

VOLUME I: CHAPTERS 1-8

2016

Courtesy: Esteban Camacho Steffensen, NOAA Fisheries, Environmental Protection Agency, and the Pacific Northwest College of Arts

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Many public and private entities have collected watershed and population data, and worked tirelessly to conserve and protect California's salmonids and their habitats. We thank all of you who care about salmonids. The financial support from Sonoma County Water Agency made it possible for us to compile the best available information at a scale and depth unprecedented for the central coast of California. These funds supported work of The Nature Conservancy, the Sonoma Ecology Center, and the exceptional work of the UC Davis Hopland Research staff.

The Nature Conservancy has been a close partner providing extensive training, support, and advice as we applied the Conservation Action Planning tool and protocol which is foundational to our analyses. The Nature Conservancy has also allowed for us to display our Conservation Action Planning tables and associated analysis on Miradi Share[3] and outputted and formatted results tables displayed in this recovery plan.

We would like to thank the members of our Statement of Understanding (SOU), which includes; Sonoma County Water Agency, Zone 7 Water Agency, Alameda County Water District, East Bay Municipal Utility District, Contra Costa County Flood Control & Water Conservation District, Santa Clara Valley Water District, Alameda County Flood Control & Water Conservation District, Marin Municipal Water District, North Bay Watershed Association, East Bay Regional Park District, North Marin Water District, Solano County Water Agency, San Mateo County Resource Conservation District, Mendocino County Resource Conservation District, Marin Resource Conservation District, Gold Ridge Resource Conservation District, San Francisquito Creek Joint Powers Authority, Sonoma Resource Conservation District, Contra Costa Resource Conservation District, Resource Conservation District of Santa Cruz County, County of Santa Cruz, Alameda County Resource Conservation District, Marin County Public Works, and San Mateo County Public Works. A special thanks to Carl Morrison who has worked to bring this group together and bring attention to this recovery plan.

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[3] https://www.miradishare.org/

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LIST OF ACRONYMS

a.k.a	Also Known As
BACI	Before After Control Impact
BFW	Bankfull Width
BiOp	Biological Opinion
BKD	Bacterial kidney disease
BLM	Bureau of Land Management
BMP	Best Management Practices
BRT	Biological Review Team
C	Celsius
CC	California Coastal
CalFire	California Department of Forestry and Fire Protection
Caltrans	California Department of Transportation
CAP	Conservation Action Planning
CIE	Center for Independent Experts
CCC	Central California Coast
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CFPA	California Forest Practices Act
cm	Centimeters
CMP	California Coastal Salmonid Monitoring Plan
CV	Coefficient of Variation

CWA	Clean Water Act
CWPAP	Coastal Watershed Planning and Assessment Program
DBH	Diameter at Breast Height
DNA	Deoxyribonucleic Acid
DP	Dependent Population
DPS	Distinct Population Segment
ECS	Egg Collection Station
EPA	US Environmental Protection Agency
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
F	Fahrenheit
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FEMAT	Forest Ecosystem Management Assessment
FERC	Federal Energy Regulatory Commission
FIP	Functionally Independent Population
FMEP	Fisheries Management and Evaluation Plan
FPR	Forest Practice Rules
FR	Federal Register
FRN	Federal Register Notice
FRGP	Fisheries Restoration Grant Program
GIS	Geographic Information System
GRTS	Generalized Random Tessellation Sampling
HCD	Habitat Conservation Division

HCP	Habitat Conservation Plan
HGMP	Hatchery and Genetic Management Plan
IP	Intrinsic Potential
IPCC	Intergovernmental Panel on Climate Change
IP-km	Intrinsic Potential per Kilometer
kg	Kilograms
Km	kilometers
KRIS	Klamath Resource Information System
LCM	Life Cycle Monitoring
LWD	Large Woody Debris
m	Meter
mg	Milligram
mm	Millimeters
MMWD	Marin Municipal Water District
MOU	Memorandum of Understanding
MRC	Mendocino Redwood Company
MWAT	Mean Weekly Average Temperature
MWMT	Mean Weekly Maximum Temperature
MBSTP	Monterey Bay Salmon and Trout Project
NCCP	Natural Communities Conservation Planning
NCCC Domain	North Central California Coast Recovery Domain
NCCO	North Central Coast Office
NC	Northern California
NFP	Northwest Forest Plan

NGO	Non-governmental Organization
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NRCS	Natural Resources Conservation Service
NTU	Nephelometric Turbidity Unit
OLE	Office of Law Enforcement
PCSRF	Pacific Coastal Salmon Recovery Fund
PDO	Pacific Decadal Oscillation
PFMC	Pacific Fishery Management Council
PSMFC	Pacific States Marine Fisheries Commission
pHOS	Percent of Hatchery Origin Spawners
PIP	Potentially Independent Population
ppm	Parts per Million
PRD	Protected Resources Division
RATS	Recovery Action Tracking System
RCD	Resource Conservation District
SCWA	Sonoma County Water Agency
SEC	Sonoma Ecology Center
SPAWN	Salmon Protection and Watershed Network
SONCC	Southern Oregon Northern California Coast
SWFSC	Southwest Fisheries Science Center
SWR	Southwest Region
SWRCB	California State Water Resources Control Board
THP	Timber Harvest Plan

TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
TRT	Technical Recovery Team
UC	University of California
UCCE	University of California Cooperative Extension
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	US Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VSP	Viable Salmonid Population
WOC	Washington, Oregon, and California
WHR	Wildlife Habitat Relationship

1.0 INTRODUCTION

"From the most narrow possible point of view, it is in the best interest of mankind to minimize the losses of genetic variations. The reason is simple: they are potential resources. They are the keys to puzzles which we cannot solve, and may provide answers to questions which we have not yet learned to ask."

U.S. House of Representatives, 1973, when enacting the Endangered Species Act

1.1 RECOVERING PACIFIC SALMON

For millions of years, salmon and steelhead (salmonids) thrived in abundance despite natural fluctuations in the marine and freshwater environments, predation, disease, prolonged droughts, flash floods, uncontrolled wildfires, marine oscillations, volcanic eruptions, climate change, and natural fluctuations--also currently challenging the human setting. Approximately 37 million people live in California and the human uses of land and water present increasing challenges to the survival and persistence of salmonids. Many streams lack sufficient water or habitat complexity, and are dammed, channelized, or polluted making it more difficult for salmonids to survive. Other factors such as ocean harvest, bycatch, and hatchery practices have had adverse impacts to salmonid survival. These human-caused and natural factors have all contributed to the decline of west coast salmonids. As a result of these declines, 28 Distinct Population Segments (DPS) or Evolutionarily Significant Units (ESU) of salmon and steelhead have been listed on the Federal Endangered Species Act (ESA; 16 U.S.C. 1531 et seq.) by NMFS across the West Coast.

Recovery is the process of restoring listed species and their ecosystems to the point where they no longer require the protections of the ESA. A recovery plan serves as a road map for species recovery—it lays out where to go and how to get there. Without a plan to organize, coordinate, and prioritize recovery actions, the efforts of the many agencies, non-profit organizations, tribal entities, stakeholders, and citizens may be inefficient, ineffective, or misdirected. Focused implementation can guide effective use of limited resources. This recovery plan covers three of the species listed by NMFS; California Coastal (CC) Chinook salmon ESU, Northern California (NC) steelhead DPS, and Central California Coast (CCC) steelhead DPS.

The recovery strategy for NC and CCC steelhead and CC Chinook salmon involves increasing abundance and diversity of salmon and steelhead, restoring habitat conditions, abating or reducing identified threats and conducting monitoring to track success in each Diversity Stratum and across the listed range.

1.2 THE ENDANGERED SPECIES ACT AND RECOVERY PLANS

The ESA was enacted by Congress and signed into law December 28, 1973, by President Richard Nixon, and has been amended several times. The ESA was established to safeguard the Nation's natural heritage by conserving species in danger of extinction for the enjoyment and benefit of current and future generations. "Nothing is more priceless and more worthy of preservation than the rich array of animal life with which our country has been blessed. It is a many-faceted treasure, of value to scholars, scientists, and nature lovers alike, and it forms a vital part of the heritage we all share as Americans. I congratulate the 93rd Congress for taking this important step toward protecting a heritage, which we hold in trust to countless future generations of our fellow citizens. Their lives will be richer, and America will be more beautiful in the years ahead…" (President Richard Nixon statement on signing the Endangered Species Act 1973). The intent of Congress in enacting the ESA, as interpreted by the United States Supreme Court, was to "halt and reverse the trend toward species extinction," "require agencies to afford first priority to the declared national policy of saving endangered species," and "give endangered species priority over the 'primary missions' of federal agencies". (Tennessee Valley Auth. v. Hill 1978).

The National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) (together referred to as "the Services") share responsibility for ESA implementation. Generally, USFWS oversees terrestrial, catadromous and freshwater species, and NMFS manages marine, and anadromous species (those that live in the ocean as adults but move into freshwater streams to reproduce, such as salmon). Either on the initiative of the Services or in response to a petition, the Services make a determination on whether a species should be listed as endangered or threatened based on the following ESA Section 4(a)(1) listing factors (16 U.S.C. 1533 (a)(1)) :

(A) The present or threatened destruction, modification, or curtailment of its habitat or range;
(B) Overutilization for commercial, recreational, scientific, or educational purposes;
(C) Disease or predation;
(D) The inadequacy of existing regulatory mechanisms; or
(E) Other natural or manmade factors affecting its continued existence.

Section 4(b)(1)(A) of the ESA requires these listing determinations be based solely on the best scientific and commercial data available after conducting a review of the status of the species and taking into account any efforts being made by states or foreign governments to protect the species. The focus of the five factors is to consider whether and to what extent a given factor represents a threat to the future survival of the species. In considering protective efforts,[4] conservation value and certainty of implementation and effectiveness are evaluated. Thus, listing decisions evaluate species status, efficacy of conservation/protective efforts and threats associated with the five ESA section 4(a)(1) factors. When the Services determine a species is endangered or threatened, the species is added to the Federal List of Endangered and Threatened Wildlife or the Federal List of Endangered and Threatened Plants (50 CFR 17.11, 17.12, 223.102, and 224.101) and the Service findings are published in Federal Register Notices (FRNs).

The ESA defines an endangered species as "any species which is in danger of extinction throughout all or a significant portion of its range…" (16 U.S.C. 1532(6)). A threatened species is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range" (16 U.S.C. 1532(20)). The ESA defines a "species" to include "any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature" (16 U.S.C.

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[4] The "Policy for Evaluation of Conservation Efforts When Making Listing Decisions" (PECE) guides the assessment of conservation and protective efforts (68 FR 15100).

1532(16)). Two policies are used for the delineation of distinct population segments: the "Policy on Applying the Definition of Species under the Endangered Species Act to Pacific Salmon"(56 FR 58612)[5] and the "Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species Act" (61 FR 4722).

ESA section 4 provides requirements, procedures and criteria applicable to listing or delisting a species, conducting status reviews, designating critical habitat, developing protective regulations, and developing and implementing recovery plans. Section 5 provides for land and water acquisition in order to carry out a program established and implemented to conserve fish, wildlife, and plants, including those listed as endangered or threatened. Section 6 provides authority for the Services to enter into cooperative agreements with states that establish and maintain programs for the conservation of threatened or endangered species as well as to provide financial assistance to states with such cooperative agreements to develop programs for the conservation of threatened or endangered species or assist in monitoring the status of candidate and recovered species. Section 7 directs Federal agencies, in consultation with and with the assistance of the Services, to: (1) utilize their authorities in furtherance of the purposes of the ESA by carrying out programs for the conservation of listed endangered and threatened species; and (2) insure that any action authorized, funded or carried out by the agency is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat designated for such species. Section 9 prohibits any person from taking any listed endangered species. The ESA defines "take" as "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (ESA Section 3(19), 16 U.S.C. 1532(19)). NMFS defines "harm" to include "significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering" (50 CFR 222.102). NMFS has promulgated protective

[5] This policy provides, "A stock of Pacific salmon will be considered a distinct population, and hence a 'species' under the ESA, if it represents an evolutionarily significant unit (ESU) of the biological species" (56 FR 58612), and explains criteria for making that determination.

regulations under ESA Section 4(d) that apply the take prohibitions under ESA Section 9 to listed threatened salmonids with certain limitations (50 CFR 223.203). Section 10 authorizes NMFS to issue permits for taking listed species for purposes of scientific research, to enhance the propagation or survival of a species, or for incidental taking of a species in conjunction with a habitat conservation plan.

ESA Section 4(f)(1) requires the Services to develop and implement recovery plans for the conservation and survival of listed endangered and threatened species, unless they find that such a plan will not promote the conservation of the species. Section 4(f)(1)(B) of the ESA specifies that contents of a recovery plan must include, to the maximum extent practicable:[6]

i. A description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species;

ii. Objective, measurable criteria which, when met, would result in the determination that the species be removed from the list; and

iii. Estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal (of species recovery) and to achieve the intermediate steps toward that goal.

In addition, recovery plan components and their development are guided by other policies and Acts, some reflecting court interpretations of the ESA. Several of these include: (1) the Interim Endangered and Threatened Species Recovery Planning Guidance Version 1.3 (Interim Recovery

[6] In 1988, Congress amended Section 4(f) of the ESA (Pub. L. No. 100-478, 102 Stat. 2306, 2307 (1988)), and this amendment included these specific contents for recovery plans. The Senate Report for the bill that led to this amendment provides, "Section 4(f) of the Act is amended to require that each recovery plan incorporate descriptions of site-specific management actions to achieve recovery, criteria by which to judge success of the plan, and time frames and estimates of costs to carry out the planned recovery" (S. Rep. No. 100-240, at 9 (1987), reprinted in 1988 U.S.C.C.A.N 2700, 2708). In addition, the Senate Report explains, "Incorporation of this information will ensure that plans are as explicit as possible in describing the steps to be taken in the recovery of a species" (S. Rep. No. 100-240, at 9 (1987), reprinted in 1988 U.S.C.C.A.N 2700, 2709). Furthermore, the Senate Report provides, "The requirement that plans contain objective, measureable criteria for removal of a species from the Act's lists and timeframes and cost estimates for intermediate steps toward that goal will provide a means by which to judge the progress being made toward recovery" (S. Rep. No. 100-240, at 9 (1987), reprinted in 1988 U.S.C.C.A.N 2700, 2709).

Guidance) (NMFS 2010); (2) the 1994 Interagency Cooperative Policy on Information Standards under the Endangered Species Act (59 FR 24271); and (3) NMFS Pre-Dissemination Review and Documentation Guidelines[7] issued in compliance with the Data Quality Act[8].

> "Recovery is the process by which listed species and their ecosystems are restored and their future safeguarded to the point that protections under the ESA are no longer needed" (NMFS 2010).

NMFS (2010) provides that recovery plans primarily: (1) "Delineate those aspects of the species' biology, life history and threats that are pertinent to its endangerment and recovery"; (2) "Outline and justify a strategy to achieve recovery"; (3) "Identify the actions necessary to achieve recovery of the species"; and (4) "Identify goals and criteria by which to measure the species' achievement of recovery". Recovery plans can also (1) "Serve as outreach tools by articulating the reasons for a species' endangerment, as well as why the particular suite of recovery actions described is the most effective and efficient approach to achieving recovery for the species"; (2) "Help potential cooperators and partners understand the rationale behind the recovery actions identified, and assist them in identifying how they can facilitate the species' recovery"; (3) "Serve as a tool for monitoring recovery activities"; and (4) "Be used to obtain funding for NMFS and its partners by identifying necessary recovery actions and their relative priority in the recovery process" (NMFS 2010). Federal agencies use recovery plans to fulfill obligations outlined in 7(a)(1) of the ESA, which requires Federal agencies to "utilize their authorities in furtherance of the purposes of this [Act] by carrying out programs for the conservation of endangered species and threatened species. . . ." Recovery plans guide other ESA work, such as consultations on Federal agency actions under ESA Section 7(a)(2) or development of Habitat Conservation Plans (HCPs) and

[7] NMFS Instruction 04-108-03, Section 515 Pre-Dissemination Review and Documentation Guidelines, December 16, 2004.

[8] Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001 (Pub. L. No. 106-554, 114 Stat. 2763A-153 to 2763A-154 (2000)).

Incidental Take Permits under ESA Section 10(a). Recovery plans are used by the Services to determine whether downlisting or delisting a species is warranted. Recovery plans are guidance documents only and are neither self-implementing nor legally binding. To ensure the listing classification of a species remains warranted, ESA section 4(c)(2) requires reviews (i.e., five-year status reviews) to determine if a change in status, or delisting, is needed. Status reviews follow procedures outlined in USFWS and NMFS (2006) and assess the same factors evaluated for listing (i.e., species status, protective efforts and threats under each ESA Section 4(a)(1) listing factor). Biannual reporting to Congress on progress to develop and implement recovery plans is also required.

THE COMPONENTS OF A RECOVERY PLAN INCLUDE SITE SPECIFIC ACTIONS, OBJECTIVE MEASURABLE CRITERIA AND ESTIMATES OF TIME AND COST DESIGNED TO PROVIDE FOR LONG-TERM SURVIVAL AND DELISTING OF THE SPECIES.

1.3 CRITICAL HABITAT

Section 3 of the ESA (16 U.S.C. 1532(5)(A)) defines critical habitat as ''(i) the specific areas within the geographical area occupied by the species, at the time it is listed…on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and (ii) specific areas outside the geographical area occupied by the species at the time it is listed…upon a determination by the Secretary that such areas are essential for the conservation of the species.'' Section 3 of the ESA (16 U.S.C. 1532(3)) also defines the terms ''conserve,'' ''conserving,'' and ''conservation'' to mean ''to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this chapter are no longer necessary.'' In designating critical habitat, NMFS: 1) identifies "the geographical area occupied by the species at the time of listing", 2) identifies "the physical and biological features essential to the conservation of the species at an appropriate level of specificity using the best available scientific data. This analysis will vary between species and may include consideration of the appropriate quality, quantity, and spatial and temporal arrangements of such features in the context of the life history, status, and conservation needs of the species", 3) determines "the specific areas within the geographic area occupied by the species that contain the physical or biological features essential to the conservation of the species", and 4) determines "which of these features may require special management considerations or protection" (50 CFR 402.12(b)(1)). The designation(s) of critical habitat for CC Chinook salmon, NC steelhead and CCC steelhead use the term primary constituent element (PCE) or essential features. NMFS and USFWS' recent revisions to their critical habitat regulations (81 FR 7414) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a ''destruction or adverse modification'' analysis in a biological opinion, which is the same regardless of whether the original designation identified primary constituent elements, physical or biological features, or essential features. NMFS uses the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat. Both the ESA and our regulations, in recognition of the divergent biological needs of species, establish criteria that are fact specific rather than ''one size fits all.''

Critical Habitat for CC Chinook salmon, NC steelhead and CCC steelhead was designated on September 2, 2005 (70 FR 52488). The primary constituent elements/physical or biological features identified at the time of the designation were;

(1) Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development;

(2) Freshwater rearing sites with:

(i) Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility;

(ii) Water quality and forage supporting juvenile development; and

(iii) Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

(3) Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.

(4) Estuarine areas free of obstruction and excessive predation with:

i) Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater;

(ii) Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels; and

(iii) Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

Specific areas eligible for designation are not automatically designated as critical habitat. Section 4(b)(2) of the ESA (16 U.S.C. 1533(b)(2)) requires that the Secretary first consider the economic impact, impact on national security, and any other relevant impact. The Secretary has the discretion to exclude an area from designation if he determines the benefits of exclusion (that is, avoiding the impact that would result from designation) outweigh the benefits of designation. The Secretary may not exclude an area from designation if exclusion will result in the extinction of the species.

The range of designated critical habitat for CC Chinook salmon is from Redwood Creek (inclusive) in Humboldt County to the Russian River (inclusive) in Sonoma County (Figure 1).

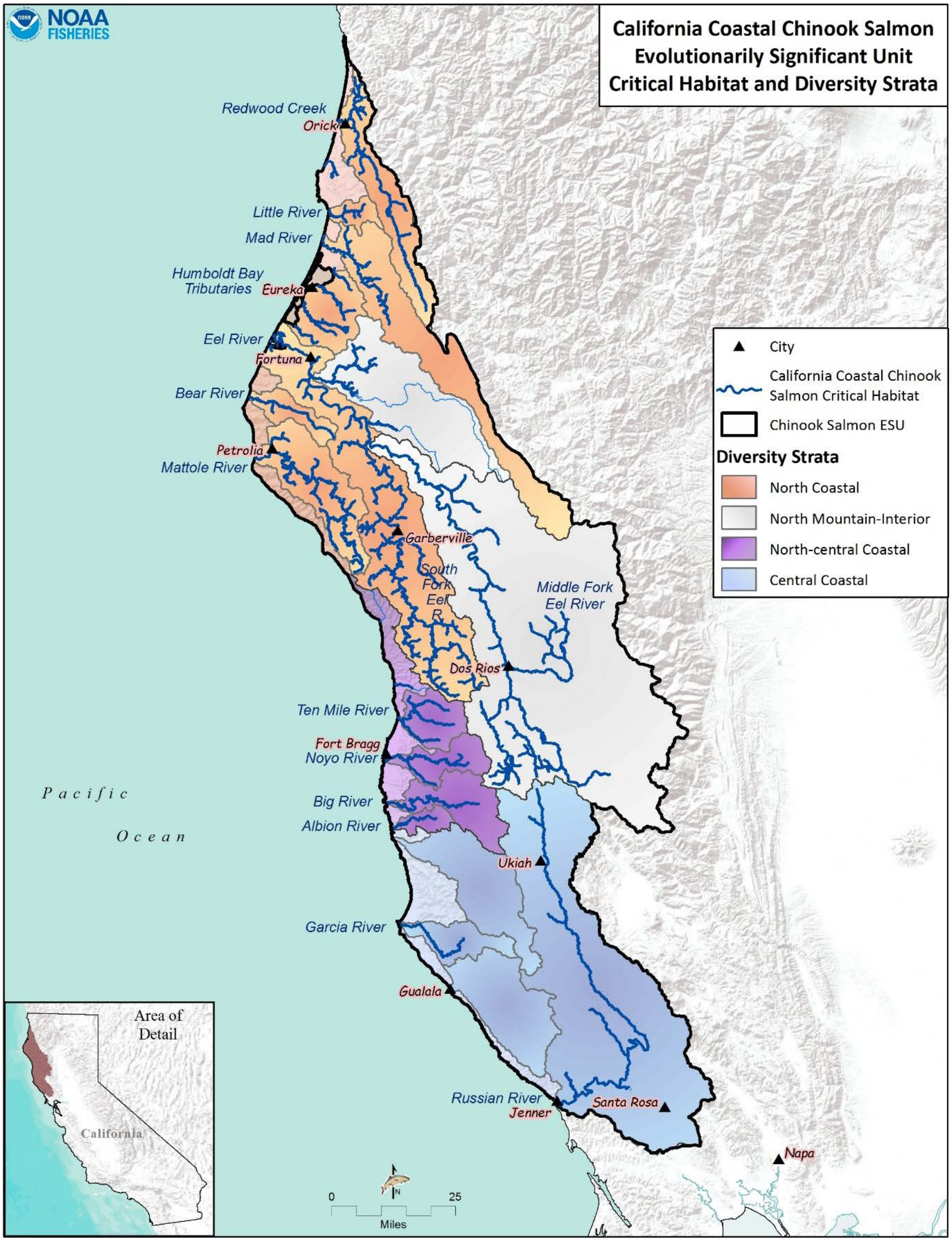

Figure 1: Critical Habitat for CC Chinook Salmon

The range of designated critical habitat for NC steelhead is from Redwood Creek (inclusive) to the Russian River (exclusive) (Figure 2).

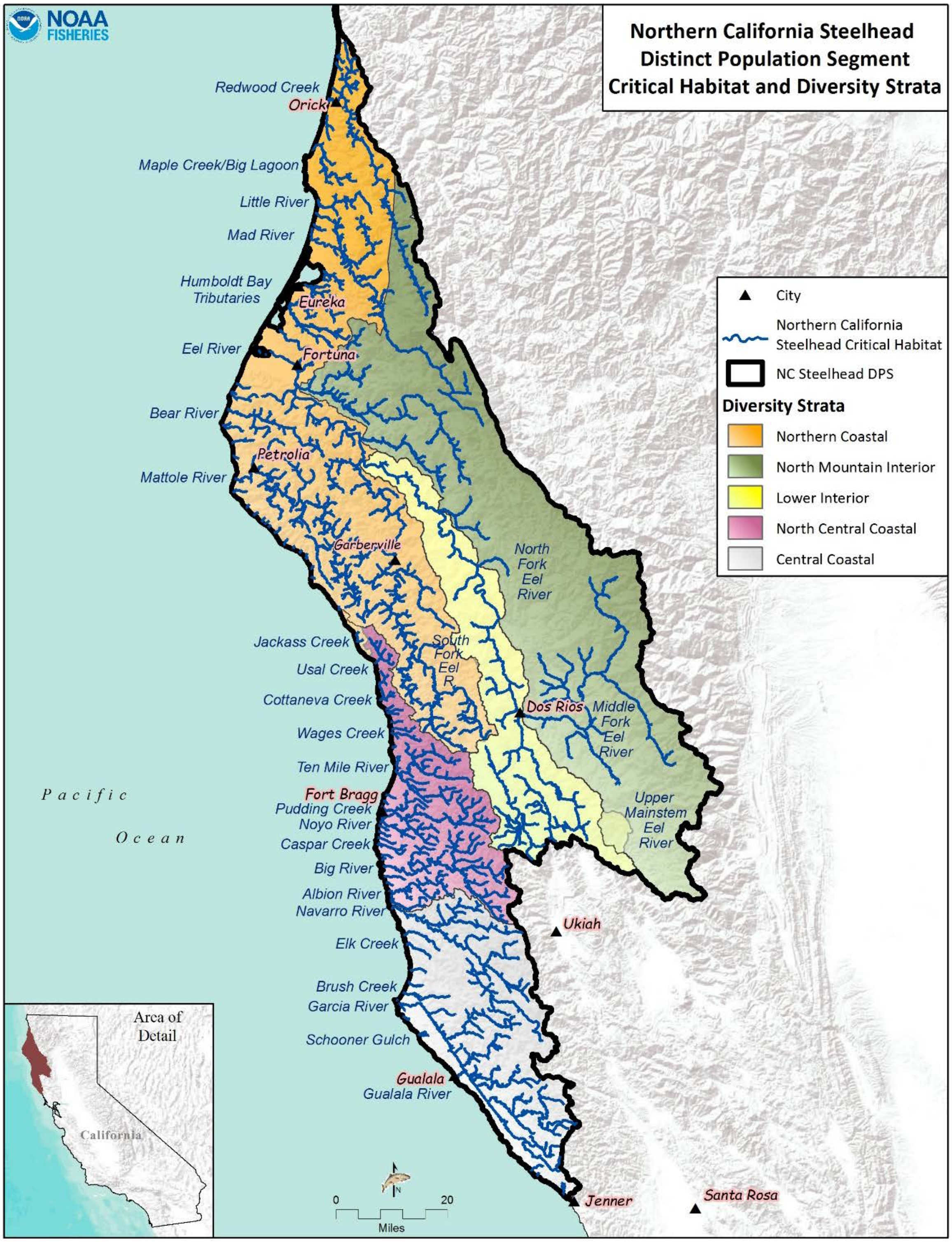

Figure 2: Critical Habitat for NC steelhead

The range of designated critical habitat for CCC steelhead is from the Russian River (inclusive) to Aptos Creek (inclusive), including the San Francisco Bay tributaries. (Figure 3).

Figure 3: Critical Habitat for CCC steelhead

1.4 CALIFORNIA'S RECOVERY DOMAINS

In 2001, NMFS organized recovery planning for listed salmonids into geographically coherent units called "recovery domains." Of the 28 salmon ESUs and steelhead DPSs listed under the ESA, ten are entirely within, or partially occur in, California. These ten species are organized into four Recovery Domains: (1) Southern Oregon/Northern California Coast Domain; (2) North-Central California Coast Domain (NCCC Domain); (3) California Central Valley Domain; and (4) Southern California/South-Central California Coast Domain (Figure 4). The NMFS offices responsible for each recovery domain are located in: (1) Arcata; (2) Santa Rosa; (3) Sacramento; and (4) Long Beach. The NMFS West Coast Region (WCR) web page provides ongoing updates and information on Federal recovery planning which can be found at: http://www.westcoast.fisheries.noaa.gov/

Each recovery domain in California includes (1) one or more listed species of salmon and steelhead; (2) a Recovery Coordinator responsible for facilitating development and implementation of the recovery plan; and (3) a Technical Recovery Team (TRT) led by the NMFS Southwest Fisheries Science Center (SWFSC). The TRT was comprised of a panel of scientists and experts to produce technical memoranda outlining the historical population structure (Bjorkstedt *et al.* 2005) and developing biological viability criteria (Spence *et al.* 2008) to be used for the recovery plans (See Chapter 3).

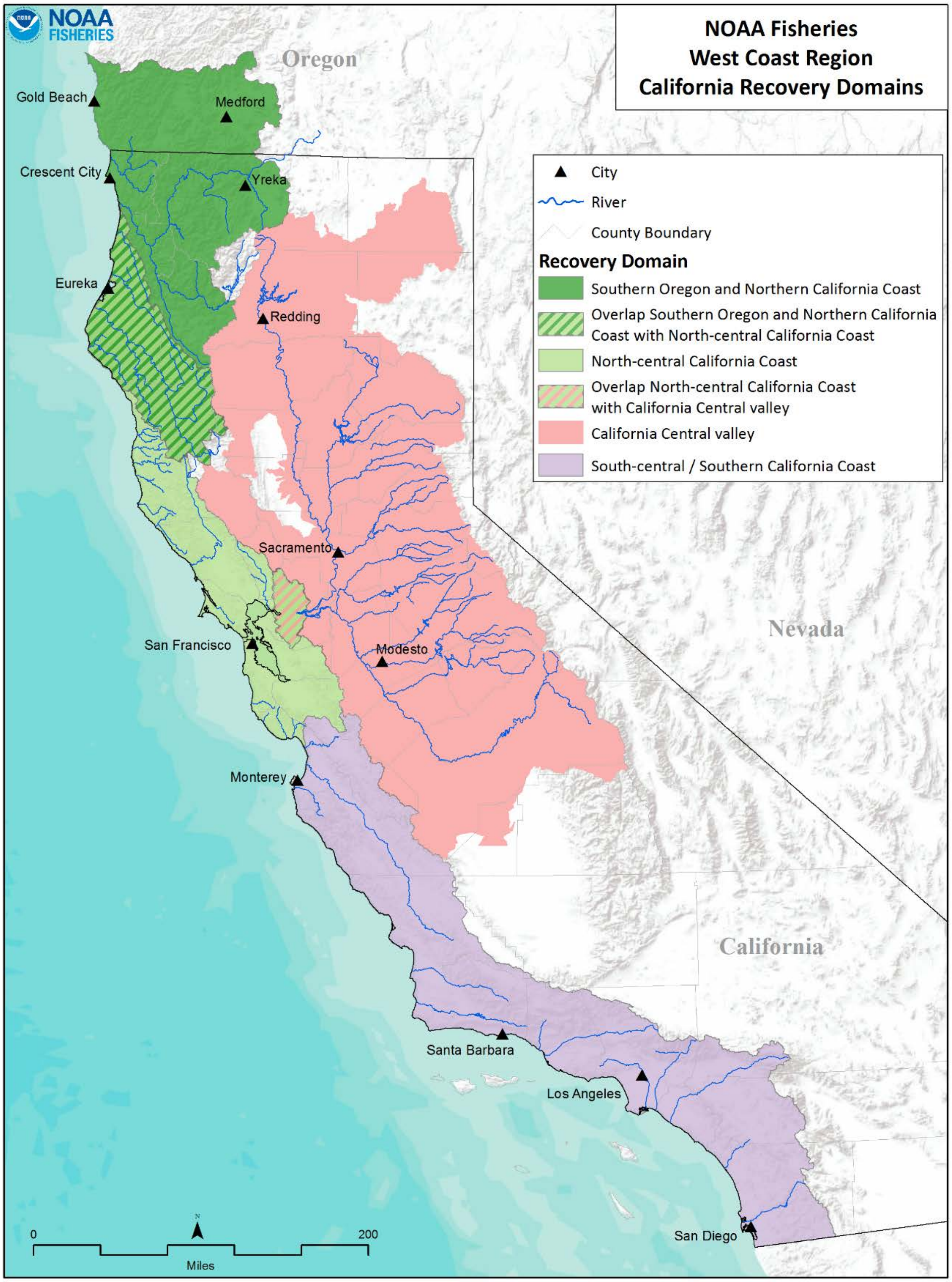

Figure 4: Salmon and Steelhead Recovery Domains in California (with overlapping Domain areas shown with cross-hatching).

The NCCC Domain (Figure 4) includes the following ESUs and DPSs:

1. Threatened California Coastal Chinook salmon ESU (CC Chinook salmon ESU);
2. Threatened Northern California steelhead DPS (NC steelhead DPS);
3. Threatened Central California Coast steelhead DPS (CCC steelhead DPS); and
4. Endangered Central California Coast coho salmon ESU (CCC coho salmon ESU).

This recovery plan covers CC Chinook salmon, NC steelhead, and CCC steelhead[9]. The geographic area associated with the NCCC Domain is approximately eight million acres of California's north central coast, extending from the Redwood Creek watershed in Humboldt County south to the Aptos Creek watershed in Santa Cruz County, including the San Francisco Bay Estuary and its tributaries (except for the Sacramento-San Joaquin rivers) and Humboldt Bay and its tributaries (Figure 5). The geographic setting of the Domain includes redwood and oak forestlands, rural working forests and agricultural lands as well as highly urbanized areas of the San Francisco Bay area.

[9] The NCCC Domain was charged with preparing two recovery plans: one for CCC coho salmon and one for the remaining three listed salmonids in the Domain. The final recovery plan for the CCC coho salmon ESU was published on September 5, 2012. This Coastal Multispecies Plan is the second plan being developed for the NCCC Domain.

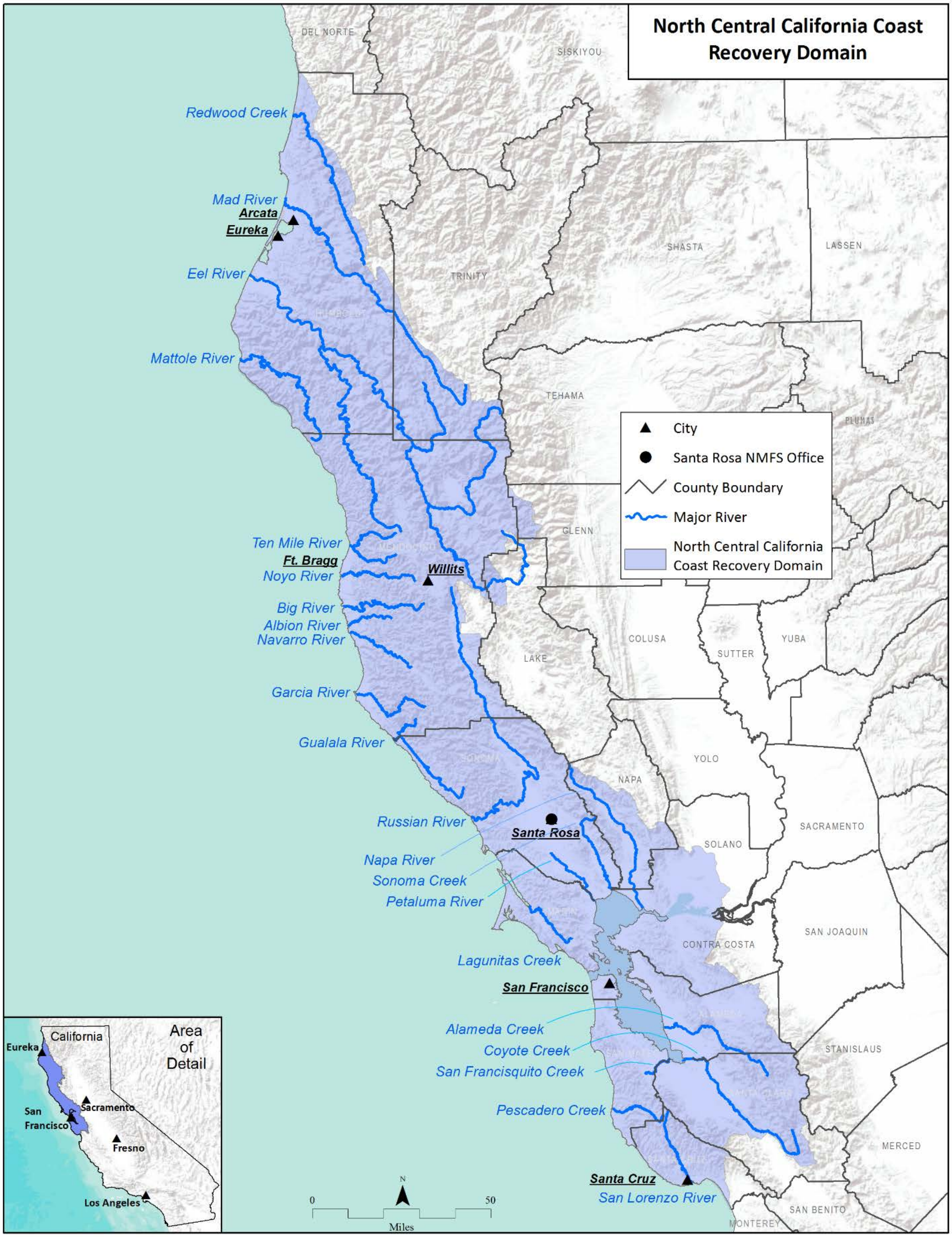

Figure 5: North Central California Coast Recovery Domain

1.5 BIOLOGICAL ORGANIZATION

In this recovery plan, Chinook salmon and steelhead are described in three levels of biological organization which include ESU/DPS, Diversity Strata, and populations. A population is defined as "*a group of fish of the same species that spawn in a particular location at a given season and do not interbreed substantially with fish from any other group*" (Bjorkstedt *et al.* 2005). For each species the populations are grouped into Diversity Strata. The Diversity Strata boundaries are determined by how similar each species population's geography, environmental and ecological conditions are to each other, not necessarily biological structure (Bjorkstedt *et al.* 2005). The CC Chinook salmon ESU extends from Redwood Creek (Humboldt County, CA.) south to the Russian River (Sonoma County, CA.). The ESU was historically comprised of 38 populations which included 32 fall-run populations and 6 spring-run populations across four Diversity Strata (Spence *et al.* 2008). All six of the spring-run populations were classified as functionally independent, but are considered extinct (NMFS 2016b; Williams *et al.* 2016). The delineation of the CC Chinook salmon ESU Diversity Strata was based on environmental and ecological similarities and life history differences between fall-run and spring-run Chinook. Four strata were identified by Bjorkstedt *et al*. (2005): North Coastal, North Mountain Interior, North-Central Coastal and Central Coastal. Of the 32 fall-run populations, 17 populations were considered either functionally independent or potentially independent, while the remaining populations were classified as dependent populations (Spence *et al.* 2008). We have selected 17 of the 32 fall-run populations across the four Diversity Strata to represent the recovery scenario for the CC Chinook salmon ESU. Figure 6 is a map of the ESU and the selected population's role in the recovery scenario (essential or supporting population, see Chapter 4 for more information). Please see Volume II for more detailed information on each population.

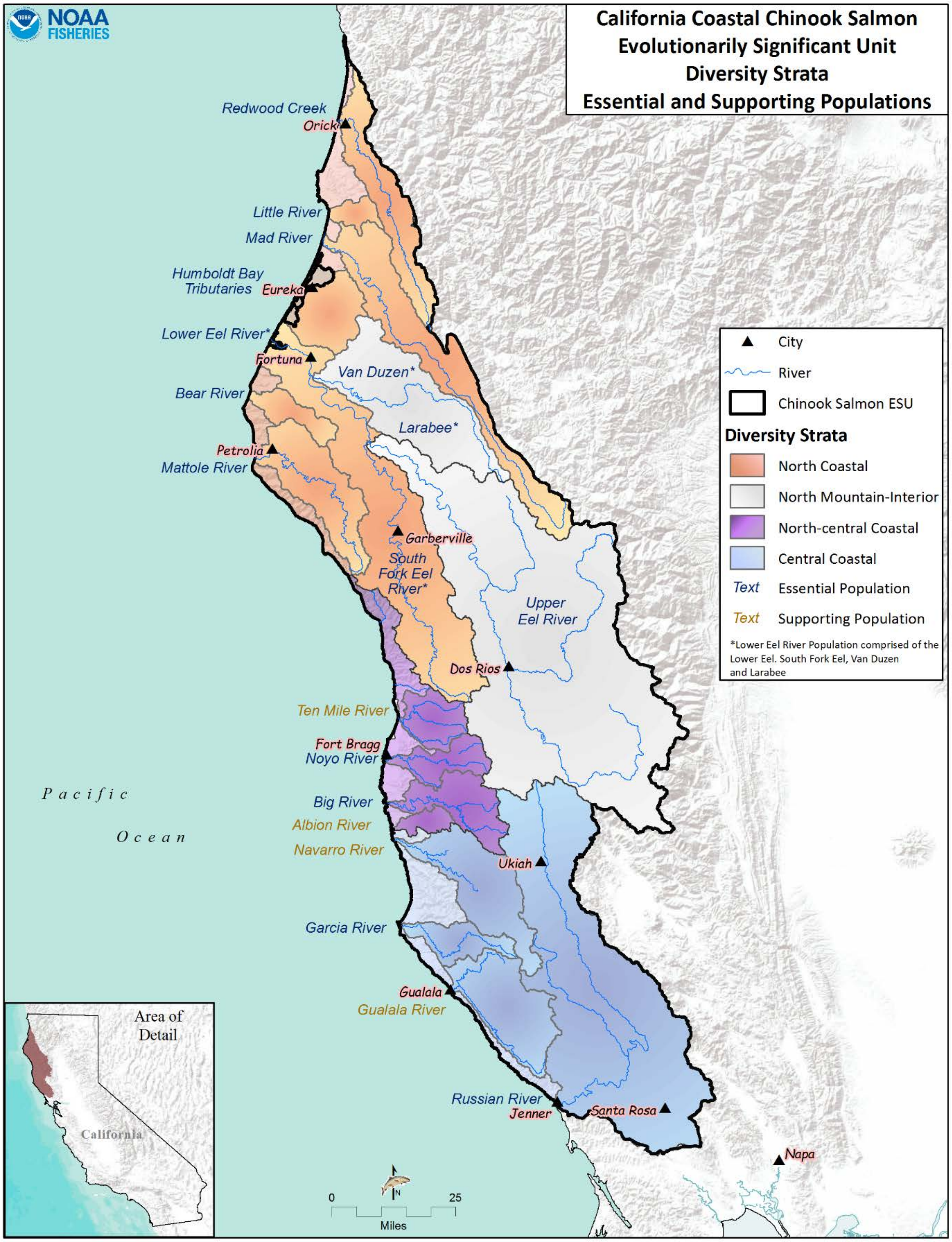

Figure 6: CC Chinook salmon ESU, Diversity Strata and Selected Essential and Supporting Populations

The NC steelhead DPS historically consisted of five Diversity Strata with 40 independent populations of winter-run steelhead (18 functionally independent and 22 potentially independent) and 10 populations of summer steelhead (all functionally independent) (Spence *et al.* 2008; Spence *et al.* 2012). The delineation of the NC steelhead DPS Diversity Strata was based on environmental and ecological similarities and life history differences between winter run and summer run steelhead. Five strata were identified by Bjorkstedt *et al.* (2005): Northern Coastal, Lower Interior, North Mountain Interior, North Central Coastal, and Central Coastal. We have selected 51 winter-run populations and 10 summer-run populations across the five Diversity Strata to represent the recovery scenario for the NC steelhead DPS. Figure 7 is a map of the DPS and the selected winter-run population's role in the recovery scenario (essential or supporting population, see Chapter 4 for more information). Figure 8 is a map of the DPS and the summer-run populations that are needed for recovery. Please see Volume III for more detailed information.

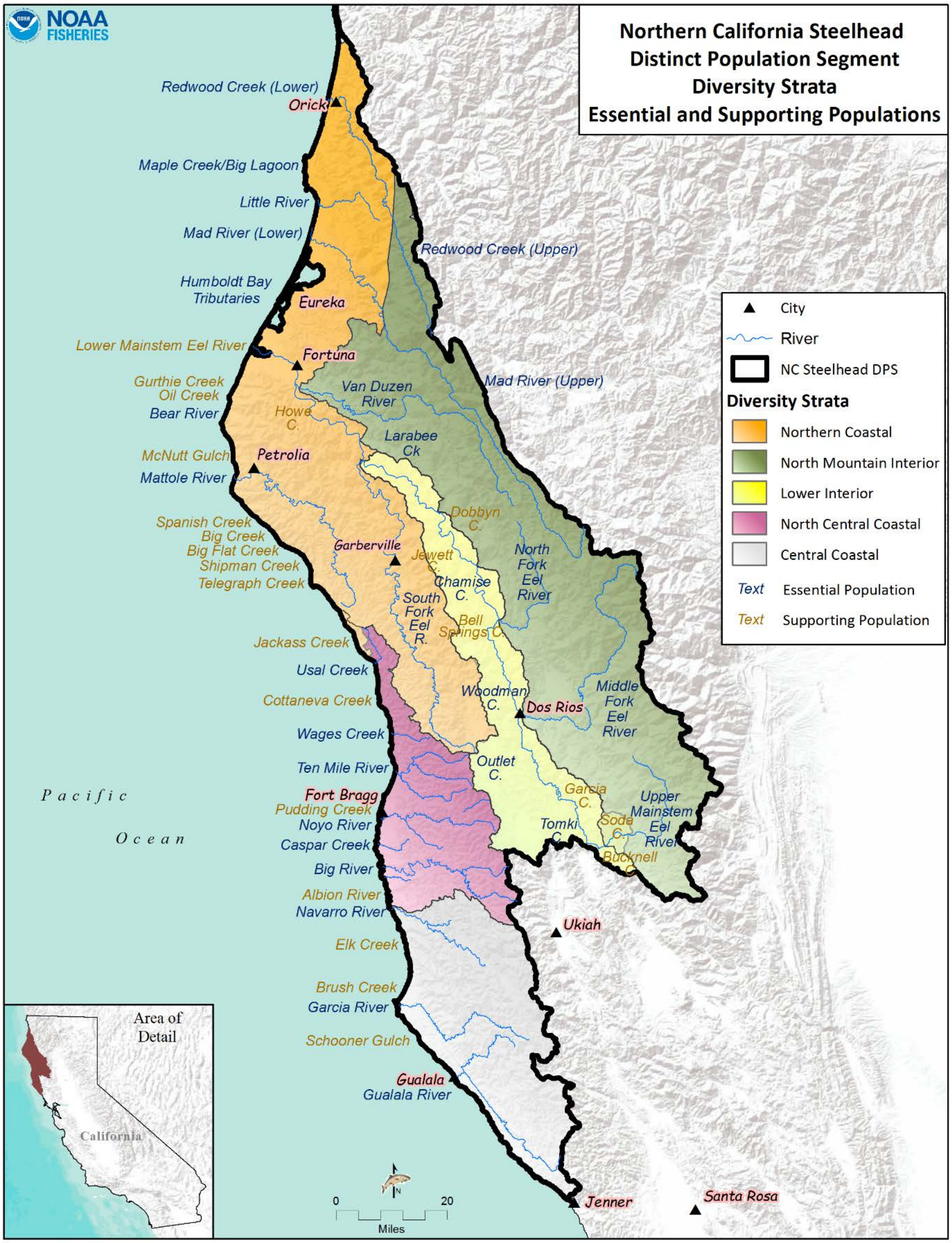

Figure 7: NC Steelhead DPS (Winter-Run Populations), Diversity Strata, and Selected Essential and Supporting Populations

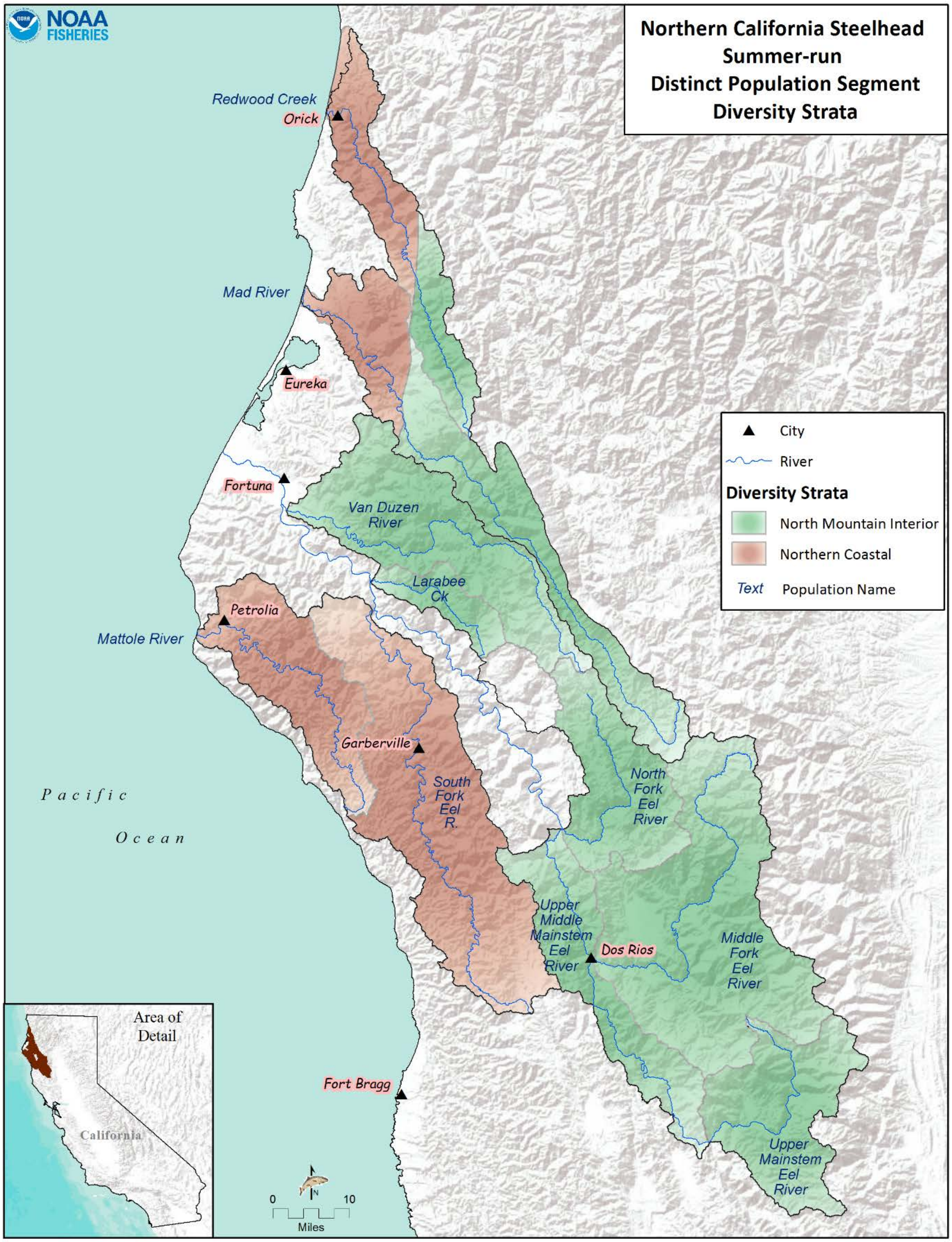

Figure 8: NC Steelhead DPS (Summer-Run Populations) and Diversity Strata

The CCC steelhead DPS historically consisted of five Diversity Strata with 37 independent populations of winter-run steelhead (10 functionally independent and 27 potentially independent) (Spence *et al.* 2008; Spence *et al.* 2012) (See Chapter 3 and 4). The delineation of the CCC steelhead DPS Diversity Strata was based on environmental and ecological similarities and life history. Five strata were identified by Bjorkstedt *et al.* (2005): North Coastal, Interior, Santa Cruz Mountains, Coastal San Francisco Bay, and Interior San Francisco Bay. From the historical structure, we have selected a total of 56 populations across the five Diversity Strata to represent the recovery scenario for the CCC steelhead DPS. Figure 9 is a map of the ESU and the selected population's role in the recovery scenario (essential or supporting population, see Chapter 4 for more information). Please see Volume IV for more detailed information.

Figure 9: CCC Steelhead DPS, Diversity Strata, and Selected Essential and Supporting Populations

1.6 BENEFITS OF RECOVERY

Healthy salmon and steelhead populations provide significant economic, societal, and environmental benefits. Entire communities, businesses, jobs, and even cultures have been built around salmonids in California. Monetary investments in watershed restoration projects can promote the economic vitality in a myriad of ways. These include stimulating the economy directly through the employment of workers, contractors, and consultants, and the expenditure of wages and restoration dollars for the purchase of goods and services. Habitat restoration projects stimulate job creation at a level comparable to traditional infrastructure investments such as mass transit, roads, or water projects (Nielsen-Pincus and Moseley 2010). In addition, viable salmonid populations provide ongoing direct and indirect economic benefits as a resource for fishing, recreation, and tourist-related activities. Dollars spent on salmonid recovery will promote local, state, Federal, and tribal economies, and should be viewed as an investment that yields a spectrum of valuable returns.

Based on studies that examined salmonid restoration in the Columbia River Basin (Washington, Oregon and Idaho), the San Joaquin River (California), and the Elwha River (Washington), the economic value of salmonid recovery could be significantly larger than the fiscal or socioeconomic costs of recovery (CDFG 2004). Importantly, the general model for viewing cost versus benefits should be viewed in terms of long-term benefits derived from short-term costs. Recovery actions taken for NC and CCC steelhead and CC Chinook salmon are likely to also benefit endangered CCC coho salmon and threatened SONCC coho salmon, thus increasing the cost effectiveness of the actions. Habitats restored to properly functioning conditions offer enhanced resource values and provide substantial benefits for human communities. These benefits include: improving and protecting the quality of important surface and ground water supplies, reducing damage from flooding resulting from floodplain development, and reduced expenditures on bank stabilization or flood control actions. Restoring and maintaining healthy watersheds also enhances important human uses of aquatic habitats, including outdoor recreation, ecological education, field-based research, aesthetic benefits, and the preservation of tribal and cultural heritage.

The largest economic returns resulting from recovered salmon and steelhead populations are associated with recreational and commercial fishing. Between the years 2001-2014, on average there were 98,755 salmon recreational fishing trips taken annually in California, Oregon and Washington (PFMC 2015). Projections of the economics and job benefits of restored salmon and steelhead fisheries for California have been estimated from $118 million to $5 billion dollars with the creation of several thousand jobs (Southwick Associates 2009; Michael 2010). With a revived sport and commercial fishery, these substantial economic gains and the creation of jobs would be realized across California, most notably for river communities and coastal counties.

Salmonid recovery is an investment and opportunity to diversify and strengthen the economy while enhancing the quality of life for present and future generations. The dollars necessary to recover salmonids should be made available without delay such that the suite of benefits can begin to accrue as soon as possible.

1.7 RECOVERY PARTNERS AND LIFE CYCLE CONSERVATION

To prevent extinction of the CC Chinook salmon and NC and CCC steelhead and shift their trajectory toward recovery, the following basic requirements must be met: clean water, sufficient stream flows, absence of barriers to migration, suitable habitats, and limited harvest. The recovery of these salmonids requires confronting the challenges of the expanding human population and modifying land and water uses to achieve and maintain healthy and sustainable habitats. It will also require public support and collaboration. Many efforts are already underway by recovery partners with considerable time and money dedicated to the cause of saving salmon. However, changing the trajectory from extinction to recovery will require a shift in the status quo. We recommend focusing on a life cycle conservation strategy in each watershed. A life cycle conservation strategy means that each stage in the salmonid life cycle is protected and recovered. Salmonids can never be recovered if the effort is focused on, for example, only adults and smolts. Scientists have widely used the life cycle concept, but it is rarely applied to guide conservation, restoration, and recovery actions. The marginal successes of efforts to save salmon in California are not totally due to lack of resources, rather they are also due to a lack of a grand plan. The implementation strategy is to thus chart a course forward using this plan to connect the societal system of authorities with salmonid life history requirements to achieve coordinated efforts across freshwater, estuaries, and ocean environments.

> **"Salmon rely on an interconnected system of forests, oceans, *etc*. Yet human agencies deal with the parts and have subdivided an interconnected system into bureaucracies so separate it all but assures that we're not likely to solve this problem."**
>
> **- David Suzuki**
>
> ***David Suzuki Foundation***

2.0 STEELHEAD AND CHINOOK SALMON ECOLOGY AND BIOLOGY

> *"Pacific salmon matter not only as a delicacy and an economic resource but also as an indicator of the state's environmental health. Wild salmon are to the rivers and the watershed and the ocean what the canary is to the miners in the coal mine."*
>
> *Congressman Mike Thompson 2008*

2.1 INTRODUCTION

Pacific salmon and steelhead share a number of common characteristics, yet their life histories are varied and complex. Pacific salmon and steelhead are anadromous fish; as adults, they migrate from the ocean to spawn in freshwater streams and lakes where their offspring hatch and rear prior to migrating to the ocean to forage until maturity. In addition, Pacific salmon and steelhead display an ability to use a trait called "homing," which enables them to return to their natal stream to spawn after spending a year or more at sea. One of the most notable differences between Pacific salmon and steelhead is that Pacific salmon die after they spawn the first time (semelparity); whereas steelhead are iteroparous, that is, not all adults die after spawning and some may spawn more than once (Figure 10).

Their larger size facilitates higher reproductive potential and survival rates; however, they sacrifice longevity for growth rate and have relatively short life spans.

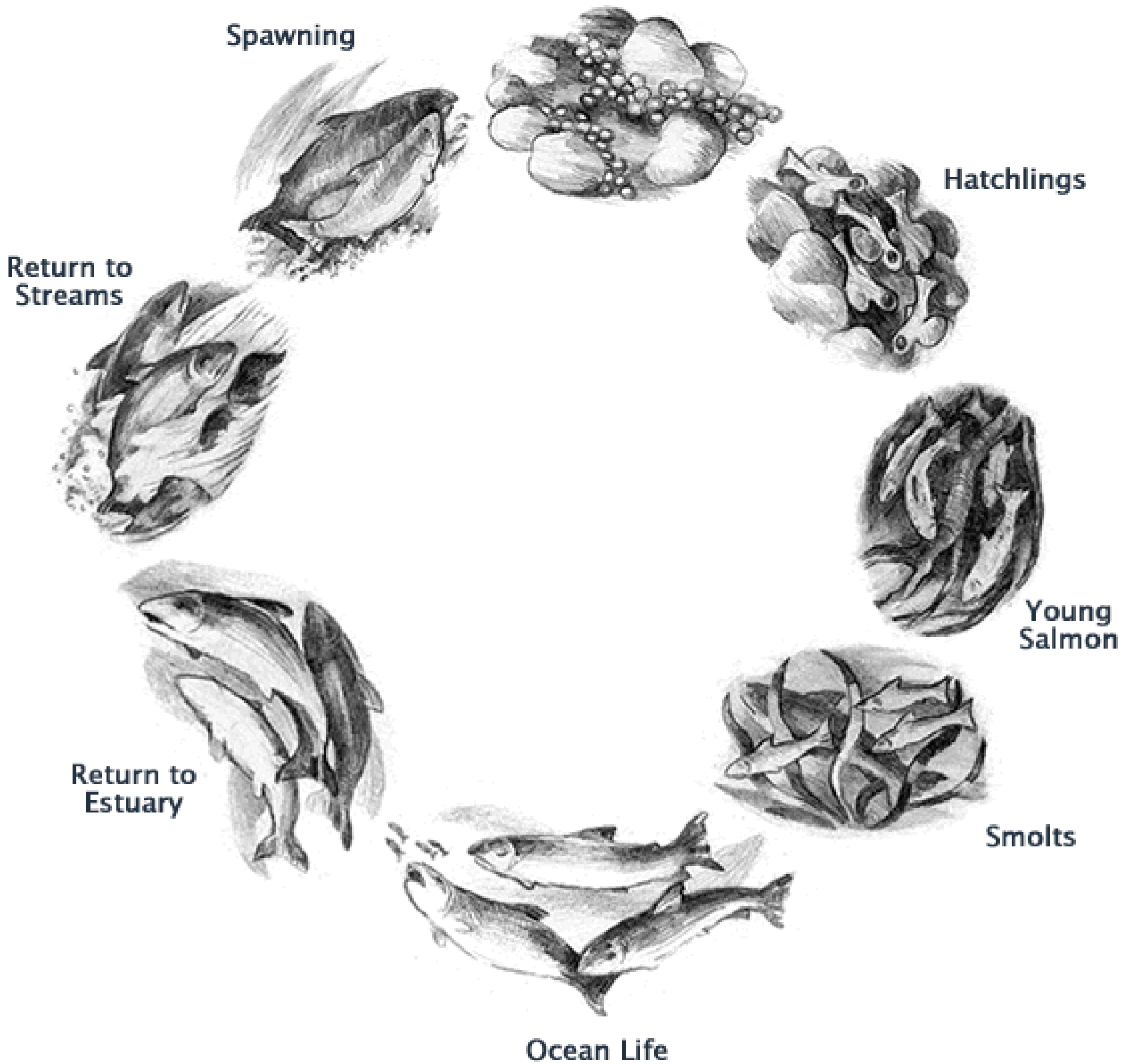

Figure 10: The generalized lifecycle of salmonids.

Salmon and steelhead spawn between fall and spring with most Chinook salmon spawning between September and January and most steelhead spawning between December and March (Moyle 2002; Quinn 2005). Salmonids are unique in that they exhibit an unusual form of female parental care in the burial of their eggs. Female salmon bury their eggs in the gravel after they are fertilized, and the semelparous species (*e.g.*, Chinook salmon) guard them from disturbance until they die. While salmon and steelhead share many traits, they have unique life histories. Steelhead in particular have greater life history plasticity than other salmonids (Thorpe 2007;

Hanson 2008). For *Oncorhynchus mykiss*, at least 32 different life history trajectories, or lifecycle pathways, have been identified (Thorpe 2007), which gives them the capability to adapt to environmental change better than other salmonids,. For example, as juveniles, some utilize freshwater habitats for multiple years, while others, sometimes within the same population, may use freshwater for just one year or only a season. Similarly, some juveniles utilize estuarine or lagoon habitats for extended periods, while others do not (Shapovalov and Taft 1954; Hayes *et al.* 2008). Because of this diversity, managers must find ways to protect each of the life history trajectories in order to ensure their persistence through periods of environmental perturbation and change (Bjorkstedt *et al.* 2005; Mangel and Satterthwaite 2008).

Oncorhynchus mykiss exhibit two distinct adult life histories, anadromy and nonanadromy. Anadromy is a life history pattern in which fish will spend one part of their life in freshwater and the other in the ocean, where food is more plentiful and growth rates are therefore considerably faster. The anadromous form of *O. mykiss* is termed "steelhead". While most biological species of salmonids are anadromous, some have nonanadromous life forms that complete their entire lifecycle in freshwater. Rainbow trout are the nonanadromous form of *O. mykiss*. Research suggests there is a degree of genetic control over the life history path experienced by *O. mykiss* individuals (Tipping 1991; Martyniuk *et al.* 2003), yet there is also substantial evidence for life history plasticity as a response to environmental cues (Zimmerman and Reeves 2000). For example, the offspring of rainbow trout may emigrate to the ocean where they become steelhead and the offspring of steelhead may spend their entire life in freshwater where they become resident rainbow trout (Wilzbach *et al.* 2012; Courter *et al.* 2013). In a study on the movement of rainbow trout relocated downstream of an impassable waterfall, Wilzbach *et al.* (2012) recaptured some of the relocated trout in downstream migrant traps as smolts and presmolts and showed that above-barrier rainbow trout can express migratory behaviors and contribute to the anadromous population. However, the life history of a rainbow trout or steelhead often remains markedly separated because of physical, physiological, ecological or behavioral factors. For these reasons, NMFS concluded that the anadromous steelhead populations are discrete from the resident rainbow trout populations within the ranges of the DPSs considered, and NMFS listed steelhead DPSs under the ESA (71 FR 834). Therefore, only steelhead will be referred to hereafter in this recovery plan.

While the provisions of the ESA generally apply to single species, salmon and steelhead belong to a complex ecosystem, and their demise has had cascading effects throughout the ecological food web. Salmon and steelhead enrich freshwater ecosystems by bringing nutrients from the ocean to riverine environments. Adult Pacific salmon and many steelhead die in the freshwater environment after spawning, supplying critical marine-derived nutrients to upstream freshwater systems as they decompose (Bilby *et al.* 1996; Bilby *et al.* 1998; Cederholm *et al.* 1999; Quinn 2005; Merz and Moyle 2006; Moore *et al.* 2011). Historically, large runs of salmon and steelhead supported a suite of predators (including juvenile salmon and steelhead), carrion feeders, detritivores, and microorganisms. In turn, the marine derived nutrients provided by the adult salmon and steelhead carcasses contributed to the healthy function of terrestrial ecosystems. Species with such strong interactions throughout an ecological web are considered "keystone species." The long-term effects of reduced or absent keystone species and the complex role they play in various ecosystems are of great concern to NMFS.

2.2 TAXONOMY

Both Chinook salmon and steelhead belong within the genus *Oncorhynchus,* which translates to "hook jaw" in Greek, referring to morphological changes male fish undergo during spawning. Chinook salmon is the common name accepted by the American Fisheries Society for *O. tshawytscha* and Chinook is the name of a Native American tribe from the Columbia River area. The species name *tshawytscha* originated from the local dialect on Russia's Kamchatka Peninsula, where European explorers first described the Chinook salmon in the 18th century. Common names include, tyee, blackmouth, and quinnat, and the most popular one used in California, king salmon (Beauchamp *et al.* 1983).

The taxonomic history and nomenclature of steelhead are more complex and difficult to trace. The species has been described with at least 22 scientific names in five genera and is known by many common or colloquial names (Scott and Crossman 1973; Healey and Jordan 1982). Until 1989, the primary scientific name used for steelhead or rainbow trout from western North America was *Salmo gairdneri* (Richardson 1836). However, in 1989, Smith and Stearley (1989) presented evidence that *Salmo gairdneri* was the same species as the previously described *Salmo mykiss* (Walbaum 1792) and was more similar to Pacific salmon (*Oncorhynchus*) than to Atlantic salmon (*Salmo*). As a result, the scientific name *Oncorhynchus mykiss* was adopted for steelhead and rainbow trout in 1989.

2.3 RANGE

The CCC steelhead DPS includes all naturally spawned populations of steelhead in streams from the Russian River (inclusive) to Aptos Creek (inclusive), and the drainages of San Francisco, San Pablo, and Suisun Bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin Rivers (71 FR 834). The DPS also includes tributary streams to Suisun Marsh, including Suisun Creek, Green Valley Creek, and an unnamed tributary to Cordelia Slough (commonly referred to as Red Top Creek), but excludes the Sacramento-San Joaquin River Basin. There are two artificial propagation programs within the DPS: steelhead hatchery programs at the Don Clausen Fish Hatchery on Dry Creek (Russian River basin) and Kingfisher Flat Hatchery located in the Scott Creek watershed (Monterey Bay Salmon and Trout Project).

The NC steelhead DPS encompasses all naturally spawned steelhead populations in California coastal river basins between Redwood Creek (inclusive) southward to (but not including) the Russian River (71 FR 834). Currently, there is one active steelhead hatchery facility in the NC steelhead DPS, the Mad River Fish Hatchery. However, steelhead produced at this facility are not included in the listed DPS (71 FR 834).

The CC Chinook salmon ESU includes naturally spawned populations of Chinook salmon from rivers and streams south of the Klamath River to the Russian River (70 FR 37160). Only fall-run Chinook salmon currently occur in the CC Chinook salmon ESU. Spring-run populations no longer occur in the ESU; however, historical information indicates they once existed in the Mad

River and the North Fork and Middle Fork of the Eel River (Keter 1995; Myers *et al.* 1998; Moyle 2002; Spence *et al.* 2008).

2.4 CURRENT STATUS AND TRENDS

2.4.1 CC CHINOOK SALMON

The CC Chinook salmon ESU historically comprised of 38 populations which included 32 fall-run populations and 6 spring-run populations (Spence *et al.* 2008). All six of the spring-run populations were classified as functionally independent, but have apparently been extirpated (NMFS 2016b; Williams *et al.* 2016). Of the 32 fall-run populations, 15 populations were considered either functionally independent or potentially independent, while the remaining populations were classified as dependent populations (Spence *et al.* 2008).

In 1965, CDFG (1965) estimated escapement for this ESU at over 76,000. Most were in the Eel River (55,500), with smaller populations in Redwood Creek (5,000), Mad River (5,000), Mattole River (5,000), Russian River (500) and several smaller populations in Humboldt County (Myers *et al.* 1998). With the exception of the Russian River population (discussed below), the most current available data indicate ESU and population-level abundances are considerably lower than those described above. Freshwater and estuarine habitat degradation, significant flood events (*e.g.*, 1955 and 1964), dams and stream flow diversions, and more recently, poor conditions in the marine environment, have all contributed to the low abundance. Also, because of their prized status in the sport and commercial fishing industries, CC Chinook salmon have been the subject of many artificial production efforts, including out-of-basin (and out-of-ESU) stocking (Bjorkstedt *et al.* 2005). It is therefore likely that CC Chinook salmon genetic diversity has been significantly adversely affected over time despite the relatively wide distribution of populations within the ESU.

On June 28, 2005, NMFS issued a final determination that the CC Chinook salmon ESU continues to warrant listing as a threatened species, reaffirming the status of CC Chinook salmon ESU as threatened (70 FR 37160). Current estimates of absolute abundance are not available for populations in this ESU or the ESU as a whole. The available data, which consist of a mixture of partial population estimates and spawner/redd indices, show somewhat mixed patterns, with some populations showing slight increases and others slight decreases, and few of the trends statistically significant (Williams *et al.* 2011). In the Russian River, adult returns have apparently improved in recent years. Since 2000, the Sonoma County Water Agency has conducted annual counts of Chinook salmon and other salmonids moving past the Mirabel Dam water diversion facility located on the lower Russian River[10]. Between 2000 and 2013, the average number of adult Chinook salmon counted at the facility has been 3,283 fish, and in 2012, 6,697 adult Chinook salmon were counted at the station which was the highest total counted to date. Similarly, since 2010, the number of returning adult Chinook salmon has increased in the Eel River population as well, and returns at the Van Arsdale Fish Station during the fall-winter of 2011/2012 and again in 2012/2013 were the highest observed at this location in over 70 years of record.

Within the North-Coastal and North Mountain Interior Diversity Strata[11], all independent populations continue to persist, though there is high uncertainty about their current abundance. The loss of the spring-run Chinook life-history type represents a loss of diversity within the ESU (Spence *et al.* 2008).

In the most recent status review, Williams *et al.* (2016)remained concerned about the loss of the spring-run life history type (two diversity substrata) and the extremely low numbers of Chinook salmon in most populations of the North-Central Coast and Central Coast strata, which diminishes connectivity across the ESU. Complicating the assessment is the fact that the historical occurrence of persistent populations in the region from Cape Mendocino to Point Arena, which includes the two southern-most Diversity Strata, is also highly uncertain (Bjorkstedt *et al.* 2005). Williams *et al.* (2016) concluded it was difficult to characterize the status of this ESU

[10] http://www.scwa.ca.gov/chinook/

[11] To capture the historical environmental and ecological conditions under which groups of populations likely evolved, the TRT delineated units called Diversity Strata and assigned populations to each Diversity Stratum.

based on the available data, but overall, did not find evidence of a substantial change in conditions since the last status reviews (Good *et al.* 2005; Williams *et al.* 2011) and maintained the ESU is threatened (likely to become endangered in the foreseeable future). In its most recent five-year review of the DPS, NMFS determined that the CC Chinook salmon ESU should remain listed as threatened (81 FR 33468).

2.4.2 NC STEELHEAD

Historically, the NC steelhead DPS consisted of 38 independent populations (16 functionally and 22 potentially independent) of winter run steelhead and 10 functionally independent populations of summer run steelhead (Spence *et al.* 2012). The ocean-maturing type (winter-run steelhead) enters freshwater between November and April, with well-developed gonads, and spawns shortly thereafter. The stream-maturing type enters freshwater in a sexually immature condition between May and October and requires several months to mature and spawn. In the NC steelhead DPS, summer-run steelhead populations historically persist in as many as ten populations with extant populations including the Mad River, Eel River (South Fork, Van Duzen, Upper Mainstem, Middle Fork), Mattole River, and Redwood Creek (Spence *et al.* 2008).

Overall, population numbers are severely reduced from pre-1960s levels, when approximately 198,000 adult steelhead migrated upstream to spawn in the major rivers of this DPS (CDFG 1965) (Busby *et al.* 1996; 65 FR 36074). Adult return data from dams on the upper Eel River and Mad River between the 1930's and 1980's indicate the populations of steelhead in these watersheds have declined substantially since the 1930's and 1940's (Good *et al.* 2005), and data from the Cape Horn Dam on the Eel River show significant declines prior to 1970 (63 FR 13347). Based on the data available, NMFS' initial status review of NC steelhead (Busby *et al.* 1996) determined that population abundance was very low relative to historical estimates, and recent trends were downward in most populations.

Updated status reviews reached the same conclusion, and noted the poor amount of data available, especially for winter run steelhead (Busby *et al.* 1997; Adams 2000; Good *et al.* 2005;

Williams *et al.* 2011). On January 5, 2006, NMFS issued a final determination to list the NC steelhead DPS as a threatened species, reaffirming the status of NC steelhead as threatened (71 FR 834).

The availability of information on steelhead populations in the NC-Steelhead DPS has improved considerably in the past 5 years, thanks to implementation of the CMP across a significant portion of the DPS. Nevertheless, significant gaps in information still remain, particularly in the Lower Interior and North Mountain Interior diversity strata, where there is very little information from which to assess viability. Overall, the available data for winter-run populations—predominately in the North Coastal, North-Central Coastal, and Central Coastal strata—indicate that all populations are well below viability targets (Williams *et al.* 2016). However, the short-term (6-year) trend has been generally positive for all independent populations in the North-Central Coastal and Central Coastal strata.

For the summer-run, the Middle Fork Eel River population has remained stable for nearly five decades and is closer to its viability target than any other population in the DPS. The remaining populations for which adult abundance has been estimated (*i.e.,* those on the Mendocino Coast) appear to be at either a moderate or high-risk of extinction. Finally, the depressed status of two of the remaining summer-run populations in Redwood Creek and Mattole River remains a concern. For all remaining populations, there is little information available to assess their status, although it is generally assumed that winter steelhead remain widespread and continue to occupy most of the watersheds in which they historically occurred.

Williams *et al.* (2016) found little evidence to suggest a change in status compared to the last status review by Williams *et al.* (2011). In its most recent five-year review of the DPS, NMFS determined that the NC steelhead DPS should remain listed as threatened (NMFS 2016b; Williams *et al.* 2016).

2.4.3 CCC STEELHEAD

Historically, approximately 70 populations[12] of steelhead existed in the CCC steelhead DPS (Spence *et al.* 2008; Spence *et al.* 2012): 37 independent or potentially independent and 33 dependent. McElhany *et al.* (2000) defined a viable salmonid population as "*an independent population of any Pacific salmonid (genus* Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame*." They defined an independent population to be "*any collection of one or more breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations*." Dependent populations are distinguished between independent populations as those whose dynamics and extinction risk *are* substantially affected by neighboring populations.

While historical and present data on abundance are limited, CCC steelhead populations are substantially reduced from historical levels. CDFG (1965) estimated a total of 94,000 adult steelhead spawned in the rivers and streams of this DPS during the mid-1960s, including 50,000 fish in the Russian River – the largest population within the DPS[13]. Near the end of the 20th Century, the steelhead population in the Russian River was believed to have declined substantially and local CDFG biologists estimated the wild run population in the Russian River Watershed was between 1,700-7,000 fish (McEwan and Jackson 1996). Abundance estimates for smaller coastal streams in the DPS indicate low but stable levels with individual run size estimates for several streams (Lagunitas, Waddell, Scott, San Vicente, Soquel, and Aptos creeks) of approximately 500 fish or less (62 FR 43937). Some loss of genetic diversity has been

[12] Population as defined by Bjorkstedt *et al*. 2005 and McElhany *et al*. 2000, in brief summary, is a group of fish of the same species that spawns in a particular locality at a particular season and does not interbreed substantially with fish from any other group. Such fish groups may include more than one stream. These authors use this definition as a starting point from which they define four types of populations (not all of which are mentioned here).

[13] The population estimates provided in CDFG (1965) were based on limited field data for a few streams which were used by local biologists to develop population estimates for similar streams throughout the region. Therefore, these estimates are the "best professional judgements" and are not linked to wide-spread, watershed-specific empirical data. Nonetheless, these estimates represent the best available information for ESU/DPS wide abundance but should be used with caution.

documented and attributed to previous out-of-basin transfers of hatchery stock as well as local hatchery production (Bjorkstedt *et al.* 2005, Good *et al.* 2005). In particular, for streams that are tributary to San Francisco Bay, reduced population sizes and habitat fragmentation caused by intense urbanization and water resource development have also led to a loss of genetic diversity in these populations.

CCC steelhead have experienced significant declines in abundance and long-term population trends suggest a negative growth rate. This indicates the DPS may not be viable in the long term. Independent populations that historically provided enough steelhead immigrants to support nearby dependent populations may no longer be able to do so, placing these dependent populations at increased risk of extirpation. However, because CCC steelhead remain present in most streams throughout the DPS, roughly approximating the known historical range, CCC steelhead may possess a resilience that is likely to slow their decline relative to other salmonid DPSs or ESUs in worse condition. Their iteroparous life history and variation in time spent in streams and the ocean have helped the steelhead populations respond to different pressures on their population (Busby *et al.* 1996).

The 2005 status review concluded the CCC steelhead DPS remains "likely to become endangered in the foreseeable future" (Good *et al.* 2005). On January 5, 2006, NMFS issued a final determination to list the CCC steelhead DPS as a threatened species (71 FR 834). A more recent viability assessment of CCC steelhead concluded that populations in watersheds that drain to San Francisco Bay are highly unlikely to be viable, and that the limited information available did not indicate that any other CCC steelhead populations could be demonstrated to be viable (Spence *et al.* 2008). The scarcity of steelhead abundance time-series data at the population level continues to hinder assessment of the CCC steelhead DPS status (Williams *et al.* 2016). The most recent biological status update concludes that steelhead in the CCC steelhead DPS remain "likely to become endangered in the foreseeable future", as new and additional information available since Williams *et al.* (2011) does not appear to suggest a change in extinction risk. In its most recent five-year review of the DPS, NMFS determined that the DPS should remain listed as threatened (NMFS 2016a; Williams *et al.* 2016).

2.5 CHINOOK SALMON LIFE HISTORY STRATEGIES

Chinook salmon follow the typical life cycle of Pacific salmon, hatching in freshwater, migrating to the ocean, and returning to freshwater to spawn and die. Diversity within this life cycle exists, however, in the time spent at each stage. Chinook salmon are classified into two groups, "ocean-type" and "stream-type," based on the period of freshwater residence (Healey 1991; Myers *et al.* 1998). In California, ocean-type fish typically are fall or late fall-run fish that enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of rivers, and spawn within a few weeks of freshwater entry. Juveniles emigrate to estuarine or marine environments shortly after emergence from the redd (Healey 1991). In California, stream-type fish are typically winter or spring-run fish that have a protracted adult freshwater residency, sometimes spawning several months after entering freshwater. Progeny of stream-type fish frequently spend one or more years in freshwater before emigrating. After emigrating, Chinook salmon remain in the ocean for two to five years and tend to stay in the coastal waters off California and Oregon (Healey 1991). Chinook salmon are also characterized by the timing of adult returns to freshwater for spawning, with the most common types referred to as fall-run and spring-run fish. Currently, the NCCC Domain includes only the fall-run life history; historic spring-run populations are thought to have been extirpated (Spence *et al.* 2008).

2.5.1 ADULTS

Chinook salmon in the CC Chinook salmon ESU generally remain in the ocean for two to five years (Myers *et al.* 1998) and tend to stay along the continental shelf of the California and Oregon coasts, but migration may continue to higher latitudes if oceanic conditions are appropriate (Allen and Hassler 1986). Some Chinook salmon return from the ocean to spawn one or more years early. These early maturing fish are referred to as jacks (males) and jills (females).

The low flows, high water temperatures, and sand bars that develop in smaller coastal rivers of coastal California during the summer months favor an ocean-type life history or fall-run (Kostow 1995) (Photo 1). With this life history, adults enter freshwater between August and January (Fukushima and Lesh 1998; Chase *et al.* 2007) and smolts typically outmigrate as sub-yearlings between April and July (Myers *et al*. 1998). Fall-run fish typically enter freshwater with fully developed gonads, move rapidly to their spawning areas on the mainstem or lower tributaries of mainstem rivers (elevations of 200 to 1,000 feet), and spawn within a few weeks of freshwater entry. In contrast, spring-run fish inhabit large river systems with high elevation tributaries fed by melting snowpack. Spring-run fish enter river systems during peak snowmelt, between April and August, with undeveloped gonads that mature over the summer. These fish migrate when high flows facilitate passage into cold, headwater tributaries where the fish hold until they spawn later that fall. Within the CC Chinook salmon ESU, spring-run populations that once existed in drainages such as the Mad River, Redwood Creek, and both the Middle and North forks of the Eel River, have been extirpated (Williams *et al.* 2016); the only extant spring-run populations occur in select tributaries to the Sacramento River (*i.e.*, the Central Valley spring-run ESU).

Photo 1: Adult CC Chinook salmon in the Russian River near Healdsburg. *Courtesy: Justin Smith, Sonoma County Water Agency*

2.5.2 EGGS AND ALEVINS

Spawning generally occurs in swift, relatively shallow riffles or along the edges of fast runs at depths greater than 24 cm. Adult female Chinook salmon prepare redds in stream areas with suitable gravel composition, water depth, and velocity. Individual females spawn for five to fourteen days and will guard or defend their redd for two to four weeks before dying (Beauchamp *et al.* 1983). The number of eggs a female produces generally ranges from 2,000–17,000 (Groot and Margolis 1991) and is not directly correlated to fish size (Hassler 1987; Moyle 2002). Optimal spawning temperatures range between 5.6 and 13.9°C. Redds vary widely in size and location within the river. Preferred spawning substrate is clean, loose gravel, mostly sized between 1.3 and 10.2 cm, with fine sediment not exceeding 10 percent.

Chinook salmon eggs incubate for 90 to 150 days depending on water temperature (Allen and Hassler 1986). Successful incubation depends on several factors, including dissolved oxygen levels, temperature, substrate size, amount of fine sediment, and water velocity. Maximum survival of incubating eggs and pre-emergent fry occurs at water temperatures between 5.6 and 13.3°C with an optimal temperature of 11.1°C. Alevins remain in the gravel for a month or longer (about four to six weeks) until they emerge as fry (Beauchamp *et al.* 1983; Allen & Hassler 1986, Moyle 2002). Fry emergence begins in December and continues into mid-April (Leidy and Leidy 1984). Emergence can be hindered if the interstitial spaces in the redd are not large enough to permit passage of the fry. In laboratory studies, Bjornn and Reiser (1991) observed that Chinook salmon and steelhead fry had difficulty emerging from gravel when fine sediments (6.4 millimeters or less) exceeded 30 to 40 percent by volume.

2.5.3 JUVENILES

After emergence, Chinook salmon fry seek out areas behind fallen trees, back eddies, undercut banks, and other cover (Everest and Chapman 1972) (Photo 2). Cover, in the form of rocks, submerged aquatic vegetation, logs, riparian vegetation, and undercut banks provides food, shade, and protects juveniles from predation. As they grow larger, juveniles move away from stream margins and begin to use deeper water areas with slightly faster water velocities, but continue to use available cover to minimize the risk of predation and reduce energy expenditure (Chapman and Bjornn 1969; Everest and Chapman 1972; Holecek *et al.* 2009). Fish size appears to be positively correlated with water velocity and depth (Chapman and Bjornn 1969, Everest and Chapman 1972). Optimal temperatures for both Chinook salmon fry and juveniles range from 12-16 °C (Boles 1988; Marine and Cech 2004). Chinook salmon feed on small terrestrial and aquatic insects and aquatic crustaceans.

Photo 2: Juvenile "ocean-type" Chinook salmon in the Russian River Watershed. *Courtesy: Sonoma County Water Agency*

Freshwater rearing duration presents a similar dichotomy of life-history strategies, with the presence of both ocean-type and stream-type outmigration patterns documented for juvenile CC Chinook salmon (Bjorkstedt *et al.* 2005). Stream-type juveniles typically reside within freshwater for a full year or more before outmigrating to the ocean as smolts, whereas ocean-type juveniles tend to migrate to the ocean relatively quickly, usually within a few weeks to several months after emergence. Spring-run adults tend to produce stream-type juveniles and fall-run fish produce juveniles that are ocean-type although recent data illustrate there exists exceptions to the rule (Sparkman 2002b; Sparkman 2002a).

The spatial and temporal differences in spawning and rearing behavior represent important life-history legacies that effectively isolated spring- and fall-runs, enabling CC Chinook ESU persistence following stochastic environmental perturbations. In California, populations of the ocean-type Chinook salmon (*i.e.*, fall-run) tend to use estuaries and coastal areas for rearing more extensively than river-type Chinook salmon (Photo 3). As is the case for all salmonids, brackish water in estuaries provides rich sources of important food and facilitates the physiological stress that occurs during parr to smolt transitions (Magnusson and Hilborn 2003). Studies have also shown the use of highly productive seasonally inundated floodplains by juvenile fall-run Chinook salmon results in substantial increases in fish growth and overall fitness, which increases their likelihood of survival in the ocean (Sommer *et al.* 2001; Jeffres *et al.* 2008; Katz 2012).

Photo 3: Chinook salmon smolt from the Russian River estuary. *Courtesy: Dave Cook, Sonoma County Water Agency*

An increase in water temperature appears to be the strongest environmental cue for fall-run Chinook salmon to initiate the parr to smolt transformation, and Zedonis and Newcomb (1997) concluded that Chinook salmon are able to complete the smoltification process at higher water temperatures (up to 20°C) compared to coho salmon or steelhead.

2.6 STEELHEAD LIFE HISTORY STRATEGIES

Of the Pacific salmonids, *O. mykiss* exhibits a range of diversity in their life history strategies rivaled only by coastal cutthroat trout (*Oncorhynchus clarki*) and possibly sockeye salmon (*Oncorhynchus nerka*) (Shapovalov and Taft 1954; Hendry *et al.* 2004; Quinn 2005; Satterthwaite *et al.* 2009; Sogard *et al.* 2009; Hayes *et al.* 2012; Hayes *et al.* 2013). This complexity is apparent in their degree of anadromy, timing of spawning migration, and the age-distributions of both smolts and spawning adults. *O. mykiss* occurs in both non-anadromous and anadromous forms, and in most populations, the distribution of these two forms overlap (Hayes *et al.* 2012). As noted above, the term "steelhead" is commonly used to describe the anadromous form of *O. mykiss*. Steelhead display considerable variation in periods of freshwater and marine residence. Research using otolith microchemistry or genetic markers has demonstrated that resident forms of *O. mykiss* may give rise to anadromous progeny and vice versa (Zimmerman and Reeves 2002; Donohoe *et al.*

2008; Courter *et al.* 2013). This diversity of life history patterns has prompted some to argue that *O. mykiss* exhibits a continuum of life histories (Behnke 1992).

In general, the life cycle of steelhead (Figure 11) involves rearing in freshwater for one to four years before migrating to the ocean where they may spend from one to four years, although one or two years is the most common. Out-migration of juveniles to the ocean (*i.e.*, emigration) usually occurs in the late winter and spring and may extend into summer months in more northern populations. These out-migrating juveniles, termed smolts, live and grow to maturity in the ocean before returning to freshwater to reproduce.

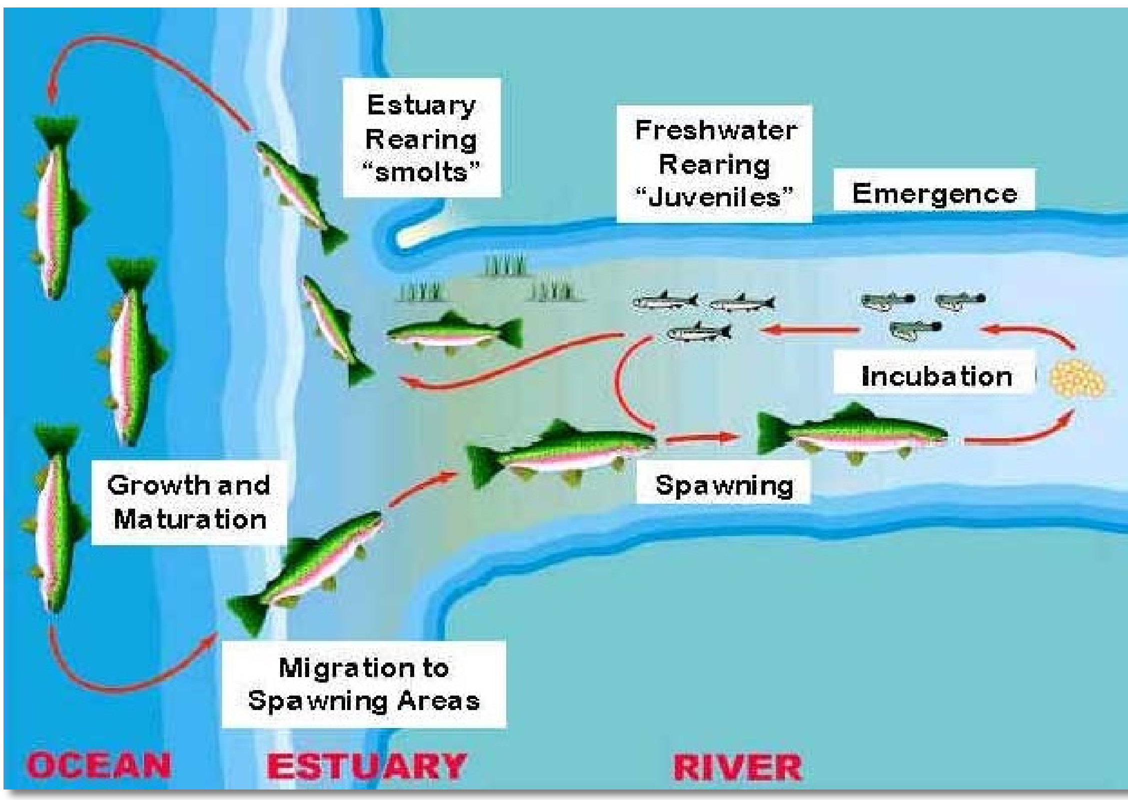

Figure 11: Life cycle of steelhead. *Courtesy of City of San Luis Obispo*

2.6.1 ADULTS

The ocean phase of steelhead is poorly understood (Photo 4). Marine migration studies of other species of *Oncorhynchus* have encountered only isolated specimens of *O. mykiss*. As a result, it is believed that the species does not generally congregate in large schools like other Pacific salmon (Burgner *et al.* 1992; Aydin *et al.* 2005; Quinn 2005; Grimes *et al.* 2007), and their movement patterns are relatively unknown. Few coded wire tag recoveries indicate most steelhead tend to migrate north and south along the continental shelf (Barnhart 1986). The increasing use of acoustic telemetry and archival tags for tracking salmonids and other species throughout their environment and linking these data with environmental data (*e.g.*, sea surface temperatures) has begun to provide some insight on the movements of these species during their ocean residency (Melnychuk *et al.* 2007; Hayes *et al.* 2013). An expansion of these methods shows promise for providing a clearer picture of steelhead life history in the marine environment.

Photo 4: Adult steelhead in Russian River. *Courtesy: Josh Fuller, NMFS*

As noted above, steelhead are iteroparous and some adults return to the ocean after spawning, and repeat the adult portion of their lifecycle one or more times. In California, steelhead typically spend one or two years in the ocean although in many populations, a small fraction will spend a third or fourth year at sea. In the Mad and Eel rivers, "half-pounders" return from the ocean after only two to four months of saltwater residence, are generally sexually immature, and return to the sea the following spring. First-time spawners in coastal basins of California most commonly enter the ocean at one or two years of age and spend from one to two years maturing in the ocean

(Shapovalov and Taft 1954; Busby *et al.* 1996). Most adult steelhead in a run are first time spawners, although Shapovalov and Taft (1954) reported repeat spawners were relatively numerous (about 17 percent) in Santa Cruz County streams. More recently, Barnett and Spence (2011) documented the survival rates of trapped steelhead adults observed in coastal streams of the Santa Cruz Mountains during the dry spring through fall period of 2008. Of the hundreds of steelhead adults first observed in early summer, they found nearly 40 percent were still alive by late October.

Steelhead adults can be divided into two reproductive ecotypes based upon their state of sexual maturity at the time of river entry and the duration of their spawning migration: stream maturing and ocean maturing. Stream maturing adult steelhead return from the ocean and enter freshwater in a sexually immature condition. These fish require several months to mature and spawn, whereas ocean maturing adult steelhead enter freshwater with well-developed gonads and spawn shortly after river entry. These two reproductive ecotypes are more commonly referred to by their season of freshwater entry (*i.e.*, summer [stream maturing] and winter [ocean maturing] steelhead). Summer steelhead typically immigrate between May and October and spawn in January and February; winter steelhead typically immigrate between December and April and spawn soon after reaching their spawning grounds (Shapovalov and Taft 1954; Moyle *et al*. 2008). For winter steelhead, the timing of upstream migration varies, and is correlated with higher flow events, and for some populations, sand bar breaches.

2.6.2 EGGS AND ALEVINS

Once females reach their spawning grounds, they will create a redd, or nest, in the streambed gravels where they deposit their eggs. The number of eggs per redd ranges from 200-12,000 (Moyle 2002). The female uses her tail to cover the eggs with a layer of gravel immediately after they are fertilized by males. Eggs hatch into "alevins" after an incubation period of approximately 25-35 days depending on water temperature (Shapovalov & Taft 1954). Alevins remain in the gravel for two to three weeks until they emerge as young juveniles known as "fry". Upon emerging from the gravel, fry rear in calmer edgewater habitats and gradually move into deeper and faster water as they grow where they establish and defend territories (Chapman and Bjornn 1969; Everest and Chapman 1972; Vondracek and Longanecker 1993).

2.6.3 JUVENILES

Across the NCCC Domain, juvenile steelhead life history strategies vary considerably. This is a reflection of the broad geographic range and diversity of environmental conditions they occupy. Freshwater residence for juvenile steelhead (Photo 2) typically ranges from one to three years although juvenile steelhead from most populations within the NCCC Domain migrate to the ocean after one or two years in freshwater (Shapovalov and Taft 1954; Busby *et al.*, 1996; Moyle, 2002). Many factors are thought to influence juvenile residence time in freshwater, one factor appears to be fish size (Shapovalov and Taft 1954; Hayes *et al.* 2008; Sogard *et al.* 2009; Beakes *et al.* 2010; Hayes *et al.* 2011; Satterthwaite *et al.* 2012). In small coastal streams with dense riparian canopies and low, cool summer baseflows, productivity is low, and therefore juvenile steelhead typically rear for two or more years prior to emigrating as smolts (McCarthy *et al.* 2009; Sogard *et al.* 2009). However, in highly productive habitats, such as lagoons (Smith 1990; Bond *et al.* 2008; Hayes *et al.* 2008) or productive yet relatively warm water streams (Moore 1980; Smith and Li 1983; Beakes *et al.* 2010; Casagrande 2010; Bell *et al.* 2011; Sogard *et al.* 2012), juvenile steelhead can reach a sufficient size to smolt after one year. For example, Hayes *et al.* (2008) concluded growth rates of steelhead reared in the warm (*i.e.*, up to 24°C) yet highly productive lagoon/estuary of Scott Creek were two to six times higher than growth rates of fish reared in cooler but less productive upstream habitats.

Photo 5: Juvenile CCC steelhead in Scott Creek. *Courtesy: Morgan Bond, NOAA SWFSC*

In late winter and spring, juvenile steelhead begin a physiological transformation called smoltification that prepares them for life in the ocean (Photo 6). Typical physical characteristics of a steelhead smolt include an elongated and thinner body shape, loss of parr marks, black tip on the caudal fin, and deciduous scales (Zedonis and Newcomb 1997). Another important physiological trait is their increased capacity to osmoregulate in saltwater. The degree of smoltification can be assessed by measuring levels of gill Na^{+}-K^{+} ATPase. Levels of Na^{+}-K^{+} ATPase increase at the onset of the smoltification process and reach a peak during emigration to the ocean. In addition to fish size, the onset of the smoltification process (*i.e.,* increasing Na^{+}-K^{+} ATPase levels) is triggered by a number of environmental cues including an increase in photoperiod and water temperature. For steelhead populations of Humboldt, San Francisco, and San Pablo bays, Fukushima and Lesh (1998), note the typical emigration window for smolts from these populations occurs between February and June, with peak periods in April and May. Upon emigration from freshwater habitats, smolts will utilize the brackish estuary environments at the coast to adjust to saltwater, and in many cases, take advantage of abundant food resources (Simenstad *et al.* 1982; Smith 1990; Robinson 1993; Collins 1998; Hayes *et al.* 2008; Atkinson 2010; Seghesio 2011).

Photo 6: A large steelhead smolt from San Gregorio Lagoon, May 2012. *Courtesy: Joel Casagrande, NMFS*

2.7 HABITAT REQUIREMENTS

Steelhead and Chinook salmon must survive conditions across many different environments during their lifecycle spanning freshwater and ocean travel. Due to the complex life history of steelhead, and to a lesser extent Chinook salmon, habitat requirements vary by life stage. Basic requirements include suitable stream flow, water temperature, depth, velocity, and dissolved oxygen concentrations. In many watersheds, suitable steelhead habitat extends farther upstream than coho and Chinook salmon habitat, including smaller headwater streams (Moyle 2002). Steelhead, and especially Chinook salmon, spend much of their lives in the ocean—an unpredictable environment that is subject to stochastic events affecting fish that are outside of human control. When ocean conditions are favorable, the sub-adult and adult survival rates appear relatively high. Most steelhead mortality occurs in freshwater, and during the rearing stage when juveniles may be exposed to a lack of suitable summer rearing habitat (*e.g.*, drying of channels or excessive water temperatures), a lack of refuge during high winter and spring floods, and predation (Shapovalov and Taft 1954, Moyle 2002, Quinn 2005). Even though Chinook salmon emigrate as juveniles in spring or early summer and then spend a much larger portion of their life cycle in the ocean environment, their mortality rates while in freshwater can also be substantial. Smolts of both species tend to utilize lagoon or estuarine habitats for saltwater transition before entering the ocean environment. Time spent feeding in these productive estuaries is also important as smolt size at ocean entry greatly enhances marine survival (Ward and Slaney 1988; Holtby *et al.* 1990; Bond 2006; Bond *et al.* 2008). Table 1 summarizes habitat requirements and vulnerabilities for each life stage.

Table 1: Habitat requirements and vulnerabilities for life stages of steelhead and salmon.

Lifestage	Habitat
Eggs: Habitat requirements and vulnerabilities at this lifestage for both steelhead and Chinook salmon are the same. Incubation of eggs within a redd requires clean, cool stream flow, free of contamination and fine sediments. Damage (scour, desiccation) to a single redd could result in the death of thousands of steelhead or Chinook salmon embryos.	**Freshwater Streams**
Alevins: After hatching, steelhead and Chinook salmon alevin remain within the gravel, and feed from their attached yolk sacs. Here, the alevin remain highly vulnerable to siltation and scour and still require cool well-oxygenated waters for survival.	**Freshwater Streams**
Juveniles: In small streams and larger rivers, both species utilize a variety of habitat types with steelhead more associated with faster water habitats. Riparian vegetation helps support some of the insects consumed by juveniles, provides cover from predators, and limits solar radiation to streams keeping water temperatures cool. Tree roots stabilize streambanks and create habitat structure. Fallen logs and other woody debris create cover and refugia during high flows. Pools, wetlands, and seasonally inundated floodplains provide shelter from high flows, opportunities for rapid growth, and facilitate sediment deposition and sorting. In some populations, juvenile steelhead may rear in estuaries, including seasonally closed lagoons, throughout the summer-fall period. Juvenile steelhead rearing successfully in estuaries or lagoons are typically larger than individuals of the same cohort reared in less productive freshwater habitats upstream. Manual breaching of closed lagoons can result in a loss of juvenile steelhead not fully adapted to seawater.	**Freshwater Streams, Estuaries**
Smolts: Steelhead and Chinook salmon smolts reared in freshwater streams need adequate stream flow to travel downstream to estuaries in spring. During spring, estuary/lagoon habitats provide productive feeding habitats and brackish water, which help facilitate the transition to life in the ocean. Estuaries should maintain sufficient depths and volumes of freshwater in order to provide cover (*i.e.,* depth), access to adjacent marsh areas for feeding, and suitable water quality conditions (*e.g.,* temperature and dissolved oxygen). The quality of these areas has implications on the survival of smolts entering the ocean environment.	**Freshwater Streams, Estuaries, Lagoons, and Ocean**
Sub-Adults/Adults: The patterns of ocean migration for both species vary and are poorly understood. Steelhead and Chinook salmon in the ocean need adequate supplies of food to facilitate rapid growth. Shifts in ocean conditions affect food, migration patterns, and survival. As the steelhead and salmon return to their natal stream to spawn, they move once again from saltwater to freshwater; they depend on the near shore and estuarine environments to assist with this transition.	**Ocean**
Spawners: Spawning adult steelhead and Chinook salmon need adequate flows, cool water temperatures, deep pools, and cover to rest and hide in as they migrate upstream. Females seek clean, loose gravel of a certain size in highly oxygenated pool tails or riffles for laying their eggs.	**Ocean, Estuaries, Freshwater Streams**

The key to preventing the further decline of steelhead and Chinook salmon is protecting their existing spawning and rearing streams and restoring or enhancing damaged habitats (Moyle 2002). While the ocean environment is where steelhead and salmon spend much of their lives, degraded freshwater habitat can depress population productivity by lowering spawning, rearing and outmigration success. Ocean productivity off California has fluctuated dramatically during the past decade.

Unfortunately, freshwater and estuarine habitat conditions (or availability) in most streams throughout the NCCC Domain have been impaired and, as a result, steelhead and Chinook salmon abundances have declined. Habitat degradation stems from significant alterations to the natural rates of critical watershed processes (*e.g.*, sediment delivery, hydrology, wood recruitment, access to floodplain habitats, temperature regulation, *etc.*) caused by human activities. The decline of steelhead and Chinook salmon in these habitats is a strong indication that the majority of the watersheds in these DPSs and ESU are substantially degraded and watershed processes are impaired.

2.7.1 OPTIMAL FRESHWATER HABITAT CONDITIONS

In freshwater, optimal habitats for steelhead and Chinook salmon include in no particular order: (1) channel complexity, (2) adequate stream flow, (3) suitable water temperatures, (4) unimpeded fish passage, (5) adequate quantities of clean spawning gravel, and (6) access to overwintering habitat during high flow events. Numerous other requirements exist (*i.e.*, adequate quantities of food, dissolved oxygen, low turbidity, *etc.*), but in many respects, these other needs are generally met when the six habitat requirements listed above are at a properly functioning condition.

Channel Complexity

A diverse stream channel consisting of an abundance of deep complex pools and productive high velocity habitats is important for the successful rearing and survival of juvenile steelhead and Chinook salmon. While juvenile steelhead are generally more associated with higher velocity habitats, such as riffles, runs, or the heads of pools (Chapman and Bjornn 1969; Fausch 1984), in many streams throughout the NCCC Domain (the CCC steelhead DPS in particular), low summer stream flows limit available summer rearing habitat to mostly pools. Large woody debris originating from adjacent riparian forests is a form of cover in many streams, and its importance within pools is widely recognized (Bisson *et al*. 1987; Holtby 1988). When large riparian trees fall into streams and rivers, particularly large diameter conifer trees, they help form a mosaic of habitat types due to their ability to enhance channel scouring, improve velocity heterogeneity, and trap coarse sediments. This combination of habitat types is important for steelhead because scour pools provide cover from predators and high flow refugia during winter (a limiting factor for freshwater survival), while the substrate and velocity enhancements improve spawning and rearing habitat quality (Photo 7).

In many streams, these essential pool and complex habitats have been altered or lost due to reduced water flows, large woody debris removal activities, increased rates of sedimentation, and loss, alteration and simplification of riparian forests. Simplification of riparian forests then leads to a lack of future large wood recruitment. This lack of recruitment is also due to the younger age of current riparian forests following older logging practices. Younger riparian forests often lack trees of sufficient size and decadence that can create habitat complexity after they fall into a stream. The removal of large wood from streams (both in channel and standing trees), in particular, has had major impacts on salmonids (Photo 8).

Photo 7: Lateral scour pool formed by large wood in Lagunitas Creek, Marin County, CA. *Courtesy: Eric Ettlinger*

This is due to the role wood contributes to physical habitat formation, in sediment and organic-matter storage, and in maintaining a high degree of habitat complexity in stream channels (National Research Council 1996). Decreases in salmonid abundance following large wood removal or loss have been documented in streams throughout the Pacific Northwest (Bryant 1983; Dolloff 1986; Reeves *et al.* 1993). In recent decades, there has been an increasing impetus to re-introduce large wood to streams lacking these materials. However, few studies on the effectiveness of large wood placement into streams to improve salmonid abundance have been conducted (Whiteway *et al.* 2010). Those that have (*i.e.*, Pess *et al.* 2011) highlight the potential effectiveness and need for continued restoration of stream habitats using large wood.

Beavers are also believed to play an important role in the formation of salmon and steelhead habitat. The felling of trees by beavers increases woody debris, leading to increased invertebrate diversity and biomass. The debris cover provided by the lodge and food cache has been shown to attract some fish species, including salmonids (Collen and Gibson 2001). The presence of beaver dams reduces siltation of spawning gravels below the impoundment (Macdonald *et al.*

1995). The deeper water in beaver ponds can provide important juvenile rearing habitat (Scruton *et al*. 1998) as well as important habitat for adults during the winter (Cunjak 1996) and in times of drought (Duncan 1984).

Photo 8: Cutting instream wood destroys salmonid habitat, San Lorenzo, Santa Cruz County. *Courtesy: Chris Berry, City of Santa Cruz*

Beaver ponds have been shown to increase stream habitat complexity and provide excellent winter and summer rearing habitat for juvenile salmonids, including steelhead (Swales *et al.* 1988; Murphy *et al.* 1989; Swales and Levings 1989; Pollock *et al.* 2004; Pollock *et al.* 2012). In some settings, the reintroduction of beavers as a tool for stream habitat enhancement must consider impacts to essential infrastructure (*e.g.,* protection of culverts and bridges), or the survival of mature trees where riparian canopy is scarce or stream bank revegetation is ongoing. Several tools or methods are available to minimize such conflicts with beavers including use of specific fence designs to protect culverts, bridges and road embankments, and the use of cages, fences, or paint applications mixed with sand to protect specific trees.

Adequate Stream Flow

Fish need water, and adequate water quantity and quality are essential for steelhead and Chinook salmon survival and recovery. Because most rearing juvenile steelhead reside in freshwater for at least their first year, adequate flow and temperature are important to the population at all times (CDFG 1997; Harvey *et al.* 2006; Grantham *et al.* 2012). Steelhead and Chinook salmon populations also require enough aquatic space for large numbers of juveniles to find sufficient food and escape from predators. Steelhead and salmon need appropriate flow levels for migration to and from the ocean, spawning and redd survival, habitat connectivity during the dry season, and survival during all other freshwater life stages. Because juvenile fall-run Chinook salmon typically have a short freshwater residency, changes in stream flow and abiotic conditions during the dry season are not as important for this species.

California's Mediterranean climate results in low flow conditions during the summer and late fall rearing periods. A lack of water during these periods is a severe limiting factor for steelhead in many watersheds in the CCC and NC DPSs. Impacts from ongoing water diversions are most severe in more urbanized watersheds and watersheds with a large percentage of agricultural development. In urbanized areas, the increasing extent of impervious surfaces results in higher and flashier winter flow and lower summer base flows (as well as a source of hydrocarbons and garbage) in these stream systems. In rural areas, water diversions during spring (smolt out-migration and redd survival) and summer rearing periods magnify the impact of naturally low flows. For example, diversion for frost protection of vineyards and illegal stream capture or similar diversions for the irrigation of marijuana in rural watersheds throughout California (Monzigo 2012) can create instantaneous flow reductions that result in dewatered stream channels and stranding of juvenile steelhead in isolated pools with suboptimal water quality. Both CDFW and NMFS have identified unauthorized and illegal summer and fall water diversions as a serious concern and many previously perennial streams are now dry in late summer. A number of these water diversions are associated with marijuana cultivation which is a very high water use activity with no regulatory oversight.

Suitable Water Temperature

Maintaining suitable water temperatures throughout each steelhead and Chinook salmon life stage is critical for the management and conservation of these populations. In central and northern California, elevated summer water temperatures are generally the most stressful for salmonids. This is particularly true for steelhead which rear in stream or lagoon habitats for at least one summer and are therefore exposed to the warmer temperatures. In general, juvenile fall-run Chinook salmon in the CC Chinook salmon ESU emigrate from freshwater during spring and early summer and therefore do not experience peak summer water temperature threats. During droughts or periods of unseasonal weather, water temperatures may reach stressful levels for Chinook salmon smolts during their spring migrations. Furthermore, in rare instances where juvenile Chinook salmon remain in freshwater through the dry season, water temperatures may reach stressful or possibly lethal levels.

Water temperature influences juvenile steelhead and Chinook salmon population density, swimming ability, oxygen consumption, and their abilities to capture and metabolize food (Hokanson *et al.* 1977; Wurtsbaugh and Davis 1977; Barnhart 1986; Myrick and Cech 2005). Because of its direct influence on metabolism, water temperature can also influence the growth and habitat use of juvenile salmonids (Everest and Chapman 1972; Moore 1980; Smith and Li 1983; Baltz *et al.* 1987; Cech *et al.* 1990; Sommer *et al.* 2001; Myrick and Cech 2002; Bell *et al.* 2011). Juvenile steelhead are sensitive to warm water temperatures but not as much as other salmonid species (Boughton *et al.* 2007; Spina 2007; Casagrande 2010; Bell *et al.* 2011; Sloat and Osterback 2013). While rearing, optimal temperatures for steelhead growth range between 12 and 19 degrees (°) Celsius (C) (Hokanson *et al.* 1977, Wurtsbaugh and Davis 1977, Moyle 2002, Myrick and Cech 2005) and both seasonal and diurnal fluctuations are important as well (Hokanson *et al.* 1977, Busby *et al.* 1996). Temperatures exceeding 25°C for prolonged periods are usually lethal to steelhead (Moyle 2002). However, they can survive short periods up to 29°C with saturated dissolved oxygen concentrations and an abundant food supply (Sloat and Osterback 2013). Streams with warm yet productive dry season flows can rear steelhead successfully and produce large fish by the end of their first summer (Moore 1980; Smith and Li 1983; Beakes *et al.* 2010;

Casagrande 2010; Bell *et al.* 2011). Conversely, streams with warm temperatures, but low flows, and therefore limited food resources generally result in reduced growth and survival because fish are not able to satisfy elevated metabolic demands (McCarthy *et al.* 2009). Suitable temperatures during the parr to smolt transformation and out-migration periods for steelhead and Chinook salmon range between 10 and 17°C with temperatures less than 15°C considered most optimal (Zedonis and Newcomb 1997).

Altered thermal regimes change many characteristics of stream habitat by changing the structure of plant and invertebrate communities (Bisson and Davis 1976), and result in adverse interspecific interactions between salmon and non-salmon fishes through increased competition and predation (Reese and Harvey 2002). One of the more important factors contributing to optimal stream temperature is intact riparian buffers (Poole and Berman 2001; Richardson *et al.* 2010). Retention of wide riparian buffers with adequate riparian canopy, provided by mature native trees, moderates water temperature. Dams and other impoundments also alter downstream water temperature patterns. Therefore, adaptive stream flow management policies are important when considering the diversity of life history strategies, growth potential, and species preservation in tail-water reaches.

Unimpeded Fish Passage

Both steelhead and Chinook salmon require adequate passage conditions from the ocean to spawning areas as adults and from rearing areas to the estuary/ocean as juveniles. Reduced flows, debris jams, plugged or improperly placed or sized culverts and fish passage facilities (*e.g.*, denil fish ladders), excessive water velocities, prolonged sandbar closures, and other conditions impede migrating adults. The minimum stream depth necessary for successful upstream migration is about 18 cm for adult steelhead and 24 cm for adult Chinook salmon (Thompson 1972; Bjornn and Reiser 1991). The preferred water velocity for upstream migration of both species is in the range of 40-90 cm/s, with a maximum velocity of 240 cm/s, beyond which upstream migration is not likely to occur. Unscreened diversions and many of the same factors listed above for adult migrations also adversely impact smolt outmigration success. Many of the more significant barriers to adult migration in the NCCC Domain have been addressed through past restoration projects. In the past, CDFW expended considerable effort in removing barriers formed by large wood accumulations that impeded salmonid migration to upstream spawning and rearing areas. Today a lack of wood exists in many streams due to some of the large wood removal activities conducted for the purpose of passage improvement and channel improvement. As described above, reduced large wood in most streams is now recognized as a habitat limiting factor for steelhead and Chinook salmon across their DPSs and ESU.

Adequate Quantities of Clean Spawning Gravel

Steelhead and Chinook salmon spawn in cool, clear streams and rivers featuring suitable water depth, gravel size, and velocity (Photo 9 and Photo 10). Chinook salmon typically spawn in larger tributary streams and rivers. Intermittent streams are also used for spawning by steelhead (Everest 1973; Barnhart 1986; Boughton *et al.* 2009). Redd locations are usually located in pool tails or the upstream head of a riffle where substrate is comprised of small and medium sized gravel (Shapovalov and Taft 1954; Beauchamp *et al.* 1983; Allen and Hassler 1986). Preferred range of spawning gravel size are 0.6-10.3 cm in diameter for steelhead and 1.3-10.3 cm for Chinook salmon (Reiser and Bjornn 1979).

To ensure survival from spawning to emergence, the gravels must be relatively free of fine sediment as gravels with high concentrations of fine sediment can substantially reduce egg survival (Lisle 1989; Bjornn and Reiser 1991). Clean gravels facilitate, via intragravel flow, a supply of oxygen-rich water to the eggs and alevin and help ensure that metabolic wastes are removed. The survival of embryos is reduced when fines smaller than 6.4 millimeters (mm) comprise 20 to 25 percent of the substrate. Phillips *et al.* (1975) found survival to emergence was only eight percent where gravel/sand mixtures were 70 percent (particle size less than 3.3 mm).

Photo 9: CCC steelhead trout digging redd March 2013 Stevens Creek. *Courtesy: Courtesy of the Guadalupe Coyote Resource Conservation District*

Photo 10: Chinook salmon on a redd in Dry Creek, Russian River tributary. *Courtesy: Eric McDermott, SCWA*

Fine sediment originates from a number of anthropogenic activities, including agriculture, livestock grazing, urbanization, roads, forestry, mining, as well as natural processes, such as landslides (Photo 11), stream bank erosion, and fire; fine sediment yield from these natural processes is often much greater in areas where anthropogenic disturbance is high such as heavily urbanized areas. Minimizing anthropogenic sources of fine sediment is readily achievable when riparian buffers of sufficient size persist along stream channels, when culverts are adequately sized and properly located, when urban development or extractive land management practices are avoided in unstable areas, when cover crops are left during the winter, and when roads are properly maintained.

Photo 11: Headwater landslide leading to sediment delivery downstream to a CCC steelhead stream making it unsuitable for steelhead for many years. *Courtesy: Jon Ambrose, NMFS.*

Access to Overwinter Habitat - Floodplains, Side Channels and Backwater Habitats

The survival of many juvenile steelhead and Chinook salmon during freshwater residency is dependent on their ability to survive periods of high winter flow and excessive velocities. A lack of available over winter refuge habitat, is often cited as a contributing limiting factor for many populations. During periods of high flow, juvenile steelhead and Chinook salmon select habitats with lower velocities, such as undercut banks, inundated floodplains and side channels (Photo 12), backwater habitats, such as alcoves, riverine ponds (*e.g.*, beaver ponds), and deep, in-channel pools formed by rootwads and other large structures. These habitat features provide both complex refugia from high flows and cover from predators; factors that cause premature emigration and increased mortality (Bustard and Narver 1975; Erman *et al.* 1988; McMahon and Hartman 1989; Sandercock 1991). Often, such refugia areas are found to be most abundant on floodplains. Studies have shown the rate of individual growth (i.e., size and weight) for salmonids that utilize floodplain habitats is substantially greater than those that do not (Sommer *et al.* 2001; Jeffres *et al.* 2008; Katz 2012), and therefore maintenance and/or reconnection of these areas may be of extraordinary importance for salmon and steelhead recovery. However, floodplains are frequently locations of human development despite also being areas prone to recurrent flooding. Many floodplain habitats in the NCCC Domain have been altered and channelized (for flood control or routine maintenance), farmed, or converted to urban land uses, and no longer support alcoves, side-channels, backwaters, *etc*. Restoring floodplain habitats and connection with their streams and rivers would substantially benefit growth and survival of juvenile salmon and steelhead.

2.7.2 THE IMPORTANCE OF ESTUARIES

Numerous studies have demonstrated the importance of coastal estuaries for rearing juvenile salmonids prior to entering marine waters (Coots 1973; Smith 1990; McMahon and Holtby 1992; Zedonis 1992; Busby and Barnhart 1995; Martin 1995; Cannata 1998; Collins 1998; Bond *et al.* 2008; Hanson 2008; Hayes *et al.* 2008; Atkinson 2010; Fuller 2011; Seghesio 2011). Many of these studies show that salmonids reared in these highly productive habitats grow faster compared to fish reared in upstream and less productive riverine habitats and contribute disproportionally to the adult returns (Collins 1998; Bond *et al*. 2008; Hayes *et al*. 2008; Atkinson 2010; Fuller 2011). For example, in a study of the small Scott Creek watershed in Central California, Bond *et al.* (2008) found that between 87 and 95.5 percent of the returning steelhead adults (based on analysis of PIT-tag returns and scale analysis, respectively) were fish that reared in the lagoon despite representing a relatively small proportion of the overall downstream migrating population.

Photo 12: Constructed side-channel habitat in Dry Creek, Russian River Watershed. *Courtesy: Joel Casagrande, NMFS.*

Estuaries are either open to the ocean year round (tidal estuaries) or seasonally closed by a sand bar (lagoons) (Photo 13). For many watersheds in the NCCC Domain, sand bars develop at the estuary mouth when stream flows and ocean swells decline in summer (Smith 1990; Behrens 2008). Left alone, the sand bar for most lagoons generally lasts until the first significant storms increase stream flows and wave heights (Smith 1990, Behrens 2008, Bond *et al.* 2008, Atkinson

2010). Manual breaching of sandbars in summer and fall is a common and ongoing problem in many systems (Photo 14). Similarly, premature and poorly executed manual breaching during winter as a means of reducing flood risk can also result in considerable adverse impacts to salmonids in the lagoon and diminish the amount of residual habitat available as refuge during high flows. Estuaries vary in size and form and, depending on the system, usually contain a mosaic of habitat types that change longitudinally with distance upstream from the beach (Smith 1990; Quiñones and Mulligan 2005). These include open water embayments, seasonally or perennially flooded marshes, and riparian scrub or forest habitats. Larger systems may support a network of tidal slough channels.

Photo 13: Pescadero Creek Lagoon and marsh at high water (and wind). *Courtesy: Joel Casagrande, NMFS*

The ability of an estuary to support highly beneficial growth rates and transitional habitat for rearing salmonids ultimately depends on its seasonal water quality dynamics. In lagoon systems, preferred rearing conditions occur once the water column converts to fresh or slightly brackish conditions (*i.e.*, without stratification of the water column). The timing of sandbar closure, amount of freshwater inflow, and the abundance of saltwater in a lagoon at the time of closure all determine how long it will take to convert to a freshwater lagoon and break down water column stratification (Smith 1990). Stream flow in most watersheds of the NCCC Domain during the dry season is low, and if the sandbar forms later in summer, the conversion to freshwater and elimination of the stratified water column are less likely to occur. Therefore water quality (and productivity) in the lagoon will be less optimal. If a sufficient volume of freshwater is impounded, the overlying freshwater layer will eventually force much of the saltwater through the sandbar and into the ocean and eliminate water column stratification (Smith 1990). Once the stratification has been eliminated or substantially reduced, mixing by wind, incoming stream flow, and increases in convection reduce water temperatures and maintain suitable dissolved oxygen concentrations throughout the column. For estuaries open to tidal action throughout the year (generally larger river systems or those with permanent harbor openings), mechanical mixing by the tides, wind, and inflowing freshwater is usually sufficient to maintain suitable water quality conditions throughout the year.

If suitable water quality conditions persist, estuarine habitats are highly productive with large quantities of prey consisting primarily of epibenthic and benthic macroinvertebrate communities (Smith 1990, Robinson 1993, Seghesio 2011). Common invertebrate taxa found in estuaries include amphipods (*Corphium spp*. and *Gammarus spp*.), shrimp (*Neomysis spp*.), isopods (*Gnorimosphaeroma spp*.), and a host of other freshwater and marine organisms (Smith 1990, Robinson 1993, Seghesio 2011).

Estuaries also provide a critical transitional environment where smolts can acclimate to salt water while taking advantage of the high productivity for feeding prior to entering the ocean. In closed, bar-built lagoons, this can occur in spring prior to sandbar formation, in summer if a stratified water column is present, or later in fall and winter when large ocean waves deliver saltwater over the sandbar (Smith 1990; Zedonis 1992; Casagrande and Watson 2003; Watson and Casagrande

2004). Juvenile salmonids, particularly steelhead, not adequately adapted to saltwater, can suffer from higher physiological stress or mortality during rapid entrance to saltwater. This can occur, for example, during an unnatural breach of the sandbar in summer (Macdonald *et al.* 1988).

Photo 14: Signs warning the public about the implications of lagoon sandbar breaching.
Courtesy: Jerry Smith, SJSU

2.7.3 OCEAN CONDITIONS

Long-term trends in marine productivity associated with atmospheric conditions in the North Pacific Ocean have a major influence on salmonid survival in the ocean. Salmonids have evolved behaviors and life history traits that enable them to survive a variety of environmental conditions. When populations are fragmented or reduced in size and range they are more vulnerable to extinction by natural events. Unusually warm ocean surface temperatures and associated changes in coastal currents and upwelling, known as El Niño conditions, result in ecosystem alterations, such as reductions in primary and secondary productivity and changes in prey and predator species distributions. More significantly, poor ocean conditions that affect the biological productivity are the result of interdecadal climate variability in the northeast Pacific (Hollowed and Wooster 1992; Beamish and Bouillon 1993). Such regime shifts in the ocean have likely resulted in significant adverse effects to all steelhead and salmon populations. For example, poor ocean conditions off the central California coast are believed to have contributed substantially to the recent (2007-2009) decline of Central Valley fall-run Chinook salmon (Lindley *et al.* 2009). Similarly, MacFarlane *et al.* (2008) suggest poor ocean conditions in 2005 and 2006 led to the sharp decline of adult coho salmon returns throughout California and coastal Oregon during the winter of 2007/08.

El Niño is often cited as a cause for the decline of West Coast salmonids. Near-shore conditions during the spring and summer months along California's coast may have dramatically affected year-class strength (i.e., abundance and fitness) of salmonids (Kruzic *et al.* 2001). Of greatest importance is not how salmonids perform during periods of high marine survival, but how prolonged periods of poor marine survival affect population viability. Salmonid populations have persisted through many such cycles. It is less certain how they will fare in periods of poor ocean survival particularly when freshwater, estuary, and nearshore marine habitats are degraded and juvenile survival in freshwater is poor (Good *et al.* 2005). Recovery of steelhead and Chinook salmon will depend on robust populations resilient enough to withstand natural changes in ocean productivity.

The interannual variations of El Niño events decrease salmonid prey abundance; however, changes to Pacific Decadal Oscillation (PDO) are more long lasting and more profound to salmonid populations. Synthesis of climate and fishery data from the North Pacific sector highlights the existence of large scale, interdecadal, coherent patterns of environmental and biotic changes. The marine ecological response to the PDO-related environmental changes starts with phytoplankton and zooplankton at the base of the food chain and works its way up to higher level predators like salmon (Venrick 1992; Roemmich and McGowan 1995; Brodeur *et al.* 1996; Hare 1996; Francis 1997). This "bottom-up" enhancement of overall productivity appears to be closely related to upper ocean changes characteristic of the positive polarity of the PDO. PDO reversals occurred in 1925, 1947, and 1977 (Mantua *et al.* 1997; Mantua and Hare 2002). These reversals significantly altered harvest patterns between Alaskan fisheries and fisheries in Washington, Oregon, and California (WOC). However, Mantua *et al.* (1997) observed a weaker connection between harvest records for the WOC salmonids than the Alaskan fisheries and indicated that climatic influences on salmon in their southern ranges may be masked or overwhelmed by anthropogenic impacts. Alaskan stocks are predominantly wild spawners in pristine watersheds, while the WOC steelhead, coho salmon, and Chinook salmon are predominately of hatchery origin and originate in watersheds significantly altered by human activities. More information about marine conditions can be found in Appendix A.

2.7.4 CLIMATE CHANGE IMPLICATIONS

Climate is a major driver of the geographic distribution and abundance of salmon and steelhead. Over 60 percent of California's anadromous salmonids are especially vulnerable to climate change, and future climate change will affect our ability to influence their recovery in most or all of their watersheds (Moyle *et al.* 2008; Moyle *et al.* 2013). Climate shifts can affect fisheries, with profound socio-economic and ecological consequences (Osgood 2008). This recovery plan provides an overview of probable climate change impacts on CC Chinook salmon and NC and CCC steelhead. We recommend improving our knowledge of climate change impacts on salmon and steelhead recovery, focusing on forests to store carbon and reduce greenhouse gases, and identifying cool water sources (See Appendix B).

A preponderance of the best available scientific information indicates that Earth's climate is warming, driven by the accumulation of heat-trapping greenhouse gases in the atmosphere (Oreskes 2004; Battin *et al.* 2007; Lindley *et al.* 2007). Human activities are warming the earth by increasing the concentrations of greenhouse gases such as carbon dioxide and methane. Activities such as burning coal, oil, and gas for transportation and power generation, and removal of trees, are largely responsible for the increase in greenhouse gases (Le Treut *et al.* 2007).

The warming is affecting large-scale atmospheric circulation patterns (Dettinger and Cayan 1995), and it is impacting climate at global, regional, and local scales (Zwiers and Zhang 2003; Cayan *et al.* 2008). Climate change is occurring and is accelerating (Battin *et al.* 2007; IPCC 2007); we can no longer assume that climate conditions in the future will necessarily resemble those in the past (Milly *et al.* 2008; Palmer *et al.* 2008), particularly over extended time horizons.

Changes in seasonal temperature regimes are already affecting fish and wildlife (Quinn and Adams 1996; Schneider and Root 2002; Walther *et al.* 2002; Root *et al.* 2003; Perry *et al.* 2005; Devictor *et al.* 2008; Chen *et al.* 2011; Comte and Grenouillet 2013). These effects manifest themselves in diverse organisms as range shifts; changes in the timing of spring activities including earlier arrival of migrants and earlier breeding in birds, butterflies and amphibians; and earlier shooting and flowering of plants (Walther *et al.* 2002; Perry *et al.* 2005; Comte and Grenouillet 2013). Fish have been observed to shift their distributions to higher elevations upstream, deeper water in oceans, or poleward in response to warming waters (Osgood 2008; Comte and Grenouillet 2013). As global temperatures rise, temperatures, winds, and precipitation patterns at smaller geographic scales are expected to change (CEPA 2006; Osgood 2008). In terrestrial environments, freshwater streams important to salmonids may experience increased frequencies of floods, droughts, lower summer flows and higher temperatures (CEPA 2006; Luers *et al.* 2006; Lindley *et al.* 2007; Schneider 2007; Osgood 2008). In marine environments, ecosystems and habitats important to sub adult and adult salmonids are likely to experience changes in temperatures, circulation and chemistry, and food supplies (Diffenbaugh *et al.* 2003; Barth *et al.* 2007; Brewer and Barry 2008; Osgood 2008; Turley 2008; O'Donnell *et al.* 2009).

Climate variability is a crucial factor directing the abundance and distribution of marine organisms and ecosystem structure. The physical ecosystem drivers related to climate will likely impact growth rates and reproductive success of marine species at all trophic levels. Estuarine and lagoon areas are likely to experience sea level rise and changes in stream flow patterns (Scavia *et al.* 2002).

Because salmon depend upon freshwater streams and oceans during different stages of their life history cycle, their populations are likely to be affected by many of the impacts as shown below in Figure 12.

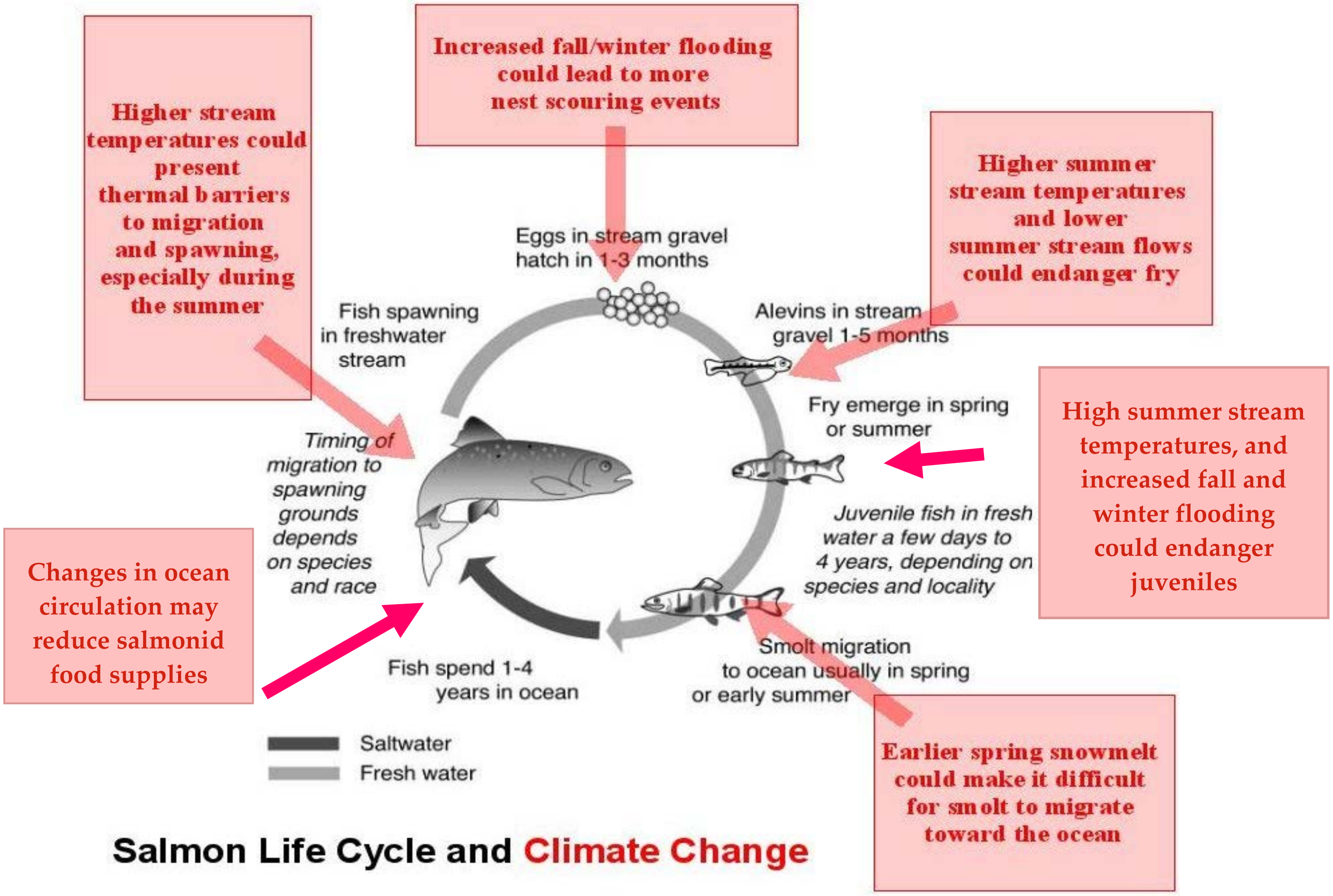

Figure 12: Potential climate change related impacts on salmonids (Modified from:Casola *et al.* 2005).

3.0 POPULATION STRUCTURE AND VIABILITY

"Our estimates of habitat lost behind barriers include only major obstructions to fish passage and do not factor in the hundreds, if not thousands, of culverts and other smaller barriers that may partially or completely prevent fish passage."

Spence et al. 2008

3.1 INTRODUCTION

The NCCC Domain TRT evaluated the historical structure and developed biological viability criteria that, if met, would indicate the Domain's salmon ESUs and steelhead DPSs are at a low risk of extinction (i.e. viable). The analyses and results of the NCCC Domain TRT are characterized in two NOAA Technical Memoranda (Bjorkstedt *et al*. 2005; Spence *et al*. 2008). In 2012, the SWFSC prepared a memo and report updating the viability criteria for the NCCC Domain steelhead populations (Spence *et al*. 2012). These three documents set the biological foundations to establish recovery criteria for the NCCC Domain recovery plans. This chapter provides a summary of the three memoranda. Appendix C provides Spence *et al*. (2008) and Spence *et al*. (2012).

3.2 SALMONID POPULATIONS

A salmon ESU or steelhead DPS consists of smaller units called populations. Since salmon and steelhead have a high fidelity to return to their natal rivers with some occasional straying into neighboring streams, they share more similar genetic characteristics within and between neighboring streams than those separated by hundreds of miles (Shapovalov and Taft 1954; Quinn 2005; Garza *et al*. 2014). Multiple populations across river systems are connected by a small degree of genetic exchange, which ensures genetic diversity and distribution providing resilience for species' persistence overtime. The CC Chinook ESU and NC and CCC steelhead DPS populations in the NCCC Domain coincide with watersheds or subwatersheds. The risk an ESU or DPS will go extinct is determined by the size, distribution, and viability of populations and the size and viability of populations are dependent on the survival of individual salmonids across all life stages. The extent and quality of habitats, natural events and anthropogenic factors dictate the survival of salmonids at each life stage.

3.3 HISTORICAL STRUCTURE

Salmonid populations have persisted in great abundance for nearly a million years; their persistence has been contingent on ecological, biological, and evolutionary dynamics across both space and time. These historical conditions under which salmonids have evolved represent a baseline for population structure and viability. As a population departs from its baseline, the risk of extinction rises. To describe these historical conditions in a data poor environment, the TRT: (1) utilized models to predict the intrinsic potential of each watershed to support populations of salmon and steelhead; (2) reviewed historical records on population size and distribution; (3) defined populations and their viability in context to the ESU/DPS; (4) grouped populations into geographical units (*i.e.*, Diversity Strata) within an ESU/DPS; and (5) analyzed genetic structure, historical out-of-basin transfers, and other information (See Bjorkstedt *et al.* 2005). The final information from Bjorkstedt *et al.* (2005) included historical habitats expected to support spawning and juvenile salmonids (*i.e.*, Intrinsic Potential in km), the likelihood of each population to persist in isolation (*e.g.*, independent versus dependent) and the geographic groupings of populations across their range (*i.e.*, Diversity Strata).

3.3.1 INTRINSIC POTENTIAL OF HISTORICAL HABITATS

Salmonid habitats are largely determined by the interactions of landform, lithology, and hydrology. These interactions are relatively constant over long time scales and govern movement of water and deposition of sediment, large wood, and other structural elements along a river network (Agrawal *et al.* 2005). Thus, modeling specific habitat characteristics is often used as a predictor of potential habitats in a watershed. Due to a lack of detailed population data and the availability of models, the TRT adopted the Oregon Coastal Landscape Analysis and Modeling Study (CLAMS) method (Burnett *et al.* 2003; Burnett *et al.* 2007) for the NCCC Domain to predict the likelihood, or intrinsic potential (IP), of stream reaches to support adult and juvenile salmonids including CC Chinook salmon and both NC and CCC steelhead (Bjorkstedt *et al.* 2005). The three habitat attributes - channel gradient, valley width, and mean annual discharge - were modeled to serve as a predictor of historical habitat. Each of these three attributes were weighted between zero to one as to their potential to provide quality habitat with lower quality habitats scoring low, or near zero, and higher quality habitats scoring high, 0.7 to one. For example, narrow valley widths and steep channel gradients are less likely to provide good spawning habitats (IP score of <0.7) while wider valley widths and low gradients are more likely to provide higher quality spawning and rearing habitats (IP score of >0.7). The IP score for each reach in a watershed was multiplied by its respective reach length (in km), and the values totaled to estimate historical IP in kilometer (IP-km) for each watershed. These weighted IP-km, which are not a linear measurement, were used to calculate the likely historical carrying capacity of adult salmonids. Depending on watershed size, 20 to 40 spawners per km were calculated relative to the amount of IP in a watershed to yield density-based criteria representing a low risk of extinction for each population (i.e. viable) (Figure 13). Smaller sized watersheds with essential populations must support higher densities of salmonids than larger watersheds to buffer against localized disasters (*i.e*. fire, flooding, and disease) (Spence *et al.* 2008) (Figure 13).

Uncertainties exist with nearly all model outputs, and there is some bias in the IP model to over or underestimate IP and historical habitat potential. To evaluate the bias and assess whether the population size predictions were reasonable, the TRT made comparisons of the modeled IP density-based spawner abundances with historical records. The TRT found in the majority of cases that modeled adult abundances were lower than those observed during the 1930s into the 1950s and concluded that projected spawner abundance targets did not overestimate natural carrying capacity for most populations within each ESU and DPS. In 2012, due to reviewer comments and field observations, IP for steelhead was re-examined and revised (Spence *et al.* 2012). IP modifications resulted in reductions in estimates of IP-km, and accordingly, spawner targets for a number of populations (Spence *et al.* 2012).

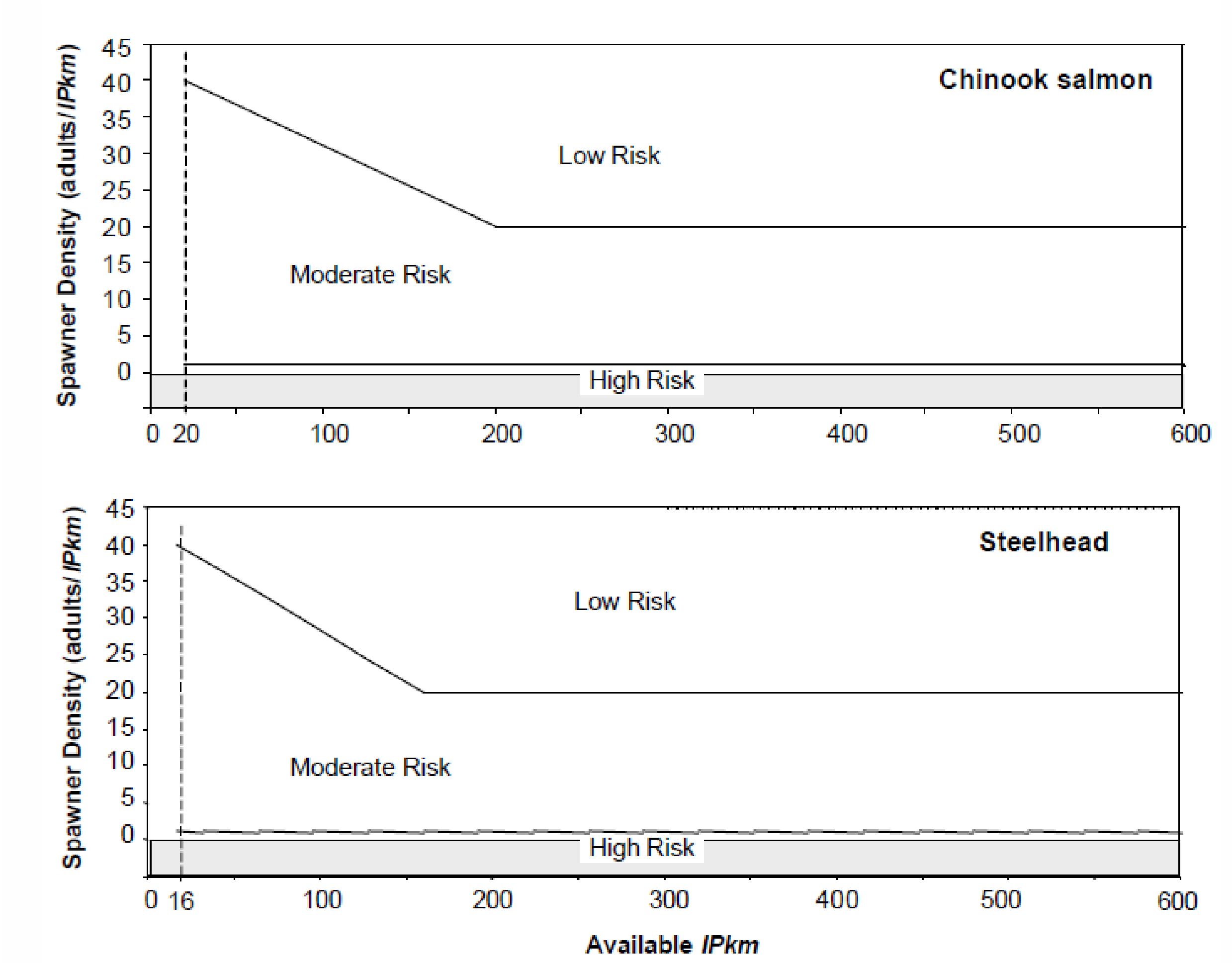

Figure 13: Relationship between risk and spawner density as a function of total intrinsic habitat potential. Values above the upper lines indicate populations at low risk of extinction (*i.e.*, viable), values below this line are at a moderate risk of extinction. Values below 1 spawner/IPkm are at a high risk of extinction.

3.3.2 ROLES OF POPULATIONS IN ESU/DPS VIABILITY

IP was also used to determine if populations were independent (*i.e.*, viable in isolation) or dependent (*i.e.*, non-viable in isolation). The independence of a population establishes its relative importance to ESU/DPS viability. For example, a large population (*e.g.*, functionally independent or potentially independent) likely functions as a regular source of surplus individuals through straying to smaller populations (*e.g.*, dependent populations). Straying adds resilience to the ESU/DPS when smaller populations are impacted by adverse environmental conditions (*e.g.*, catastrophic wildfire). Surplus individuals from large populations can re-colonize these watersheds overtime. This resilience confers more importance onto large populations for their role in the viability and recovery of the ESU/DPS.

The TRT defined (1) functionally independent populations (FIP) as those likely to persist over a 100-year time scale in isolation and without the influence of migrants from neighboring populations; (2) potentially independent populations (PIP) as those likely to persist over a 100-year time scale but are influenced by immigration from neighboring populations; and (3) dependent populations (DP) as those likely to go extinct within a 100-year time period in isolation and rely on immigration from neighboring populations to persist. While independent populations have a more significant role in ESU/DPS viability, the role of dependent populations is very important in situations where associated historical independent populations are extirpated or at a high risk of extirpation. In these cases, dependent populations can become the vital source of colonizers and genetic diversity to support restoration of the extirpated populations associated with the larger watershed.

For NC and CCC steelhead, watersheds with ≥16 IP-km of potential habitat were deemed independent populations and <16 IP-km were deemed dependent populations. Due to the lack of sufficient information, the TRT selected 16 IP-km, which is one-half the threshold used for coho salmon, as the threshold for viability-in-isolation. The threshold is based on the following assumptions:

1. A given reach of equal IP to coho is capable of supporting more juvenile steelhead than coho since steelhead can use a broader range of habitats.
2. Life history of winter run steelhead with broader distributions of age-at-ocean entry and age-at-maturation allow greater flexibility over coho.
3. Steelhead spawn across greater distances (and time scales) and in upper tributaries, spreading the risk of disturbance over space and time and reducing overall impacts to the species.

For CC Chinook, watersheds with ≥20 IP-km of potential habitat are independent populations and <20 IP-km dependent populations.

The 20 IP-km was derived from the following assumptions:

1. IP score of 1.0 corresponds to a maximum density of 20 redds per linear stream km.
2. Chinook populations require an average abundance of 2500 spawners per generation to be at a negligible risk of extinction. A typical generation time for Chinook is 4 years which gives an average of 625 spawners per year for a population that is viable-in-isolation.
3. Chinook salmon exhibit a 1:1 sex ratio.

Using these assumptions, the TRT arrived at a viability-in-isolation threshold of 15.6 IP-km for Chinook. They adopted a precautionary approach and used a higher threshold of 20 IP-km to account for uncertainty.

3.3.3 RESULTS FROM HISTORICAL STRUCTURE ANALYSIS

To capture the historical environmental and ecological conditions under which groups of populations likely evolved, the TRT delineated units called Diversity Strata and assigned populations to each Diversity Stratum.

The NC steelhead DPS historically consisted of 5 Diversity Strata with 40 independent populations of winter-run steelhead (18 functionally independent and 22 potentially independent) and as many as 10 populations of summer steelhead (all functionally independent) (Figure 14). The CCC steelhead DPS was historically comprised of 5 Diversity Strata with 10 functionally independent populations and 27 potentially independent populations (Figure 15). The CC Chinook salmon ESU was historically comprised of 4 Diversity Strata, with 16 independent populations of fall-run Chinook salmon (11 functionally independent and 5 potentially independent) and six independent populations of spring-run Chinook salmon (all functionally independent) (Figure 16).

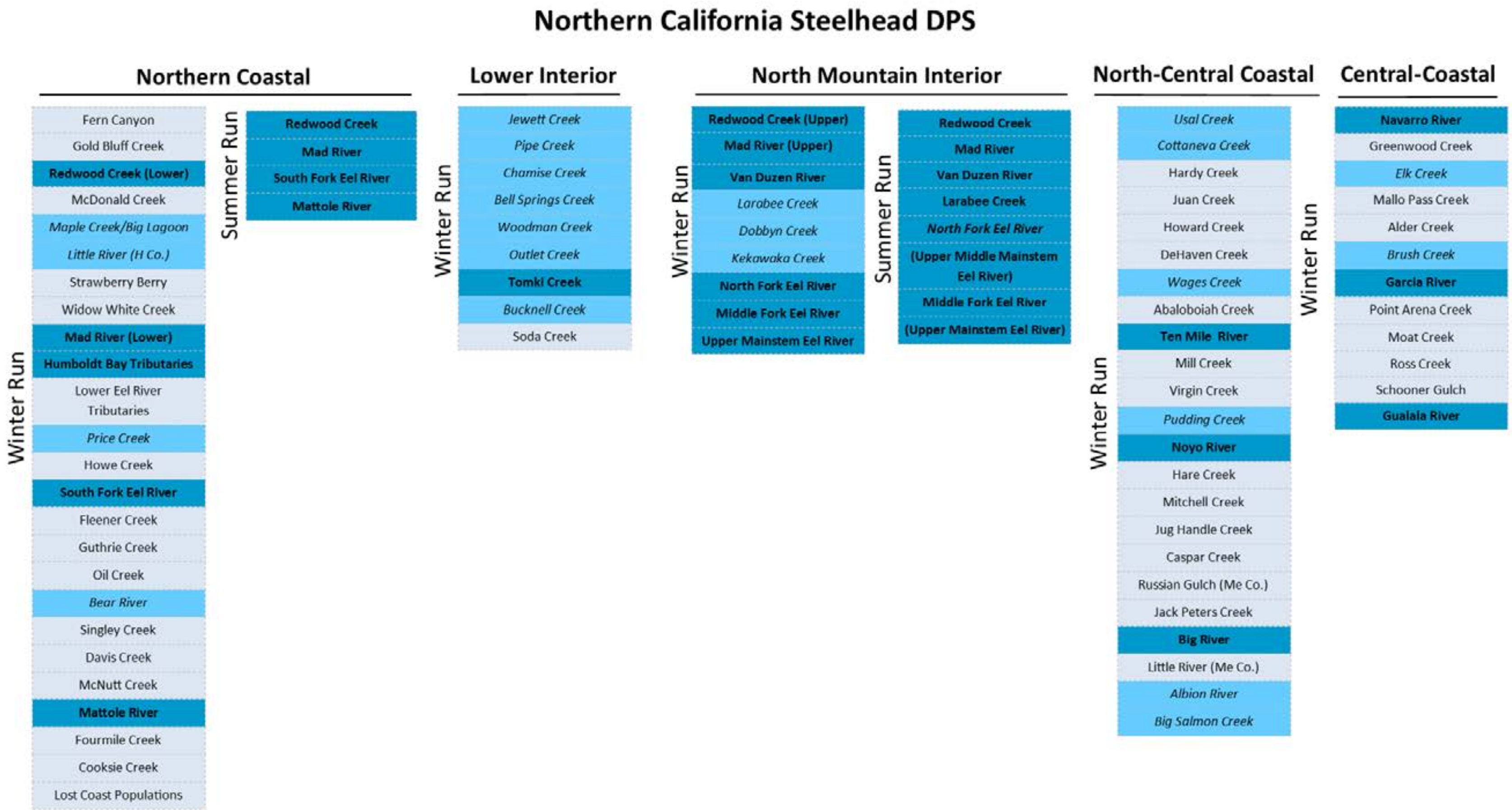

Figure 14: Historical Population Structure of NC steelhead DPS arranged by Diversity Strata. Functionally Independent Populations are listed in bold font with dark blue background. Potentially Independent Populations are listed in italic font with a medium blue background. Dependent Populations are listed in regular font, with a grey background (not all Dependent Populations are shown). Populations listed parenthetically are those for which potential historical existence is inferred from environmental correlates (From Spence *et al.*, 2012).

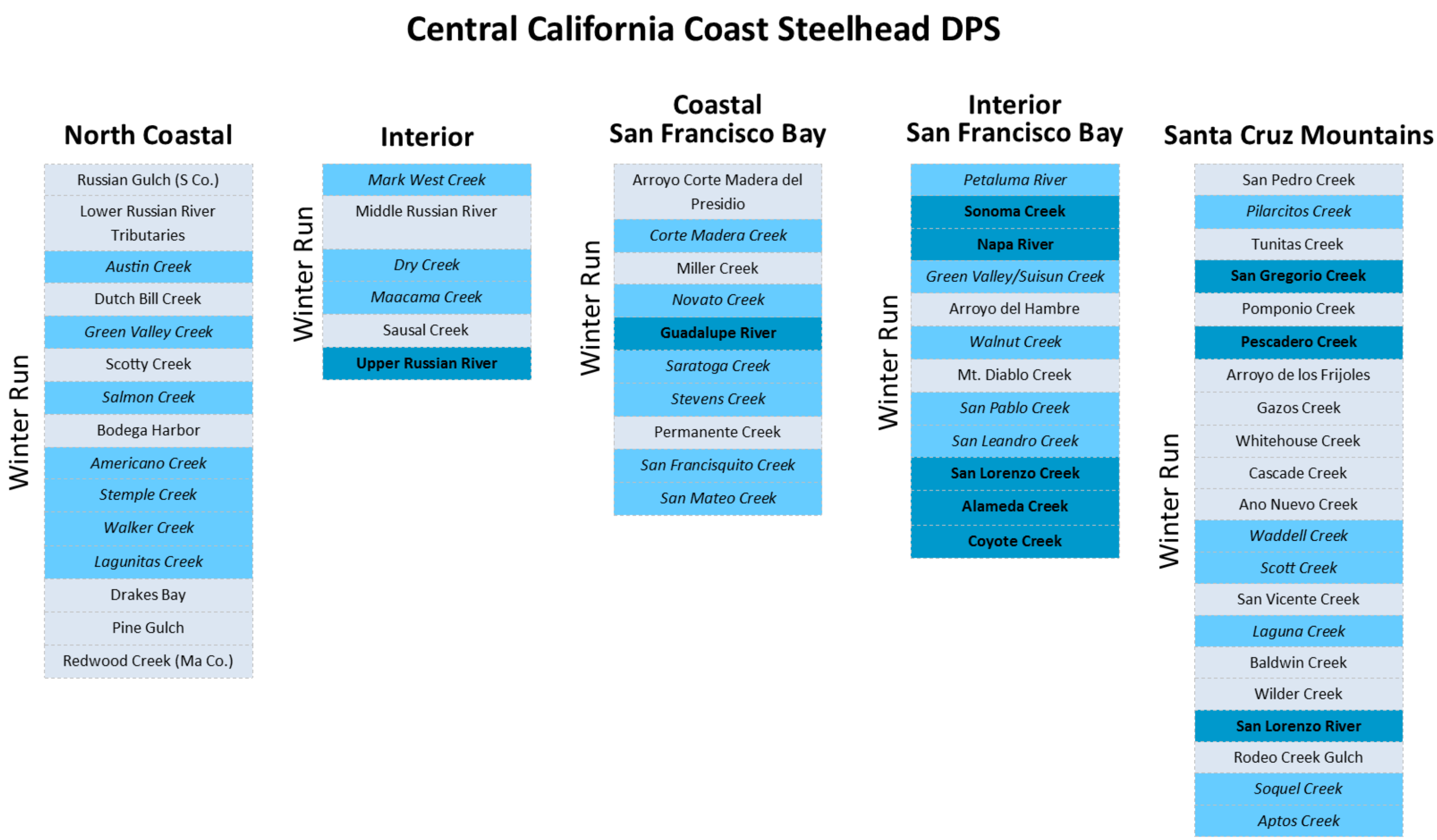

Figure 15: Historical Population Structure of the CCC steelhead DPS arranged by Diversity Strata. Functionally Independent Populations are listed in bold font with dark blue background. Potentially Independent Populations are listed in italic font with a medium blue background. Dependent Populations are listed in regular font, with a grey background (not all Dependent Populations are shown). (From Spence *et al.*, 2012).

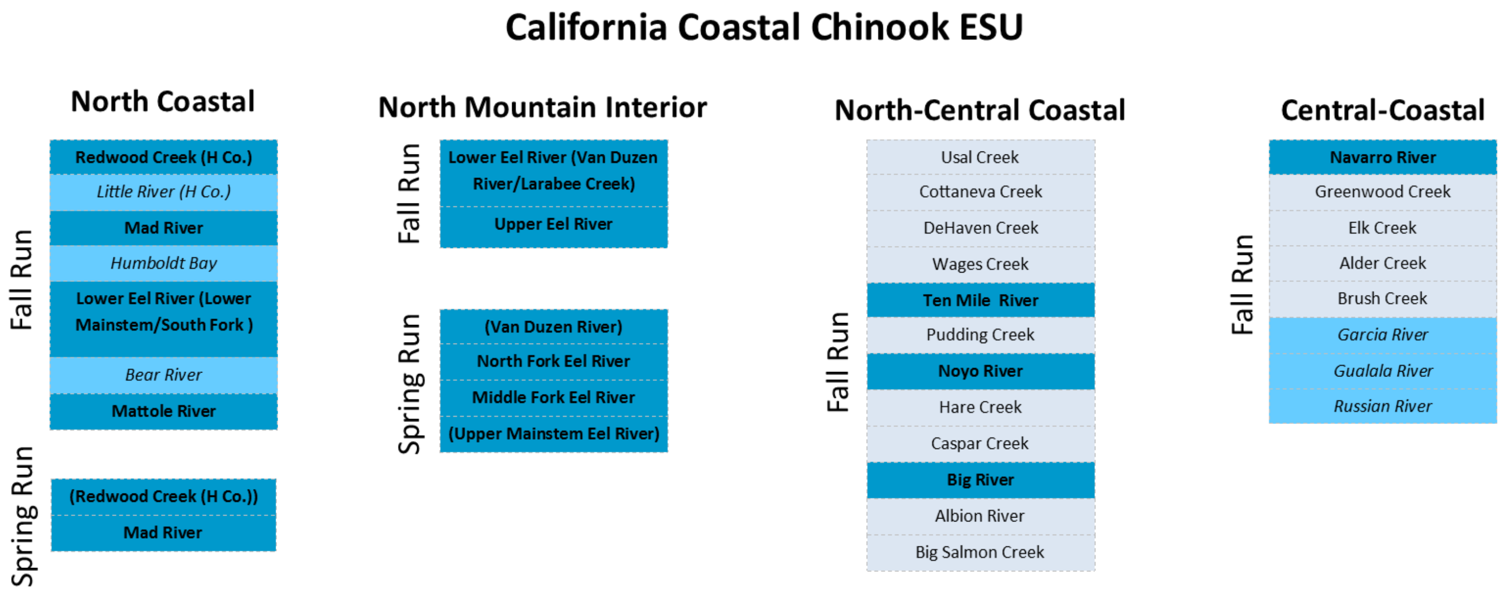

Figure 16: Historical Population Structure of the CC Chinook ESU arranged by Diversity Strata. Functionally Independent Populations are listed in bold font with dark blue background. Potentially Independent Populations are listed in italic font with a medium blue background. Dependent Populations are listed in regular font, with a grey background (not all Dependent Populations are shown). Spring-run Chinook salmon populations listed parenthetically are those for which potential historical existence is tentatively inferred from environmental correlates (Spence et al. 2008).

3.4 BIOLOGICAL VIABILITY CRITERIA

Spence *et al.* (2008) developed biological viability criteria for the three levels of biological organization (*i.e.*, populations, Strata, ESU/DPS), important for the long term persistence of salmon and steelhead as outlined by Bjorkstedt *et al.* (2005). The biological viability criteria "defines sets of conditions or rules that, if satisfied, would suggest that the ESU is at low risk of extinction" (i.e. viable) (Spence *et al.* 2008). These criteria involve a minimum number of populations achieving viability and populations, not required to achieve viability, demonstrating occupancy and distribution patterns to suggest sufficient connectivity within and between populations.

3.4.1 POPULATION VIABILITY CRITERIA

McElhany *et al.* (2000) states that four parameters form the key to evaluating population viability status: abundance, population growth rate, spatial structure, and diversity. Abundance is the number of adult spawners measured over time based on life history. Population growth rate (*i.e.*, productivity) is a measure of a population's ability to sustain itself overtime (*e.g.*, returns per spawner). Population spatial structure describes how populations are arranged geographically based on dispersal factors and quality of habitats. Population diversity is the underlying genetic and life history characteristic providing for population resilience and persistence across space and time.

Spence *et al*. (2008) applied the population viability concept described in McElhany *et al*. (2000) in order to develop extinction risk categories for the Domain (Table 2). Low, moderate, and high extinction risk categories are described in terms of: (1) likelihood of extinction based on population viability modeling; (2) effective population size or total population size; (3) population decline; (4) catastrophic decline; (5) spawner density; and (6) hatchery influence (Table 2). For this recovery plan, a population that meets the low extinction risk criteria in Table 2 is considered a viable population.

Table 2: Population Extinction Risk Criteria (Spence *et al.* 2008)

Population Characteristic	Extinction Risk: High	Moderate	Low
Extinction risk from population viability analysis (PVA)	≥ 20% within 20 yrs - or any ONE of the following -	≥ 5% within 100 yrs but < 20% within 20 yrs - or any ONE of the following -	< 5% within 100 yrs - or ALL of the following -
Effective population size per generation *-or-* Total population size per generation	$N_e \leq 50$ *-or-* $N_g \leq 250$	$50 < N_e < 500$ *-or-* $250 < N_g < 2500$	$N_e \geq 500$ *-or-* $N_g \geq 2500$
Population decline	Precipitous decline[a]	Chronic decline or depression[b]	No decline apparent or probable
Catastrophic decline	Order of magnitude decline within one generation	Smaller but significant decline[c]	Not apparent
Spawner density	$N_a/IPkm^{d} \leq 1$	$1 < N_a/IPkm <$ MRD[e]	$N_a/IPkm \geq$ MRD[e]
Hatchery influence[f]	Evidence of adverse genetic, demographic, or ecological effects of hatcheries on wild population		No evidence of adverse genetic, demographic, or ecological effects of hatchery fish on wild population

[a] Population has declined within the last two generations or is projected to decline within the next two generations (if current trends continue) to annual run size $N_a \leq 500$ spawners (historically small but stable populations not included) *or* $N_a > 500$ but declining at a rate of ≥10% per year over the last two-to-four generations.
[b] Annual run size N_a has declined to ≤ 500 spawners, but is now stable *or* run size $N_a > 500$ but continued downward trend is evident.
[c] Annual run size decline in one generation < 90% but biologically significant (e.g., loss of year class).
[d] *IPkm* = the estimated aggregate intrinsic habitat potential for a population inhabiting a particular watershed (i.e., total accessible km weighted by reach-level estimates of intrinsic potential; see Bjorkstedt et al. [2005] for greater elaboration).
[e] MRD = minimum required spawner density and is dependent on species and the amount of potential habitat available. Figure 5 summarizes the relationship between spawner density and risk for each species.
[f] Risk from hatchery interactions depends on multiple factors related to the level of hatchery influence, the origin of hatchery fish, and the specific hatchery practices employed.

3.4.2 ESU/DPS Viability Criteria

The goals of the ESU/DPS criteria are to reduce the risk of extinction by ensuring: (1) connectivity between populations; (2) representation of ecological, morphological, and genetic diversity; and (3) redundancy in populations to minimize risks associated with catastrophic events. In characterizing a viable ESU/DPS the TRT applied the hypothesis that populations as they functioned in their historical context were highly likely to persist and that "increasing departure from historical characteristics logically requires a greater degree of proof that a population is indeed viable" (Spence *et al.* 2008). Due to the likely historical roles of functionally independent or potentially independent populations, these populations form the foundation of the ESU/DPS viability criteria. Dependent populations play a key role by providing reservoirs of genetic diversity, are a vital source of colonizers for adjacent FIPs in the ESU/DPS that are extirpated, provide connectivity between FIPs, reduce risk of ESU/DPS extinction, and act as a buffer to impacts resulting from poor ocean conditions and disturbances to independent populations. While viability criteria (i.e. low or moderate risk extinction criteria) were not developed for dependent populations since they are inherently non-viable, the TRT did develop guidance for recovery planners to include these populations into the biological goals and criteria for the recovery plan (See below).

The TRT developed four criteria which provide the framework for the minimum number and distribution of viable and non-viable populations likely to support ESU/DPS persistence over 100 year time frame (*i.e.*, a viable ESU/DPS).

The four ESU/DPS viability criteria are as follows:

(1) Representation

1.a. All identified Diversity Strata that include historical FIPs or PIPs within an ESU/DPS should be represented by viable populations for the ESU/DPS to be considered viable.

1.b. Within each Diversity Stratum, all extant phenotypic diversity (*i.e.*, major life-history types) should be represented by viable populations.

(2) Redundancy and Connectivity

2.a. At least 50 percent of historically independent populations (FIPs or PIPs) in each Diversity Stratum must be demonstrated to be viable. For strata with three or fewer independent populations, at least two populations must be viable.

2.b. Within each Diversity Stratum, the total aggregate abundance of independent populations selected to satisfy criterion 2.a. must meet or exceed 50 percent of the aggregate viable population abundance for all FIPs and PIPs in each Stratum.

(3) Remaining populations, including historically dependent populations or any historical FIPs or PIPs not expected to attain a viable status, must exhibit occupancy[14] patterns consistent with those expected under sufficient immigration subsidy arising from the essential independent populations selected to satisfy the preceding Redundancy and Connectivity criteria.

(4) The distribution of extant populations regardless of historical status must maintain connectivity within the Diversity Stratum as well as connectivity to neighboring Diversity Strata.

These criteria set the framework for the Coastal Multispecies Recovery Plan. The framework described above for NC and CCC steelhead and CC Chinook salmon represents our best understanding of their historical biological structure at a low extinction risk (Bjorkstedt *et al.* 2005). However, we believe recovery is possible at a threshold below the historical setting and not all populations are needed for, or are capable of contributing to, recovery. In fact, the biological viability criteria (Spence *et al.* 2008) indicate there are several ways salmon and steelhead can achieve viability. The Spence *et al. (*2008) criteria provide guidance to attain a number and configuration of viable populations across the landscape without explicitly specifying which populations must be selected for the recovery scenario from each Diversity Strata. The application of these criteria for recovery of Chinook salmon and steelhead are outlined in Chapter 4 Methods and Volumes II, III and IV.

[14] In the case of steelhead, occupancy is defined as the presence of the anadromous life history. In other words, the presence of juvenile *O. mykiss* alone does not confirm anadromy.

4.0 METHODS

> *"The wide-ranging migration patterns and unique life histories of anadromous salmonids take them across ecosystem and management boundaries in an increasingly fragmented world, which creates the need for analyses and strategies at similarly large scales."*
>
> *- Good et al. 2007*

4.1 INTRODUCTION

This chapter summarizes methods used to: (1) prioritize populations for recovery using the viability criteria framework provided by Bjorkstedt *et al.* (2005) and Spence *et al.* (2008); (2) assess current conditions; (3) identify future stresses and threats to these populations and their habitats; and (4) develop site-specific and range-wide recovery actions. Please see Appendix D for a full description of the methods.

4.1.1 SELECTING POPULATIONS FOR RECOVERY SCENARIOS

As described in Chapter 3, the historical role of independent populations in terms of ESU/DPS viability make them foundational for achieving the biological viability criteria requirements outlined in Spence *et al.* (2008). Dependent populations have a different role in recovery than independent populations. Dependent populations experience periodic local extinctions, and overtime are repopulated by immigration of spawners from nearby populations. Dependent populations: (1) are important reservoirs of genetic diversity; (2) are vital sources of colonizers for adjacent extirpated independent populations; (3) provide connectivity between independent populations; and (4) can act as a buffer for independent populations during poor ocean conditions and catastrophic disturbances (Spence *et al.* 2008).

NMFS applied the guidance and criteria in Bjorkstedt *et al.* (2005), Spence *et al.* (2008), and Spence *et al.* (2012) and considered the following conditions to select populations to represent the recovery scenario based on that guidance and criteria:

- Independent or dependent status;

- Likelihood to achieve a low extinction risk threshold;
- Phenotypic diversity (*i.e.,* major life-history types);
- Historical range and diversity;
- Susceptibility to catastrophic events;
- Current density, abundance and distribution of spawners;
- Connectivity of populations within and between Strata;
- Unique life history traits;
- Likelihood of the watershed to support the specified spawner abundances;
- Possibility of recolonization if extirpated and suitability of unoccupied habitats to support salmonids;
- Quantitative and qualitative information regarding current presence or prolonged absence of the species;
- Habitat suitability and severity of habitat degradation; and
- Threats and current protective efforts.

The historical IP-kms for selected populations were verified based on current habitat survey information, local knowledge, Google Earth images, watershed documents, several ground-truthing surveys, and outreach to agencies and other entities for information. IP and critical habitat are not the same, at times IP is designated for a stream that does not have critical habitat. IP is an historical designation that does not take into account, as is done for critical habitat, the impact to the economy, tribes, national security, or any other relevant impact. Changes to IP-kms were made for several populations where natural barriers (Passage Assessment Database 2014[15]), steep gradient changes, or stream flow dynamics were undetected by the model. In addition, IP-kms above dams were included for CCC steelhead populations where minimum viability criteria could not be achieved using the current conditions and passage in these areas is being explored (See Appendix G and Vol. IV for more information). Using the Spence *et al.* (2008) formulas,

[15] https://nrm.dfg.ca.gov/PAD/

spawner targets for each changed population were re-calculated by multiplying the number of spawning adults per IP-km.

4.1.2 Methods to Establish Biological Recovery Criteria

Three categories of independent and dependent populations were selected for ESU and DPS recovery scenarios based on viability criteria. Table 3 describes these criteria in more detail.

1. Essential independent populations attaining a low extinction risk threshold and contribute to meeting the ESU/DPS viability criteria. These populations are expected to achieve a spawner density of 20-40 spawners per IP-km depending on watershed size. The spawner abundance required for recovery across these independent populations must meet or exceed 50 percent of the aggregate historical abundance for each Diversity Stratum.

2. Supporting independent populations expected to attain a moderate extinction risk threshold and contribute to meeting the occupancy/connectivity criteria. These populations are expected to achieve a spawner density of 6-12 spawners per IP-km depending on watersheds size. The numeric targets for these populations do not contribute to meeting 50 percent of the aggregate historical abundance for the Stratum.

3. Supporting dependent populations expected to attain a spawner density of 6-12 spawners per IP-km and contribute to meeting the redundancy/occupancy/connectivity criteria. The numeric targets for these populations do not contribute to meeting 50 percent of the aggregate historical abundance for the Stratum.

The 20-40 spawners per IP-km range was derived according to Spence *et al.* (2008). The 6-12 spawners per IP-km range for independent and dependent populations was derived based on our assessment of depensation literature. Depensation is a reduction in per capita growth rate of the population with declining abundances and involves factors such as reduced probability of finding mates, inability to withstand predator populations, impairment to group dynamics, and loss of environmental adaptation and genetic diversity (Spence *et al.* 2008). In Spence *et al. (*2008), the high risk extinction threshold used for biological viability criteria is a population averaging 1 spawner per IP-km. Spence *et al.* (2008) notes, however, that various other authors suggest thresholds ranging from 1 to 5 spawners per IP-km (Chilcote 1999; Sharr *et al.* 2000; Barrowman *et al.* 2003; Wainwright *et al.* 2008). Extinction risk is high for populations with these densities due in large part to depensation conditions. For coho salmon, Borrowman (2003) estimates depensation at 0.6 spawners per km; Sharr (2000) estimates 3.1 spawners per km; Chilcotes (1999) estimates 2.3 spawners per km; and Wainwright (2008) estimates 2.5 spawners per km. Wainwright (2008) found six spawners per km the threshold where depensation is likely not occurring and 12 spawners per km the threshold where depensation is highly likely not to be occurring. Thus, 6-12 were selected to meet redundancy and connectivity criteria.

All selected populations play an important role in recovery regardless of status (*e.g.,* essential independent, supporting independent or supporting dependent). The selected populations meet the ESU/DPS viability criteria for representation, redundancy, connectivity, occupancy, and distribution required in Spence *et al.* (2008). While not all historical populations were included, they are still important to ESU/DPS persistence because they: (1) produce fish; (2) have habitats supporting environmental conditions that may lead to local adaptation; and (3) provide biological insurance against catastrophic loss of genetic material from neighboring independent populations. These small populations, therefore, contribute to overall ESU/DPS viability (Spence *et al*., 2008).

Table 3: Viability Criteria and NCCC Domain Methods to Select Populations for Recovery Scenarios Based on Those Criteria

	Spence *et al*. 2008 Criteria	Methods to Select Populations
ESU Representation Criteria	1.a. All strata that include historical FIPs or PIPs within an ESU or DPS should be represented by viable populations for the ESU or DPS to be considered viable, and 1.b. Within each stratum extant phenotypic diversity (*i.e.*, major life-history types) should be represented by viable populations.	➢ The final selection of all populations for the recovery scenarios was compared with the Representation criteria to ensure 1.a. and 1.b. were met.
ESU Redundancy and Connectivity Criteria	2.a. At least 50 percent of historically independent populations (FIPs or PIPs) in each diversity stratum must be demonstrated to be at low risk of extinction (i.e. viable) according to the population viability criteria. For strata with three or fewer independent populations, at least two must be viable.	➢ At least 50 percent of the historical FIPs and PIPs in each stratum selected for recovery scenarios are required to be at low risk of extinction (i.e. viable) according to the population viability criteria for four generations. For strata with three or fewer independent populations at least two are required to be viable. ➢ Populations selected were those identified as having a higher likelihood of recovery and an exceptional value or importance for recovery. ➢ For populations where IP-km for a population was not changed, the current low extinction risk spawner abundance targets outlined in Spence *et al.* (2008) (Chinook) and Spence *et al.* (2012) (steelhead) were applied. ➢ For essential populations where IP-km was changed to account for natural barriers, steep gradient changes, or stream flow dynamics undetected by the model, the low extinction risk spawner abundance target was re-calculated (weighted IP-km times a spawner density of 20-40 spawners per km based on basin size). ➢ Spawner abundances represent the low extinction risk targets outlined in Spence *et al.* (2008) (Chinook), Spence *et al.* (2012) (steelhead), and the biological recovery criteria for the population.
	2.b. Within each diversity stratum, the total aggregate abundance of independent populations selected to satisfy this criterion must meet or exceed 50 percent of the aggregate viable populations abundance (that is, it must meet density-based criteria for low risk) for all FIPs and PIPs.	➢ Using the historically predicted spawner targets in Spence *et al.* (2008) and Spence *et al.* (2012), the aggregate for each stratum, and 50 percent of the aggregate, were calculated. ➢ Total abundance of spawners in all FIP and PIP populations used to satisfy stratum criteria meet or exceed 50 percent of the historically predicted aggregate for the stratum.

	FIPs or PIPs selected to satisfy stratum abundance criteria must be a viable population and must have abundance above the minimum level for a small basin (*e.g*., 800 for Chinook and 640 for steelhead).	➢ All FIP and PIP populations used to satisfy stratum abundance criteria have spawner targets above the minimum level and are expected to be viable.
	3. [16]Remaining populations, including historical DPs and any historical FIPs and PIPs that are not expected to attain a viable status, must exhibit occupancy patterns consistent with those expected under sufficient immigration subsidy arising from the "essential" independent populations.	➢ FIPs or PIPs selected to satisfy this criterion have spawner targets at a moderate risk of extinction or higher. ➢ Dependent populations have occupancy patterns consistent with those expected under sufficient immigration subsidy. ➢ Additional dependent populations selected are a vital source of colonizers and genetic diversity to support restoration of adjacent FIPs/PIPs.
	4. The distribution of extant populations, regardless of historical status, must maintain connectivity within the diversity stratum as well as connectivity to neighboring Diversity Strata.	➢ If the linear distance between selected populations was greater than 20-30 km, additional populations were selected for recovery scenarios to fulfill connectivity criteria and reduce unoccupied gaps between populations to less than 20km (Spence *et. al* 2008). ➢ When feasible, FIPs or PIPs were chosen over dependent populations to fulfill connectivity criteria. Dependent populations selected to meet this criterion were those with higher self-recruitment values and IP-km of habitat. The higher self-recruitment value the less the population relies on immigrants from the source populations (FIPs or PIPs). ➢ Additional considerations made when selecting a population for recovery scenarios based on viability criteria included: known habitat/threat conditions, population parameters, and likelihood recovery actions would be implemented. In the absence of population data, weighted IP-km, spatial distribution of individuals across the watershed, or other available data that described present population status were used.

4.2 ANALYSIS OF CONDITIONS AND THREATS FOR SELECTED POPULATIONS

The Conservation Action Planning (CAP) method was used to assess conditions and threats for the CC Chinook salmon ESU and NC and CCC steelhead DPSs. Two types of analyses were

[16] Most FIPs/PIPs selected to satisfy connectivity criteria have spawner targets equal to or greater than those at a moderate risk of extinction according to Spence calculations and criteria. According to Spence *et al.* (2008), "Maintaining dependent populations in situations where FIPs or PIPs are extirpated or at a high risk of extirpation" means that dependent populations have a role in recovery and those selected should be "maintained" over time.

conducted: (1) CAP analysis and (2) rapid assessment analysis. The larger independent populations expected to achieve a low extinction risk threshold were analyzed using the CAP method - these populations are the essential populations. The dependent populations and independent populations expected to achieve a moderate extinction risk or 6-12 spawners/IP-km threshold were analyzed at the Diversity Stratum scale (not population level) using an abbreviated CAP protocol called the rapid assessment - these are the supporting populations. The rapid assessment analysis utilized a subset of the factors analyzed in the full CAP protocol. Although the rapid assessment analysis utilized a subset of the factors used in the full CAP protocol, it reflects the same range of current conditions and threats. Two types of analysis were used because of the role the rapid assessment populations (i.e., supporting) are playing in the recovery scenario. As a supporting population they did not warrant the same amount of analysis and often there was not data to support the more detailed CAP process. Our findings are presented for each population in Volumes II, III, and IV for each species. ESU and Diversity Stratum results are outlined in the results section and population-level results are provided in each population profile. These results were used to set priorities for recovery and develop recovery actions targeted at improving conditions and reducing threats.

The CAP tables and underlying result tables can now be found on Miradi Share[17]. Miradi Share is a cloud-based software system that enables conservation practitioners, managers, and funders to design, manage, monitor data. It also allows for the CAP tables to be on-line in an open-source format, so that anyone can easily view them.

4.2.1 CONSERVATION ACTION PLANNING OVERVIEW

The Nature Conservancy's (TNC) CAP protocols were developed by the Conservation Measures Partnership, a partnership of over ten different non-governmental biodiversity organizations including TNC. CAP is TNC's version of the Conservation Measures Partnership "*Open Standards for the Practice of Conservation*"[18]. CAP is an Excel-based user-defined tool with specific protocols

[17] https://www.miradishare.org/

[18] For more information, see www.conservationmeasures.org.

to organize a project, assess conditions and threats, and identify strategies. The Excel CAP workbook warehouses all data for the project including assessment methods, results and references. It's an assessment method for threats recommended in the Interim Recovery Planning Guidance (NMFS 2010). In 2006, the NCCC Domain adopted CAP for recovery planning work and partnered with TNC for training and support on the CAP protocol. CAP was used according to CAP protocols to assess conditions (viability analysis), stresses, and threats (threats analysis) for NCCC Domain salmonids and their habitats (Figure 17, Figure 18). NMFS used the CAP protocol to: (1) develop a standardized analysis for all ESU and DPS populations; (2) characterize current conditions for key habitat attributes across freshwater life stages for each population essential for salmonid survival; and (3) identify threats reasonably expected to continue or occur into the future that will have a direct or indirect effect on life stages for each population. Data inputs are computed by CAP algorithms to produce viability and threat results. Because the same assessment is conducted across all essential populations, a compilation of the CAPs for each ESU and DPS allows for comparisons of conditions and threats between populations and Diversity Strata. Thus, results are assembled into tables organized by ESU/DPS, stratum, population, and life stage and provide a snapshot of conditions of and threats to salmonid life stages across all populations. These results are used to formulate recovery actions to improve current conditions (restoration actions) and abate future threats (threat actions) for a population, a Stratum and the ESU or DPS. A simplified version of CAP, the rapid assessment, was used for supporting populations, both dependent populations and independent populations selected for the recovery. The CAP protocol will be used to update our assessments, if new information becomes available, and track recovery criteria over time. Ideally, watershed organizations or groups will use the CAP workbook and associated data to inform data gaps, focus efforts and provide feedback to NMFS during five-year reviews of recovery plans. With nearly all analysis methods there exists limitations and uncertainties and the level of precision with results will vary based on the amount and type of information used. Absent a more robust California habitat and threat monitoring program, we believe the CAP outputs provide the best available data and information for recovery planning. A detailed description of criteria and protocols developed to assess current habitat conditions, stresses, and threats, is provided in the *Protocol for Assessing Current Conditions and Future Threats* (Appendix D).

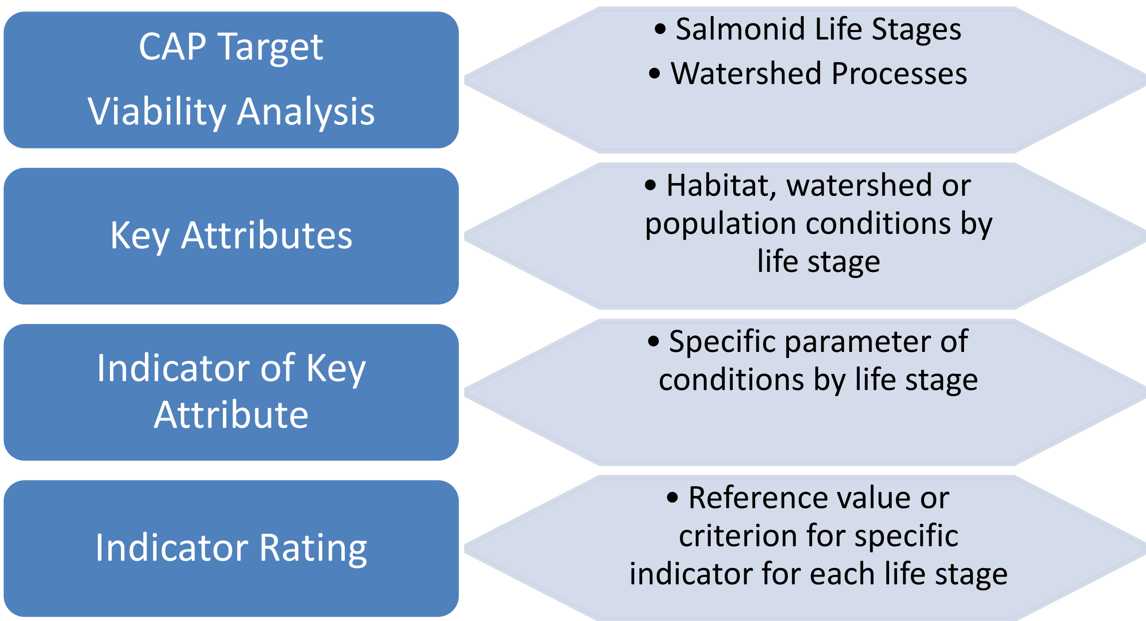

Figure 17: Schematic structure of the Viability Analysis in CAP for salmonids

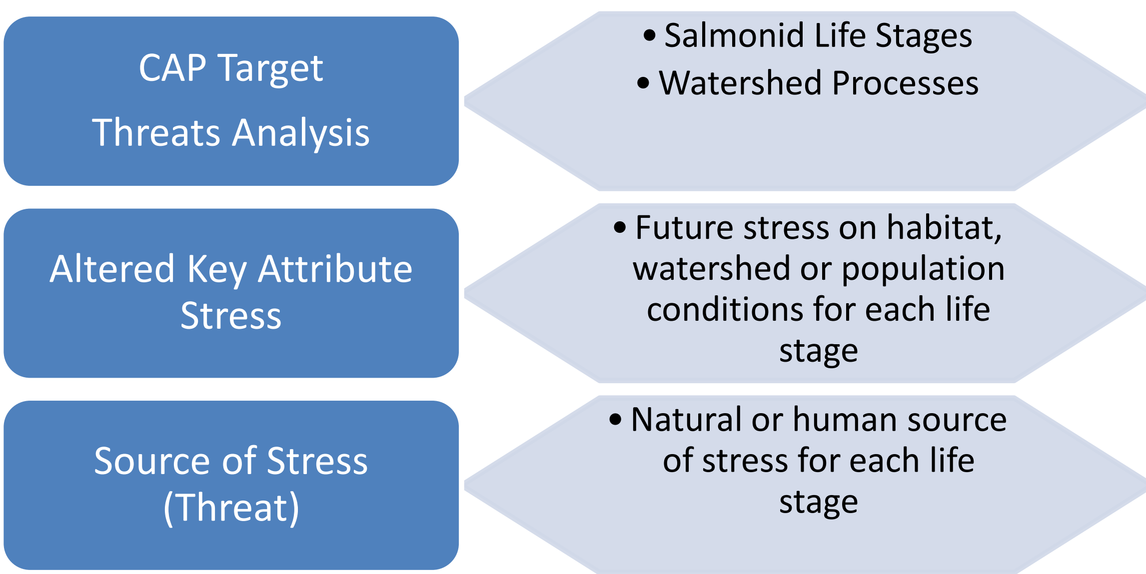

Figure 18: Schematic structure of the Threat Analysis in CAP for salmonids

4.2.2 PROJECTS AND CONSERVATION TARGETS

The viability of a salmon or steelhead population relies on an individual salmonid surviving across all of its life stages, and life stage survival depends on habitat conditions, natural events and anthropogenic factors. Each CAP workbook represents an essential ESU or DPS population. Since a population's viability relies on the conditions and threats associated with life stages, life stages were identified as the conservation targets for each CAP workbook. The CCC and NC steelhead DPS life stages assessed as conservation targets were: adults, eggs, summer rearing juveniles, winter rearing juveniles and smolts, and in some populations of NC steelhead, summer adults. The CC Chinook salmon ESU life stages assessed as conservation targets were: adults, eggs, pre smolt and smolt. These life stages are defined below (Table 4). Watershed processes was also identified as a conservation target. These same targets were used in both the CAPs and rapid assessments.

- Adults – Includes the period when adult salmonids enter freshwater, through their upstream migration, and subsequent spawning. For the purposes of our analysis, we considered late fall through spring as the migration season for both immigrating and emigrating (*i.e.*, kelts) adult winter steelhead; and the fall through early winter period for upstream migrating adult CC Chinook salmon;
- Summer Adult (NC steelhead only) – Includes the period when adult summer-run steelhead enter freshwater, through their upstream migration, and rearing period prior to spawning. For the purposes of our analysis, we considered spring through fall for the migration and staging period for adult summer run steelhead;
- Egg – Includes fertilized eggs placed in spawning redds, and the incubation of these eggs through the time of emergence from the gravel as fry. For the purposes of our analysis, we considered winter through spring to be the incubation period for steelhead; and from late fall through winter for CC Chinook salmon;
- Summer Rearing Juveniles (steelhead only) – Includes rearing of juveniles from emergence as fry to the onset of early fall rains. This also includes pre-smoltification summer rearing of juveniles in estuaries and freshwater lagoons. For the purposes of

our analysis, we considered late spring through early fall to be the summer rearing period for steelhead;

- Winter Rearing Juveniles (steelhead only) – Includes winter rearing of juvenile steelhead from the onset of fall rains through the spring months (typically fall through early spring). Includes significant main stem rearing for steelhead juveniles that utilize floodplain and off-channel habitats during high winter flow events;
- Pre-smolt (CC Chinook salmon only) - Includes rearing of CC Chinook salmon from the time of emergence as fry through the transition to emigration. This life stage also includes significant main stem rearing prior to complete smoltification. For the purposes of our analysis, we considered winter through spring to be the rearing period for pre-smolt CC Chinook salmon;
- Smolt – Includes downstream riverine residency of emigrating juvenile salmonids prior to ocean entry and estuarine residency where smolts may undergo additional growth and physiological changes, as they adapt to the marine environment. For the purposes of our analysis, the riverine period is considered to occur from late fall through spring for steelhead; and spring for CC Chinook salmon. For the purposes of our analysis, the estuarine period may generally persist late into the fall months, or until the first rains occur.
- Watershed processes - Landscape scale patterns related to land use for all species.

Table 4: CAP workbook identifying life stages as conservation targets for the Pilarcitos CCC steelhead population.

The Nature Conservancy
Protecting nature. Preserving life.

Conservation Action Planning Workbook
A tool for developing strategies, taking action, and measuring success
© 2010 The Nature Conservancy Version: CAP_v6b May 21, 2010

ConserveOnline Help | Changes for Excel 2007 | Full Version

Welcome	Hide/Zoom Worksheets	Workbook Setup (Establecer libro de trabajo) (Organização do Programa) (Установка рабочей книги)	Reset Menus and Tables	Switch to Basic Version

To enter, edit or delete data in protected cells (which are shaded or contain entries in black font), double-click on the cell. An entry form will appear.
To change the table format, double-click on the table header. A table format form will appear.

Project and Conservation Targets	
Project	**Central California Coast Steelhead ~ Pilarcitos Creek Population**
Target #1	**Adults**
Target #2	**Eggs**
Target #3	**Summer Rearing Juveniles**
Target #4	**Winter Rearing Juveniles**
Target #5	**Smolts**
Target #6	**Watershed Processes**

4.2.3 CURRENT CONDITIONS: VIABILITY TABLE

Once the target is defined a viability analysis is conducted. Viability describes the status or health of the target (TNC 2007) and the ability of a target (*e.g.*, life stage) to withstand or recover from most natural or anthropogenic disturbances and thereby persist for many generations or over long time periods. The viability table provides an objective consistent framework for defining the current status and the desired future condition for a life stage, and allows for the tracking of changes in the status of a life stage over time.

Viability Table: Key Attributes

Key attributes are defined as critical components of a conservation target's biology or ecology (TNC 2007). Attributes in CAP have been identified as necessary processes needed for successful transition between life stages that will lead to abundant and well-distributed populations. If attributes are missing, altered, or degraded then it is likely the species will experience more difficulty moving from one life stage to the next. There are three categories of key attributes which have associated indicators and indicator ratings: (1) habitat condition; (2) landscape context; and (3) life stage viability. Attributes have an associated suite of indicators and indicator ratings. The rapid assessments used a subset of the attributes.

Viability Table: Indicators and Indicator Ratings

Indicators are specific habitats, watershed processes or population parameters which measure the condition of a key attribute. An attribute may have one or more indicators (Table 5) with qualitative or quantitative values detailing the likelihood of the attribute to support life stage survival and transition (*e.g.*, indicator rating). These indicator ratings were derived from published scientific literature and other best available information regarding habitats and their relative importance to survival of a specific life stage. Attribute categories vary between steelhead and Chinook salmon to reflect their different life history requirements. Ratings apply to specific life stages or watershed processes at a population level based on data from reach, stream or watershed spatial scales. Natural variability was considered for all ratings. Viability table results inform the second phase of the CAP protocol that assesses stresses and sources of the stress (*e.g.*, threats).

There are four types of indicator rating results: Poor, Fair, Good or Very Good (Table 6). Very Good indicator ratings suggest high life stage survival and the habitat is fully functional to support high survival and abundance. Good ratings suggest high life stage survival and the habitat is functional but slightly impaired. Fair ratings suggest there is likely some mortality and the habitat is moderately impaired. Poor ratings suggest there is high mortality and the habitat is highly impaired.

In watersheds where the majority of indicators were rated as Good or Very Good, overall conditions are likely to represent the historical range of variability and support transition between life stages. Conversely, where many indicators were rated as Fair or Poor, overall conditions are likely to result in higher stress and mortality. The rapid assessment protocol used a subset of the CAP attributes and indicators and was conducted at a Diversity Stratum level rather than the population level (Table 7, Table 8).

Table 5: CAP attributes and indicators for each species and life stage.

Key Attribute	CAP Indicator	CAP Target (Life Stage)
Estuary/Lagoon	Quality and Extent	Steelhead - Summer Rearing, Smolts
		Chinook - Adult, Pre Smolt, Smolts
Habitat Complexity	LWD (BFW 0-10 and BFW 10-100)	Steelhead - Adults, Summer Rearing, Winter Rearing, Smolts
		Chinook - Adults
	Shelter Rating	Steelhead - Adults, Summer Rearing, Winter Rearing
		Chinook - Pre Smolt, Smolts
	Percent Primary and Staging Pools	Steelhead - Summer Rearing (Primary pools)
		Chinook - Adults (Staging Pools), Pre Smolt (Primary Pools)
	Pool/Riffle/Flatwater Ratio	Steelhead - Adults, Summer Rearing, Winter Rearing
		Chinook - Adults, Pre Smolt
	V* Star (Pool Volume)	Steelhead - Adults, Summer Rearing, Winter Rearing
		Chinook - NA
Hydrology	Redd Scour	Steelhead - Eggs
		Chinook - Eggs
	Flow Conditions (Baseflow and Instantaneous)	Steelhead - Eggs (Instantaneous) Summer Rearing (both), Summer Adults (Baseflow)
		Chinook - Eggs (instantaneous), Pre Smolt (both), Smolts, (Instantaneous)
	Passage Flows	Steelhead - Adults, Smolts, Summer Adults
		Chinook - Adults, Pre Smolt, Smolts
	Impervious surfaces	Steelhead - Watershed Processes
		Chinook - Watershed Processes
	Number, Conditions, and/or Magnitude of Diversions	Steelhead - Summer Rearing, Smolts
		Chinook - Pre Smolt, Smolts
Landscape Patterns	Agriculture	Steelhead - Watershed Processes
		Chinook - Watershed Processes
	Timber Harvest	Steelhead - Watershed Processes
		Chinook - Watershed Processes
	Urbanization	Steelhead - Watershed Processes
		Chinook - Watershed Processes
Passage/Migration	Passage at Mouth or Confluence	Steelhead - Adults, Summer Rearing, Smolts, Summer Adults
		Chinook - Adults, Pre Smolt, Smolts
	Physical Barriers	Steelhead - Adults, Summer Rearing, Winter Rearing, Summer Adults
		Chinook - Adults, Smolts
Riparian Vegetation	Tree diameter (North and South)	Steelhead - Adults, Summer Rearing, Winter Rearing
		Chinook - Adults, Pre Smolt
	Canopy Cover	Steelhead - Summer Rearing
		Chinook - NA
	Species Composition	Steelhead - Watershed Processes
		Chinook- Watershed Processes

Key Attribute	CAP Indicator	CAP Target (Life Stage)
Sediment	Quantity & distribution of Spawning Gravels	Steelhead - Adults, Summer Adults
		Chinook - Adults
	Gravel Quality (Bulk)	Steelhead - Eggs, Summer Adults
		Chinook - Eggs
	Gravel Quality (Embeddedness)	Steelhead - Eggs, Summer Adults
		Chinook - Eggs
	Gravel Quality (Food Productivity) (Embeddedness)	Steelhead - Summer Rearing and Winter Rearing
		Chinook - Pre Smolt, Smolts
	Gravel Quality (Food Productivity) (D 50)	Steelhead - Adults, Eggs, Summer Rearing, Winter Rearing
		Chinook - NA
Sediment Transport	Road Density	Steelhead - Watershed processes
		Chinook - Watershed Processes
	Streamside Road Density	Steelhead - Watershed processes
		Chinook - Watershed Processes
Smoltification	Temperature	Steelhead - Smolts
		Chinook - Smolts
Velocity Refuge	Floodplain Connectivity	Steelhead - Adults, Winter Rearing, Summer Adults
		Chinook - Adults, Pre Smolt, Smolts
Viability	Spatial Structure	Steelhead - Summer Rearing
		Chinook - Adults, Pre Smolt
	Density	Steelhead - Adults, Summer Rearing
		Chinook - Adults
	Abundance	Steelhead - Smolts
		Chinook - Smolts
Water Quality	Temperature (MWMT)	Steelhead - Summer Rearing
		Chinook - Pre Smolt
	Mainstem Temperature (MWMT)	Steelhead - Summer Adults
		Chinook - NA
	Turbidity	Steelhead - Adults, Summer Rearing, Winter Rearing, Smolts
		Chinook - Adults, Pre Smolt, Smolts
	Toxicity	Steelhead - Adults, Summer Rearing, Winter Rearing, Smolts, Summer Adults
		Chinook - Adults, Pre Smolt, Smolts
	Aquatic invertebrates (B-IBI NorCal, Rich, EPT)	Steelhead - Adults, Summer Rearing, Winter Rearing, Smolts (Rich only)
		Chinook - NA

Table 6: CAP Assessment of Target Viability

Assessment of Target Viability: Northern California Steelhead DPS ~ Bear River Population

#	Conservation Targets	Category	Key Attribute	Indicator	Poor	Fair	Good	Very Good	Ratings Source	Current Indicator Measurement	Current Rating
1	Adults	Condition	Habitat Complexity	Large Wood Frequency (BFW 0-10 meters)	**<50% of streams/ IP-Km (>6 Key Pieces/100 meters)**	50% to 74% of streams/ IP-Km (>6 Key Pieces/100 meters)	75% to 90% of streams/ IP-Km (>6 Key Pieces/100 meters)	>90% of streams/ IP-Km (>6 Key Pieces/100 meters)	External Research	<50% of streams/ IP-km (>6 Key Pieces/100 meters)	Poor
			Habitat Complexity	Large Wood Frequency (BFW 10-100 meters)	**<50% of streams/ IP-Km (>1.3 Key Pieces/100 meters)**	50% to 74% of streams/ IP-Km (>1.3 Key Pieces/100 meters)	75% to 90% of streams/ IP-Km (>1.3 Key Pieces/100 meters)	>90% of streams/ IP-Km (>1.3 Key Pieces/100 meters)	External Research	<50% of streams/ IP-Km (>1.3 Key Pieces/100 meters)	Poor
			Habitat Complexity	Pool/Riffle/Flatwater Ratio	**<50% of streams/ IP-Km (>30% Pools; >20% Riffles)**	50% to 74% of streams/ IP-Km (>30% Pools; >20% Riffles)	75% to 90% of streams/ IP-Km (>30% Pools; >20% Riffles)	>90% of streams/ IP-Km (>30% Pools; >20% Riffles)	External Research	<50% of streams/ IP-km (>30% Pools; >20% Riffles)	Poor
			Habitat Complexity	Shelter Rating	**<50% of streams/ IP-Km (>80 stream average)**	50% to 74% of streams/ IP-Km (>80 stream average)	75% to 90% of streams/ IP-Km (>80 stream average)	>90% of streams/ IP-Km (>80 stream average)	External Research	<50% of streams/ IP-km (>80 stream average)	Poor
			Hydrology	Passage Flows	NMFS Flow Protocol: Risk Factor Score >75	NMFS Flow Protocol: Risk Factor Score 51-75	**NMFS Flow Protocol: Risk Factor Score 35-50**	NMFS Flow Protocol: Risk Factor Score <35	Expert Knowledge	NMFS Flow Protocol: Risk Factor Score 35-50	Good
			Passage/Migration	Passage at Mouth or Confluence	<50% of IP-Km or <16 IP-Km accessible*	50% of IP-Km to 74% of IP-km	75% of IP-Km to 90% of IP-km	**>90% of IP-km**	Rough Guess	>90% of IP-km	Very Good
			Passage/Migration	Physical Barriers	<50% of IP-Km or <16 IP-Km accessible*	50% of IP-Km to 74% of IP-km	75% of IP-Km to 90% of IP-km	**>90% of IP-km**	Expert Knowledge	100% of IP-km	Very Good
			Riparian Vegetation	Tree Diameter (North of SF Bay)	**≤39% Class 5 & 6 across IP-km**	40 - 54% Class 5 & 6 across IP-km	55 - 69% Class 5 & 6 across IP-km	>69% Class 5 & 6 across IP-km	External Research	35.05% Class 5 & 6 across IP-km	Poor
			Riparian Vegetation	Tree Diameter (South of SF Bay)	≤69% Density rating "D" across IP-km	70-79% Density rating "D" across IP-km	≥80% Density rating "D" across IP-km	Not Defined	External Research	N/A	
			Sediment	Quantity & Distribution of Spawning Gravels	**<50% of IP-Km or <16 IP-Km accessible***	50% of IP-Km to 74% of IP-km	75% of IP-Km to 90% of IP-km	>90% of IP-km	Expert Knowledge	<50% of IP-km or <16 IP-km accessible*	Poor
			Velocity Refuge	Floodplain Connectivity	<50% Response Reach Connectivity	**50-80% Response Reach Connectivity**	>80% Response Reach Connectivity	Not Defined	Expert Knowledge	50-80% Response Reach Connectivity	Fair

Table 7: NC and CCC steelhead rapid assessment example of a completed Viability Table, rating the condition of each attribute in the Diversity Stratum. Twelve attributes were rated for CCC and NC steelhead.

NC Steelhead DPS: Central Coastal Diversity Stratum (Brush/Elk/Schooner Gulch)

TABLE 1

Habitat & Population Condition Scores By Life Stage:
0 = Very Good
1 = Good
2 = Fair
3 = Poor

Key Attribute: Indicators	Steelhead Life History Stages: Adults	Eggs	Summer-Rearing Juveniles	Winter-Rearing Juveniles	Smolts
Riparian Vegetation: Composition, Cover & Tree Diameter			G		
Estuary: Quality & Extent	G		F	G	F
Velocity Refuge: Floodplain Connectivity	G			G	G
Hydrology: Redd Scour		G			
Hyrology: Baseflow & Passage Flows	G	G	F		F
Passage/Migration: Mouth or Confluence & Physical Barriers	G		G	G	G
Habitat Complexity: Percent Primary Pools & Pool/Riffle/Flatwater Ratios	F		F	F	
Habitat Complexity: Large Wood & Shelter	F		P	P	F
Sediment: Gravel Quality & Distribution of Spawning Gravels	F	F	F	F	
Viability: Density, Abudance & Spatial Structure	F		F		F
Water Quality: Temperature			G		G
Water Quality: Turbidity & Toxicity	F		G	F	F

Table 8: CC Chinook salmon rapid assessment example of a completed Viability Table, rating the condition of each attribute in the Diversity Stratum. Ten attributes were rated for CC Chinook salmon.

CC Chinook Salmon ESU: Central Coastal Diversity Stratum (Navarro/Gualala)					
TABLE 1 Habitat & Population Condition Scores By Life Stage: 0 = Very Good 1 = Good 2 = Fair 3 = Poor		Chinook Salmon Life History Stages			
		Adults	Eggs	Pre-Smolt	Smolts
Key Attribute: Indicators	Estuary: Quality & Extent	F		G	G
	Velocity Refuge: Floodplain Connectivity	VG		G	G
	Hydrology: Redd Scour		F		
	Hyrology: Baseflow & Passage Flows	G	G	G	G
	Passage/Migration: Mouth or Confluence & Physical Barriers	VG		VG	VG
	Habitat Complexity: Percent Primary/Staging Pools & Pool/Riffle/Flatwater Ratios	F		F	F
	Habitat Complexity: Large Wood & Shelter	F		F	F
	Sediment: Gravel Quality & Distribution of Spawning Gravels	G	F	G	G
	Viability: Density, Abudance & Spatial Structure	P		P	P
	Water Quality: Turbidity & Toxicity	G		G	G

4.2.4 FUTURE STRESSES AND SOURCES OF STRESS (THREATS)

The CAP threats analysis is a two-step process: evaluating current conditions likely to persist into the future (*i.e.*, stresses) and the cause, or source, of the current and future stress (*i.e.*, threats). Conducting an assessment of threats is required since threats associated with the five section 4(a)(1) listing factors are identified at listing as the cause of the species decline. The Interim Recovery Planning Guidance (NMFS 2010) recommends threats be assessed and tracked, and their scope, severity, and magnitude be evaluated.

Assessing Future Conditions: Stresses

Stresses represent altered or impaired key attributes. For example, the stress of the attribute 'passage' is 'impaired passage'. For each population and life stage, stresses were rated using two metrics "*Severity of Damage*" and "*Scope of Damage*". The scores for each are combined by the CAP to generate a single rating for each stress and life stage.

Severity of damage is the severity of the stress to the life stage that can be reasonably expected to occur over the next 10 years[19] under current circumstances.

- Very High severity scores suggest the stress will destroy or eliminate the life stage and habitats are highly impaired.
- High scores suggest high mortality and moderately impaired habitat.
- Medium scores suggest moderately degraded habitats and moderate survival of individuals at each life stage.
- Low scores suggest functional habitats and high survival.

Scope of damage is the geographic scope of the stress to the life stage that can be reasonably expected to occur over the next 10 years[20] under current circumstances.

- Very High scores indicate the stress is likely to be pervasive or widespread in its scope and will impact all aspects of the life stage.
- High scope scores indicate the stress is likely widespread but may not impact all aspects of the life stage.
- Medium scores indicate the stress is localized in scope and may impact a few aspects of the life stage.
- Low scores indicate the stress is very localized and is not likely impacting the life stage.

Sixteen stresses were identified for the CAP analyses and rapid assessments (Table 9). These were evaluated for life stages and then compared against a suite of threats. Not every indicator had an identified stress; some were grouped for the stress analysis.

[19] 10 year time period is part of the standard CAP methodology and protocol

[20] 10 year time period is part of the standard CAP methodology and protocol

Table 9: Linkages between key attributes used in the viability analysis and their altered or impaired state, identified as stresses.

Key Attribute	Stress
Estuary/Lagoon	Estuary: Impaired Quality & Extent
Habitat Complexity	Instream Habitat Complexity: Altered Pool Complexity and/or Pool/Riffle Ratios Instream Habitat Complexity: Reduced Large Wood and/or Shelter
Hydrology	Hydrology: Gravel Scouring Events Hydrology: Impaired Water Flow Impaired Watershed Hydrology
Landscape Patterns	Landscape Disturbance
Passage/Migration	Impaired Passage & Migration
Riparian Vegetation	Altered Riparian Species Composition & Structure
Sediment	Altered Sediment Transport: Road Condition & Density Instream Substrate/Food Productivity: Impaired Gravel Quality & Quantity
Smoltification	Water Quality: Impaired Instream Temperature
Velocity Refuge	Floodplain Connectivity: Impaired Quality & Extent
Viability	Reduced Density, Abundance & Diversity
Water Quality	Water Quality: Impaired Instream Temperatures Water Quality: Increased Turbidity or Toxicity

Stresses to the populations are compiled in summary tables to describe major stresses for each essential population by target life stage (Table 10). Stresses with a high level of severity and/or broad geographic scope are rated as High or Very High. For example, in Table 10, the stress of Hydrology – Impaired Water Flow - was rated as Very High for impacts to the summer and winter rearing life stages. This stress rated High for smolts because in low water years, flows are inadequate for out-migration, yet Medium for adults and eggs since flows during adult migration and egg development periods are typically adequate.

Table 10: Example of CAP stress table.

	Stress Matrix Central California Coast Steelhead ~ Pilarcitos Creek Population						
	Stresses (Altered Key Ecological Attributes) Across Targets	Adults	Eggs	Summer Rearing Juveniles	Winter Rearing Juveniles	Smolts	Watershed Processes
		1	2	3	4	5	6
1	Instream Habitat Complexity: Reduced Large Wood and/or Shelter	Very High		Very High	Very High	Very High	
2	Hydrology: Impaired Water Flow	Medium	Medium	Very High	Very High	Very High	
3	Reduced Density, Abundance & Diversity	Very High		High		Very High	
4	Estuary: Impaired Quality & Extent	Medium		Very High		Very High	
5	Instream Habitat Complexity: Altered Pool Complexity and/or Pool/Riffle Ratios	High		Very High	High		
6	Instream Substrate/Food Productivity: Impaired Gravel Quality & Quantity		High	High	Very High		
7	Floodplain Connectivity: Impaired Quality & Extent	Medium			Very High	High	
8	Impaired Passage & Migration	Medium		Medium	Low	Very High	
9	Water Quality: Increased Turbidity or Toxocity	High		Medium	High	High	
10	Altered Riparian Species Composition & Structure						High
11	Hydrology: Gravel Scouring Events		High				
12	Water Quality: Impaired Instream Temperatures			Medium		Low	
13	Altered Sediment Transport: Road Condition/Density, Dams, etc.						Medium
14	Impaired Watershed Hydrology						Medium
15	Landscape Disturbance						Medium

For the supporting population in the rapid assessments, a subset of these stresses was identified and evaluated (Table 11). The assessment was conducted at a Diversity Stratum level and was used to consider the specificity associated with each population. Stresses were distinct between steelhead and CC Chinook salmon due to different life history strategies. As with the CAP, these were evaluated for specific conservation targets (life stages) and then compared against a suite of threats.

Table 11: Example of a rapid assessment stress/threat table for NC steelhead.

NC Steelhead DPS: Central Coastal Diversity Stratum (Brush/Elk/Schooner Gulch)												
Habitat/Population/Life History Score from Table 1 →	G	F	G	G	F	G	F	P	F	F	G	F
	Stresses											
Stress-Threat Scores 0 = Very Good 1 = Good 2 = Fair 3 = Poor	Altered Riparian Species: Composition & Structure	Estuary: Impaired Quality & Extent	Floodplain Connectivity: Impaired Quality & Extent	Hydrology: Gravel Scouring Events	Hydrology: Impaired Water Flow	Impaired Passage & Migration	Instream Habitat Complexity: Altered Pool Complexity and/or Pool/Riffle Ratio	Instream Habitat Complexity: Reduced Large Wood and/or Shelter	Instream Substrate/Food Productivity: Impaired Gravel Quality & Quantity	Reduced Density, Abundance & Diversity	Water Quality: Impaired Instream Temperatures	Water Quality: Increased Turbidity or Toxicity
Threats - Sources of Stress												
Agriculture	G	G	G	G		VG	G	G	F		G	G
Channel Modification	G	G	G	G	G	G	G	G	G		G	G
Disease, Predation, and Competition	G	G	G			G	G	G		G	G	G
Fire, Fuel Management, and Fire Suppression	G	G	VG	G		G	G	F	F		G	F
Livestock Farming and Ranching	G	VG	G	VG		VG	G	VG	G		G	G
Logging and Wood Harvesting	F	G	G	F		VG	F	F	F		F	F
Mining	VG	VG	VG	VG		VG	VG	VG	VG		VG	VG
Recreational Areas and Activities	G	G	G	G		G	G	G	G		G	G
Residential and Commercial Development	G	G	G	G		VG	G	G	G		G	G
Roads and Railroads	F	G	F	F		G	G	G	F		G	F
Severe Weather Patterns	G	G	G	G	F	G	G	G	F		F	F
Water Diversions and Impoundments	G	P	G	VG	F	F	F	G	F	F		
Fishing and Collecting										P		
Hatcheries and Aquaculture										VG	VG	VG

Assessing Future Conditions: Sources of Stress (Threats)

CAP defines threats as the proximate cause of the stress. Many threats are driven by human activities; however, naturally occurring events, such as earthquakes, may also threaten salmonids and their habitats. For each population's life stages, threats were rated using two metrics "*Contribution*" and "*Irreversibility*". The scores for each are combined by the CAP to generate a single rating for each threat at a particular life stage.

1. Contribution is the expected contribution of the threat, acting alone, on the stress under current circumstances (*i.e.*, given the continuation of the existing management). Threats rated as Very High for contribution are very large contributors to the particular stress and

Low ratings are applied to threats that contribute little to the particular stress. Contribution is rated from Very High to Low according to the following criteria:

- Very High: The threat is a significant contributor acting on the stress;
- High: The threat is a predominant contributor acting on the stress;
- Medium: The threat is a moderate contributor acting on the stress;
- Low: The threat is a low contributor acting on the stress.

2. Irreversibility is defined as the degree to which the effects of a threat can be reversed. Irreversibility is rated from Very High to Low according to the following criteria:
    - Very High: Generally not reversible;
    - High: Moderately reversible with a significant commitment of resources;
    - Medium: Reversible with a reasonable commitment of resources;
    - Low: Easily reversible and at a low cost.

Threats with a high level of contribution to a stress and/or high irreversibility were rated as High or Very High. The list of threats is based on their known impact to salmonid habitat, species viability, and the likelihood that the threat would continue into the future (Table 12). For example, in Table 12 the threat of residential and commercial development was rated as Very High for summer juveniles and High for adults, winter rearing and smolts due to poor water quality and impaired riparian conditions in San Lorenzo River. Threats rated as High or Very High are more likely to contribute to a stress that, in turn, reduces the viability of a target life stage. When multiple life stages of a population have High or Very High threats, the viability of the population is diminished.

Table 12: Example of a summary threat table.

Summary of Threats Central California Coast Steelhead ~ San Lorenzo River								
	Threats Across Targets	Adults	Eggs	Summer Rearing Juveniles	Winter Rearing Juveniles	Smolts	Watershed Processes	Overall Threat Rank
	Project-specific threats	1	2	3	4	5	6	
1	Roads and Railroads	High	High	Very High	Very High	High	Very High	Very High
2	Severe Weather Patterns	Medium	High	Very High	High	High	Very High	Very High
3	Water Diversion and Impoundments	Medium	Medium	Very High	Medium	High	Very High	Very High
4	Residential and Commercial Development	High	Medium	Very High	High	High	High	Very High
5	Channel Modification	Medium	Medium	Very High	High	High	Medium	High
6	Recreational Areas and Activities	Medium	Low	Very High	Medium	High	Medium	High
7	Fire, Fuel Management and Fire Suppression	Medium	Medium	High	High	Medium	Medium	High
8	Logging and Wood Harvesting	Medium	Medium	Medium	High	Medium	Medium	High
9	Disease, Predation and Competition	Medium	Low	Medium	Medium	High	Medium	Medium
10	Agriculture	Medium	Medium	Medium	Medium	Low	Medium	Medium
11	Mining	Medium	Medium	Medium	Medium	Low	Medium	Medium
12	Livestock Farming and Ranching	Low	Low	Medium	Medium	Low	Medium	Medium
13	Fishing and Collecting	Medium	-	Low	-	Medium	-	Medium
14	Hatcheries and Aquaculture	Low	-	Low	Low	Medium	-	Low
	Threat Status for Targets and Project	High	High	Very High	Very High	Very High	Very High	Very High

To reduce overestimating impacts of a stress across multiple threats, NMFS developed a matrix illustrating which threats contribute to a particular stress (Table 13). This ensured a direct linkage between the threat and a particular stress. For example, the threat of fishing and collecting was only rated against the population stress of reduced abundance, diversity, and competition. This approach reduced the potential for over estimating the effect of a stress across multiple threats. Finally, the matrix facilitated the development of recovery actions with direct relationships to stresses or threats.

Table 13: Protocol Matrix of Stresses Compared Against Threats

Stresses	Habitat Condition											Watershed Processes			Population
Threats	Estuary: Impaired Quality & Extent	Floodplain Connectivity: Impaired Quality & Exent	Hydrology: Gravel Scouring Events	Hydrology: Impaired Water Flow	Instream Habitat Complexity: Altered Pool	Instream Habitat Complexity: Reduced Large Wood	Instream Substrate/ Food Productivity: Impaired	Impaired Passage & Migration	Water Quality: Increased Turbidity or Toxicity	Water Quality: Impaired Instream Temperatures	Altered Riparian Species Composition & Structure	Impaired Watershed Hydrology	Landscape Distrubance	Altered Sediment Transport: Road Construction	Reduced Density, Abudance & Diversity
Agriculture				N/A											N/A
Channel Modification															N/A
Disease/Predation/ Competition(Invasive Animals and Plants)			N/A	N/A			N/A								
Fire				N/A											N/A
Fishing/Collecting	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Hatcheries	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A			N/A	N/A	N/A	N/A	
Livestock				N/A											N/A
Logging				N/A											N/A
Mining				N/A											N/A
Recreation				N/A											N/A
Residential Development				N/A											N/A
Roads				N/A											N/A
Severe Weather Patterns															N/A
Water Diversion and Impoundments															

4.2.5 Methods to Establish Threats Based Criteria

Threats based recovery criteria are for the ESA Section 4(a)(1) listing factors. The primary method to establish the threats based recovery criteria is to utilize the CAP analyses to reassess habitat attribute and threat conditions in the future, and (2) track the implementation of identified recovery actions unless otherwise found unnecessary. See Chapter 5 for more information.

4.3 CLIMATE CHANGE VULNERABILITY ANALYSIS

Modeling of climate change impacts in California suggest average summer air temperatures are expected to increase (Lindley *et al.* 2007). Heat waves are expected to occur more often, and heat wave temperatures are likely to be higher (Hayhoe *et al.* 2004). Total precipitation in California may decline; the frequency of critically dry years may increase (Lindley *et al.* 2007; Schneider 2007). Wildfires are expected to increase in frequency and magnitude, by as much as 55 percent under the medium emissions scenarios modeled (Luers *et al.* 2006). Vegetative cover may also change, with decreases in evergreen conifer forest and increases in grasslands and mixed evergreen forests. Impacts on forest productivity are less clear. Tree growth may increase under higher CO_2 emissions, but as temperatures increase, the risk of fires and pathogens also increases (CEPA 2006). NMFS anticipates these changes will affect freshwater streams in California used by CC Chinook salmon and NC and CCC steelhead (Appendix B).

Scientists studying the impacts of climate change on the marine environment predict the coastal waters, estuaries, and lagoons of the West Coast of the United States will experience continued 1) increases in climate variability, 2) changes in the timing and strength of the spring transition (onset of upwelling), 3) warming, and stratification, and changes in ocean circulation, and 4) changes in ocean chemistry (Scavia *et al.* 2002; Diffenbaugh *et al.* 2003; Feely *et al.* 2004; Harley *et al.* 2006; Osgood 2008). Estuaries and lagoons will also likely undergo changes in environmental conditions due to sea level rise (Scavia *et al.* 2002).

We conducted a vulnerability analysis (Appendix B) for climate change impacts based on the CAP workbook results for CC Chinook salmon, NC Steelhead, and CCC steelhead. Our approach evaluated the vulnerability of each essential population or focus area for each species relative to the other populations of that species in the NCCC Domain. Vulnerability was evaluated by: 1) using the available information on climate change to select ecological attributes, indicators and threats from the CAP process most likely affected by climate change, 2) examining how these indicators, attributes, and threats may be affected by climate change using climate change emissions scenarios, 3) weighting the results of CAP threat and current condition vulnerability assessments for those ecological attributes, indicators and threats identified for each essential population, 4) summing the weights for each essential population, and 5) using the sums to rank the essential populations relative to each other for each species. Our approach will need to be improved upon as more information becomes available. For example, we did not attempt to assess whether or not specific populations of each species would be more or less vulnerable to climate change impacts in the marine environment due to more limited information and higher uncertainties.

4.4 INFORMATION SOURCES

The data that informed our analyses came from a wide variety of sources. Sources included the California Department of Fish and Wildlife (CDFW), Statement of Understanding Partners (see below), the State Water Resources Control Board (SWRCB), the U.S. Environmental Protection Agency (USEPA), Resource Conservation Districts (RCDs), private timber companies, conservation organizations, consultants, local watershed groups and other contributors. In particular, CDFW provided extensive habitat typing data for most of the essential populations. Some data required additional evaluation, analysis and synthesis. To provide focused support for data acquisition, NMFS contracted with the Sonoma Ecology Center (SEC) to search for, compile, manage, and apply the disparate data necessary to inform many of the indicators and ratings. Major data sources and the methods used to analyze and apply the data for the analyses are detailed in Appendix D and discussed in more detail below. These sources and methods are briefly summarized into the following categories:

1. CDFW Stream Survey Data (Hab-8 Data): NMFS secured all available CDFW habitat typing data for the NCCC Domain. These datasets were standardized into an Access database under funds provided by Sonoma County Water Agency (SCWA). This "*Stream Summary Application*" (Appendix E) was developed by University of California Hopland Research & Extension Center (UC Hopland) and CDFW. UC Hopland completed the following: (1) entering field data from datasheets and importing databases from individual surveys into the stream habitat application; (2) performing quality control and assurance on spatial datasets; (3) creating spatial representations of stream surveys; and (4) using the *Stream Summary Application* to summarize the data for use by NMFS, CDFW, SCWA, stakeholders and the general public. This database summarizes reach level data of all CDFW surveys across all habitat parameters collected under the CDFW Habitat Typing protocols. These CDFW habitat assessments were never intended to be used for monitoring and represent conditions observed at the time of the survey. Despite these limitations and the lack of robust habitat monitoring data, these habitat-typing surveys represent the best available information at the time of recovery plan development. Seven indicators were informed by the CDFW stream habitat-typing dataset (pool/riffle/flatwater ratio, canopy cover, large woody debris, shelter rating, embeddedness, embeddedness (food productivity), and percent primary and staging pools). This data is stored in the *Stream Summary Application* database and has been uploaded to the California Salmon Snapshot hosted by The Nature Conservancy at http://www.casalmon.org/salmon-snapshots.
2. NMFS contracted with the Sonoma Ecology Center (SEC) to manage data acquisition (from CDFW and other sources); spatially reference data, conduct bias analyses and quality control, as well as develop necessary queries to match data to the essential populations and associated indicators. SEC supported assessments of passage issues using the California Department of Fish and Wildlife Passage Assessment Database and

used the National Landcover Database[21] to calculate the percent of impervious surface and percent of land in agricultural use.

3. Stream flow: Lack of sufficient gage data in rearing and migration habitats led NMFS to derive ratings for stream flow indicators from a structured decision making model informed by a panel of experts familiar with watershed conditions. Four indicators (Baseflow, Instantaneous Condition, Passage Flows, and Redd Scour) were developed with this method. The indicator for number of diversions was calculated using SWRCB data sets.
4. Instream Temperature Data: Three indicators (Temperature (MWMT), Smoltification, and Mainstem Temperature (MWMT)) were used to inform this habitat attribute, but it required extensive compilation of disparate datasets. Temperature data was grouped into condition classes when multiple location information was available and extrapolated to inform a watershed-wide rating. Final ratings were made by estimating the proportion of a watershed's IP network that fell within each temperature class.
5. Water quality (Turbidity and Toxicity): The indicator for turbidity was difficult to quantify, so ratings were informed by an assessment of the erosion potential developed by the California Department of Conservation, Division of Mines and Geology (NMFS GIS 2008), literature review and expert opinion. A structured decision making model was used to rate toxicity.
6. Estuary conditions: Multiple indicators for open estuaries and closed lagoons were used in a structured protocol informed by a panel of NMFS staff familiar with individual estuaries to provide an overall rating of quality and extent. Factors assessed in the protocol included historical extent, current configuration, and alteration of physical extent, as well as other physical, chemical and biological parameters to describe conditions for rearing and smolt life stages.

[21] http://www.mrlc.gov/nlcd2001.php

7. Watershed Processes or Landscape Patterns: Six indicators (agriculture, timber harvest, urbanization, road density, streamside road density, and riparian species composition) were informed by GIS queries of available spatial datasets (NMFS GIS 2008).
8. Population viability: Three viability indicators (abundance, density, and spatial structure) were informed by review and synthesis of readily available fisheries monitoring data in the ESU/DPS.
9. NMFS developed a Statement of Understanding (SOU) with local public agencies (Agency or Agencies) within the CCC steelhead DPS. All parties agreed that a collaborative dialog on CCC steelhead recovery planning would be mutually beneficial. These benefits included a common vision of developing plans that (1) are based on best available data and information, (2) provide focused recovery strategies which recognize, to the maximum extent possible, opportunities and constraints and (3) allow for adaptation of strategic actions when projects are implemented or new information is provided. Additional goals and benefits include development of good working relationships and improved communications between NMFS and Agency staff, and Agency understanding of forthcoming recommendations which is expected to reduce public comments. Also, alignment of recovery actions, to the maximum extent possible, with Agency projects that address the limiting factors for the species can make Agency projects more competitive for grants. The Agencies provided NMFS with extensive data on the populations within their area.
10. Other indicators: The remaining indicators (physical barriers, passage at mouth/confluence, riparian canopy cover and tree diameter, and floodplain connectivity) were informed by various methods ranging from queries of existing databases to best professional judgment. For example, physical barriers were assessed using the California Department of Fish and Wildlife Passage Assessment Database[22]. The indicator for passage at mouth or confluence was assessed by NMFS staff with local knowledge of the watershed conditions.

[22] http://nrm.dfg.ca.gov/PAD/Default.aspx

NMFS' Geographical Information System (GIS) unit provided extensive information and analysis, particularly for land use attributes. For each essential and supporting population, a report was developed with information on factors such as acreage and percentage of urbanization, land ownership, land cover, current and projected development, road densities, erosion potential, amount of farmland, timber harvesting history, location and types of barriers, diversions, and industrial influences (mines, discharge sites, toxic release sites) and stream temperature. These reports are called watershed characterizations. Other resources used to evaluate conditions and threats were watershed assessment documents, government planning documents, personal communications, staff expertise, spatial data (*e.g.* GIS and Google Earth), and CDFW habitat inventories. The sources are provided for each population in both the CAP workbooks and the profiles.

4.5 METHODS TO DEVELOP RECOVERY ACTIONS

Section 4(f)(1)(B)(i) of the ESA requires each recovery plan include to the maximum extent practicable, "a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species." The Interim Recovery Planning Guidance (NMFS 2010) states, "Recovery actions must include specific actions to control each of the identified threats to the species, as categorized under the five-listing factors of the ESA."

Recovery actions for CCC and NC steelhead and CC Chinook salmon are designed to meet ESA requirements. They are site-specific (*e.g.*, action steps), organized by the ESA section 4(a)(1) listing factors and link directly to the CAP and Rapid Assessment analysis and result tables. Recovery actions were developed to improve a Poor or Fair condition and abate/reduce a High or Very High threat and, in general, were not developed for Very Good/Good conditions or Low threats. Using individual and aggregate result tables, actions were created for life stages, populations, and the overall ESU or DPS. If actions were broad in scope (*e.g.*, work with State Water Resources Control Board), they were incorporated into the ESU/DPS level actions. There are two types of actions (*i.e.*, actions to improve conditions and actions to abate threats) and three levels of hierarchy (*i.e.*, objectives, recovery actions and action steps). Since the underlying purpose of implementing recovery actions is to address threats specifically associated with the five listing factors, we have assigned all actions to one of the five factors through the Objective. Organizing actions and action steps to a specific listing factor allows improved and more direct tracking of the listing factors over time. The recovery action is the condition found poor or threat found high or very high we intend to improve via the action steps. Action steps are the lowest level and most site-specific restoration or threat abatement action needed and are written to address a specific recovery action. Action steps include additional required information such as cost, priority, *etc.* Figure 19 provides the example hierarchy of the recovery actions and illustrates the relationship of actions and action steps to listing factors.

CENTRAL CA COAST STEELHEAD ~ San Lorenzo Population

ACTIONS FOR RESTORING HABITATS

1. Restoration- Estuary

1.1. **Objective:** Address the present or threatened destruction, modification or curtailment of the species habitat or range

1.1.1. **Recovery Action:** Increase the quality and extent of estuarine habitat

1.1.1.1. **Action Step:** Restore estuarine habitat and the associated wetlands and sloughs by providing fully functioning habitat (CDFG 2004).

1.1.1.2. **Action Step:** Remove structures impairing or reducing the historical feeding and salt water transition habitat where feasible and benefits to rearing steelhead and/or the estuarine environment are predicted. Evaluate benefits to lagoon tidal prism from modification and/or reduction in the size of the San Lorenzo Park in the City of Santa Cruz.

Figure 19: Objective, Recovery Action and Action Step Example for San Lorenzo.

NMFS capitalized on a full range of resources to develop and prioritize recovery actions which included public comments, watershed assessment reports, online resources, Total Maximum Daily Loads, Environmental Impact Report documents, plans from counties, coordination with other divisions of NOAA, outreach to watershed knowledgeable individuals, staff expertise, and many other sources. The California Recovery Strategy for California Coho Salmon (CDFG 2004) was used where appropriate for CCC and NC steelhead and CC Chinook salmon for , ESU/DPS, level actions, as well as watershed specific strategies.

4.5.1 IMPLEMENTATION SCHEDULES

Volumes II, III and IV contain implementation schedules (tables) of all recovery actions specific to each essential and supporting population and each ESU or DPS. An example implementation schedule is provided in Table 14. The schedule provides a unique action identification number, the targeted attributes or threats, action descriptions, priority level, duration recovery partners and a comment section. Every recovery action step has an estimated cost to complete that action. The cost estimates are found in Appendix F and organized by a population's unique identification number. Each column heading is described below.

ACTION ID

A unique recovery number is assigned to each objective, action and action step, and the numbers are hierarchical. The first series of digits correspond to the specific population, the second series to the ESU or DPS, and the third series the recovery action number (Table 15). The recovery action number corresponds to the targeted attribute or threat (Table 16). For example, the recovery action number PinC-CCCS-1.1 corresponds to an action for the Pinole Creek population in the CCC steelhead DPS and is an objective for Estuary (Table 17). In general, no recovery actions were developed for attributes rating Very Good/Good or threats rating Low. Thus, the numbering of the implementation schedule will likely not be sequential (*e.g.*, 3.1, 4.1, and 8.1).

Table 14: Example Implementation Schedule (Gualala River CC Chinook Salmon Population)

Gualala River Chinook Salmon (Central Coastal) Recovery Actions

Action ID	Level	Targeted Attribute or	Action Description	Priority Number	Action Duration	Recovery Partner	Comment
GuR-CCCh-1.1	**Objective**	**Estuary**	**Address the present or threatened destruction, modification, or curtailment of the species habitat or range**				
GuR-CCCh-1.1.1	Recovery Action	Estuary	Increase the physical extent of estuarine habitat				
GuR-CCCh-1.1.1.1	Action Step	Estuary	Investigate the extent of sedimentation within the estuary/lagoon associated with watershed legacy impacts (logging). Evaluate sediment transport within the estuary and determine if the estuary is "filling" with sediment or "flushing" sediment (recovering).	3	10	CDFW, NMFS, NOAA RC, NRCS, RCD, RWQCB	
GuR-CCCh-1.1.1.2	Action Step	Estuary	Identify past mechanical fill sites (inside of Mill Bend) and develop strategies targeting the re-establishment of wetland marsh habitat (if feasible).	3	10	CDFW, NMFS, NOAA RC, NRCS, RCD	
GuR-CCCh-1.1.1.3	Action Step	Estuary	Develop and implement rehabilitation projects designed to increase the physical extent of high quality habitat for rearing juvenile salmonids within the Gualala River estuary.	3	10	CDFW, Gualala Watershed Council, NMFS, NOAA RC, NRCS, Private Landowners	
GuR-CCCh-1.1.1.4	Action Step	Estuary	Investigate the historical functions and ecology of the estuary	3	10	CDFW, Gualala Watershed Council	
GuR-CCCh-1.1.2	Recovery Action	Estuary	Increase and enhance estuarine habitat complexity features				
GuR-CCCh-1.1.2.1	Action Step	Estuary	Increase the percentage of area containing high value habitat complexity elements and features (SAV, LWD, boulders, marshes, vegetation, pools > 2 meters).	2	10	CDFW, Gualala Watershed Council, NMFS, NOAA RC, NRCS, Private Landowners	
GuR-CCCh-1.1.2.2	Action Step	Estuary	Identify strategic locations to install LWD structures designed to increased pool depth and habitat conditions within the Gualala River estuary.	2	10	CDFW, Gualala Watershed Council, NMFS, NOAA RC, NRCS, Private Landowners	
GuR-CCCh-1.1.3	Recovery Action	Estuary	Improve the quality of freshwater lagoon habitat				
GuR-CCCh-1.1.3.1	Action Step	Estuary	Install continuous water quality monitoring stations in the Gualala estuary during the summer months. Monitor at a minimum temperature, dissolved oxygen, and salinity.	2	5	CDFW, Gualala Watershed Council, NMFS, NOAA RC, North Gualala Water Company, NRCS, Private Landowners, RCD, RWQCB	
GuR-CCCh-1.1.4	Recovery Action	Estuary	Improve freshwater inflow				
GuR-CCCh-1.1.4.1	Action Step	Estuary	Install a stream gauge immediately upstream of the estuary/lagoon to monitor inflow conditions during the dry season.	2	5	CDFW, Gualala Watershed Council, NMFS, NOAA RC, North Gualala Water Company, NRCS, Private Landowners, Public, RWQCB	
GuR-CCCh-1.1.4.2	Action Step	Estuary	Investigate the hydrodynamics of freshwater inflow and estuary water quality conditions relative to juvenile salmonid estuarine summer rearing (osmo-regulating and non-osmoregulating).	2	10	CDFW, Friends of the Gualala River Watershed, Gualala Watershed Council, NMFS, NOAA RC, North Gualala Water Company, NRCS, Private Landowners, RCD, RWQCB, SWRCB	
GuR-CCCh-1.1.4.3	Action Step	Estuary	Identify and implement minimum freshwater inflow thresholds to ensure optimal estuary health and function.	2	5	CDFW, Gualala Watershed Council, NMFS, NOAA RC, North Gualala Water Company, NRCS, RWQCB, SWRCB	

Table 15: Recovery Strategy Number

Recovery Strategy Number Follows Example: **XXXX-A-1.2.3.4**	
XXXX:	Unique Identifier for Population Group
A:	Species Identifier
1:	Strategy Level
2:	Objective Level
3:	Recovery Action Level
4:	Action Step Level

Table 16: Strategy Categories and Unique Identifiers

Strategies	
1	Estuary
2	Floodplain Connectivity
3	Hydrology
4	Landscape Patterns
5	Passage
6	Habitat Complexity
7	Riparian
8	Sediment
9	Temperature
10	Water Quality
11	Viability
12	Agriculture
13	Channel Modification
14	Disease/Predation/Competition
15	Fire/Fuel Management
16	Fishing/Collecting
17	Hatcheries
18	Livestock
19	Logging
20	Mining
21	Recreation
22	Residential/Commercial Development
23	Roads/Railroads
24	Severe Weather Patterns
25	Water Diversion/Impoundment
26	Habitat Condition
27	Habitat Modification
28	Pollution
29	Shipping
30	Climate Change and Sea Level Rise
31	Dredging
32	Noise
33	Sand Mining

Table 17: Action ID example

Pinole Creek (Interior San Francisco Bay) Threats and Associated Recovery Actions			
Action ID	**Level**	**Targeted Attribute or Threat**	**Action Description**
PinC-CCCS-1.1	Objective	Estuary	Address the present or threatened destruction, modification, or curtailment of the species habitat or range
PinC-CCCS-1.1.1	Recovery Action	Estuary	Prevent impairment to the estuary (impaired quality and extent)
PinC-CCCS-1.1.1.1	Action Step	Estuary	Develop an estuary rehabilitation and enhancement plan in efforts to reclaim historically tidal influenced areas.
PinC-CCCS-1.1.1.2	Action Step	Estuary	Increase the inner estuary hydrodynamics that have been altered by levees, dikes, culverts, and tide gates.

LEVEL

Indicates the level of action which can be an Objective, Recovery Action or Action Step.

TARGETED ATTRIBUTE OR THREAT

Describes whether the action is intended to improve habitats, populations or watershed conditions or abate a future threat.

ACTION DESCRIPTION

The specific action needed to improve conditions or abate threats.

PRIORITY NUMBER

Priorities are assigned to each action step in the implementation table in accordance with NMFS' Interim Recovery Planning Guidance (NMFS 2010) and the NMFS Endangered and Threatened Species Listing and Recovery Priority Guidelines (55 FR 24296).

Priority 1: Actions that must be taken to prevent extinction or to prevent the species from declining irreversibly. These actions are generally focused on areas where steelhead and Chinook salmon persist and where actions are necessary to increase freshwater survival probabilities.

Priority 2: Actions that must be taken to prevent a significant decline in population abundance, habitat quality, or other significant negative impacts short of extinction. These actions focus primarily on efforts directed to restore and expand the current range of steelhead and Chinook salmon.

Priority 3: All other actions necessary to achieve full recovery of the species. These actions focus on preventing further degradation and reestablishing long-term recovery for expanding populations.

ACTION DURATION

These time estimates are important in estimating the overall cost of recovery and describe the estimated length of time for the action to be implemented.

RECOVERY PARTNERS

This information outlines the suite of partners capable of implementing each action step. Designation of a recovery partner in the implementation schedule does not require the identified party to implement the action(s) or to secure funding for implementation.

COMMENTS

In some instances comments are provided with the action to provide specificity regarding rationale, context, references, *etc.* to clarify the action.

4.5.2 COSTS

Cost estimates are mainly focused on the direct expenditure required to physically perform the task, and may not always include secondary costs associated with administrative needs. A more detailed explanation of costs is described below and in Appendix F.

We assigned costs to the lowest level actions (*e.g.* specific action steps). Our cost estimates are presented in five year intervals out to 25 years and include a total cost for the duration of the action. Costs are aggregated to estimate a total cost for recovery. Cost estimates are provided wherever practicable. The accuracy of recovery cost estimates will vary and are governed by many factors such as the specificity of the recovery action step, labor, materials, site location, duration, and timing of action. As a result, predicting costs into the future becomes increasingly imprecise due to a lack of information regarding these various constraints. Please see Appendix F for a complete methodology and the costs for every recovery action step. The table below is an example of the cost estimates for the Gualala River CC Chinook salmon population organized by action ID (Table 18). The action ID is the same unique identification code that is used in the implementation tables and can be cross walked.

Table 18: Gualala River CC Chinook salmon Recovery Action Cost Estimates.

Gualala River Chinook Salmon (Central Coastal) Recovery Actions Costs

Action ID	Costs ($K)						Cost Comment
	FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	Entire Duration	
GuR-CCCh-1.1.1.1	117.00	117.00				234	Cost based on sediment assessment estimated at $12/acre. Assume 10% of total watershed acres.
GuR-CCCh-1.1.1.2						0	Cost accounted for in other action steps. Feasibility of re-establishing wetland marsh habitat should be identified in estuary monitoring.
GuR-CCCh-1.1.1.3	680	680				1,360	Cost based on treating 5 acres (assume 5% of total estuarine habitat) at a rate of $272,000/acre.
GuR-CCCh-1.1.1.4	141.00	141.00				282	Cost based on estuary use/residence monitoring at a rate of $282,000/project.
GuR-CCCh-1.1.2.1	126					126	Cost based on stream complexity recovery action at $101,000/mile from estuary mouth to Highway 1 bridge (approximately 1.25 miles)
GuR-CCCh-1.1.2.2	103.5	103.5				207	Costs associated with installation of LWD would be encompassed by increasing the percentage of area high value habitat. Cost of assessment estimated at $207,000.
GuR-CCCh-1.1.3.1	15.00					15	Cost based on continuous monitoring gauges estimated at $5,000/unit. Assume a minimum of 3 for lagoon. Cost does not account for maintenance or data management.
GuR-CCCh-1.1.4.1	1.00					1	Cost based on stream gauges estimated at $1,000/gauge. Cost does not account for maintenance or data management.
GuR-CCCh-1.1.4.2	136.6	136.6				273	Cost based estuary use estimated at $273,000/project.
GuR-CCCh-1.1.4.3	63.00					63	Cost based on stream flow model estimated at $63,000/project.
GuR-CCCh-3.1.1.1						0	Action is considered In-Kind
GuR-CCCh-3.1.1.2	2	2	2	2	2	20	Costs may be minimal due to the low number of diverters in this basin. Cost of assessment estimated at $20,000.
GuR-CCCh-3.1.1.3						0	Problems should be identified through mapping diversion and developing stream flow model (other action steps). All other costs are in-kind
GuR-CCCh-3.1.1.4	0.50	0.50				1	Provide consistent funding for the North Fork Gualala River and possible funding for the Wheatfield Forks of the Gualala River. Cost of installing stream gage is $1000/unit. Cost does not account for maintenance or data management.

4.6 CONCLUSIONS

The Interim Recovery Planning Guidance (NMFS 2010) strongly recommends utilizing "a structured approach to assessing threats, sources of threats, and their relative importance to the species' status…" For this recovery plan, NMFS selected populations for recovery scenarios, assessed the status of conditions and threats, and developed site-specific recovery actions to shift the status of listing factors. Actions are linked with NMFS' threats/conditions analysis and organized according to the ESA Section 4(a)(1) listing factors. This approach will provide a foundation for future status reviews and evaluations regarding the threats identified at the time of listing.

5.0 LISTING, STATUS REVIEWS AND RECOVERY

ESA Section 2(a) states, "The Congress finds and declares that -- (1) various species of fish, wildlife, and plants in the United States have been rendered extinct as a consequence of economic growth and development untempered by adequate concern and conservation; (2) other species of fish, wildlife, and plants have been so depleted in numbers that they are in danger of or threatened with extinction; (3) these species of fish, wildlife, and plants are of esthetic, ecological, educational, historical, recreational, and scientific value to the Nation and its people; (4) the United States has pledged itself…to conserve to the extent practicable the various species of fish or wildlife and plants facing extinction, pursuant to [several international agreements]; and (5) encouraging the States and other interested parties…to develop and maintain conservation programs which meet national and international standards is a key to meeting the Nation's international commitments and to better safeguarding, for the benefit of all citizens, the Nation's heritage in fish, wildlife, and plants" (16 U.S.C. 1531(a)).

5.1 INTRODUCTION

When making determinations for a species' ESA listing status, NMFS must (1) evaluate species status, (2) analyze the five ESA section 4(a)(1) factors that may pose a threat to the species , and (3) assess the extent to which conservation measures and protective efforts mitigate threats, all without reference to economic impacts associated with the determination (50 CFR 424.11). The SWFSC evaluates species status, according to the biological viability criteria in Spence *et al.* (2008) and Spence *et al.* (2012), and provides updated summaries to NMFS regional offices. NMFS regional staff conduct an assessment of: (1) ESA section 4(a)(1) factors and associated threats pursuant to NMFS regulations, policies and guidance (Figure 20) (50 CFR 424; USFWS and NMFS 2006; USGAO 2006; NMFS 2010) and (2) the efficacy of conservation efforts according to the "Policy for Evaluation of Conservation Efforts When Making Listing Decisions" (PECE) (68 FR 15100). Status review determinations are conducted in accordance with the "5-Year Guidance: Procedures for Conducting 5-Year Reviews under the Endangered Species Act" (USFWS and NMFS 2006). We publish our findings for listing and delisting in FRNs and post 5-year status review findings on the NMFS WCR website[23].

[23] http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/salmon_and_steelhead.html

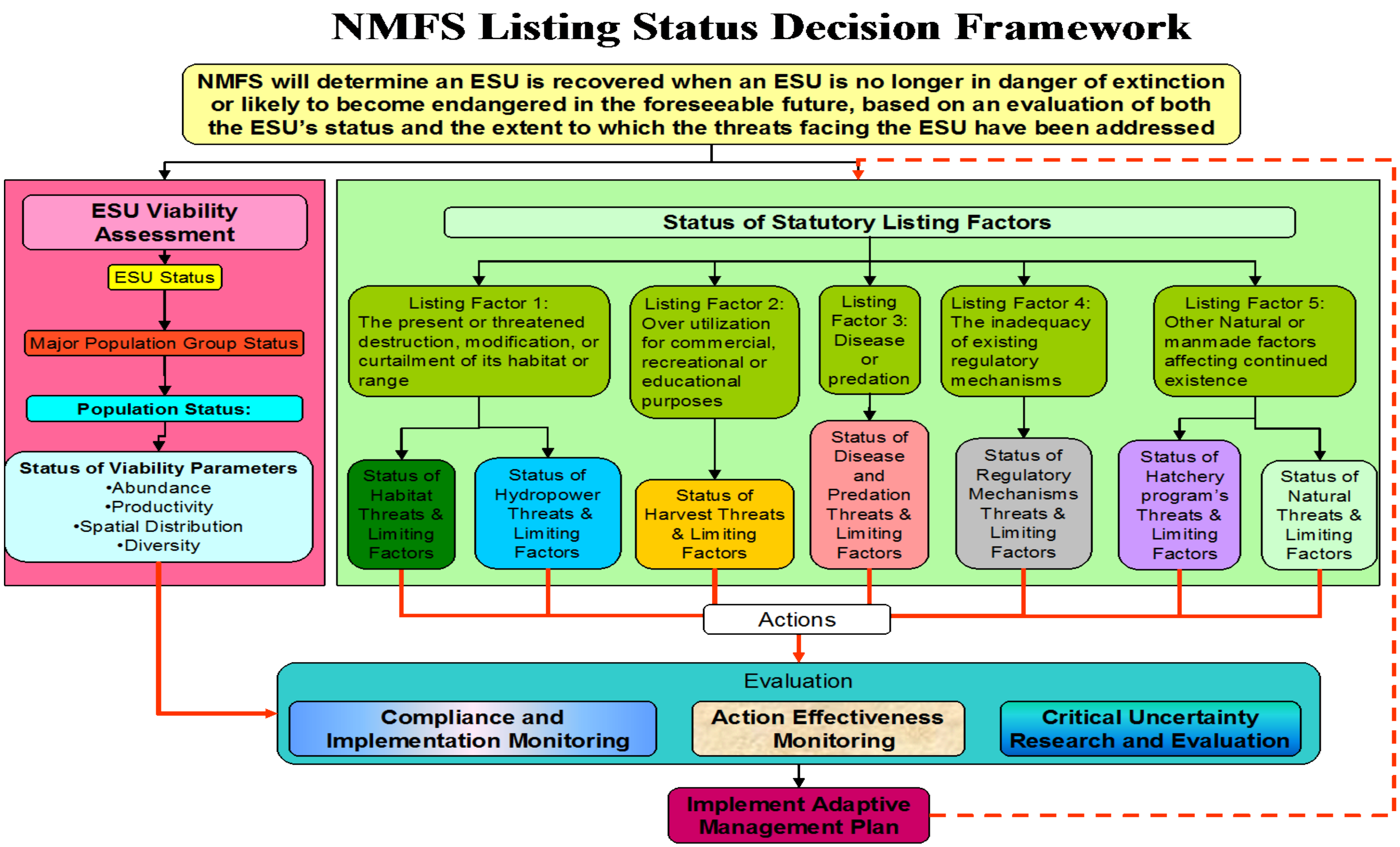

Figure 20: NMFS Listing Status Decision Framework

Recovery plan information provides continuity from listing and status reviews to delisting determinations and details the conditions needed for recovery (*i.e.*, recovery criteria). We intend to use eight categories of recovery criteria for conducting status reviews and making delisting decisions for CC Chinook salmon and NC and CCC steelhead: biological status; the level of threats identified under each of the five ESA section 4(a)(1) factors; the degree to which recovery actions for each factor have been implemented; and the efficacy of protective/conservation efforts.

This chapter describes the process we used to evaluate the section 4(a)(1) factors and conservation efforts and, generally, the results of our analyses for CC Chinook salmon and NC and CCC steelhead. It also specifies recovery goals, objectives and criteria that will guide our delisting determinations for the three salmonid species. The terms "recovery" and "delisting" refer to the same outcome, that is, the successful plan development and implementation which have led to the conservation and survival of these threatened species (ESA section 4(f)(1)).

5.2 FACTORS FOR DECLINE, EFFORTS AND STATUS REVIEWS

To ensure the recovery plan analysis and criteria are sufficiently correlated with the five ESA section 4(a)(1) factors and conservation efforts identified at listing, we examined all FRNs and status reviews for the CC Chinook salmon ESU and NC and CCC steelhead DPSs (Table 19). We catalogued into Excel spreadsheets all threats associated with each ESA section 4(a)(1) factor A through E, and associated conservation efforts, identified at the time of listing. The spreadsheets record FRN dates, page numbers, threats, and conservation efforts described in each FRN (either specifically or incorporated by reference) and their current status according to status review documents and other currently available information. The specific threats and conservation efforts associated with each ESU and DPS are included in Volumes II, III and IV of this recovery plan.

Table 19: Federal Register Notices reviewed to assess threats and protective efforts for CC Chinook salmon and NC and CCC steelhead

Date	Citation	Title	Content Description
August 9, 1996	61 FR 41541	Endangered and Threatened Species: Proposed Endangered Status for Five ESUs of Steelhead and Proposed Threatened Status for Five ESUs of Steelhead in Washington, Oregon, Idaho, and California	Proposed rule: proposed listing CCC steelhead as endangered and NC steelhead as threatened.
August 18, 1997	62 FR 43937	Endangered and Threatened Species: Listing of Several Evolutionary Significant Units (ESUs) of West Coast Steelhead	Final rule: listing CCC steelhead as threatened.
March 09, 1998	63 FR 11482	Endangered and Threatened Species: Proposed Endangered Status for Two Chinook Salmon ESUs and Proposed Threatened Status for Five Chinook Salmon ESUs; Proposed Redefinition, Threatened Status, and Revision of Critical Habitat for One Chinook Salmon ESU; Proposed Designation of Chinook Salmon Critical Habitat in California, Oregon, Washington, Idaho	Proposed rule: proposed listing Southern Oregon and California Coastal Chinook salmon as threatened.
March 19, 1998	63 FR 13347	Endangered and Threatened Species: Threatened Status for Two ESUs of Steelhead in Washington, Oregon, and California	Notice of Determination: NC steelhead listing not warranted.
March 24, 1999	64 FR 14308	Endangered and Threatened Species; Threatened Status for Three Chinook Salmon Evolutionarily Significant Units (ESUs) in Washington and Oregon, and Endangered Status for One Chinook Salmon ESU in Washington	6-month extension of final listing determination for Southern Oregon and California Coastal Chinook salmon.
September 16, 1999	64 FR 50394	Endangered and Threatened Species; Threatened Status for Two Chinook Salmon Evolutionarily Significant Units (ESUs) in California	Final Rule: listing CC Chinook salmon as threatened.
February 11, 2000	65 FR 6960	Endangered and Threatened Species: Threatened Status for One Evolutionarily Significant Unit of Steelhead in California	Proposed rule: proposed listing NC steelhead as threatened.
June 07, 2000	65 FR 36074	Endangered and Threatened Species: Threatened Status for One Steelhead Evolutionarily Significant Unit (ESU) in California	Final rule: listing NC steelhead as threatened.
June 14, 2004	69 FR 33102	Endangered and Threatened Species: Proposed Listing Determinations for 27 ESUs of West Coast Salmonids	Proposed rule: proposed reaffirming listing of CC Chinook salmon as threatened, CCC steelhead as threatened, and NC steelhead as threatened.
June 28, 2005	70 FR 37160	Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs	Final rule: reaffirmed listing of CC Chinook salmon as threatened.
January 05, 2006	71 FR 834	Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead; Final Rule	Final rule: listing CCC steelhead DPS as threatened and NC steelhead DPS as threatened.
2011	N/A	North-Central California Coast Recovery Domain 5-Year Review: Summary and Evaluation of California Coastal Chinook Salmon ESU and Central California Coast Coho Salmon ESU	Approved retaining CC Chinook salmon threatened status classification
2011	N/A	North-Central California Coast Recovery Domain 5-Year Review: Summary and Evaluation of Central California Coast Steelhead DPS and Northern California Steelhead DPS	Approved retaining CCC steelhead DPS and NC steelhead DPS threatened status classification

April 14, 2014	79 FR 20802	Endangered and Threatened Wildlife; Final Rule To Revise the Code of Federal Regulations for Species Under the Jurisdiction of the National Marine Fisheries Service	Final rule: clarified and updated descriptions of species under NMFS' jurisdiction and that are currently listed as endangered or threatened.
2016	81 FR 33468	2016 5-Year Review: Summary and Evaluation of California Coastal Chinook Salmon ESU and Northern California Steelhead DPS	Approved retaining CC Chinook salmon and NC steelhead threatened status classification
2016	81 FR 33468	2016 5-Year Review: Summary and Evaluation of Central California Coast Steelhead DPS	Approved retaining CCC steelhead threatened status classification

5.2.1 SECTION 4(A)(1) FACTORS

NMFS must consider the following five ESA section 4(a)(1) factors in determining whether to list, delist or reclassify any species as endangered or threatened (50 CFR 424.11):

(A) Present or threatened destruction, modification, or curtailment of its habitat or range;

(B) Overutilization for commercial, recreational, scientific, or educational purposes;

(C) Disease or predation;

(D) Inadequacy of existing regulatory mechanisms; and

(E) Other natural or manmade factors affecting its continued existence.

Therefore, this recovery plan addresses the threats that were considered in relation to these ESA section 4(a)(1) factors in the rules listing the CC Chinook salmon ESU and NC and CCC steelhead DPSs; and assesses whether there are any new threats, changes in severity of threats, and threats that have been reduced or removed since publication of the final rules listing the CC Chinook salmon ESU and NC and CCC steelhead DPSs. Table 20: Threats Identified At Listing for Each Section 4(a)(1) Factor provides an overview of threat categories identified at listing for CC Chinook salmon and NC and CCC steelhead as they relate to each of the five ESA section 4(a)(1) factors. These factors include the human activities and natural events that constitute threats to a species survival and long term recovery. While the term "threat" carries a negative connotation, it does not mean that activities identified as threats are always inherently undesirable. Often they are legitimate human activities with unintended negative consequences on fish and their habitats that could be offset with protective efforts or managed in a manner that minimizes or eliminates their negative impacts. In considering the inadequacy of existing regulatory mechanisms under

Factor D we evaluate regulatory mechanisms as if the ESA were not in place. “If improvements in status are solely dependent on regulatory effects of the ESA and those effects would disappear upon delisting, then threats under Factor D likely have not been reduced or eliminated” (USFWS and NMFS 2006). The greatest threats for all three salmonid species relate to habitat modification (*i.e.*, Listing Factor A), inadequacy of regulatory mechanisms (*i.e.*, Listing Factor D), and other natural or manmade factors such as low abundances and lack of monitoring (*i.e.*, Listing Factor E). Detailed descriptions of the specific threats associated with each ESU and DPS are found in Volumes II, III, and IV of this recovery plan.

Table 20: Threats Identified At Listing for Each Section 4(a)(1) Factor

Listing Factor A: Habitat & Range
Agriculture
Estuarine modification
Forestry
Freshwater Conditions
Habitat Degradation
Mining
Removal of Riparian Habitat
Removal of Wetland Habitat
Urbanization
Water Diversions
Wildfires
Listing Factor B: Overutilization
Collection
Freshwater Harvest
Illegal Harvest
Overfishing
Listing Factor C: Disease & Predation
Avian Freshwater Predation
Predation
Disease
Marine Mammal Predation
Marine Predation (other)
Piscivorous Predators
Predation by non-native species
Predation by seabirds
Listing Factor D: Inadequate Regulatory Mechanisms
Federal, State, local governments, municipalities and others

Listing Factor E: Other natural or manmade factors
Artificial Propagation
Ocean Conditions: El Nino
Ocean Conditions: Other
Floods – scour, sedimentation, erosion
Forest Fires
Natural Climatic Conditions
Natural Events
Drought
Ocean Conditions - El Nino

5.2.2 CONSERVATION EFFORTS AT LISTING

A summary of organization's conservation efforts assessed at listing are outlined below. A more detailed discussion of the organization's conservation efforts is provided in Volumes II, III and IV. In making listing determinations, ESA section 4(b)(1)(A) requires NMFS to "tak[e] into account those efforts, if any, being made by any State or foreign nation, or any political subdivision of a State or foreign nation, to protect such species…" In ESA section 4(a)(1), Factors (D) ("the inadequacy of existing regulatory mechanisms") and (E) (''other … manmade factors affecting [the species'] continued existence'') require us to consider the pertinent laws, regulations, programs, and other specific actions of any entity that either positively or negatively affect the species. Thus, the analysis outlined in section 4 of the Act requires us to consider the conservation efforts of not only State and foreign governments but also of Federal agencies, Tribal governments, businesses, organizations, or individuals that positively affect the species' status. Therefore, ESA section 4(a)(1) and 4(b)(1)(A) act together to ensure threats are identified and that protective efforts and conservation efforts taken to reduce those threats are also acknowledged. We used the PECE when assessing conservation efforts and whether they positively affect the species. The policy specifies the use of 15 evaluation criteria when assessing formalized conservation efforts: nine criteria to assess the certainty an effort will be implemented and six criteria to assess the certainty an effort will be effective. Conservation efforts are specific actions, activities, or programs designed to eliminate or reduce threats or otherwise improve a species' status. Formalized conservation efforts are conservation efforts identified in conservation agreements, conservation plans, management plans, or similar documents. As described in PECE, ESA section 4 requires us to consider the conservation efforts of Federal agencies, State and local governments, Tribal governments, businesses, organizations, and individuals (68 FR 15100, March 28, 2003). PECE directs NMFS to consider the following 15 evaluation criteria:

A. The certainty that the conservation effort will be implemented:
   1. The conservation effort, the party(ies) to the agreement or plan that will implement the effort, and the staffing, funding level, funding source and other resources necessary to implement the effort are identified.
   2. The legal authority of the party(ies) to implement the formalized conservation effort, and the commitment to proceed are described.
   3. The legal procedural requirements necessary to implement the effort are described, and information is provided indicating that fulfillment of these requirements does not preclude commitment to the effort.
   4. Necessary authorizations (*e.g.*, permits, landowner permission) are identified and there is a high level of certainty these authorizations will be obtained.
   5. The type and level of voluntary participation necessary to implement the conservation effort are identified, and a high level of certainty is provided that the necessary level of voluntary participation will be realized.
   6. Regulatory mechanisms necessary to implement the conservation effort are in place.
   7. A high level of certainty is provided that necessary funding will be obtained.
   8. An implementation schedule is provided.
   9. The conservation agreement or plan that includes the conservation effort is approved by all parties to the agreement or plan.
B. The certainty that the conservation effort will be effective:
   1. The nature and extent of threats being addressed, and how the conservation effort reduces those threats, are described.
   2. Explicit incremental objectives for the conservation effort and dates for achieving them are stated.
   3. The steps necessary to implement the conservation effort are identified in detail.

4. Quantifiable, scientifically valid parameters that will demonstrate achievement of objectives, and standards for these parameters by which progress will be measured, are identified.
5. Provisions for monitoring and reporting progress on implementation and effectiveness are provided.
6. Principles of adaptive management are incorporated.

A summary of organizations whose formalized conservation efforts were assessed at listing are outlined below. A more detailed discussion of the organizations and their efforts is provided in Volumes II, III and IV.

Organizations Assessed At Listing

- Association of California Water Agencies
- Caltrans Operations
- California Fish and Game Commission – Rearing programs, water development/wetlands policies, fishing regulations
- California Regional Water Quality Control Board – Water codes, water management plans
- California Department of Fish and Game (now CDFW) – Fisheries management, California Steelhead Management Plan, Hatchery programs, Stock Management Policies, Coastal Monitoring Management Plan, Streamside Alteration Agreements, the Fisheries Restoration Grant Program, Keene-Nielsen Fisheries Restoration Act, predation control, Senate Bill 271, Steelhead Report Card, Trout and Steelhead Conservation and Management Planning Act of 1979, and California Fish and Game Code sections 1385, 1600-1616, 2786, 5937, 6900
- Environmental Protection Agency – Coastal waters and wetland protection programs
- FishNet 4C – Multi-county forum to protect and enhance salmonid habitats
- Local watershed councils and other local restoration programs
- Mattole Salmon Group
- NRCS

- NMFS – ESA section 4, 7, 10, Magnuson-Stevens Fishery Conservation and Management Act, Pacific Coastal Salmon Recovery Fund, hatchery reforms, NMFS/CDFG agreements, NMFS/5Counties agreement, NMFS/California State Resources Memorandum of Understanding
- North Coast Regional Water Quality Control Board – Total Maximum Daily Load program
- National Park Service
- Pacific Fisheries Management Council
- Range Management Advisory Committee
- Resource Conservation Districts
- State Land Management and Timber Harvest Practices
- State Parks and Recreation
- Sub-watershed groups and organizations
- U.S. Forest Service and Bureau of Land Management
- U.S Army Corps of Engineers

5.2.3 Status Reviews Since Listing

NMFS reviews the status of listed species at least once every five years to determine whether they should be removed from the list or have their listing status changed. These 5-year reviews are required by section 4(c)(2) of the ESA and are conducted according to the "5-Year Review Guidance: Procedures for Conducting 5-Year Reviews under the Endangered Species Act" (USFWS and NMFS 2006). We base these five-year reviews on the best scientific and commercial data available including new information since the last listing or 5-year review. We publish a FRN announcing the 5-year review to notify the public and solicit new information for us to consider in the review. Each 5-year review includes:

1. A summary and analysis of available information on a given species.
2. Tracking of a species' progress toward recovery, including an assessment of the five section 4(a)(1) factors, and if applicable, recovery criteria outlined in the species recovery plan.
3. A description of the deliberative process we used to make a recommendation on whether or not to reclassify a species.

4. A recommendation on whether reclassification of the species is warranted.

To complete the reviews for CC Chinook salmon and NC and CCC steelhead, NMFS asks scientists from the SWFSC to collect and analyze new information about ESU and DPS viability according to the biological viability criteria (See Chapter 3). The SWFSC prepares Technical Memoranda detailing the findings and whether new information suggests a change in extinction risk. NMFS considers the biological status information along with recovery plan criteria (for species with recovery plans), listing factors, and protective/conservation efforts to prepare final recommendations on whether the species should be removed from the list or have its status changed. If a status change is found warranted, we initiate rulemaking.

Previous status review updates for CC Chinook salmon and NC and CCC steelhead were conducted in 2005 (Good *et al.* 2005) and 2011 (Williams *et al.* 2011). In its most recent five-year reviews for the CC Chinook salmon ESU and NC and CCC steelhead DPSs, after considering the status reviews and other information described above, NMFS determined that the ESU and DPSs should remain listed as threatened (NMFS 2016a; NMFS 2016b; Williams *et al.* 2016).

5.3 DELISTING AND RECOVERY

In recovery plans, NMFS must, to the maximum extent practicable, include "objective, measurable criteria which, when met, would result in a determination…that the species be removed from the list"[24] (ESA section 4(f)(1)(B)(ii)). These criteria (recovery criteria) must: (1) be objective and measurable; (2) provide a measure to of progress toward achievement of recovery objectives; and (3) address each of the five ESA section 4(a)(1) factors. The importance of addressing the five section 4(a)(1) listing factors in recovery criteria was underscored in a Federal district court opinion:

[24] The delisting criteria in this plan will only focus on delisting because the species in this plan are listed as threatened not endangered and thus cannot be downlisted.

> "Congress has spoken in clarion terms: the objective, measurable criteria must be directed towards the goal of removing the endangered or threatened species from the list. Since the same five statutory factors must be considered in delisting as in listing, 16 U.S.C. § 1533 (a), (b), (c), the Court necessarily concludes that the FWS, in designing objective, measurable criteria, must address each of the five statutory delisting factors and measure whether threats to the [species] have been ameliorated." *Fund for Animals v. Babbitt*, 903 F. Supp. 96, 111 (D.D.C. 1995) (emphasis added; citations omitted).

In addition, in *Defenders of Wildlife v. Babbitt*, 130 F.Supp.2d 121, 133-134 (D.D.C. 2001), the court remanded a recovery plan to USFWS to incorporate the five section 4(a)(1) factors into the objective, measurable criteria of the recovery plan or provide adequate explanation why it is not practicable to do so. Finally, in a U.S. Government Accountability Office (GAO) report on time and costs to recover listed species, the GAO recommended that the Secretaries of Commerce and the Interior direct USFWS and NMFS "to include in recovery planning guidance, direction that all new and revised recovery plans have either recovery criteria evidencing consideration of all five delisting factors or a statement regarding why it is not practicable to do so" (USGAO 2006). Therefore, NMFS' recovery planning guidance provides:

> "For this reason, we require that all the criteria section of all plans now list out the 5 factors, and place the criteria that will address them below the appropriate factor. In the case that there are no threats that correspond to a given factor, simply note that this factor, e.g., habitat loss or destruction or modification, is not considered a threat to the given species. We anticipate that recovery plans will also include demographic criteria (abundance, distribution etc.), and that these appear separately from the 'threats-based' criteria." (NMFS 2010)

5.3.1 RECOVERY PLAN GOALS, OBJECTIVES AND CRITERIA

The goal for this plan is to remove the NC steelhead DPS, CCC steelhead DPS and CC Chinook salmon ESU from the Federal List of Endangered and Threatened Wildlife (50 CFR 17.11; 50 CFR 223.102) due to their recovery. Our vision is to have restored freshwater and estuarine habitats that are supporting self-sustaining, well-distributed and naturally spawning salmonid populations that provide ecological, cultural, social and economic benefits to the people of California. Recovery plan objectives are to:

1. Reduce the present or threatened destruction, modification, or curtailment of habitat or range;
2. Ameliorate utilization for commercial, recreational, scientific, or educational purposes;
3. Abate disease and predation;
4. Establish the adequacy of existing regulatory mechanisms for protecting the ESU and DPSs now and into the future (*i.e.,* post-delisting);
5. Address other natural or manmade factors affecting the continued existence of the ESU and DPSs; and
6. Ensure the status of the ESU and DPSs are at a low risk of extinction (i.e. viable) based on abundance, growth rate, spatial structure and diversity.

Recovery goals, objectives and criteria provide a means by which the public can measure progress in the efforts at recovery and are used to link listing with status reviews and reclassification determinations. We developed the following categories of recovery criteria for the CC Chinook salmon ESU and NC and CCC steelhead DPSs: biological viability, criteria for each of the five listing factors (including degree recovery actions have been implemented), and certainty conservation efforts are ameliorating threats.

5.3.2 BIOLOGICAL RECOVERY CRITERIA

Populations selected for recovery scenarios must achieve the following criteria based on their role in recovery. Populations selected for recovery scenarios in all the Diversity Strata of the DPS or ESU must meet these criteria in order for the DPS or ESU to meet biological recovery criteria (*BR-4 only applies to CCC steelhead).

- **Low Extinction Risk Criteria:** Essential independent populations (those selected to be viable), the low extinction risk criteria for effective population size, population decline, catastrophic decline, hatchery influence and density-based spawner abundances must be met according to Spence *et al*.(2008) (See Chapter 3, Table 2)

AND

- **Moderate Extinction Risk Criteria:** Spawner density abundance targets have been achieved for Supporting Independent populations

AND

- **Redundancy and Occupancy Criteria:** Spawner density and abundance targets for dependent populations, which are the occupancy goals for each of those populations, have been achieved. See Spence *et al*. (2008) (Table 2)

AND

- **Redundancy and Occupancy Criteria**: For the Pinole Creek, San Pedro Creek, Drakes Bay, Wildcat Creek, and Codornices Creek dependent populations, that did not have IP developed for them by the SWFSC, confirm presence of steelhead juveniles and/or adults for at least one year class over 4 generations (*i.e*., a 16 year period).

AND

- **NC steelhead summer-run populations must meet effective population size criteria** outlined by Spence *et al*. (2008) (Table 2)

The selected populations and associated recovery criteria for the CC Chinook salmon ESU (Also see Table 21:

a. Selected populations in all four Diversity Strata achieving biological recovery criteria;

b. **CC-BR1** 13 Independent essential populations attaining low extinction risk criteria (*i.e*., Bear River, Big River, Garcia River, Humboldt Bay tributaries, Lower Eel River (Van Duzen and Larabee), Lower Eel River (South Fork and Lower Eel), Little River, Mad River, Mattole River, Noyo River, Redwood Creek (Humboldt Co.), Russian River, and Upper Eel River);

c. **CC-BR2:** Three supporting independent populations attaining moderate extinction risk criteria (*i.e*., Gualala River, Navarro River and Ten Mile River);

d. **CC-BR3**: Dependent population contributing to redundancy and occupancy criteria (*i.e.*, Albion River).

Table 21: CC Chinook Salmon ESU Diversity Strata, Populations, Historical Status, Population's Role in Recovery, Current IP-km, and Spawner Density and Abundance Targets for Delisting. The Diversity Stratum recovery targets are only comprised of the essential populations because these are the populations that are expected to be viable. *The Lower Eel River Chinook population is divided between two diversity strata, and as a result has one recovery target for the North Mountain Interior DS (Van Duzen and Larabee) and one for the North Coastal DS (Lower and South Fork Eel River).

Diversity Strata	CC Chinook salmon Populations	Historical Population Status	Population's Role In Recovery	Current Weighted IP-km	Spawner Density	Spawner Abundance
North Coastal	Bear River	I	Essential	39.4	37.8	1,500
	Humboldt Bay Tributaries	I	Essential	76.6	33.7	2,600
	Little River (Humboldt Co.)	I	Essential	17.4	40.0	700
	Lower Eel River ~ *Lower Mainstem/ South Fork Eel River**	I	Essential	368.4	20	7,400
	Mad River	I	Essential	94.4	31.7	3,000
	Mattole River	I	Essential	177.5	22.5	4,000
	Redwood Creek (Humboldt Co)	I	Essential	116.1	29.3	3,400
	North Coastal Diversity Stratum Recovery Target					**22,600**
North Mountain Interior	Lower Eel River ~ *Larabee Creek/ Van Duzen River**	I	Essential	144.0	20.0	2,900
	Upper Eel River	I	Essential	528.5	20.0	10,600
	North Mountain Interior Diversity Stratum Recovery Target					**13,500**
North-Central Coastal	Albion River	D	Supporting	17.6	6-12	104-209
	Big River	I	Essential	104.3	30.6	3,200
	Noyo River	I	Essential	62.2	35.3	2,200

	Ten Mile River	I	Supporting	67.2	6-12	401-804
	North-Central Coastal Diversity Stratum Recovery Target					**5,400**
Central Coastal	Garcia River	I	Essential	56.2	36.0	2,000
	Gualala River	I	Supporting	175.6	6-12	1,052-2,105
	Navarro River	I	Supporting	131.5	6-12	787-1,576
	Russian River	I	Essential	465.2	20.0	9,300
	Central Coastal Diversity Stratum Recovery Target					**11,300**
	CC Chinook ESU Recovery Target					**52,800**

The selected populations and associated recovery criteria for NC steelhead DPS (Also see Table 22 and Table 23).

a. Selected populations in all five Diversity Strata achieving biological recovery criteria;

b. **NC-BR-1:** 27 essential independent populations attaining low extinction risk criteria (*i.e.*, Garcia River, Gualala River, Navarro River, Chamise Creek, Outlet Creek, Tomki Creek, Woodman Creek, Larabee Creek, Middle Fork Eel River, North Fork Eel River, Upper Mainstem Eel River, Van Duzen River, Big River, Noyo River, Ten Mile River, Usal Creek, Wages Creek, Maple Creek/Big Lagoon, Bear River, Humboldt Bay Tributaries, Little River (Humboldt County), Mattole River, South Fork Eel River, Mad River (Upper), Mad River (Lower), and Redwood Creek (Upper) and Redwood (Lower) (Humboldt County);

c. **NC-BR-2:** Ten supporting independent populations attaining moderate extinction risk criteria (*i.e.*, Brush Creek, Elk Creek, Bell Springs, Bucknell Creek, Dobbyn Creek, Garcia Creek, Jewett River, Albion River, Cottaneva Creek and Pudding Creek; and

d. **NC-BR-3:** 14 dependent populations contributing to redundancy and occupancy criteria (*i.e.*, Schooner Gulch, Soda Creek, Caspar Creek, Guthrie Creek, Oil Creek, Big Creek, Big Flat Creek, Howe Creek, Jackass Creek, Lower Mainstem Eel River, McNutt Gulch, Shipman Creek, Spanish Creek, and Telegraph Creek.

e. **NC-BR-4:** 10 independent summer-run steelhead populations expected to meet effective population size criteria (Table 2) (*i.e.*, Redwood Creek, Mad River, South Fork Eel River, Mattole River, Van Duzen River, Larabee Creek, North Fork Eel River, Upper Middle Mainstem Eel River, Middle Fork Eel River, and Upper Mainstem Eel River.

Table 22: NC winter-run steelhead: Diversity Strata, Populations, Historical Status, Population's Role in Recovery, Current IP-km, and Spawner Density and Abundance Targets for Delisting. Redwood Creek and Mad River cross two diversity strata and were broken into an upper and lower to reflect this.

Diversity Strata	NC winter-run steelhead populations	Historical Population Status	Population's Role In Recovery	Current Weighted IP-km	Spawner Density	Spawner Abundance
Northern Coastal	Bear River	I	Essential	107.8	27.2	2,900
	Big Creek	D	Supporting	3.8	6-12	21-44
	Big Flat Creek	D	Supporting	5.9	6-12	33-69
	Guthrie Creek	D	Supporting	9.2	6-12	53-108
	Howe Creek	D	Supporting	13.9	6-12	81-165
	Humboldt Bay Tributaries	I	Essential	203.4	20.0	4,100
	Jackass Creek	D	Supporting	6.9	6-12	39-81
	Little River (Humboldt Co.)	I	Essential	50.0	35.3	1,800
	Lower Mainstem Eel River Tributaries	D	Supporting	166.4	6-12	996-1,995
	Mad River (Lower)*	I	Essential	146.3	21.9	3,200
	Maple Creek/Big Lagoon	I	Essential	71.7	32.3	2,300
	Mattole River	I	Essential	534.4	20.0	10,700
	McNutt Gulch	D	Supporting	11.3	6-12	66-134
	Oil Creek	D	Supporting	10.6	6-12	62-125
	Redwood Creek (Humboldt Co) (Lower)*	I	Essential	161.1	20.0	3,200
	Shipman Creek	D	Supporting	2.3	6-12	12-26
	South Fork Eel River	I	Essential	951.8	20.0	19,000

	Spanish Creek	D	Supporting	1.9	6-12	9-21
	Telegraph Creek	D	Supporting	5.3	6-12	30-62
	Northern Coastal Diversity Stratum Recovery Target					**47,200**
North Mountain Interior	Dobbyn Creek	I	Supporting	47.0	6-12	280-562
	Larabee Creek	I	Essential	86.4	30.2	2,600
	Mad River (Upper)*	I	Essential	289.6	20.0	5,800
	Middle Fork Eel River	I	Essential	472.4	20.0	9,400
	North Fork Eel River	I	Essential	315.7	20.0	6,300
	Redwood Creek (Humboldt Co) (Upper)*	I	Essential	86.2	30.2	2,600
	Upper Mainstem Eel River	I	Essential	317.5	20.0	6,400
	Van Duzen River	I	Essential	312.2	20.0	6,200
	North Mountain Interior Diversity Stratum Recovery Target					**39,300**
Lower Interior	Bell Springs Creek	I	Supporting	18.1	6-12	107-215
	Bucknell Creek	I	Supporting	9.0	6-12	52-106
	Chamise Creek	I	Essential	36.2	37.2	1,300
	Jewett Creek	I	Supporting	16.8	6-12	99-200
	Garcia Creek	D	Supporting	14.1	6-12	83-167
	Outlet Creek	I	Essential	176.0	20.0	3,500
	Soda Creek	D	Supporting	15.7	6-12	92-186
	Tomki Creek	I	Essential	89.5	29.8	2,700
	Woodman Creek	I	Essential	35.0	37.4	1,300
	Lower Interior Diversity Stratum Recovery Target					**8,800**
North-Central Coastal	Albion River	I	Supporting	48.6	6-12	290-581
	Big River	I	Essential	255	20	5,100
	Caspar Creek	D	Essential	12.9	40.4	500
	Cottaneva Creek	I	Supporting	21.9	6-12	129-261

	Noyo River	I	Essential	152.8	21.0	3,200
	Pudding Creek	I	Supporting	23.9	6-12	141-285
	Ten Mile River	I	Essential	171.1	20	3,400
	Usal Creek	I	Essential	27.5	38.4	1,100
	Wages Creek	I	Essential	17.4	39.8	700
	North-Central Coastal Diversity Stratum Recovery Target					**14,000**
Central Coastal	Brush Creek	I	Supporting	21.4	6-12	126-255
	Elk Creek	I	Supporting	34.5	6-12	205-412
	Garcia River	I	Essential	135.4	23.4	3,200
	Gualala River	I	Essential	396.7	20.0	7,900
	Navarro River	I	Essential	387.6	20.0	7,800
	Schooner Gulch	D	Supporting	7.7	6-12	44-90
	Central Coastal Diversity Stratum Recovery Target					**18,900**
	NC Steelhead DPS Recovery Target					**128,200**

Table 23: NC summer-run steelhead: Diversity Strata, Populations, Historical Population Status, and Effective Population Size (N_e). *The Redwood Creek and Mad River populations each occur in two diversity strata (Spence *et al.* 2008). In both watersheds, the location of actual spawning grounds is poorly understood and therefore each will be treated as one population until more information is obtained from monitoring.

Diversity Strata	NC summer-run steelhead populations	Historical Population Status	Effective Population Size
Northern Coastal/ North Mountain Interior	Redwood Creek*	I	$N_e \geq 500$
Northern Coastal/ North Mountain Interior	Mad River*	I	$N_e \geq 500$
Northern Coastal	South Fork Eel River	I	$N_e \geq 500$
Northern Coastal	Mattole River	I	$N_e \geq 500$
North Mountain Interior	Van Duzen River	I	$N_e \geq 500$
North Mountain Interior	Larabee Creek	I	$N_e \geq 500$
North Mountain Interior	North Fork Eel River	I	$N_e \geq 500$

North Mountain Interior	Upper Middle Mainstem Eel River	I	$N_e \geq 500$
North Mountain Interior	Middle Fork Eel River	I	$N_e \geq 500$
North Mountain Interior	Upper Mainstem Eel River	I	$N_e \geq 500$

The selected populations and associated recovery criteria for the CCC steelhead DPS (See also Table 24).

a. Selected populations in all five Diversity Strata achieving biological recovery criteria;

b. **CCC-BR-1** 28 essential independent populations attaining a low extinction risk (*i.e.*, Corte Madera Creek, Guadalupe River, Novato Creek, San Francisquito Creek, Stevens Creek, Dry Creek, Maacama Creek, Mark West Creek, Upper Russian River, Alameda Creek, Coyote Creek, Green Valley/Suisun Creek, Napa River, Petaluma River, Sonoma Creek, Austin Creek, Green Valley Creek, Lagunitas Creek, Salmon Creek, Walker Creek, Aptos Creek, Pescadero Creek, Pilarcitos Creek, San Gregorio Creek, San Lorenzo River, Scott Creek, Soquel Creek and Waddell Creek);

c. **CCC-BR-2:** Five supporting independent populations attaining moderate extinction risk criteria (*i.e.*, San Mateo Creek, San Leandro Creek, San Lorenzo Creek, Americano Creek and Laguna Creek); and

d. **CCC-BR-3:** 18 supporting dependent populations contributing to redundancy and occupancy criteria (*i.e.*, Miller Creek (Marin Co.), Arroyo Corte de Madera Creek; Crocker Creek, Gill Creek, Miller Creek (Russian), Sausal Creek, San Pablo Creek, Dutch Bill Creek (Russian), Freezeout Creek (Russian), Hulbert Creek (Russian), Pine Gulch, Porter Creek (Russian), Redwood Creek (Marin Co.), Sheephouse Creek (Russian), Willow Creek (Russian), Gazos Creek, San Vicente Creek, and Tunitas Creek).

e. **CCC-BR-4:** Five supporting dependent populations that did not have IP developed for them by the SWFSC, contribute to the redundancy and occupancy criteria; Codornices Creek, Pinole Creek, Wildcat Creek, Drakes Bay tributaries, and San Pedro Creek

Table 24: CCC steelhead DPS Diversity Strata, Populations, Historical Status, Population's Role in Recovery, Current IP-km, and Spawner Density and Abundance Targets for Delisting. *IP was not developed for these populations by the SWFSC. **Although IP-km values for Waddell Creek are lower than 16 IP-km, historically productive lagoon habitats were assumed to have resulted in steelhead populations large enough to be independent (Spence *et al*. 2012).

Diversity Strata	CCC Steelhead Population	Historical Population Status	Population's Role In Recovery	Current Weighted IP-km	Spawner Density	Spawner Abundance
North Coastal	Austin Creek	I	Essential	95.1	29.0	2,800
	Drakes Bay Tributaries*	D	Supporting	N/A	N/A	N/A
	Dutch Bill Creek	D	Supporting	13.2	6-12	77-156
	Estero Americano Creek	I	Supporting	35.4	6-12	210-423
	Freezeout Creek	D	Supporting	1.3	6-14	5-12
	Green Valley Creek	I	Essential	24.9	38.8	1,000
	Hulbert Creek	D	Supporting	10.2	6-12	59-120
	Lagunitas Creek	I	Essential	53.3	34.8	1,900
	Pine Gulch	D	Supporting	9.7	6-12	56-114
	Porter Creek	D	Supporting	10.3	6-12	60-122
	Redwood Creek (Marin Co.)	D	Supporting	6.7	6-12	38-78
	Salmon Creek	I	Essential	33.6	37.6	1,300
	Sheephouse Creek	D	Supporting	3.8	6-12	21-44
	Walker Creek	I	Essential	54.2	34.7	1900
	Willow Creek	D	Supporting	8.0	6-12	46-94
	North Coastal Diversity Stratum Recovery Target					**8,900**
Interior	Crocker Creek	D	Supporting	4.5	6-12	25-52
	Dry Creek	I	Essential	116.7	26.0	3,000
	Gill Creek	D	Supporting	7.2	6-12	41-84
	Maacama Creek	I	Essential	76.2	31.6	2,400
	Mark West Creek	I	Essential	164.2	20	3,300
	Miller Creek (Russian)	D	Supporting	3.1	6-12	17-35

	Sausal Creek	D	Supporting	11.1	6-12	65-131
	Upper Russian River	I	Essential	423.9	20	8,500
	Interior Diversity Stratum Recovery Target					**17,200**
Coastal S.F. Bay	Arroyo Corte Madera del Presidio	D	Supporting	6.9	6-12	39-81
	Corte Madera Creek	I	Essential	19.8	39.5	800
	Guadalupe River	I	Essential	51.9	35.0	1,800
	Miller Creek (Marin Co.)	D	Supporting	9.1	6-12	53-107
	Novato Creek	I	Essential	28.3	38.3	1,100
	San Francisquito Creek	I	Essential	35.5	37.3	1,300
	San Mateo Creek	I	Supporting	6.3	6-12	36-74
	Stevens Creek	I	Essential	22.9	39.0	900
	Coastal San Francisco Bay Diversity Stratum Recovery Target					**5,900**
Interior S.F. Bay	Alameda Creek	I	Essential	108.7	27.1	2,900
	Codornices Creek*	D	Supporting	N/A	N/A	N/A
	Coyote Creek	I	Essential	109.3	27.0	3,000
	Green Valley/Suisun Creek	I	Essential	64.3	33.3	2,100
	Napa River	I	Essential	233.9	20	4,700
	Petaluma River	I	Essential	64.3	33.2	2,100
	Pinole Creek*	D	Supporting	N/A	N/A	N/A
	San Leandro Creek	I	Supporting	5.5	6-12	31-64
	San Lorenzo Creek	I	Supporting	18.6	6-12	110-221
	San Pablo Creek	I	Supporting	8.5	6-12	49-100
	Sonoma Creek	I	Essential	129.0	24.3	3,100
	Wildcat Creek*	D	Supporting	N/A	N/A	N/A
	Interior San Francisco Bay Diversity Stratum Recovery Target					**17,900**
Santa Cruz Mountains	Aptos Creek	I	Essential	25.0	38.7	1,000

	Gazos Creek	D	Supporting	12.5	6-12	73-148
	Laguna Creek	I	Supporting	4.5	6-12	25-52
	Pescadero Creek	I	Essential	66.1	33.0	2,200
	Pilarcitos Creek	I	Essential	28.5	38.3	1,100
	San Gregorio Creek	I	Essential	46.6	35.7	1,700
	San Lorenzo River	I	Essential	146.2	21.9	3,200
	San Pedro Creek*	D	Supporting	N/A	N/A	N/A
	San Vicente Creek	D	Supporting	5.7	6-12	32-66
	Scott Creek	I	Essential	16.4	39.9	700
	Soquel Creek	I	Essential	52.1	35	1,800
	Tunitas Creek	D	Supporting	10.7	6-12	62-126
	Waddell Creek**	I	Essential	10.6	40	500
Santa Cruz Mountains Diversity Stratum Recovery Target						**12,200**
CCC Steelhead DPS Recovery Target						**62,100**

5.3.3 ESA § 4(a)(1) Factors Recovery Criteria

The following are the recovery criteria for the section ESA 4(a)(1) listing factors. The primary metrics for assessing whether each of the listing factor criteria have been achieved will be to utilize the CAP analyses to reassess habitat attribute and threat conditions in the future, and track the implementation of identified recovery actions unless otherwise found unnecessary.

All recovery actions were assigned to a specific section 4(a)(1) listing factor in order to track progress of implementation of actions for each factor. Recovery Action Priorities are assigned to each action step in the implementation table in accordance with NMFS' Interim Recovery Planning Guidance (NMFS 2010) and the NMFS Endangered and Threatened Species Listing and Recovery Priority Guidelines (55 FR 24296) (See Chapter 4 for more information).

Listing Factor A: Present or threatened destruction, modification or curtailment of habitat or range

A1 CAP/Rapid Assessment attribute ratings for:

a. **Essential Populations** found Good or better for all attributes in each Stratum.
b. **Supporting Populations** found Good or better for 50 percent of attribute ratings[25] and the remaining rated Fair throughout the DPS/ESU.

A2 All recovery actions have been implemented under Listing Factor A, or the actions are deemed no longer necessary for recovery.

Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

B1 CAP/Rapid Assessment threat ratings for Fishing and Collecting:

a. **Essential and Supporting Populations** found Medium or Low.

B2 All recovery actions have been implemented under Listing Factor B, or the actions are deemed no longer necessary for recovery.

Listing Factor C: Disease, Predation and Competition

C1 CAP/Rapid Assessment threat ratings for Disease, Predation and Competition:

a. **Essential and Supporting Populations** found Medium or Low.

C2 All recovery actions have been implemented under Listing Factor C, or the actions are deemed no longer necessary for recovery.

Listing Factor D: The Inadequacy of Existing Regulatory Mechanisms

D1 CAP/Rapid Assessment threat ratings related to Listing Factor D (see list below):

a. **Essential and Supporting Populations** found Medium or Low.

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[25] The role of supporting populations within the recovery scenario is to provide for redundancy and occupancy across Diversity Stratum. Because of their role, we use lower criteria for Factor A (*i.e.*, 50 percent as Good or better and the remaining as Fair). A "Fair" CAP/rapid assessment rating means that habitat conditions, while impaired to some degree, are functioning. Therefore, at least all habitat conditions are expected to function within these populations, and at least half are expected to be in proper condition (*i.e.*, Good), which NMFS expects will be sufficient for these populations to fulfill their role within the recovery scenario.

Listing Factor D Threats

- Agriculture
- Channel Modification
- Fire, Fuel Management and Fire Suppression
- Livestock Farming and Ranching
- Logging and Wood Harvesting
- Mining
- Residential and Commercial Development
- Roads and Railroads
- Water Diversions and Impoundments

D2 All recovery actions have been implemented under Listing Factor D, or the actions are deemed no longer necessary for recovery.

Listing Factor E: Other Natural and Manmade Factors Affecting the Species' Continued Decline

E1 CAP/Rapid Assessment threat ratings for Hatcheries and Aquaculture, Recreational Areas and Activities, and Severe Weather Patterns:

a. Essential and Supporting Populations found Medium or Low.

E2 All recovery actions have been implemented under Listing Factor E, or the actions are deemed no longer necessary for recovery.

5.3.4 CONSERVATION EFFORTS

CE1 Formalized conservation efforts applicable to the ESU or DPS have been or are being implemented and are effective in ameliorating any remaining threats associated with the five section 4(a)(1) factors.

6.0 MONITORING AND ADAPTIVE MANAGEMENT

"It is imperative that California, which is well behind other states in the Pacific Northwest, begin conducting monitoring at spatial scales relevant to recovery planning if we are to have any hope of accurately evaluating status and progress towards recovery."

Spence et al. 2008

6.1 INTRODUCTION

Monitoring that addresses biological viability criteria and listing factors is needed to inform federal recovery criteria provided in Chapter 5. This chapter describes specific monitoring and adaptive management strategies needed to measure progress toward meeting recovery criteria and determine whether any revisions to those recovery criteria should be made in the 5-year reviews of the recovery plan. The purpose of this chapter is to better assist those interested or involved in salmon and steelhead monitoring along California's central coast.

In addition to recommendations in this recovery plan, NOAA has several documents outlining federal ESA needs for monitoring:

- Recommendations to federal and state agencies, tribes, local governments and watershed organizations on monitoring priorities can be found in the *Guidance for Monitoring Recovery of Pacific Northwest Salmon and Steelhead listed under the Federal Endangered Species Act* (Crawford and Rumsey 2011).
- Guidance directed toward habitat restoration monitoring has been provided to states and tribes through the Pacific Coastal Salmon Recovery Fund's *Performance Goals, Measures, and Reporting Framework* (NMFS 2006)

We specifically refer readers to Crawford and Rumsey (2011) when designing monitoring programs. Monitoring conducted specifically to inform federal recovery criteria should include, for each Diversity Stratum, the following for all ESU's and DPS': (1) estimates of adult abundances from one to two populations, (2) habitat status and trends, and (3) the status of the five federal listing factors and associated threats (including the adequacy or inadequacy of regulatory mechanisms). Table 25 and Table 26 show what is most important for state, tribal, and local governments to monitor to determine recovery. Each type of monitoring effort for populations and listing factors has been ranked based on the guidance provided in Crawford and Rumsey (2011) and Adams *et al.* (2011). Those with higher priorities should be the focus for distribution of funds and developing additional or new monitoring programs.

Table 25. NMFS recommended biological monitoring priorities (adapted from Crawford and Rumsey 2011).

Criteria	Monitoring Priority	Confounding Effects of Sources of Error	Comments
VSP CRITERIA			
Adult Abundance	Highest	• Estimation methods • Inaccurate harvest or abundance estimates • Conversion and confusion between spawners and escapement • Unidentified hatchery spawners (steelhead only) • Estimates without accuracy and precision • Exclusion or inclusion of jacks • Confusion about conversion of escapement to spawners	• It must be recognized that tracking spawning populations is at the heart of VSP criteria. • Measuring adult abundance for the populations within the ESU/DPS could be sufficient to determine recovery but may take a considerable number of years to be confident that the listing factors are apparently no longer threats to the continued existence of the species.
Juvenile Abundance	Very High	• Trapping efficiencies (migrant abundance and timing) • Variable age at migration • Migrating hatchery releases (steelhead only) • Rainbow trout / steelhead interfaces • Supplementation programs (steelhead only)	• Juvenile migrant abundance estimates are critical in order to estimate freshwater production and survival. • Juvenile parr estimates provide spatial distribution and correlate habitat quality to fish abundance.
Productivity	Very High	• Juvenile and adult supplementation • Age class structure • Hatchery spawners (steelhead only) • Hatchery density dependent impacts in the estuary and marine environment (steelhead only)	• Productivity is only accurate if the estimates of adult abundance and (where employed) juvenile abundance are accurate. As used by the TRT, productivity is defined in terms of spawner to redd ratios. Juvenile info is valuable where available, but it is not available for many populations.
Spatial Distribution	High	• Lack of a periodic census or valid spatially balanced sampling program (*i.e.*, CMP not implemented throughout the ESU/DPS) • Low abundance can lead to risky conclusions regarding spatial structure.	• Spatial distribution tends to be a collection of individual site records developed over time. NMFS will utilize spatially balanced data derived from the CMP as well as other data sources to determine annual spatial distribution of Chinook salmon and steelhead throughout the ESU/DPS.

Diversity	High	• Inadequate baseline information for phenotype and genotype diversity • Hatchery effects (steelhead only) • Harvest effects • Changes to habitat	• Many diversity traits can be tracked through the various sampling elements of the CMP including juvenile migrant sampling, juvenile abundance sampling, and juvenile estuary sampling and spawner surveys. • A standardized protocol for appropriate reference conditions for phenotype and genotype diversity is needed.

Table 26. NMFS recommended listing factor monitoring priorities (adapted from Crawford and Rumsey 2011).

Criteria	Monitoring Priority	Confounding Effects or Sources of Error	Comments
LISTING FACTORS			
A. Present or threatened destruction, modification or curtailment of habitat or range	High	• Lack of adequate habitat sampling program. Need to know the status/trends of multiple key habitat attributes. • Only tracking the number of restoration projects completed does not necessarily indicate net improvement in salmon habitat	• The loss of freshwater and estuarine habitat is of major importance in the decline of salmon and steelhead. • Quantifying status/trends of habitat conditions continues to be underfunded and sparsely applied. • Funding to develop and implement a comprehensive monitoring protocol for habitat conditions is needed.
B. Overutilization for commercial, recreational, scientific, or educational purposes	Very High	• Poor stock identification techniques for naturally produced adults in the fisheries including lack of Genetic Stock Index (GSI) measurements • Unmarked hatchery adults in the fisheries • Unknown compliance with harvest regulations (unaccounted losses) • Assumptions regarding long term survival of marked fish	• Although harvest is considered a threat, it is integral to calculating productivity and potential spawner abundance. • Since it is probably the threat that can be controlled to the greatest extent, estimating accurately its impact to recovery is crucial. • Development and finalization of Fisheries Management and Evaluation Plans is needed.

C. Disease, predation and competition	Medium	• Salmonid mortality due to predators is not well documented • Hatchery contributions to disease	• Development and implementation of monitoring to assess the extent and impact of diseases is needed (at least in areas where disease is of concern). • Development and implementation of monitoring to assess predation rates is needed (at least in populations where predation is of concern).
D. Inadequacy of existing regulatory mechanisms	Medium	• Unknown compliance with zoning and other land use regulations	• An audit of compliance with state and local land use and environmental laws and regulations should be completed periodically to test for effectiveness.
E. Other natural and manmade factors affecting the species' continued decline	Medium	• Spatial and temporal patterns difficult to discern • Lack of spawning ground survey data on hatchery straying into natural production areas • Lack of GSI measurements • Lack of marking of all hatchery fish • Competition	• This factor is already monitored by the NWFSC and SWFSC and universities, with several models in development. • Marine survival of salmon and steelhead is a direct measure of ocean and climate conditions and is essential for determining viability of salmon. More focused information is needed at the ESU/DPS scale. • Development and finalization of Hatchery and Genetic Management Plans is needed.

6.2 CALIFORNIA COASTAL MONITORING PROGRAM

CDFW and NMFS are implementing a statewide plan, the California Coastal Monitoring Program (CMP), to standardize monitoring of coastal populations of anadromous native salmonids and inform recovery, conservation, and management. The CMP is being guided by *Fish Bulletin 180 California Coastal Salmonid Monitoring: Strategy, Design and Methods* (Adams *et al*. 2011).

While the current CMP process focuses on coastal streams, it is the ultimate goal of CDFW and NMFS to have a robust and adaptive monitoring program that includes all salmon and steelhead populations in California. The CMP Management and Technical Teams are developing a plan intended to:

- provide regional (ESU/DPS-level) and population abundance estimates for both status and trend of salmonid populations that will provide the basis for recovery criteria;
- estimate productivity trends from status abundance data;
- provide estimates of regional and population level spatial structure of coastal salmonids;
- include spatially balanced spawner/redd surveys;
- consider the diversity of life history and ecological differences in the three species of interest (steelhead, Chinook salmon, and coho salmon);
- create permanent life cycle monitoring (LCM) stations to calibrate redd survey estimates and provide in-depth evaluations of both freshwater and marine fish-habitat relationships and provide long-term population status and trend monitoring;
- include juvenile spatial distribution, diversity and abundance; and
- assess freshwater and estuarine habitat conditions.

Currently, only a few organizations have implemented population-level monitoring programs for adult returns outlined in the CMP (*e.g.*, CDFW and NMFS' SWFSC). These efforts provide a critical first step for building experience and collecting data that can ultimately be used to determine the status toward our recovery goals. Several other organizations (*e.g.*, Sonoma County Water Agency, Marin Municipal Water District and National Park Service) also have extensive population level monitoring programs in other coastal populations and progress is being made towards adapting these ongoing monitoring programs into the CMP.

NMFS and CDFW acknowledge the CMP must be built over time as methods are tested and refined and funding secured. While the fundamental principles of the CMP (*i.e.,* the need for random, spatially balanced sampling and robust population estimates) will remain more or less the same, the specific metrics and procedures used to evaluate recovery will likely evolve as we learn from early implementation of the plan. To track Chinook salmon and steelhead abundance trends, however, we must expand upon our existing monitoring efforts immediately throughout each ESU and DPS using the existing CMP framework. Data collected over a broad geographic scope will assist with the refinement of methods, experimentation of other methods, and highlight additional data needs. To do this, we must prioritize and secure additional funding sources.

The CMP, if adequately funded and implemented, could serve as the State's leading program to communicate the type of monitoring needed to inform ESA 5-year status reviews and recovery progress of California's salmon and steelhead. Currently, the CMP is limited in scope and funding; thus, obtaining data from other monitoring and research activities may be used to augment NOAA's required 5-year status reviews and assessment on the status and trends of populations, habitats, recovery action implementation, and the federal listing factors and threats.

6.3 MONITORING ABUNDANCE, PRODUCTIVITY, STRUCTURE AND DIVERSITY

The most fundamental population viability metric is spawner abundance measured over time (*e.g.,* abundance over multiple generations). Spawner abundance will be assessed using a two-staged sampling approach (Adams *et al.* 2011). First-stage sampling is comprised of extensive regional and spatially- balanced spawning (redd) surveys to estimate escapement in stream reaches selected under a Generalized Random Tessellation Sampling (GRTS; Gallagher *et al.* 2010) design. The GRTS is a rotating panel design at a survey level of a minimum of ten percent of available habitat each year (some streams, or reaches of interest, may require greater levels and this plan recommends a minimum of 30 percent). As outlined in Adams *et al.* (2011), sample units (or reaches) selected by the GRTS sampling scheme will be allocated to four panel groups that are in turn assigned different visitation schedules. The four different visitation schedules for panel groups are as follows: one panel that will be visited every year (Panel 1), three panels that will be visited once every three years (Panel 2 through 4), 12 panels that will be visited once every 12 years (Panels 5 through 16), and 30 panels that will be visited once every 30 years (Panels 17 through 46), the entire life of the project. For populations, or specific reaches where traditional spawner surveys are not physically possible, the use of methods such as drift surveys or aerial counts from helicopters (DeHaven 2008) or Unmanned Aerial Systems (UAS, or drones) may be employed (Arnsberg *et al.* 2014). Protocols for these methods will be developed by the CMP Technical Teams as needed.

Second-stage sampling consists of producing escapement estimates in intensively monitored streams (*e.g.*, LCM stations) through either total counts of returning adults or mark-recapture based estimates. The second-stage estimates are considered to represent true adult escapement and resulting spawner to redd ratios are used to calibrate first-stage estimates of regional adult abundance (Crawford and Rumsey 2011).

The LCM stations consist of either fixed counting facilities, or portable, seasonally installed facilities where fish are either trapped and marked, or directed through a viewing chamber and counted. Another method used under the CMP, makes use of Dual Frequency Identification Sonar (DIDSON) technology (Atkinson *et al.* 2016). DIDSON has been shown to provide reliable adult escapement estimates in a variety of riverine environments throughout California (Holmes *et al.* 2006; Pipal *et al.* 2010; Metheny 2012; Pipal *et al.* 2012; Larson 2013; Atencio and Reichmuth 2014). For populations with more than one salmonid species the use of DIDSONs presents substantial challenges, and methods to resolve these challenges are still under development. However, research on identifying different species using DIDSON images is encouraging (Fleischman and Burwen 2003; Burwen *et al.* 2010; Mueller *et al.* 2010). The newest technology is the use of Adaptive Resolution Imaging Sonar (ARIS) imaging which provides even higher resolution images of fish. The CMP Technical Team and researchers in California are developing protocols and methods to improve species assignment using sonar imaging technologies. Other methods that could be used at counting stations may include Vaki Riverwatcher technology and fish wheels.

Estimates of freshwater and marine survival as well as life history information inferred from adult, smolt and summer rearing abundance monitoring gathered at LCM stations are used to inform regional status and trend information. These LCM populations (watersheds) are also intended to be focal points for evaluating restoration and encouraging further research. The monitoring needs and recommendations presented below rely heavily on the CMP discussions ongoing between NMFS and CDFW (CMP Technical, Management and Policy teams) along with guidelines presented in Crawford and Rumsey (2011).

6.3.1 ADULT SPAWNER ABUNDANCE

Recommendations for monitoring adult spawner abundance include:

1. Implementation of an unbiased two-stage GRTS-based ESU/DPS-wide monitoring program (*i.e.,* the CMP) for adult Chinook salmon and steelhead that has known precision and accuracy. The monitoring plan should:
    a. Provide yearly adult spawner abundance estimates at the ESU/DPS, diversity stratum, and, population level. Establish a minimum of one (or preferably two) LCM stations within each diversity stratum to estimate spawner: redd ratios. These stations will be used for calibrating regional redd counts, and smolt/adult ratios for marine/freshwater survival estimations.
    b. Prioritize monitoring in locations that inform the biological criteria of this recovery plan and NOAA's 5-Year Status Reviews.
    c. Maintain current LCM stations in Humboldt, Mendocino, and Santa Cruz counties and seek to incorporate other existing monitoring programs into the master sample GRTS design;

d. Over time and as populations approach recovery, strive to have ESU/DPS-level adult spawner data with a coefficient of variation (CV) on average of 15 percent or less (Crawford and Rumsey 2011);

e. Regional (*i.e.*, ESU/DPS) spawner data should have the statistical power to detect a change of ± 30 percent with 80 percent certainty within 10 years (Crawford and Rumsey 2011);

f. Strive to have abundance estimates at the LCM stations with a CV on average of 15 percent or less; and

g. In time, develop and implement an element within the CMP that will evaluate steelhead hatchery impacts and hatchery-to-wild ratios (that should cover a range of issues from genetic changes to brood stock mining) and implement hatchery recommendations per Spence *et al.* (2008).

6.3.2 PRODUCTIVITY

Recommendations for monitoring population productivity[26] include:

1. Since productivity is calculated as the trend in abundance over time, develop a 16 year[27] or greater data set of accurate spawner information to estimate geometric mean recruits per spawner and evaluate population trends.

2. Using the LCM stations, conduct annual smolt abundance/trend monitoring.

   a. Juvenile monitoring should strive to have data with a CV on average of 15 percent or less (Crawford and Rumsey 2011);

   b. Power analysis for each monitored juvenile population should be conducted to determine the statistical power of the data to detect significant changes in abundance; and

[26] Productivity is generally defined as a population's growth rate over time. The CMP Technical Team have proposed using the cohort replacement rate.

[27] Approximately four generations as required in Spence *et al.* 2008.

c. Estimate apparent marine and fresh water survival (couple adult data with the smolt abundance estimates and/or conduct mark-recapture of smolt to adult studies).

6.3.3 Spatial Distribution and Occupancy

Recommendations for monitoring spatial distribution and occupancy include:

1. Develop and implement a spatially balanced GRTS-based summer and fall sampling strategy for juvenile salmonids. Juvenile Chinook salmon generally migrate out of their natal streams[28] during spring and early summer and therefore are unlikely to be observed during summer and fall snorkel or electrofishing surveys. Instead, spawner/redd surveys will provide the primary information on spatial distribution of spawners and out-migrant trapping may provide some watershed-level information on spatial structure. In addition to juvenile sampling, steelhead adult spawner/redd surveys may also provide information on spatial distribution and out-migrant trapping may provide some watershed-level information on spatial structure.

2. Evaluate changes in adult spawning distribution (stage one sampling) using probabilistic sampling. Environmental conditions, such as precipitation and stream flow, will influence the distribution of spawners by expanding (wet years) or shrinking (dry years) the amount of habitat available to returning adults. Therefore, analysis of annual spawner distribution must consider both biological (small population) and environmental (weather patterns) factors.

3. Determine spatial distribution of CC Chinook salmon (primarily spawning/redd surveys) and steelhead (juvenile distribution and spawning/redd surveys) with the ability to detect a change in distribution of ± 15 percent with 80 percent certainty (Crawford and Rumsey 2011).

4. As discussed above, the relationship between environmental factors (particularly stream flow and water temperature) can influence the likelihood of salmon and steelhead presence and spatial distribution. Where necessary and applicable, develop and implement stream flow

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[28] Although spring-early summer emigration is the general trend, in 2013, juvenile Chinook salmon were collected later in summer in Redwood Creek, Lower Eel, Van Duzen, Mattole, and South Fork Eel Rivers. It is unknown whether this recent finding is a characteristic of their life history strategy or if it is reflection of the unusual year (2012-13) of high adult Chinook salmon escapement and low winter flows.

and water temperature monitoring programs to assess their implications on occupancy during the adult (stream flow) and juvenile (stream flow and water temperature) life stages.

5. As part of the CMP, develop a biological monitoring program for estuaries and seasonal, bar-built lagoons, particularly in LCM populations, that will track salmonid abundance and use of these habitats over time. These data can be used to document potential limiting factors (*e.g.*, stresses) affecting salmonid rearing in these habitats and highlight emerging threats over time. As noted above, the CMP Technical Teams have begun early planning for the development of an Estuary monitoring protocol that would include habitat and biological monitoring.

6.3.4 DIVERSITY

"*Diversity traits are strongly adaptive for local areas and populations, and these traits allow salmonids to survive in the face of unique local natural and anthropogenic challenges. Higher level diversity traits have been considered in the creation of the listing and stratification units; however, population level diversity traits may be very different from one geographical or population unit to another. Therefore, local diversity traits will need to be surveyed, eventually leading to local diversity monitoring plans. Specific projects targeting both broad and focused levels and patterns of genetic diversity will be developed*." Adams *et al.* (2011).

Recommendations for monitoring diversity traits include:

1. Monitor status and trends of spawn timing, sex ratio, age distribution, fecundity, *etc.* (see Adams *et al.* 2011) across populations, Diversity Strata, and the ESU/DPS. Spawn timing, sex ratio, and age distribution should be assessed during both stage-one (redd surveys) and stage-two (LCM station) adult monitoring. Age distributions for juvenile steelhead should be assessed during spatial distribution monitoring using length frequencies, analysis of scales, and by mark-recapture PIT-tagging programs.

2. The CMP Technical Teams should develop monitoring components that will track the status of the following life history pathways for Chinook salmon and steelhead: (1) yearling vs. sub-yearling ocean entry (ocean vs stream type) of juvenile Chinook salmon; (2) the "1/2 pounder" steelhead (*e.g.,* Eel River watershed); and (3) the degree of estuarine-rearing by Chinook salmon and steelhead, as well as bar-built lagoon rearing of steelhead (see also #5 under Spatial Distribution and Occupancy above).
3. Develop a genetic baseline of DNA markers, or single nucleotide polymorphisms (SNPs), for the CC Chinook salmon ESU and both the NC and CCC steelhead DPSs. Tissue sample collection required for the development of this baseline can be conducted during spawner/redd surveys (*i.e.,* from carcasses encountered during spawner/redd surveys), LCM stations (live adult and juvenile fish), and during spatial distribution surveys (live juvenile fish).
4. Assess the percent of hatchery origin spawners (pHOS) in populations.
5. Over time, compare differences and trends in population abundance, growth rates, habitat use, and juvenile migration timing with overall watershed and in-stream habitat conditions (*i.e.,* water temperature, canopy closure, substrate conditions, escape shelter, and summer base stream flow volumes).

6.4 COSTS FOR MONITORING BIOLOGICAL VIABILITY

Cost estimates for implementing the CMP have not been developed (Adams *et al.* 2011). However, some cost estimates are available for ongoing monitoring conducted in the Pudding Creek watershed in coastal Mendocino County, California (Gallagher *et al.* 2010) as well as Redwood Creek and tributaries to Humboldt Bay in Humboldt County, California (S. Ricker, CDFW personal communication, September 2013). These values were used to form preliminary costs estimates (Table 27, Table 28, Table 29) for the monitoring needed for informing progress toward meeting recovery criteria and trends for CC Chinook salmon, NC steelhead, and CCC steelhead populations. Monitoring actions are provided in Table 31. Populations selected for LCM station placement will also affect totals costs due to watershed size differences and potential for multiple species. Costs associated with data management, analysis, storage, and report production will vary as CMP methods, protocols, and analyses are modified and streamlined in the future. The costs provided in this plan are general estimates and do not take into account regional cost-of-living adjustments, although we anticipate higher costs for monitoring in populations surrounding the San Francisco Bay Area. Costs for components of the CMP that are net yet developed (*e.g.,* estuarine monitoring and stream/watershed habitat monitoring) will be estimated once these programs are in place. Finally, monitoring the recovery of CC Chinook salmon, NC steelhead, and CCC steelhead will require continuing evaluation of costs, dedicated funding, and a long-term commitment of resources by all involved parties.

6.4.1 SPAWNER GROUND SURVEYS

For streams on the Mendocino Coast, regional spawning ground surveys cost between approximately $3,800 and $4,000 to survey one 3.0 km reach a sufficient number of times each season to generate reliable redd counts. Sample units, or reach lengths, for both spawner distribution/abundance and juvenile spatial distribution described in Adams *et al.* (2011) range from approximately 1.6 to 3.2 km. A sample draw of 30 or 40 percent will be necessary to sufficiently assess population level trends of adult escapement (S. Ricker, CDFW, personal communication). Using the total number of kilometers of potential habitat for each population and a minimum 30 percent sample of 3 km reaches[29], the estimated annual cost to conduct first-stage, GRTS spawning ground surveys for each of the three species would be: CC Chinook salmon ($1,056,680), NC steelhead ($2,615,120), and CCC steelhead ($1,977,920) (Table 27, Table 28, and Table 29). These estimates do not include data storage and report preparation. For watersheds with more than one salmonid species (including coho salmon), there will be some degree of overlap of species monitoring due to differences in run times and life history strategies.

[29] A minimum of 6 (3 km) reaches are needed for 95 % confidence intervals (Trent McDonald personal communication). If a target stream has fewer than 6 reaches (18 km) of potential habitat, then either a complete census of the stream must be done, or the stream needs to be broken into smaller reaches. The CMP Technical Team is working on these technical issues. Therefore, higher sampling fractions will be needed in these smaller populations if population-specific population estimates are desired.

Depending on the degree of overlap, total costs for monitoring spawner abundance may be reduced considerably as these costs estimates will be shared across species.

Table 27: CC Chinook salmon ESU annual spawning ground survey cost estimates. *Includes IP-km currently inaccessible to Chinook salmon due to dams; assumes passage in the future. Note: The actual sample draw will be from all available habitat. Some of this habitat may be IP-km, but the sampling universe is not limited to IP-km.

Diversity Strata / populations	IP (km)	30% IP (km)	# of 3 km reaches	Annual Cost
North Coastal				
Redwood Cr.	116.1	35	12	$46,440
Little R.	17.4	5	2	$6,960
Mad R.	94.0	28	9	$37,600
Humboldt Bay	76.6	23	8	$30,640
L. Eel R. - South Fork Eel River	368.4	111	37	$147,360
Bear R.	39.4	12	4	$15,760
Mattole R.	177.5	53	18	$71,000
sub-total	**889**	**267**	**89**	**$355,760**
North Mountain Interior				
U. Eel River *	528.5	159	53	$211,400
L. Eel River (*Larabee and Van Duzen*)	144	43	14	$57,600
sub-total	**673**	**202**	**67**	**$269,000**
North-Central Coastal				
Ten Mile R.	67.2	20	7	$26,880
Noyo R.	62.2	19	6	$24,880
Big R.	104.3	31	10	$41,720
Albion R.	17.6	5	2	$7,040

sub-total	**251**	**75**	**25**	**$100,520**
Central Coastal				
Navarro R.	131.5	39	13	$52,600
Garcia R.	56.2	17	6	$22,480
Gualala R.	175.6	53	18	$70,240
Russian R.	465.2	140	47	$186,080
sub-total	**829**	**249**	**83**	**$331,400**
GRTS SGS Estimated Annual Cost (30%)				**$1,056,680**
GRTS SGS Estimated Annual Cost (40%)				**$1,408,907**

Table 28: NC Steelhead DPS annual spawning ground survey cost estimates. Populations with less than 10 IP-km were assigned a value of 1 for the number of reaches to survey. *Includes IP-km currently inaccessible to steelhead due to dams; assumes passage in the future. Note: The actual sample draw will be from all available habitat. Some of this habitat may be IP-km, but the sampling universe is not limited to IP-km.

Diversity Strata / populations	IP (km)	30% IP (km)	# of 3 km reaches	Annual Cost
Northern Coastal				
Redwood Cr. (Lower)	161.1	48.3	16	$64,440
Maple Cr. / Big Lagoon	71.7	21.5	7	$28,680
Little R.	50.0	15.0	5	$20,000
Mad R. (Lower)	146.3	43.9	15	$58,520
Humboldt Bay Tributaries	203.4	61.0	20	$81,360
Lower Main. Eel Tributaries	166.4	49.9	17	$66,560
Howe Cr.	13.9	4.2	1	$5,560
South Fork Eel R.	951.8	285.5	95	$380,720
Guthrie Cr.	9.2	2.8	1	$3,680

Oil Cr.	10.6	3.2	1	$4,240
Bear R.	107.8	32.3	11	$43,120
McNutt Gulch	11.3	3.4	1	$4,520
Mattole R.	534.4	160.3	53	$213,760
Spanish Creek	1.9	0.6	1	$4,000
Big Cr.	3.8	1.1	1	$4,000
Big Flat Cr.	5.9	1.8	1	$2,360
Shipman Cr.	2.3	0.7	1	$4,000
Telegraph Cr.	5.3	1.6	1	$2,120
Jackass Cr.	6.9	2.1	1	$2,760
sub-total	**2,464**	**739.2**	**249**	**$994,400**
Lower Interior				
Chamise Cr.	36.2	10.9	4	$14,480
Bell Springs Cr.	18.1	5.4	2	$7,240
Woodman Cr.	35.0	10.5	4	$14,000
Outlet Cr.	176.0	52.8	18	$70,400
Tomki Cr.	89.5	26.9	9	$35,800
Jewett Cr.	16.8	5.0	2	$6,720
Garcia Cr.	14.1	4.2	1	$5,640
Soda Cr.	15.7	4.7	2	$6,280
Bucknell Cr.	9.0	2.7	1	$3,600
sub-total	**423**	**126.9**	**42**	**$164,160**
North Mountain Interior				
Redwood Cr. (Upper)	86.2	25.9	9	$34,480
Mad R. (Upper)	289.6	86.9	29	$115,840

Dobbyn Cr.	47.0	14.1	5	$18,800
Larabee Cr.	86.4	25.9	9	$34,560
Van Duzen R.	312.2	93.7	31	$124,880
North Fork Eel R.	315.7	94.7	32	$126,280
Middle Fork Eel R.	472.4	141.7	47	$188,960
Upper Main. Eel R.**	317.5	95.3	32	$127,000
sub-total	**1,504**	**451.3**	**193**	**$770,800**
North-Central Coastal				
Usal Cr.	27.5	8.3	3	$11,000
Cottaneva Cr.	21.9	6.6	2	$8,760
Wages Cr.	17.4	5.2	2	$6,960
Ten Mile R.	171.1	51.3	17	$68,440
Pudding Cr.	23.9	7.2	2	$9,560
Noyo R.	152.8	45.8	15	$61,120
Caspar Cr.	12.9	3.9	1	$5,160
Big R.	255	76.5	26	$102,000
Albion R.	48.6	14.6	5	$19,440
sub-total	**731**	**219**	**73**	**$292,440**
Central Coastal				
Navarro R.	387.6	116.3	39	$155,040
Elk Cr.	34.5	10.4	3	$13,800
Brush Cr.	21.4	6.4	2	$8,560
Garcia R.	135.4	40.6	14	$54,160
Schooner Gulch	7.7	2.3	1	$3,080
Gualala R.	396.7	119.0	40	$158,680

sub-total	**983**	**295**	**98**	**$393,320**
GRTS SGS Estimated Annual Cost (30%)				**$2,615,120**
GRTS SGS Estimated Annual Cost (40%)				**$3,486,827**

Table 29: CCC steelhead DPS annual spawning ground survey cost estimates. Populations with less than 10 IP-km were assigned a value of 1 for the number of reaches to survey. *Includes IP-km currently inaccessible to steelhead due to dams; assumes passage in the future. ** IP-km were not developed for San Pedro Creek (Bjorkstedt *et al*. 2005), however CMP spawner surveys have been conducted in recent years and therefore an estimate of accessible habitat is provided. Note: The actual sample draw will be from all available habitat. Some of this habitat may be IP-km, but the sampling universe is not limited to IP-km.

Diversity Strata / populations	IP (km)	30% IP (km)	# of 3 km reaches	Annual Cost
North Coastal				
Willow Cr.	8.0	2	1	$4,000
Sheephouse Cr.	3.8	1	1	$4,000
Freezeout Cr.	1.3	0	1	$4,000
Austin Cr.	95.1	29	10	$38,040
Dutch Bill Cr.	13.2	4	1	$4,000
Green Valley	24.9	7	2	$9,960
Hulbert Cr.	10.2	3	1	$4,000
Porter Cr.	10.3	3	1	$4,000
Salmon Cr.	33.6	10	3	$13,440
Estero Americano Cr.	35.4	11	4	$14,160
Walker Cr. *	54.2	16	5	$21,680
Lagunitas Cr. *	53.3	16	5	$21,320
Pine Gulch	9.7	3	1	$4,000
Redwood Creek	6.7	2	1	$4,000

sub-total	**409**	**123**	**43**	**$150,600**
Interior				
Mark West Cr.	164.2	49	16	$65,680
Dry Cr.	116.7	35	12	$46,680
Maacama Cr.	76.2	23	8	$30,480
Sausal Cr.	11.1	3	1	$4,000
Miller Cr.	3.1	1	1	$4,000
Gill Cr.	7.2	2	1	$4,000
Crocker Cr.	4.5	1	1	$4,000
Upper Russian R.	423.9	127	42	$169,560
sub-total	**807**	**242**	**82**	**$328,400**
Santa Cruz Mountains				
San Pedro Cr. **	6.7	2.0	1	$4,000
Pilarcitos Cr.	28.5	8.6	3	$11,400
Tunitas Cr.	10.7	3.2	1	$4,000
San Gregorio Cr.	46.6	14.0	5	$18,640
Pescadero Cr.	66.1	19.8	7	$26,440
Gazos Cr.	12.5	3.8	1	$4,000
Waddell Cr.	10.6	3.2	1	$4,000
Scott Cr.	16.4	4.9	2	$6,560
San Vicente Cr.	5.7	1.7	1	$4,000
Laguna Cr.	4.5	1.4	1	$4,000
San Lorenzo R.	146.2	43.9	15	$58,480
Soquel Cr.	52.1	15.6	5	$20,840
Aptos Cr.	25.0	7.5	3	$10,000

sub-total	**432**	**129**	**44**	**$176,360**
Coastal San Francisco Bay				
Arroyo Corte Madera del Presidio	6.9	2.1	1	$4,000
Corte Madera Cr.	19.8	5.9	2	$7,920
Miller Cr.	9.1	2.7	1	$4,000
Novato Cr. *	28.7	8.6	3	$11,480
San Mateo Cr.	6.3	1.9	1	$4,000
San Francisquito Cr.*	35.5	10.7	4	$14,200
Stevens Cr.*	22.9	6.9	1	$4,000
Guadalupe R. *	51.9	15.6	5	$20,760
sub-total	**181**	**54**	**18**	**4**
Interior San Francisco Bay				
Petaluma R.	64.3	19.3	6	$25,720
Sonoma Cr.	129.0	38.7	13	$51,600
Napa R. *	233.9	70.2	23	$93,560
Green Valley / Suisun Cr.	64.3	19.3	6	$25,720
San Pablo Cr.	8.5	2.6	1	$4,000
San Leandro Cr.	5.5	1.7	1	$4,000
San Lorenzo Cr.	18.6	5.6	2	$7,440
Alameda Cr. *	108.7	32.6	11	$43,480
Coyote Cr. *	109.3	32.8	11	$43,720
sub-total	**731**	**73**	**24**	**$299,240**
GRTS SGS Estimated Annual Cost (30%)				**$1,977,920**
GRTS SGS Estimated Annual Cost (40%)				**$2,637,227**

6.4.2 LIFE CYCLE MONITORING STATIONS

In this Plan, a minimum of one LCM station was recommended for each diversity stratum. In this chapter, NMFS provides cost estimates for one and two LCM station per diversity stratum. Although some LCM stations have already been established, others will be necessary across the recovery domain. Fixed station adult monitoring at the Pudding Creek LCM station (a small watershed) costs about $40,000 per year (Gallagher and Wright 2008; Gallagher *et al.* 2010) for monitoring adult escapement. This estimate does not include smolt or summer rearing abundance estimates, nor does it include data analysis and reporting. Operation of a LCM station in larger watersheds may cost twice as much ($80,000). Operating costs for an LCM in an urban watershed are also likely to be much higher than those in Pudding Creek. Based on the above values, annual cost estimates for adult monitoring counts at LCM stations within each diversity stratum will range between $504,000 to $1,008,000 (for 1 station per Diversity Stratum for small and large populations) and $1,008,000 to $2,016,000 (for 2 stations per Diversity Stratum for small and large populations) (Table 30). There are some initial "start-up" costs associated with LCMs that include purchase of equipment (weirs, traps, DIDSON), necessary facility installation/construction and testing. These costs are not provided as they will vary depending on the wide range of environmental settings and methods used to estimate fish abundance.

At Pudding Creek, the costs of conducting juvenile (smolt) steelhead and coho salmon monitoring (down-migrant counts) at the LCM stations range from approximately $15,000 to $30,000 per year. For larger populations, such as Redwood Creek in Humboldt County, annual costs for out-migrant trapping focused on CC Chinook salmon have been approximately $60,000 (S. Ricker, CDFW personal communication, September 2013). Based on these values, total annual cost estimates for juvenile (smolt) steelhead and Chinook salmon monitoring at the LCM stations may range between $315,000 and $840,000 (one station per diversity stratum for small and large populations) and between $630,000 to $1,680,000 (two stations per diversity stratum for small and large populations) (Table 30). The annual cost estimates (see bottom row of Table 30) for both adult and juvenile monitoring at LCM stations may be reduced substantially by selecting drainages with more than one listed salmonid species.

Table 30: Annual cost estimates for operating LCM stations in each diversity stratum (2 stations and 1 station per diversity stratum) and based on relative population/watershed size (large and small).

LCM Station - Adult

ESU/DPS	# of Diversity Strata	Adult Monitoring (Large, 2 stations)	Adult Monitoring (Small, 2 stations)	Adult Monitoring (Large, 1 station)	Adult Monitoring (Small, 1 station)
CC Chinook salmon	4	$576,000	$288,000	$288,000	$144,000
NC steelhead	5	$720,000	$360,000	$360,000	$180,000
CCC steelhead	5	$720,000	$360,000	$360,000	$180,000
Sub-Total		$2,016,000	$1,008,000	$1,008,000	$504,000

LCM Station - Juvenile

ESU/DPS	# of Diversity Strata	Juvenile Monitoring (Large, 2 stations)	Juvenile Monitoring (Small, 2 stations)	Juvenile Monitoring (Large, 1 station)	Juvenile Monitoring (Small, 1 station)
CC Chinook salmon	4	$480,000	$180,000	$240,000	$90,000
NC steelhead	5	$600,000	$225,000	$300,000	$112,500
CCC steelhead	5	$600,000	$225,000	$300,000	$112,500
Sub-Total		$1,680,000	$630,000	$840,000	$315,000
TOTAL		**$3,696,000**	**$1,638,000**	**$1,848,000**	**$819,000**

6.4.3 JUVENILE SPATIAL DISTRIBUTION AND ABUNDANCE

In populations with both steelhead and Chinook salmon, the distribution of juvenile steelhead would cover and exceed the distribution of CC Chinook (if present during summer and fall surveys). Therefore, the estimated annual costs for monitoring juvenile spatial distribution and abundance presented below are for NC and CCC steelhead only.

Assessing juvenile steelhead spatial distribution, abundance and habitat conditions using a spatially balanced GRTS-based sampling design will likely cost approximately $2,000 per reach to survey. Assuming a 10 percent sample effort and the rate of $2,000 per reach, estimated annual costs for monitoring juvenile steelhead spatial distribution would be: NC steelhead ($424,087) and CCC steelhead ($176,713). These estimates do not include data analysis, storage, or report preparation. Final sample size and reach variance issues will have to be developed for juvenile spatial structure (and habitat monitoring).

Table 31: Monitoring Actions for CC Chinook Salmon ESU and NC and CCC Steelhead DPSs

CC Chinook Action ID	NC Steelhead Action ID	CCC Steelhead Action ID	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs Entire Duration ($K)	Comment
ESU-CCCh-11.2	**DPS-NCSW-11.2**	**DPS-CCCS-11.2**	**Objective**	**Viability**	**Address the present or threatened destruction, modification, or curtailment of the species habitat or range**					
ESU-CCCh-11.2.1	DPS-NCSW-11.2.1	DPS-CCCS-11.2.1	Recovery Action	Viability	Monitor habitat quality and extent and watershed land use change					
ESU-CCCh-11.2.1.1	DPS-NCSW-11.2.1.1	DPS-CCCS-11.2.1.1	Action Step	Viability	Establish at least one Intensively Monitored Watershed (IMW) within each diversity stratum (preferably a population with a LCM station) to assess the habitat conditions and the effectiveness of implemented restoration actions.	2	50	CDFW, Counties, NGO, NOAA SWFSC, NPS, Private Consultants, Private Landowners, Resource Conservation Districts, Water Agencies	TBD	IMWs are watersheds that are monitored to the extent that the limiting factors are followed and the impact of management actions on fish or habitat can be demonstrated (see ISEMP at http://www.isemp.org/). Conduct power analysis early in development to determine amount of watershed required to be treated necessary to detect 30-50 percent change in population response. Also, use salmonid response (i.e., presence, abundance, and fitness monitoring) at restoration sites to inform effectiveness over time
ESU-CCCh-11.2.1.2	DPS-NCSW-11.2.1.2	DPS-CCCS-11.2.1.2	Action Step	Viability	Conduct implementation, effectiveness and validation monitoring for restoration projects where necessary and appropriate.	2	50	CDFW, Cities, Counties, NGO, NOAA SWFSC, NPS, NRCS, Private Consultants, Private Landowners, Resource Conservation Districts, State Parks, USFS, Water Agencies	0	Monitoring must be in accordance with the following specifications: a)The design and implementation of restoration actions should be reported and correlated with known habitat limiting factors, so cumulative impacts can be tracked across the ESU/DPS. b) Where restoration actions are implemented, effectiveness monitoring should be conducted at both the reach and site-specific scales following the Before After Control Impact (BACI) design; and c) Use salmonid response (i.e., presence, abundance, and fitness monitoring) at restoration sites to inform effectiveness over time. Cost estimates for these types of monitoring would be included in the total cost of individual restoration actions (see recovery actions). Action is considered in-kind.
ESU-CCCh-11.2.1.3	DPS-NCSW-11.2.1.3	DPS-CCCS-11.2.1.3	Action Step	Viability	Monitor land use and other non-landscape attributes using GIS. In addition to general land use patterns (i.e. agriculture, timber, and urban), other watershed-specific attributes that should be measured include: the extent of impervious surfaces, landslides, watershed road density, and overall riparian conditions. This should be repeated approximately every 10 years.	1	50	CDFW, Counties, NGO, NMFS, NPS, Private Consultants, Private Landowners, Resource Conservation Districts, US EPA, USFS, Water Agencies	TBD	

CC Chinook Action ID	NC Steelhead Action ID	CCC Steelhead Action ID	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs Entire Duration ($K)	Comment
ESU-CCCh-11.2.1.4	DPS-NCSW-11.2.1.4	DPS-CCCS-11.2.1.4	Action Step	Viability	Monitor storm-water and agricultural runoff to assess status/trends of turbidity and concentrations of other identified toxins and identify their sources. Where necessary, expand monitoring beyond those already implemented and required by other agencies or laws.	2	50	Cities, Counties, Farm Bureau, NGO, NPS, Private Consultants, Private Landowners, Resource Conservation Districts, State Parks, State Water Resources Control Board, Trout Unlimited, USEPA, USFS	TBD	Where necessary, expand monitoring beyond to other areas or increased frequency than those already required of by other agencies or laws.
ESU-CCCh-11.2.1.5	DPS-NCSW-11.2.1.5	DPS-CCCS-11.2.1.5	Action Step	Viability	Monitor water temperature throughout individual populations using arrays of automated data loggers (Isaak et al. 2011), particularly within populations with an LCM station or in populations where water temperature has been identified as a potential limiting factor.	1	50	California Coastal Conservancy, CDFW, Counties, NGO, NOAA SWFSC, NPS, Private Consultants, Private Landowners, Resource Conservation Districts, Trout Unlimited, USEPA, USFS, USGS, Water Agencies	TBD	Temperature data loggers (e.g., Onset HOBO v2 Data Loggers) cost approximately $130 per unit. Cost estimates per population would depend on the size of the watershed and number of units needed within each watershed. Also, cost for data management and analysis would need to be considered.
ESU-CCCh-11.2.1.6	DPS-NCSW-11.2.1.6	DPS-CCCS-11.2.1.6	Action Step	Viability	Monitor the status and spatial pattern of stream flows, particularly for populations where impaired stream flow was identified as a potential limiting factor.	2	50	CDFW, Cities, Counties, NGO, NOAA SWFSC, NPS, PG&E, Private Consultants, Private Landowners, Resource Conservation Districts, State Parks, State Water Resources Control Board, USEPA, USFS, USGS, Water Agencies	TBD	Where necessary, coordinate with USGS and/or local governments, non-governmental organizations and water agencies to install additional stream flow gages to assist with stream flow tracking. Seek funding to maintain existing facilities, particularly long-term monitoring gages that may be discontinued due to funding shortages.

CC Chinook Action ID	NC Steelhead Action ID	CCC Steelhead Action ID	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs Entire Duration ($K)	Comment
ESU-CCCh-11.2.1.7	DPS-NCSW-11.2.1.7	DPS-CCCS-11.2.1.7	Action Step	Viability	In accordance with the Coastal Monitoring Plan, develop and implement a water-quality and habitat-condition monitoring program for estuaries and seasonal bar-built lagoons	2	50	CDFW, Counties, NGO, NOAA/NMFS, NPS, Resource Conservation Districts, State Parks	TBD	As of Fall 2016, protocols and methods for monitoring water quality and habitat conditions in the estuaries/lagoons have not been developed for the CMP. At a minimum, lagoon water quality monitoring should be conducted for populations where the quality and extent of estuarine/lagoon habitat was identified as a current stress. This should include diurnal, seasonal, and event-based (i.e., a sudden change in weather, inflow, or management actions) monitoring of water temperature, dissolved oxygen, salinity profiles as well as an analysis of seasonal changes in freshwater inflow, depths, and invertebrate abundance and community composition. In addition, monitor the frequency, timing, and associated impacts (see above) of sand bar breaching for all lagoons where authorized and unauthorized manual breaching occurs.
ESU-CCCh-11.2.1.8	DPS-NCSW-11.2.1.8	DPS-CCCS-11.2.1.8	Action Step	Viability	As part of the Coastal Monitoring Plan, develop and implement a GRTS-based habitat status and trend monitoring program coordinated with the juvenile spatial structure evaluations	1	50	CDFW, Counties, NGO, SWFSC, Resource Conservation Districts, State Parks	TBD	The general methods for assessing habitat attributes will follow established programs such as the Columbia River Habitat Monitoring Program (CHaMP)
ESU-CCCh-11.3	**DPS-NCSW-11.3**	**DPS-CCCS-11.3**	**Objective**	**Viability**	**Address the overutilization for commercial, recreational, scientific or educational purposes**					
ESU-CCCh-11.3.1	DPS-NCSW-11.3.1	DPS-CCCS-11.3.1	Recovery Action	Viability	Monitor density, abundance, spatial structure and diversity					
ESU-CCCh-11.3.1.1			Action Step	Viability	In accordance with the Coastal Monitoring Plan, implement an unbiased GRTS-based monitoring program to assess CC Chinook salmon adult spawner abundance estimates at the ESU, diversity stratum, and, population level.	1	50	CDFW, Counties, NGO, NOAA SWFSC, NPS, Private Consultants, Private Landowners, Resource Conservation Districts, State Parks, Trout Unlimited, USACE, USGS, Water Agencies	53,000	See the Monitoring and Adaptive Management Chapter in Volume 1 for more information on adult spawner abundance cost estimates. Cost estimates are for 50 years of implementation and assume a minimum 30% sampling effort. Cost estimates likely to be higher with greater sampling effort. However, costs of spawning ground surveys will be shared across species for populations with multiple species (including coho salmon).

CC Chinook Action ID	NC Steelhead Action ID	CCC Steelhead Action ID	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs Entire Duration ($K)	Comment
	DPS-NCSW-11.3.1.1		Action Step	Viability	In accordance with the Coastal Monitoring Plan, implement an unbiased GRTS-based monitoring program to assess NC steelhead adult spawner abundance estimates at the DPS, diversity stratum, and, population level.	1	50	CDFW, Counties, NGO, NOAA SWFSC, NPS, Private Consultants, Private Landowners, Resource Conservation Districts, State Parks, Trout Unlimited, USACE, USGS, Water Agencies	131,000	See the Monitoring and Adaptive Management Chapter in Volume 1 for more information on adult spawner abundance cost estimates. Cost estimates are for 50 years of implementation and assume a minimum 30% sampling effort. Cost estimates likely to be higher with greater sampling effort. However, costs of spawning ground surveys will be shared across species for populations with multiple species (including coho salmon).
		DPS-CCCS-11.3.1.1	Action Step	Viability	In accordance with the Coastal Monitoring Plan, implement an unbiased GRTS-based monitoring program to assess CCC steelhead adult spawner abundance estimates at the DPS, diversity stratum, and, population level.	1	50	CDFW, Counties, NGO, NOAA SWFSC, NPS, Private Consultants, Private Landowners, Resource Conservation Districts, State Parks, Trout Unlimited, USACE, USGS, Water Agencies	99,000	See the Monitoring and Adaptive Management Chapter in Volume 1 for more information on adult spawner abundance cost estimates. Cost estimates are for 50 years of implementation and assume a minimum 30% sampling effort. Cost estimates likely to be higher with greater sampling effort. However, costs of spawning ground surveys will be shared across species for populations with multiple species (including coho salmon).
ESU-CCCh-11.3.1.2	DPS-NCSW-11.3.1.2	DPS-CCCS-11.3.1.2	Action Step	Viability	In accordance with the Coastal Monitoring Plan, establish a minimum of one (or preferably two) Life Cycle Monitoring stations within each diversity stratum to estimate spawner : redd ratios, conduct annual smolt abundance/trends, calibrate regional redd counts, and estimate smolt/adult ratios for marine/freshwater survival.	1	50	CDFW, Counties, NGO, NOAA SWFSC, NPS, Private Consultants, Private Landowners, Resource Conservation Districts, State Parks, USACE, USGS, Water Agencies	TBD	Strive to have abundance estimates at the LCM stations with a CV on average of 15 percent or less. Annual cost estimate is based on 1 LCM per diversity stratum in a large watershed. Annual cost estimates for LCM station monitoring could range from $819,000 (1 LCM per diversity stratum in a small watershed) to $3,696,000 (2 LCMs per diversity stratum in large watersheds). Final costs will depend on watershed size and number of LCMs per stratum. See the Monitoring and Adaptive Management Chapter in Volume 1 of the Multi-Species Recovery Plan for additional information on LCM cost estimates.

CC Chinook Action ID	NC Steelhead Action ID	CCC Steelhead Action ID	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs Entire Duration ($K)	Comment
ESU-CCCh-11.3.1.3			Action Step	Viability	In accordance with the Coastal Monitoring Plan, implement GRTS-based summer and fall sampling to assess the abundance, distribution and diversity of juvenile steelhead and Chinook salmon.	1	50	CDFW, Counties, NGO, NOAA SWFSC, NPS, Private Consultants, Private Landowners, Resource Conservation Districts, State Parks, Trout Unlimited, USACE, USGS, Water Agencies	0	Juvenile Chinook salmon are generally not present in freshwater during late summer and fall and their rare presence during this period would be observed while conducting spatially balanced surveys for juvenile steelhead. See DPS-NCSW-11.3.1.3 and DPS-CCCS-11.3.1.3
	DPS-NCSW-11.3.1.3		Action Step	Viability	In accordance with the Coastal Monitoring Plan, implement GRTS-based summer and fall sampling to assess the abundance, distribution and diversity of juvenile NC steelhead.	1	50	CDFW, Counties, NGO, NOAA SWFSC, NPS, Private Consultants, Private Landowners, Resource Conservation Districts, State Parks, Trout Unlimited, USACE, USGS, Water Agencies	21,300	Cost estimates are for 50 years of implementation. Annual cost estimate for juvenile spatial distribution, abundance and diversity would cost approximately $2,000 per reach. This estimate assumes a 10% sampling effort of the IP-km for steelhead. Cost of juvenile distribution surveys will be shared across species for populations with multiple species (i.e., coho salmon).
		DPS-CCCS-11.3.1.3	Action Step	Viability	In accordance with the Coastal Monitoring Plan, implement GRTS-based summer and fall sampling to assess the abundance, distribution and diversity of juvenile CCC steelhead.	1	50	CDFW, Counties, NGO, NOAA SWFSC, NPS, Private Consultants, Private Landowners, Resource Conservation Districts, State Parks, Trout Unlimited, USACE, USGS, Water Agencies	8,840	Cost estimates are for 50 years of implementation. Annual cost estimate for juvenile spatial distribution, abundance and diversity would cost approximately $2,000 per reach. This estimate assumes a 10% sampling effort of the IP-km for steelhead. Cost of juvenile distribution surveys will be shared across species for populations with multiple species (i.e., coho salmon).

CC Chinook Action ID	NC Steelhead Action ID	CCC Steelhead Action ID	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs Entire Duration ($K)	Comment
ESU-CCCh-11.3.1.4	DPS-NCSW-11.3.1.4	DPS-CCCS-11.3.1.4	Action Step	Viability	In accordance with the Coastal Monitoring Plan, develop a biological monitoring program for estuaries and seasonal, bar-built lagoons (particularly in LCM populations) that will track salmonid abundance and use of these habitats over time.	1	50	CDFW, Counties, NOAA SWFSC, NPS, Private Consultants, Resource Conservation Districts, State Parks, Trout Unlimited, USACE, USFWS, Water Agencies	TBD	These data can be used to document potential limiting factors (e.g., stresses) affecting salmonid rearing in these habitats and highlight emerging threats over time. The estuary/lagoon monitoring protocol for the CMP has not been developed yet. Costs will be determined at a later date.
ESU-CCCh-11.3.1.5	DPS-NCSW-11.3.1.5	DPS-CCCS-11.3.1.5	Action Step	Viability	Monitor incidental capture and mortality rates of CC Chinook salmon, NC steelhead, and CCC steelhead in the recreational freshwater fisheries reported from Steelhead Fishing Report-Restoration Cards and creel surveys conducted by CDFW	2	50	CDFW	0	Action is considered in-kind.
ESU-CCCh-11.3.1.6	DPS-NCSW-11.3.1.6	DPS-CCCS-11.3.1.6	Action Step	Viability	Continue to annually monitor and assess intentional and incidental capture and mortality rates of CC Chinook salmon, NC steelhead, and CCC steelhead resulting from permitted research to ensure established take limits are adequate to protect these species.	2	50	CDFW, NMFS PRD	0	Action is considered in-kind.
ESU-CCCh-11.3.2	DPS-NCSW-11.3.2	DPS-CCCS-11.3.2	Recovery Action	Viability	Prevent reduced density, abundance, and diversity					
ESU-CCCh-11.3.2.1	DPS-NCSW-11.3.2.1	DPS-CCCS-11.3.2.1	Action Step	Viability	Develop Fisheries Monitoring and Evaluation Plans (FMEP) that incorporate delisting criteria, does not limit attainment of population-specific criteria and are specifically designed to monitor and track catch and mortality of wild and hatchery salmon and steelhead stemming from recreational fishing in freshwater and the marine habitats	2	20	CDFW, NMFS	TBD	
ESU-CCCh-11.3.2.2	DPS-NCSW-11.3.2.2	DPS-CCCS-11.3.2.2	Action Step	Viability	Develop and implement an expanded Genetic Stock Index (GSI) monitoring program for Pacific salmonids. This will help track ocean migrations of Chinook salmon, their origin, and an index of incidental capture and mortality rates in the commercial and recreational fisheries.	3	50	CDFW, NMFS, NOAA SWFSC	0	Action is considered in-kind.
ESU-CCCh-11.3.2.3	DPS-NCSW-11.3.2.3	DPS-CCCS-11.3.2.3	Action Step	Viability	Encourage continued scientific research on the effects of Chinook salmon and steelhead population declines on reduced marine-derived nutrients in freshwater habitats (Hill et al. 2010; Moore et al. 2011)	2	50	CDFW, NMFS, NOAA SWFSC	0	Action is considered in-kind.
ESU-CCCh-11.3.2.4	DPS-NCSW-11.3.2.4	DPS-CCCS-11.3.2.4	Action Step	Viability	Continue coordination between NMFS and CDFW on revisions to freshwater sport fishing regulations to ensure impacts do no preclude CC Chinook salmon, NC steelhead, and CCC steelhead recovery and impacts to their populations during migrations are minimized	2	50	CDFW, NMFS	0	Action is considered in-kind.

CC Chinook Action ID	NC Steelhead Action ID	CCC Steelhead Action ID	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs Entire Duration ($K)	Comment
ESU-CCCh-11.4	**DPS-NCSW-11.4**	**DPS-CCCS-11.4**	**Objective**	**Viability**	**Address disease or predation**					
ESU-CCCh-11.4.1	DPS-NCSW-11.4.1	DPS-CCCS-11.4.1	Recovery Action	Viability	Increase density, abundance, spatial structure and diversity					
ESU-CCCh-11.4.1.1	DPS-NCSW-11.4.1.1	DPS-CCCS-11.4.1.1	Action Step	Viability	Annually, estimate the infection and mortality rates of juvenile Chinook salmon and steelhead from pathogens in populations where diseases are identified as a High or Very High threat	3	50	CDFW, Counties, NGO, NOAA SWFSC, NPS, Private Consultants, Private Landowners, State Parks, USGS, Water Agencies	TBD	Infection rates may be determined during spatial sampling throughout the ESU/DPS. Cost estimates for mortality rates would require further study and estimates of costs for these studies are unknown at this time. These would depend on the extent (severity and distribution) of the pathogens.
ESU-CCCh-11.4.1.2	DPS-NCSW-11.4.1.2	DPS-CCCS-11.4.1.2	Action Step	Viability	Annually monitor the status and trends of non-native predators in populations where predation is identified as a High or Very High threat.	3	50	CDFW, Counties, NGO, NOAA SWFSC, NPS, Private Consultants, Private Landowners, Resource Conservation Districts, State Parks, Water Agencies	TBD	General status and trends of non-native predators would partially be assessed during the spatially balanced GRTS sampling for juvenile distribution and abundance. Additional monitoring/funding may be necessary for populations with large or fluctuating populations of these species.
ESU-CCCh-11.4.1.3	DPS-NCSW-11.4.1.3	DPS-CCCS-11.4.1.3	Action Step	Viability	Coordinate with CDFW to develop and implement plans to assess the impacts of non-native predators on Chinook salmon and steelhead populations, and where necessary, reduce populations of these species	2	50	CDFW, NMFS	0	Action is considered in-kind.
ESU-CCCh-11.4.1.4	DPS-NCSW-11.4.1.4	DPS-CCCS-11.4.1.4	Action Step	Viability	During the 5-year status reviews, re-assessing the status of non-native predatory species in populations where predation was not originally identified as a High or Very High threat to ensure expansion of non-native predatory species or the introduction of new predatory species has not occurred	3	50	CDFW, NMFS	0	Action is considered in-kind.
ESU-CCCh-11.4.1.5	DPS-NCSW-11.4.1.5	DPS-CCCS-11.4.1.5	Action Step	Viability	Compile information on predation rates of juvenile steelhead and Chinook salmon by birds (freshwater and marine), pinnipeds, and introduced fish species (e.g., striped, largemouth, and smallmouth bass) and encourage additional research and monitoring to further evaluate their impacts and potential strategies for predation reduction	2	50	CDFW, NMFS	0	Action is considered in-kind.
ESU-CCCh-11.4.1.6	DPS-NCSW-11.4.1.6	DPS-CCCS-11.4.1.6	Action Step	Viability	Where applicable encourage implementation of Co nservation Hatchery programs for severely depress ed populations that follow criteria outlined in Spenc e et al. (2008) and CDFG (2004)	2	50	CDFW, NMFS, SWFSC	TBD	

CC Chinook Action ID	NC Steelhead Action ID	CCC Steelhead Action ID	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs Entire Duration ($K)	Comment
ESU-CCCh-11.5	**DPS-NCSW-11.5**	**DPS-CCCS-11.5**	**Objective**	**Viability**	**Address the inadequacy of existing regulatory mechanisms**					
ESU-CCCh-11.5.1	DPS-NCSW-11.5.1	DPS-CCCS-11.5.1	Recovery Action	Viability	Increase density, abundance, spatial structure and diversity					
ESU-CCCh-11.5.1.1	DPS-NCSW-11.5.1.1	DPS-CCCS-11.5.1.1	Action Step	Viability	Develop a recovery plan tracking system to track the implementation status of specific recovery actions identified in this recovery plan	1	20	NMFS	In-kind	
ESU-CCCh-11.5.1.2	DPS-NCSW-11.5.1.2	DPS-CCCS-11.5.1.2	Action Step	Viability	Monitoring the implementation and effectiveness of Best Management Practices (BMPs)	3	50	BLM, CDFW, Counties, NGO, NMFS, NRCS, Private Consultants, Resource Conservation Districts, State Parks, State Water Resources Control Board, USGS, Water Agencies	0	With the assistance of other Federal, State, and local resource agencies, track voluntary and required implementation of best management practices (BMPs) within each diversity stratum, compile any post-implementation data that may indicate the effectiveness of the implemented BMPs, and where necessary, conduct effectiveness monitoring of BMPs. Action is considered in-kind.
ESU-CCCh-11.5.1.3	DPS-NCSW-11.5.1.3	DPS-CCCS-11.5.1.3	Action Step	Viability	Develop and implement a randomized sampling program to determine whether permitees are in compliance with permits issued under local and State regulatory actions designed to protect riparian and instream habitat and applicable agencies are enforcing permit requirements.	2	50	CDFW, NMFS, SWRCB, USACE, USEPA, USFWS	TBD	
ESU-CCCh-11.5.1.4	DPS-NCSW-11.5.1.4	DPS-CCCS-11.5.1.4	Action Step	Viability	Work with CDFW to develop a revised protocol for implementing fish rescue for threatened species under NMFS' ESA section 4(d) rule (50 C.F.R. 223.203(b)(3)) that will enhance rescue response and efficiency, tracking relevant fisheries data obtained during the rescues (e.g., number/densities of fish per area rescued, age classes of rescued fish, and sex ratios of rescued adults), and developing criteria for estimating population-level benefits from the rescues.	1	50	CDFW, NMFS	0	Action is considered in-kind.
ESU-CCCh-11.6	**DPS-NCSW-11.6**	**DPS-CCCS-11.6**	**Objective**	**Viability**	**Address other natural or manmade factors affecting the species' continued existence**					
ESU-CCCh-11.6.1	DPS-NCSW-11.6.1	DPS-CCCS-11.6.1	Recovery Action	Viability	Increase density, abundance, spatial structure and diversity					
ESU-CCCh-11.6.1.1	DPS-NCSW-11.6.1.1	DPS-CCCS-11.6.1.1	Action Step	Viability	Develop and implement Hatchery and Genetic Management Plans (HGMPs). This will rely on the development of a consistent and timely approval process between CDFW and NMFS	2	20	CDFW, NMFS	TBD	

CC Chinook Action ID	NC Steelhead Action ID	CCC Steelhead Action ID	Level	Targeted Attribute or Threat	Action Description	Priority Number	Action Duration (Years)	Recovery Partners	Costs Entire Duration ($K)	Comment
ESU-CCCh-11.6.1.2	DPS-NCSW-11.6.1.2	DPS-CCCS-11.6.1.2	Action Step	Viability	Conduct annual assessments of the percent of hatchery origin spawners (pHOS) where applicable	1	50	CDFW, NGO, NMFS, NOAA SWFSC, NPS, Pacific States Marine Fisheries Commission, Private Consultants, Private Landowners, Resource Conservation Districts, State Parks, Water Agencies	0	To achieve broad sense recovery, pHOS should not exceed 10 percent in any population. Estimates of percent hatchery origin would developed using data obtained from spawning ground surveys and from both LCMs and hatcheries. Action is considered in-kind.
ESU-CCCh-11.6.1.3	DPS-NCSW-11.6.1.3	DPS-CCCS-11.6.1.3	Action Step	Viability	Encourage funding for the continuation and expansion of the SWFSC's ocean net surveys conducted as part of their California Current Salmon Ocean Survey	2	50	CDFW, NMFS, NOAA SWFSC, Pacific States Marine Fisheries Commission	0	Action is considered in-kind.

6.5 MONITORING LISTING FACTORS

In addition to monitoring for biological criteria, recovery plans must also provide monitoring strategies to address each of the ESA Section 4(a)(1) listing factors. These are tracked using the key habitat attributes used in the CAP analysis. In addition, NMFS developed criteria and monitoring recommendations to track reduction in threats and implementation of recovery actions. The criteria and recommended monitoring are designed to track the effectiveness of actions specifically implemented to improve current habitat conditions, reduce the impacts of current threats (and the stresses they contribute to), or highlight new and emerging threats.

6.5.1 LISTING FACTOR A: THE PRESENT OR THREATENED DESTRUCTION, MODIFICATION, OR CURTAILMENT OF THE SPECIES' HABITAT OR RANGE

Recommendations for monitoring changes under Listing Factor A include:

1. As part of the CMP, develop and implement a GRTS-based habitat status and trend monitoring program coordinated with the juvenile spatial structure evaluations.
    a. The CMP Technical Teams are currently developing a standardized survey method for evaluating habitat attributes. Once competed and implemented, the monitoring will incorporate consistent habitat monitoring protocols that provide comparable watershed information and integrate ongoing habitat assessment work into a master GRTS sample design. The general methods for assessing habitat attributes will follow established programs such as the Columbia River Habitat Monitoring Program (CHaMP)[30].
    b. In addition to the GRTS-based monitoring discussed above, select one population within each diversity stratum (a LCM station) to conduct a basin-wide intensive

[30] http://www.nwfsc.noaa.gov/research/divisions/cb/mathbio/isemp.cfm

habitat assessment which is repeated every 12-15 years[31] and;

c. Approximately every 10 years[32] or as data become available, assess changes in land use and other non-landscape attributes using remote sensing. In addition to general land use patterns (*i.e.* agriculture, timber, and urban), other watershed-specific attributes that should be measured include: the extent of impervious surfaces, landslides, watershed road density, and overall riparian conditions. These assessments should follow other established programs such as the The Riverscape Analysis Project[33].

2. Implementation of habitat restoration activities should consider some level of effectiveness and validation monitoring components (Roni and Beechie 2012; see also ISEMP at http://www.isemp.org/), particularly at projects where information may inform important data gaps. NMFS is currently emphasizing the importance of effectiveness monitoring as one of its priorities for the Pacific states seeking Pacific Coastal Salmon Recovery Funds (Whiteway *et al.* 2010; NMFS 2012). Work in populations with LCM stations and other intensively monitored watersheds should also incorporate validation monitoring according to the following specifications:
   a. The design and implementation of all restoration actions must be reported and correlated with known habitat limiting factors (existing CAP results), so cumulative impacts can be tracked across the ESU/DPS. Additional limiting factors may be identified during the GRTS habitat surveys and/or during more intensive watershed-scale habitat assessments;
   b. Reach scale, or project, effectiveness monitoring should be conducted for various habitat improvement categories using a robust statistical design such as a Before and

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[31] The 12-15 year period represents approximately 4 generations of steelhead and Chinook salmon. This is the period for which adult populations counts of each species should be made to determine their status (Spence *et al.* 2008).

[32] Changes in land use patterns should be revisited on an approximate decadal scale in order to better understand the rate and extent of change for various attributes across the landscape.

[33] http://rap.ntsg.umt.edu/

After Control Impact (BACI) design whenever possible (Crawford and Rumsey 2011). Recovery entities should coordinate their monitoring to reduce costs and improve sample size. However, where designs such as BACI cannot be conducted, an extensive post-treatment design is likely a cost-effective and usable substitute for a BACI design. See (Hilborn, 1992) for other statistical designs that have power to detect change.;

c. Establish at least one Intensively Monitored Watershed (IMW) (as detailed in Crawford and Rumsey 2011) within each diversity stratum (preferably a population with a LCM station). IMWs are watersheds that are monitored to the extent that the limiting factors are followed and the impact of management actions on fish or habitat can be demonstrated (see ISEMP). Conduct power analysis early in development to determine amount of watershed required to be treated necessary to detect 30-50 percent change in population response; and,

d. Use salmonid response (*i.e.*, presence, abundance, and fitness monitoring) at restoration sites to inform effectiveness over time.

3. Conduct annual assessments of the status and spatial patterns of water quality and stream flow conditions within individual populations and across Diversity Strata.

   a. EPA, state agencies, and local governments should monitor storm-water and agricultural runoff to assess status/trends of turbidity and concentrations of other identified toxins and identify their sources;

   b. Basin-wide water temperature monitoring using stratified arrays of automated data loggers (Isaak *et al.* 2011) should be implemented wherever feasible, particularly within each watershed with an LCM station. In addition, water temperature monitoring using data loggers should be conducted in streams within populations where water temperature has been identified as Fair or Poor; and,

   c. Annually monitor the status and spatial pattern of stream flows, particularly for populations where impaired stream flow was rated as Fair or Poor. Where necessary, coordinate with USGS and/or local governments, non-governmental organizations and water agencies to install additional stream flow gages to assist with stream flow tracking. Seek funding to maintain existing facilities, particularly long-term monitoring gages that may be discontinued due to funding shortages.

4. As part of the CMP, develop and implement a water-quality and habitat-condition monitoring program for estuaries and seasonal bar-built lagoons.
    a. At a minimum, lagoon water quality monitoring should be conducted for populations where the quality and extent of estuarine/lagoon habitat was identified as a current stress. This should include diurnal, seasonal, and event-based (*i.e.,* a sudden change in weather, inflow, or management actions) monitoring of water temperature, dissolved oxygen, salinity profiles as well as an analysis of seasonal changes in freshwater inflow, depths, and invertebrate abundance and community composition;
    b. Monitor the frequency, timing, and associated impacts (see above) of sand bar breaching for all lagoons where authorized and unauthorized manual breaching occurs; and
    c. Work closely with local governments and state agencies to develop strategies to reduce the frequency of sand bar breaching, particularly during the critical summer rearing period. This should include outreach materials (*e.g.,* posting signs outlining the legal and biological implications of sand bar breaching and increasing enforcement patrols during critical summer months or when lagoons are near capacity).

6.5.2 LISTING FACTOR B: OVER-UTILIZATION FOR COMMERCIAL, RECREATIONAL, SCIENTIFIC OR EDUCATIONAL PURPOSES

Recommendations for monitoring changes under Listing Factor B include:

1. A comprehensive and coast-wide monitoring program tracking the freshwater and ocean catch/harvest of CC Chinook salmon, NC steelhead, and CCC steelhead does not exist. Therefore, NMFS recommends:
    a. Developing Fisheries Management and Evaluation Plans (FMEP) that: (1) incorporate delisting criteria, (2) determine impacts of fisheries management in terms of VSP parameters, (3) do not limit attainment of population-specific criteria, (4) annually

estimate the commercial and recreational fisheries bycatch and mortality rate, (5) are specifically designed to monitor and track catch and mortality of wild and hatchery salmon and steelhead stemming from recreational fishing in freshwater and the marine habitats, and (6) provide for adaptive management options as needed to ensure actual fisheries impacts do not exceed those consistent with recovery goals.

   b. Develop funding for the continued implementation, refinement, and expansion of the GSI monitoring of Pacific salmon. This will help track ocean migrations of Chinook salmon, their origin, and an index of incidental capture and mortality rates in the commercial and recreational salmon fisheries.

2. Encouraging continued scientific research on the effects of Chinook salmon and steelhead population declines on reduced marine-derived nutrients in freshwater habitats (Hill *et al.* 2010; Moore *et al.* 2011).
3. Continuing coordination between NMFS and CDFW on revisions to freshwater sport fishing regulations to ensure impacts do not preclude CC Chinook salmon, NC steelhead, and CCC steelhead recovery and impacts to their populations during migrations are minimized.
4. Annually reviewing results from Steelhead Fishing Report-Restoration Cards and creel surveys conducted by CDFW to assess incidental capture and mortality rates of CC Chinook salmon, NC steelhead, and CCC steelhead in the recreational freshwater fisheries.
5. Continuing to annually monitor and assess intentional and incidental capture and mortality rates of CC Chinook salmon, NC steelhead, and CCC steelhead resulting from permitted research to ensure established take limits are adequate to protect these species Utilizing the results of this research to help assess population status.

6.5.3 LISTING FACTOR C: DISEASE OR PREDATION

Recommendations for monitoring changes under Listing Factor C include:

1. Annually estimating the infection and mortality rates of juvenile Chinook salmon and steelhead from pathogens in populations where diseases are identified as a High or Very High threat;
2. Annually monitoring the status and trends of non-native predators in populations where predation is identified as a High or Very High threat. Coordinate with CDFW to develop and implement plans to track their impacts on Chinook salmon and steelhead populations, and where necessary, reduce populations of these predatory, non-native species;
3. During the 5-year status reviews, re-assessing the status of non-native predatory species in populations where predation was not originally identified as a High or Very High threat to determine whether expansion of non-native predatory species or the introduction of new predatory species has occurred; and
4. Compiling information on predation rates of juvenile steelhead and Chinook salmon by birds (freshwater and marine), pinnipeds, and introduced fish species (*e.g.,* striped, largemouth, and smallmouth bass) and encouraging additional research and monitoring to further evaluate their impacts and potential strategies for predation reduction.

6.5.4 LISTING FACTOR D: THE INADEQUACY OF EXISTING REGULATORY MECHANISMS

Recommendations for monitoring changes under Listing Factor D include:

1. Developing a recovery plan tracking system to track the implementation status of specific recovery actions identified in this recovery plan;
2. Monitoring the implementation and effectiveness of Best Management Practices (BMPs). With the assistance of other Federal, State, and local resource agencies, track voluntary and required implementation of BMPs within each diversity stratum, compile any post-implementation data that may indicate the effectiveness of the implemented BMPs, and where necessary, conduct effectiveness monitoring of BMPs;

3. Developing and implementing a randomized sampling program to test whether conditions of permits issued under local and State regulatory actions designed to protect riparian and instream habitat are being met and that the provisions have been enforced; and;
4. Working with CDFW to develop a revised protocol for implementing fish rescue for threatened species under NMFS' ESA section 4(d) rule (50 C.F.R. 223.203(b)(3)) that will enhance rescue response and efficiency, tracking relevant fisheries data obtained during the rescues (*e.g.*, number/densities of fish per area rescued, age classes of rescued fish, and sex ratios of rescued adults), and developing criteria for estimating population-level benefits from the rescues.

6.5.5 Listing Factor E: Other natural or manmade factors affecting the species' continued existence

Recommendations for monitoring changes under Listing Factor E include:

1. Monitoring the effects of climate change on CC Chinook salmon, NC steelhead, and CCC steelhead and their habitats should include expanding stream flow and water temperature monitoring and the effects of climate change on freshwater and estuarine survival;
2. Tracking ocean conditions (*i.e.* productivity) relying on monitoring data obtained from the LCM stations (ocean survival), ocean net surveys conducted by the SWFSC as part of their California Current Salmon Ocean Survey (early ocean survival/condition), hatchery returns, and compiling and assessing existing and ongoing oceanic data collected by satellites and buoy arrays throughout the northeastern Pacific Ocean;
3. Where applicable, conducting annual assessments of the percent of hatchery origin spawners (pHOS). To achieve broad sense recovery, pHOS should be less than 10 percent in any population (McElhaney *et al*. 2000); and
4. Developing and implementing Hatchery and Genetic Management Plans (HGMPs). This will rely on the development of a consistent and timely approval process between CDFW and NMFS.

6.5.6 DATA MANAGEMENT AND REPORTING

All monitoring data must be coordinated in a regional set of databases or distributed data system using a common set of metadata and data dictionaries that fits within an integrated master sample program. This should be housed and maintained in one place by one entity. All entities collecting habitat and fish monitoring data should coordinate their sampling and data collection to fit into a master sample program.

Currently, CMP data are collected in the field using handheld devices which are then transferred initially to distributed (individual) Microsoft Access databases. The data are then uploaded to the Aquatic Survey Program database. The CMP technical team is assisting CDFW's Information Technology Branch on the development of a centralized database system.

6.5.7 POST-DELISTING MONITORING

ESA section 4(g) requires NMFS to implement a system in cooperation with the states to monitor delisted species for at least five years after delisting to ensure that removal of the protections of the ESA does not result in a return to threatened or endangered status. The development of a post-delisting monitoring plan is therefore recommended to ensure a plan is in place at the time of delisting.

6.6 ADAPTIVE MANAGEMENT: LEARNING FROM RECOVERY

Adaptive management is a systematic process that uses scientific methods for monitoring, testing, and adjusting resource management policies, practices, and decisions based on specifically defined and measurable objectives and goals (Panel on Adaptive Management for Resource Stewardship 2011). Adaptive management is predicated on the recognition that natural resource systems are variable and that knowledge of natural resource systems is often uncertain. Further, the response of natural resource systems to restoration and management actions is complex and frequently difficult to predict with precision. This Recovery Plan provides both overall goals in the form of viability criteria and a suite of ESU/DPS-wide watershed specific recovery actions. However, there is a need to adapt resource management policies, practices, and research decisions to changing circumstances and to adopt a better understanding of natural resource systems and their responses.

The success of an adaptive management program depends on coordination among stakeholders and scientists who should develop a shared vision for an adaptive management program that will align interests and enhance cooperation in a complex recovery plan process. Maintaining a shared vision may lead to finding new alternative solutions.

Adaptive management can be applied at two basic levels: the overall goals of the recovery effort and the individual recovery or management actions undertaken in pursuit of overall goals. The monitoring sections above are intended to address the first application. The following discussion is focused on the second application of the concept of adaptive management.

6.6.1 Elements of an Adaptive Management Program

While adaptive management must be tailored to action-, site- and impact-specific issues, any effective adaptive management programs will contain three basic components: 1) adaptive experimentation where scientists and others with appropriate expertise learn about the response of ecosystem function to recovery or management actions; 2) social learning through public education and outreach where stakeholders share in the knowledge gained about ecosystem functions; and 3) institutional structures and processes of governance where people respond by making shared decisions regarding how the ecosystem will be managed and how the natural services it provides will be allocated. (Thomas *et al.* 2001) identified the following six specific elements associated with adaptive management:

1st Element: Recovery Strategy and Actions are Regularly Revisited and Revised

The recovery strategy and actions should be regularly reviewed in an iterative process to maintain focus and allow revision when appropriate. Progress and implementation of the recovery actions at the ESU, diversity stratum, and population scales should provide a starting point for the adjustment of recovery strategy and actions. The mandatory five-year review process can serve as a means of conveying any needed modification to the overall recovery strategy, as well as individual recovery actions.

2nd Element: Model(s) of the System Being Managed

Four types of models are identified in the use of adaptive management program to test hypotheses regarding the effectiveness of recovery actions (Ruckelshaus *et al.* 2008; Levin *et al.* 2009; Tallis *et al.* 2010). These include:

a. **Conceptual model:** Synthesis of current scientific understanding, field observation and professional judgment concerning the species, or ecological system;
b. **Diagrammatic model:** Explicitly indicates interrelationships between structural components, environmental attributes and ecological processes;
c. **Mathematical model:** Quantifies relationships by applying coefficients of change, formulae of correlation/causation; and,
d. **Computational Model:** Aids in exploring or solving the mathematical relationships by analyzing the formulae on computers.

River systems are generally too complex and unique for controlled, replicated experiments per traditional scientific models. However, conceptual models based on generally recognized scientific principles can provide a useful framework for refining recovery actions and testing their effectiveness. Diagrammatic models, such as the one used to characterize the parallel and serial linkages in the Chinook salmon and steelhead life cycles, can also be used in lieu of formal mathematical models to test hypotheses regarding the effectiveness of recovery actions. Mathematical and computational models themselves have their limitations in the context of an adaptive management program—they are difficult to explain and require specific assumptions that may be difficult to justify. Nevertheless, such models can be useful for highlighting where a better understanding of the system is needed, identifying additional limiting factors as well as allowing a formal process where managers can assess the potential impact upon populations resulting from a suite of proposed restoration scenarios.

3rd Element: A Range of Management Choices

Even when a recovery strategy is agreed upon, uncertainties about the ability of possible recovery or management actions to achieve that strategy are common. The range of possible recovery or management choices should be considered at the outset. This evaluation addresses the likelihood of achieving management objectives and the extent to which each alternative will generate new information or foreclose future choices. A range of recovery actions and management measures should be considered during the environmental review process or by the results generated from a restoration scenario based assessment using mathematical and computational models prior to permitting the individual recovery action.

4th Element: Monitoring and Evaluation of Outcomes

Gathering and evaluating data allow testing of alternative hypotheses and are central to improving knowledge of ecological and other systems. Monitoring should focus on significant and measurable indicators of progress toward meeting recovery objectives. Monitoring programs and their results should be designed to improve understanding of environmental systems and models, to evaluate the outcomes of recovery actions, and to provide a basis for improved decision making. It is critical that "thresholds" for interpreting the monitoring results are identified during the planning of a monitoring program. This element of adaptive management will require a design based upon scientific knowledge and principles. Practical questions include which indicators to monitor and when and where to monitor. Guidance on a number of these issues is provided in the sections above regarding research and monitoring.

5th Element: A Mechanism for Incorporating Learning into Future Decisions

This element recognizes the need for protocols and guidance to disseminate information to a variety of stakeholders and a decision process for adjusting various management measures in view of the monitoring findings. Periodic evaluations of a proposed recovery action, monitoring data and other related information, and decision-making should be an iterative process where management objectives are regularly revisited and revised accordingly. This process could be formalized with a dynamic limiting factors model. Public outreach, including web-based programs, should be actively pursued. Additionally, the mandatory five-year review process can serve as the process for conveying needed modification to the Recovery Plan including individual recovery actions.

6th Element: A Collaborative Structure for Stakeholder Participation and Learning

This element includes dissemination of information to a variety of stakeholders as well as a proactive program for soliciting decision-related inputs. This general framework can be a shared vision to develop and pursue restoration that supports a network of viable Chinook salmon and steelhead populations while providing sustainable ecological services to the human communities of northern and central coasts of California (NMFS 2010). Such a vision also provides opportunities for the protection and restoration of other native freshwater and riparian species which form an integral part of the ecosystems upon which Chinook salmon and steelhead depend.

7.0 FOCUSING RESOURCES FOR RECOVERY

It is not the strongest of the species that survives, nor the most intelligent that survives. It is the one that is the most adaptable to change.

Charles Darwin

Historically, wild salmon and steelhead provided an important food and cultural resource to Native American communities and the vibrant local communities and businesses following European settlement. Today, to protect, recover, and sustainably manage these species, it is necessary to address the challenges that expanding human populations and associated land uses create. This Plan offers a strategy that focuses on restoration, threat abatement, and improvements in regulatory mechanisms for salmonids throughout their entire lifecycle. Scientists have widely considered the life cycle as a whole to assess limiting factors, but it has been rarely applied to guide conservation, restoration, and recovery actions. Focusing on all life stages of the species, instead of just one stage, offers a more coordinated approach to implementing actions from the headwaters to the sea. For example, improving fish passage is a widely-accepted restoration practice, but unless upstream habitat conditions can support all life stages of salmonids, this single action will have little benefit. Indeed, recovery will depend on utilizing a more holistic approach to restoration that weighs benefits, costs, and priorities with the goal of the survival of salmonids during each key life stage.

7.1 PRIORITIZING POPULATIONS FOR RESTORATION AND FOCUS

While immediately working to restore and recover all populations simultaneously would be preferable, the cost to implement such an effort is prohibitive. Instead, initially focusing efforts in fewer watersheds provides the best chance for species recovery. Decisions to focus efforts and funding to specific areas do not imply other areas are less important or not needed for recovery.

Rather, decisions to prioritize populations are necessary to ensure efforts are optimizing benefits to fisheries and ecosystem processes across each of the ESU/DPSs. This prioritization protocol was used to identify essential populations, based on a consistent protocol, that are closest to achieving recovery and that are important to the recovery of the overall Diversity Strata.

NOAA Fisheries evaluated all the essential (i.e. must meet low viability criteria) CCC and NC steelhead and CC Chinook salmon populations within the recovery plans using a prioritization framework based on Bradbury et al. (1995). Oregon State Senate President, Bill Bradbury, asked the Pacific Rivers Council for help in assembling a diverse group to create a prioritization process for effective and scientifically-sound watershed protection and restoration. The framework developed provides a common basis from which diverse groups can develop mutually agreed-upon restoration priorities reflecting a strong scientific basis (Bradbury et al. 1995).

The prioritization framework uses three criteria groupings for ranking populations:

1. biological and ecological resources (Biological Importance);
2. watershed integrity and risk (Integrity and Risk); and
3. potential for restoration (Optimism and Potential).

The following tables are the prioritization results for each species (Table 32, Table 33, Table 34). Please see Appendix H for a more detailed discussion of methods and for the scores and supporting information for each population.

Table 32: CC Chinook Restoration and Focus Prioritization Results

Diversity Strata	California Coastal Chinook Salmon Populations	Biological & Ecological			Integrity & Risk			Optimism & Potential			Total	Priority #
		CAP Biological Viability (Weighted)	Number of Listed Species	High IP-km	CAP Watershed Characterization	CAP Threats	Public Lands	CCC Coho Focus Population	SONCC Core 1 Population	Monitoring (LCM) Priority		
North Coastal	Redwood Creek	4	3	3	3	1	3	0	1	1	19	A
North Coastal	Little River	2	3	1	1	1	1	0	0	0	9	B
North Coastal	Mad River	6	3	2	2	1	3	0	0	0	17	A
North Coastal	Humboldt Bay Tributaries	4	3	2	1	1	2	0	1	1	15	B
North Coastal	South Fork/ Lower Mainstem Eel River	4	3	3	2	1	2	0	1	1	17	A
North Coastal	Bear River	6	3	1	1	1	1	0	0	0	13	B
North Coastal	Mattole River	6	3	3	3	3	3	0	0	0	21	A
North Mountain Interior	Van Duzen River	4	3	2	1	1	2	0	1	1	15	B
North Mountain Interior	Larabee Creek	4	3	1	1	3	1	0	1	0	14	B
North Mountain Interior	Upper Eel River	2	3	3	3	3	3	0	0	0	17	A
North-Central Coastal	Ten Mile River											C
North-Central Coastal	Noyo River	2	3	1	1	3	2	1	0	1	14	B
North-Central Coastal	Big River	2	3	2	3	3	3	1	0	0	17	A
North-Central Coastal	Albion River											C
Central Coastal	Navarro River											C
Central Coastal	Garcia River	2	3	1	3	1	1	1	0	1	13	B
Central Coastal	Gualala River											C
Central Coastal	Russian River	2	3	3	2	1	1	1	0	1	14	A

Table 33: NC steelhead Restoration and Focus Prioritization Results

Diversity Strata	Northern California Steelhead Populations	Biological & Ecological			Integrity & Risk		Optimism & Potential				Total	Extant Summer Steelhead (+)	Priority #
		CAP Biological Viability (Weighted)	Number of Listed Species	High IP-km	CAP Watershed Characterization	CAP Threats	Public Lands	CCC Coho Focus Population	SONCC Core 1 Population	Monitoring (LCM) Priority			
Northern Coastal	Redwood Creek	4	3	3	2	1	3	0	1	1	18	+	A
	Maple Creek/Big Lagoon	6	2	1	1	2	1	0	0	0	13		B
	Little River	2	3	1	1	2	1	0	0	0	10		B
	Mad River	2	3	3	2	1	3	0	0	1	15	+	A
	Humboldt Bay Tributaries	4	3	2	1	1	2	0	1	1	15		A
	Lower Mainstem Eel River												C
	Howe Creek												C
	Guthrie Creek												C
	Oil Creek												C
	South Fork Eel River	6	3	3	2	1	3	0	1	1	20		A
	Bear River	6	3	2	1	1	1	0	0	0	14		B
	McNutt Gulch												C
	Mattole River	6	3	3	2	1	2	0	0	1	18	+	A
	Spanish Creek												C
	Big Creek												C
	Big Flat Creek												C
	Shipman Creek												C
	Telegraph Creek												C
	Jackass Creek												C
Lower Interior	Jewett Creek												C
	Chamise Creek	2	3	1	3	2	2	0	1	0	14		A
	Bell Springs Creek												C
	Woodman Creek	2	3	1	3	2	3	0	1	0	15		A
	Outlet Creek	2	3	2	1	2	1	0	1	1	13		B
	Garcia Creek												C
	Tomki Creek	2	3	1	2	2	2	0	1	0	13		B
	Soda Creek												C
	Bucknell Creek												C
North Mountain Interior	Van Duzen River	6	3	3	1	1	2	0	1	1	18	+	A
	Larabee Creek	4	3	1	1	2	1	0	1	0	13		B
	Dobbyn Creek												C
	North Fork Eel River	6	3	3	2	2	3	0	0	0	19		A

	Middle Fork Eel River	4	3	3	3	1	3	0	0	1	18	+	A
	Upper Mainstem Eel River	2	3	2	2	1	3	0	0	0	13		B
North Central Coastal	Usal Creek	6	2	1	2	2	1	1	0	0	15		B
	Cottaneva Creek												C
	Wages Creek	2	2	1	2	2	1	1	0	0	11		B
	Pudding Creek												C
	Ten Mile River	4	3	2	1	1	1	1	0	1	14		A
	Noyo River	4	3	2	2	3	2	1	0	1	18		A
	Caspar Creek	4	2	1	2	2	3	1	0	0	15		B
	Big River	2	3	2	1	3	3	1	0	0	15		A
	Albion River												C
Central Coastal	Navarro River	2	3	3	1	2	2	1	0	1	15		A
	Elk Creek												C
	Brush Creek												C
	Garcia River	4	3	2	2	1	1	1	0	1	15		A
	Schooner Gulch												C
	Gualala River	2	3	3	3	1	1	1	0	0	14		B

Table 34: CCC steelhead Restoration and Focus Prioritization Results

Diversity Strata	Central California Coast Steelhead Populations	Biological & Ecological			Integrity & Risk		Optimism & Potential			Total	Priority #
		CAP Biological Viability (Weighted)	Number of Listed Species	Amount of High IP-km	CAP Watershed Characterization	CAP Threats	Public Lands	CCC Coho Focus Population	Monitoring (LCM) Priority		
North Coastal	Austin Creek	6	2	3	3	3	2	1		20	A
	Porter Creek										C
	Green Valley Creek	4	2	1	1	1	1	1		11	B
	Hulbert Creek										C
	Dutch Bill Creek										C
	Freezeout Creek										C
	Sheephouse Creek										C
	Willow Creek										C
	Salmon Creek	6	2	1	2	3	1	1		16	B
	Estero Americano										C
	Walker Creek	6	2	2	3	3	1	1		18	A
	Drakes Bay										C
	Lagunitas Creek	6	2	2	2	3	3	1	1	20	A

	Pine Gulch										C
	Redwood Creek (Marin Co.)										C
Interior	Crocker Creek										C
	Gill Creek										C
	Miller Creek										C
	Sausal Creek										C
	Mark West Creek	4	3	3	1	2	1	1		15	B
	Dry Creek	4	3	3	2	3	2	1	1	19	A
	Maacama Creek	6	3	2	3	3	1	1		19	A
	Upper Russian River	4	3	3	3	2	2	0		17	B
Santa Cruz Mountains	Pilarcitos Creek	2	1	1	2	1	3	0		10	B
	Tunitas Creek										C
	San Gregorio Creek	4	2	2	3	1	2	1		15	B
	Pescadero Creek	6	2	2	3	1	3	1	1	19	A
	Gazos Creek										C
	Waddell Creek	4	2	1	3	3	3	1		17	A
	Scott Creek	4	2	2	3	3	1	1	1	17	A
	San Vicente Creek										C
	Laguna Creek										C
	San Lorenzo River	4	2	3	2	1	2	1		15	B
	Soquel Creek	6	2	3	2	2	2	1		18	A
	Aptos Creek	4	2	2	2	1	3	1		15	B
Coastal San Francisco Bay	Novato Creek	2	1	1	1	2	3	0		10	B
	Miller Creek										C
	Corte Madera Creek	2	1	1	1	2	3	0		10	B
	Arroyo Corte Madera del Presidio										C
	San Mateo										C
	Guadalupe River	2	1	2	1	2	2	0		10	B
	Stevens Creek	2	1	2	1	2	3	0	1	12	A
	San Francisquito Creek	2	1	1	1	3	3	0	1	12	A
Interior San Francisco Bay	Petaluma River	2	1	1	1	2	1	0		8	B
	Sonoma Creek	4	1	3	1	1	2	0	1	13	A
	Napa River	4	1	3	1	1	1	0	1	12	A
	Green Valley/Suisun Creek	2	1	1	2	2	1	0		9	B
	Pinole Creek										C
	San Pablo Creek										C
	Wildcat Creek										C
	Codornices Creek										C
	San Leandro Creek										C
	San Lorenzo Creek										C
	Alameda Creek	2	1	3	2	1	2	0		11	A
	Coyote Creek	2	1	3	1	1	3	0		11	B

7.2 RESTORING OUR WATERSHEDS

To sequence and implement actions, NMFS proposes a framework to maximize the probability of recovery within an accelerated timespan. Action implementation should be based on the potential of the action to effectuate recovery regardless of difficulty, expense, controversy, and popularity and should involve:

- Coordinating restoration work in each watershed to address the poorest conditions and highest threats across life stages, including near-shore environments and the estuary;
- Implementing actions (described in Volumes II, III, and IV) that significantly improve the probability of survival and abundance of the most threatened life stage;
- Incorporating resiliency to climate change in planning; and
- Championing implementation of actions addressing listing factors, including those identified as inadequate regulatory mechanisms.

7.3 RESTORATION PROJECT PLANNING

Salmon recovery is a shared responsibility that requires action at all levels of government and by all stakeholders. Building partnerships among federal, state, local, and tribal entities together with non-governmental and private organizations is key to restoring healthy salmon runs and securing the economic and cultural benefits they provide.

Effective salmon recovery should be implemented at the local level, but NMFS staff can play a key role in the recovery process, including: providing scientific and policy support, providing funding as available, and working with our partners to improve regulatory mechanisms for salmon recovery. NMFS is committed to working with its partners and stakeholders to restore salmon so we can all share the benefits of this common resource. Many federal, state, local, and private entities have participated in and made important contributions to recovery planning and implementation.

Collaboration is essential for recovery because many restoration and recovery actions are voluntary. To date, the time and resources dedicated to salmon restoration have yielded significant benefits. This work must continue in order to shift the trajectory from extinction to recovery. Recovery will require continued collaboration and focus to strategically implement recovery actions. NMFS will rely on and commit to collaboration, cooperation, technical assistance, outreach, education, and dialog with our recovery partners. In this time of budget reduction and greater competition for available resources, it is imperative that recovery partners:

- Build projects from recovery actions outlined in this recovery plan;
- Develop partnerships across and between watersheds for information exchange and efficiency;
- Develop a comprehensive pool of resources beyond PCSRF and FRGP funding;
- Work with government entities to simplify permitting processes and incentivize restoration; and
- Contact NMFS for technical assistance and early coordination prior to project submission.

7.3.1 FUNDING, PERMITTING AND PARTNERSHIPS

Securing funding and obtaining necessary permits can be a complex process for those developing and implementing salmon restoration projects. Sources of funding for restoration include FRGP, NOAA Restoration Center, RWQCB, Coastal Conservancy, Integrated Regional Water Management, EPA, NRCS, Trout Unlimited, Natural Resource Conservation Service, Wildlife Conservation Board, Sea Grant Program and many others. The website www.grants.gov can be a good information source for those seeking funds for restoration. Permits from federal, state, and local agencies (*e.g*. the Corps, RWQCB, CDFW, county, *etc.*) are required to comply with laws related to the Clean Water Act, State and federally listed species, streambed alteration, grading, *etc*. Technical assistance, streamlined permitting processes, grants and partners in recovery are highlighted below:

The NOAA Restoration Center

The NOAA Restoration Center provides funding and technical assistance for restoration projects benefiting NOAA trust resources, including salmon and steelhead. Since 1996, the Restoration Center has funded over 400 projects benefiting California's salmon and steelhead. The

Restoration Center works with NMFS staff and others to develop and implement projects addressing limiting factors to salmonid recovery such as partnering with grassroots organizations to encourage hands-on citizen participation and providing technical support. Funding opportunities come from a variety of sources managed by the Restoration Center. More information is available at: http://www.habitat.noaa.gov/funding/southwest.html.

The Restoration Center has administered two biological opinions on behalf of the Army Corps of Engineers to streamline permit authorization for projects explicitly intended to benefit salmonids and their habitats within the jurisdictional area of the San Francisco Corps District. This provides another avenue for permitting for restoration projects not funded by FRGP (and thus not covered under the permitting "umbrella" of the program) and includes coverage for projects in the coastal zone without need to obtain a separate permit from the Coastal Commission. NMFS' biological opinion for the North Central Coast Office (Santa Rosa, California) is available at http://www.habitat.noaa.gov/funding/applicantresources.html under the dropdown option of, "Environmental Compliance Resources for Restoration Projects" and at http://www.habitat.noaa.gov/pdf/noaa_restoration_center_corps.pdf for the North Coast Office (Arcata, California). Additional information regarding the NOAA Restoration Center grants can be found at http://www.habitat.noaa.gov/funding/applicantresources.html.

California Fisheries Restoration Grant Program (FRGP)

FRGP is a competitive grant program to support watershed restoration and education throughout coastal California. FRGP is funded in part by the Federal Pacific Coastal Salmonid Restoration Fund. FRGP requires the applicant's project to address a specific recovery action identified in either a state or federal management or recovery plan. A major benefit for projects funded under FRGP is a streamlined and coordinated framework that meets permitting requirements of almost all pertinent regulatory agencies. Additional information is available at: http://www.dfg.ca.gov/fish/Administration/Grants/FRGP/

Coho HELP Act and Habitat Restoration and Enhancement Act

Two other restoration permitting programs administered by the CDFW do not directly apply to steelhead and Chinook. However, restoration projects under these two programs often benefit multiple salmonid species and these two programs can help with permitting restoration projects when coho salmon benefit from the projects. The programs are: the Coho Salmon Habitat Enhancement Leading to Preservation Act (Coho HELP Act; California Fish and Game Code Section 6950 *et seq*.) and the Habitat Restoration and Enhancement Act (HREA; California Fish and Game Code Section 1650 *et seq*.). Information about the Coho HELP Act can be found at: https://www.dfg.ca.gov/fish/Resources/Coho/HELP/. Information about the HREA can be found at: https://www.wildlife.ca.gov/Conservation/Environmental-Review/HRE-Act.

NCRWQCB Restoration Policy in the North Coast Region

On January 29, 2015, the NCRWQCB adopted the Policy in Support of Restoration in the North Coast Region - Resolution R1-2015-0001 (Restoration Policy). The State Water Board subsequently approved the Restoration Policy on May 19, 2015. The Restoration Policy is primarily a narrative expressing support for restoration and similar type projects. The Restoration Policy directs staff of the NCRWQCB to work closely with state and federal agencies to promote actions identified in state and federal recovery plans. It also describes in more detail: (1) the importance of restoration projects for the protection, enhancement and recovery of beneficial uses, (2) the obstacles that slow or preclude restoration actions, (3) the legal and procedural requirements for permitting restoration projects, (4) the ongoing NCRWQCB effort to provide support towards the implementation of restoration projects, and (5) direction to staff to continue to support restoration in the future. The Restoration Policy can be found at the following location: http://www.waterboards.ca.gov/northcoast/board_decisions/adopted_orders/pdf/2015/150129_0001_Restoration_Policy.pdf.

CEQA Categorical Exemption for Small Habitat Restoration Projects

In 2002, California's former Secretary of Resources, Mary Nichols, convened a multi- stakeholder group known as the *State Task Force on Removing Barriers to Restoration*. Amongst the recommendations generated by the Task Force was the creation of a new categorical exemption from the California Environmental Quality Act (CEQA) for certain types of small habitat restoration projects. This categorical exemption was created and codified at 14 California Code of Regulations Section 15333. The CEQA is a statute that requires state and local agencies to identify the significant environmental impacts of their actions and to avoid or mitigate those impacts if feasible. CEQA Guidelines identify classes of projects which have been determined not to have a significant effect on the environment and which are therefore exempt from the provisions of CEQA. Restoration projects of less than 5 acres undertaken to ensure the maintenance, restoration, enhancement, or protection of habitat for fish, plants, or wildlife can utilize this categorical exemption if the project meets specific conditions and certain exceptions do not apply. Each public agency must decide whether specific activities fall in this category. This categorical exemption can be found at: http://resources.ca.gov/ceqa/guidelines/art19.html

State Water Resources Control Board's General Order for Small Habitat Restoration Projects

The State Water Resources Control Board issued a Clean Water Act Section 401 General Water Quality Certification for Small Habitat Restoration Projects (SHRPs). This General Order authorizes SHRPs that qualify for a CEQA categorical exemption under 14 California Code of Regulations Section 15333 if the applicant follows listed application requirements. SHRPs are intended to improve the quality of waters of the state and contribute to the state's No Net Loss Policy (Executive Order W-59-93). This General Order can be found at: http://www.waterboards.ca.gov/water_issues/programs/cwa401/generalorders_wb.shtml

Resource Conservation Districts and Natural Resources Conservation Service

Resource conservation districts (RCDs) and the Natural Resources Conservation Service play a big role in assisting landowners to address pollution or conduct restoration activities on private lands. These organizations can assist landowners with permit acquisition, funding, and project planning. For example, the Mendocino County RCD administers the Mendocino County Permit Coordination Program to help facilitate project implementation that promotes actions identified in the Recovery Plan. The Sonoma RCD, Napa County RCD, Gold Ridge RCD, and Mendocino

RCD all support and engage in the Landsmart initiative. Through Landsmart, the RCDs provide support to landowners through four distinct program offerings: Water Resources, Planning, On-the-Ground Projects, and Education. Information about the Landsmart program can be found at: http://www.sonomarcd.org/htm/what-is-landsmart.htm. The Marin RCD's Conserving Our Watershed Program has worked with private landowners to put seven million dollars towards restoration actions on private lands resulting in the implementation of over 1,000 BMPs across 110,000 acres, preventing an estimated 266,365 CY of sediment from entering waterways.

Wood For Salmon Working Group

Wood for Salmon Working Group is a resource for restoration practitioners seeking to implement large wood augmentation projects. Formed in 2010, the Wood for Salmon Working Group has brought together several state and federal regulatory agencies, environmental non-profits, non-governmental agencies, and stakeholders to promote voluntary projects that restore salmonid habitat through the reintroduction of trees and root wads (large woody material) and systematically addressing the obstacles and "red tape" that prevent them from occurring. The Wood for Salmon Working Group includes representatives from the NCRWQCB, CalFire, State Water Board – DWQ, CDFW, California Geologic Survey, NMFS, USACE, Prunuske Chatham Inc., Alnus Ecological Consulting, Campbell Global Inc., Mendocino County RCD, Sonoma RCD, Gold Ridge RCD, NRCS, Sustainable Conservation, The Nature Conservancy, Trout Unlimited, Sonoma County Water Agency, and University of California Cooperative Extension. Information about the Wood for Salmon Working Group can be found at: https://www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/california/salmon/woodforsalmon/Pages/default.aspx.

The Nature Conservancy: Salmon Snapshot

The California Salmon Snapshots is one of the most comprehensive sources of information regarding the numbers of returning adults in each watershed (escapement data) for Chinook salmon, steelhead trout, and coho salmon. Additionally, the Salmon Snapshots website provides multiple resources for focusing restoration actions, identifying what limiting factors exist for each watershed, what watershed partners are present, and more. The Nature Conservancy's Salmon Snapshots website can be found at the following location: http://www.casalmon.org/salmon-snapshots.

Other Funding Sources Available

This list is not extensive, there are other sources of funding available that are not listed below.

- San Francisco Bay Joint Venture's website list numerous funding opportunities: http://www.sfbayjv.org/funding.php
- Nonpoint Source (NPS) Grant Program - Clean Water Act §319(h) and Timber Regulation and Forest Restoration Fund: http://www.waterboards.ca.gov/water_issues/programs/nps/grant_program.shtml
- NOAA Habitat Conservation: Coastal and Marine Habitat Restoration: http://www.habitat.noaa.gov/funding/coastalrestoration.html
- United States Forest Service: Forest Legacy Program: http://www.fs.fed.us/spf/coop/programs/loa/flp.shtml
- State of California Coastal Conservancy Grants: http://scc.ca.gov/grants/

7.4 FINDING ASSISTANCE

Federal Partners

Federal agencies that can provide information, funding and/or technical assistance include:

- NMFS, West Coast Region http://www.westcoast.fisheries.noaa.gov/
- NOAA Restoration Center www.nmfs.noaa.gov/habitat/restoration/
- USFWS Partners for Fish and Wildlife www.fws.gov/partners/ and Coastal Program http://www.fws.gov/coastal/
- US EPA www.epa.gov
- NRCS www.nrcs.usda.gov
- USACE http://www.usace.army.mil/Missions/Environmental.aspx
- NFWF http://www.nfwf.org/Pages/default.aspx
- USFS http://www.fs.fed.us/

- BLM http://www.blm.gov/wo/st/en.html

State and Local Partners

Entities with information, funding and/or technical assistance include:

- SOU Partners: Sonoma County Water Agency, Zone 7 Water Agency, Alameda County Water District, East Bay Municipal Utility District, Contra Costa County Flood Control & Water Conservation District, Santa Clara Valley Water District, Alameda County Flood Control & Water Conservation District, Marin Municipal Water District, North Bay Watershed Association, East Bay Regional Park District, North Marin Water District, Solano County Water Agency, San Mateo County Resource Conservation District, Mendocino County Resource Conservation District, Marin Resource Conservation District, Gold Ridge Resource Conservation District, San Francisquito Creek Joint Powers Authority, Sonoma Resource Conservation District, Contra Costa Resource Conservation District, Resource Conservation District of Santa Cruz County, Alameda County Resource Conservation District, Marin County Public Works, and San Mateo County Public Works.
- California Department of Fish and Wildlife www.dfg.ca.gov/fish/ and the environmental enhancement fund https://www.wildlife.ca.gov/OSPR/Science
- California Coastal Conservancy www.scc.ca.gov
- State Water Resources Control Board www.swrcb.ca.gov
- CA Department of Water Resources http://www.water.ca.gov/irwm/grants/index.cfm
- California Conservation Corps www.ccc.ca.gov/
- University of California Cooperative Extension http://ucanr.org/index.cfm
- CalFish www.calfish.org
- California Department of Forestry and Fire Protection http://bofdata.fire.ca.gov/
    - CALFIRE http://www.fire.ca.gov/
- Coastal Watershed Planning and Assessment Program http://coastalwatersheds.ca.gov/Home/tabid/54/Default.aspx
- Resource Conservation Districts www.carcd.org
    - Santa Cruz Resource Conservation District http://www.rcdsantacruz.org/
    - San Mateo County Resource Conservation District http://www.sanmateorcd.org/
    - Gold Ridge Resource Conservation District http://www.goldridgercd.org/

- Napa County Resource Conservation District http://naparcd.org/
- Sonoma Resource Conservation District http://www.sonomarcd.org/
- Marin Resource Conservation District http://www.marinrcd.org/
- Mendocino County Resource Conservation District http://www.mcrcd.org/
- Humboldt County Resource Conservation District http://www.humboldtrcd.org/
- Guadalupe Coyote Resource Conservation District http://www.gcrcd.org/

Local and regional entities for information, funding and/or technical assistance include:

- Sonoma County Fish and Wildlife Commission http://www.sonoma-county.org/wildlife/grants.htm
- Marin County Fish and Wildlife Commission http://cemarin.ucdavis.edu/Programs/The_Marin_County_Fish_and_Wildlife_Commission/
- Five Counties Salmonid Conservation Program www.5counties.org
- The Fish Passage Forum http://www.cafishpassageforum.org/
- Klamath Resource Information System (KRIS) http://www.krisweb.com/

Non-Governmental Organizations (NGOs)

Non-governmental organizations with information, funding and/or technical assistance include:

- Salmonid Restoration Federation http://www.calsalmon.org/
- Trout Unlimited http://www.tu.org/
- California Trout http://www.caltrout.org/
- The Nature Conservancy http://www.nature.org/
- Various land trusts and open space districts

8.0 IMPLEMENTATION

"If anthropogenic changes can be shaped to produce disturbance regimes that more closely mimic (in both space and time) those under which the species evolved, Pacific salmon should be well equipped to deal with future challenges, just as they have throughout their evolutionary history."

Dr. Robin R. Waples, NOAA Fisheries, Research Fish Biologist

8.1 INTEGRATING RECOVERY INTO NMFS' ACTIONS

NMFS is working to incorporate recovery plan information and actions into its programs, policies, and decision-making (*i.e.*, status reviews, critical habitat designations, section 7 consultations, enforcement, permit actions, *etc*.). Implementation of the recovery plan by NMFS will involve exploring opportunities to shift workload priorities and act in a strategic and proactive manner. To promote implementation of the recovery plan NMFS could:

- Prioritize work load allocation and decision-making, including developing mechanisms to promote implementation (*e.g.*, restoration);
- Participate in land use and water planning processes at the Federal, state, and local level to ensure recommendations of the plan are reflected in a wide range of decision making processes;
- Conduct outreach and education programs aimed at stakeholders (*i.e.*, Federal, tribal, state, local, non-governmental organizations, landowners and interested parties);
- Provide a consistent framework for research, monitoring, and adaptive management that directly informs recovery objectives and goals listed in the plan; and
- Establish an implementation tracking system that is adaptive and pertinent for annual reporting for the Government Performance and Results Act, bi-annual recovery reports to Congress and five-year status review up-dates for ESA-listed species.

8.2 REGULATORY MECHANISMS

The ESA provides NMFS with various mechanisms for protecting and recovering listed species. The ESA first focuses on identifying species and ecosystems in danger of immediate or foreseeable extinction or destruction and protecting them as their condition warrants. Once protected, the focus is on the prevention of further declines in a species' condition through the consultation provisions of section 7(a)(2), habitat protection and enhancement provisions of sections 4 and 5, take prohibitions through sections 4(d) and 9, cooperation with the state(s) where these species are found (section 6), and needed research and conservation taken by non-federal actions through section 10. Ultimately, the ESA objectives are to conserve and protect the listed species and their ecosystems.

The following sections describe methods NMFS may use when implementing various sections of the ESA. These methods are intended to explore opportunities to institutionalize recovery planning in daily work and decision-making of NMFS' West Coast Region.

8.2.1 ESA SECTION 4

Section 4 provides a mechanism to list new species as threatened or endangered, designate critical habitat, develop protective regulations for threatened species, and develop recovery plans. Critical habitat is designated in specific geographic areas where physical or biological features essential to the conservation of the species are found and where special management considerations or protections may be needed. Critical habitat for CC Chinook salmon and NC and CCC steelhead was designated at listing and redesignated in 2005.

Unlike endangered species under ESA section 9, which prohibits take of endangered species, ESA section 4(d) gives NMFS authority to tailor take prohibitions and regulatory limits that are deemed necessary and advisable to provide for the recovery of threatened species. NMFS has promulgated such rules for take of threatened salmonids, including CC Chinook salmon and NC and CCC steelhead (50 C.F.R. 223.203).

Section 4(c)(2) of the ESA requires NMFS to conduct a review of listed species at least once every five years. Five year status reviews conducted by the Services consider the status of listed species and identified threats as well as progress towards recovery as outlined in the recovery plan. A determination to change the status (by uplisting or downlisting) is made on the basis of the same five listing factors that resulted in the initial listing of the species [50 C.F.R. 424.11 (d)] and recovery plan criteria.

8.2.2 ESA SECTION 5

Section 5 is a program that applies to land acquisition by the Services, or by the Secretary of Agriculture with respect to the National Forest System. National Forest lands occur in some areas of the CC Chinook salmon ESU and NC steelhead DPS. NMFS does not have any plans for land acquisition with respect to Section 5 of the ESA.

8.2.3 ESA SECTION 6

In 2003, NMFS instituted a grant program for states pursuant to section 6 of the ESA using funding provided by Congress. Species recovery grants to states can support management, research, monitoring, and outreach activities that provide direct conservation benefits to listed species and recently delisted species. However, projects focusing on listed Pacific salmonids are not considered under this grant program because state conservation efforts for these species are supported through PCSRF.

8.2.4 ESA SECTION 7

Section 7(a) (1)

Section 7(a)(1) states all federal agencies shall "in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this [Act] by carrying out programs for the conservation of endangered species and threatened species...." Section 7(a)(1) allows a Federal agency the discretion to deem the conservation of endangered and threatened species a high priority. "Conservation" is defined in the ESA as "to use and the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this [Act] are no longer necessary." To aid in the development of conservation programs, NMFS will:

- After the finalization of the recovery plan, prepare and send a letter to all other appropriate Federal agencies outlining section 7(a)(1) obligations and meet with these agencies to discuss salmon and steelhead conservation and recovery priorities;
- Consider development of a formal agreement, *e.g.*, MOU, with Federal agencies to further implementation of recovery priorities.
- Incorporate recovery actions in formal ESA consultations as conservation recommendations;
- Encourage meaningful and focused recommendations, in alignment with recovery goals for restoration and threat abatement, for all actions that incidentally take salmonids or affect their habitat;
- Encourage all entities to include recovery actions in project proposals;
- Encourage all entities to implement conservation efforts (*i.e.*, restoration and mitigation efforts) that are in alignment with recovery goals and objectives identified in the plan;
- Support the establishment of "conservation banks" which protect and restore habitat and provide credits as compensation for unavoidable impacts from actions that may affect salmonids; and
- Incorporate conservation actions, as appropriate, into the actions that NMFS authorizes, funds or carries out.

Section 7(a)(2)

The purpose of section 7(a)(2) is to "insure that any action authorized, funded, or carried out by [a Federal agency] is not likely to jeopardize the continued existence of any [listed species] or result in the destruction or adverse modification of [a listed species' critical habitat]." Federal agencies request interagency consultation with NMFS when they determine an action may affect a listed salmon or steelhead species or its critical habitat. NMFS then conducts an analysis of potential effects of the proposed action and provides a biological opinion on whether an agency's actions are likely to jeopardize a species continued existence or destroy or adversely modify its critical habitat. The Services define "jeopardize the continued existence of" as "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. 402.02). Recovery plans do not create legally enforceable obligations for action agencies to carry out any particular measure. However, they may be directly relevant and highly informative to the question of whether or not an action agency will appreciably reduce the likelihood of recovery of the species. NMFS currently assists agencies in avoiding and minimizing the potential adverse effects of proposed actions and ensuring federal agency actions are not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat. Whether the action has a negative effect on the likelihood of the species recovering is considered part of the analysis. As a result, these consultations have helped avoid and minimize direct take and have contributed to recovery.

Because section 7(a)(2) applies only to Federal actions, its applications are limited only to those areas and actions with Federal ownership, oversight, or funding. Across the CC Chinook salmon ESU and NC and CCC steelhead DPSs, land ownership varies by watershed, from areas with some portions of publicly owned land to areas entirely privately owned. Most land and water use practices on private lands do not trigger interagency consultation. This lack of Federal review and oversight is due in part to the Clean Water Act section 404(f) exemptions for discharges of dredged or fill material into waters of the United States that are associated with farming, logging, and ranching activities. Although take is prohibited under the ESA, these exemptions hinder Federal oversight of actions that may adversely affect salmonids and their habitat.

In order to devote more resources to recovery action implementation and to ensure section 7(a)(2) consultations are effective, NMFS will utilize its authorities to:

- Use the recovery plan information on conditions and threats and recovery criteria as a reference point to determine effects of proposed actions on the likelihood of species' recovery;

- Prioritize consultations for those activities that have the most potential to influence species conservation, including but not limited to those consultations for actions that implement the recovery strategy or specific recovery actions;
- Develop and maintain databases to track the amount of incidental take authorized through section 7 consultations and the effectiveness of conservation and mitigation measures;
- Incorporate recovery actions in formal consultations as Reasonable and Prudent Measures (RPMs) and conservation recommendations, as appropriate;
- Focus staff priorities towards sections 7 and 9 compliance in essential and supporting populations for the purposes of minimizing take and preventing extirpation;
- Streamline consultations for actions that will have little or no adverse effects on recovery areas or priorities;
- Develop streamlined programmatic approaches for those actions that do not pose a threat, or are entirely beneficial, to the survival and recovery of the species;
- Consider whether any reduction in viability of an affected population is likely to be sufficient to reduce the viability of a Diversity Stratum and/or the ESU/DPS; and
- Apply the VSP framework and recovery priorities to evaluate population and area importance in jeopardy and adverse modification analyses.

In addition, NMFS can encourage:

- USACE to re-evaluate Clean Water Act section 404(f) exemptions for farming, logging, and ranching activities;
- FEMA to fund upgrades and modify flood insurance programs for flood-damaged facilities to meet both ESA requirements and facilitate recovery objectives;
- EPA to prioritize actions on pesticides known to be toxic to fish and are likely to be found in fish habitat and to develop regulatory mechanisms, such as restrictions on pesticide use near surface waters;
- FHWA and Caltrans to develop pile driving guidelines approved by NMFS for bridge construction projects in essential and supporting populations and other watersheds;

- Development of section 7 conservation recommendations based on recovery actions to help prioritize Federal funding towards recovery actions (NMFS, USFWS, NRCS, EPA, *etc*.) during formal consultations;
- Federal agencies or their designated non-Federal representatives to coordinate with NMFS prior to the development of a biological assessment (BA); and
- Federal agencies or their designated representatives to conduct field reviews upon completion of projects to determine whether or not they have been implemented as planned and report findings to NMFS.

8.2.5 ESA SECTION 9

Section 9 prohibits any person subject to the jurisdiction of the United States, among several provisions, from taking endangered species. Through section 4(d), NMFS has applied take prohibitions of Section 9 to threatened species, with limits allowing take under specific circumstances (see, e.g., 50 C.F.R. 223.203 (applicable to threatened anadromous salmonids)). The ESA defines "take" as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 U.S.C. 1532(19)). NMFS defines "harm" as "an act which actually kills or injures fish or wildlife [including] significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering" (50 C.F.R. 222.102). Thus, section 9 prohibitions include direct forms of take, such as killing an individual fish, or indirect forms, such as destroying habitat where fish rear or spawn. NOAA's Office of Law Enforcement (OLE) is responsible for enforcing laws that conserve and protect our nation's living marine resources and their natural habitat. Essential and supporting populations should be considered the highest priority areas for oversight and enforcement. NMFS West Coast Region staff will work closely with OLE. NMFS staff will:

- Conduct outreach and provide NOAA's OLE with a summary document that includes threats, recovery priorities, and high priority focus areas for oversight and enforcement.

- Work with OLE and the CDFW, under the Joint Enforcement Agreement, to inform landowners of outreach opportunities and potential areas for increased patrols in essential and supporting populations;
- Periodically review existing protocols establishing responsibilities between NMFS West Coast Region and OLE to ensure staff support of OLE are focused on the highest recovery priorities;
- When unauthorized take occurs in an essential or supporting population and/or watershed, NMFS West Coast Region will make it a high priority to work closely with OLE to develop a take investigation; and
- Periodically assess and review existing protocols that increase and streamline collaboration between NMFS and OLE in high priority areas to ensure the highest level of protection for ESA-listed species.

8.2.6 ESA SECTION 10

Section 10(a)(1)(A)

Section 10(a)(1)(A) provides NMFS authority to issue permits for the authorization of take of listed salmonids for scientific research, or to enhance the propagation or survival of listed salmonids. NMFS has authorized conservation hatcheries and research activities under section 10(a)(1)(A). Section 10(a)(1)(B) provides NMFS authority to issue permits for the incidental take of listed salmonids while carrying out otherwise lawful non-Federal activities. In order to obtain an incidental take permit, the applicant must develop a Habitat Conservation Plan and demonstrate, among other things, that the activity will minimize and mitigate the impacts of the incidental taking to the maximum extent practicable. To improve the section 10 authorization process, NMFS will utilize its authorities in the following ways.

For section 10(a)(1)(A) permits NMFS will:

- Prioritize staff time to streamline the section 10 permitting process to achieve recovery objectives and goals in the plan;

- Prioritize permit applications and develop streamlined approaches for research, monitoring, and enhancement activities that have the potential to influence species conservation;
- Support implementation of the California Coastal Salmonid Population Monitoring and align permitting with the monitoring protocols; and
- Improve NMFS' tracking of authorized take.

Section 10(a)(1)(A) and (B)

For Habitat Conservation Plans (HCPs) under section 10(a)(1)(B) and Safe Harbor Agreements under section 10(a)(1)(A), NMFS will:

- Promote the use of recovery plan information and actions in developing HCPs;
- Place a high priority on cooperation and assistance to landowners proposing HCPs or Safe Harbor Agreements designed to achieve recovery objectives in essential and supporting populations;
- Develop strategies to identify potential focus areas to increase the number of HCPs and Safe Harbor Agreements (*e.g.*, key watersheds, activities amenable to consolidated landowner application such as forestry, water diverters and target increased participation, *etc.*); and
- Streamline the HCP process for landowners implementing recovery plan priorities.

Section 10(j) Experimental Populations

Among changes made in the 1982 amendments to the ESA was the creation of section 10(j), which allows the Services to authorize the release of an "experimental population" of a listed species outside the species' current range if the release would further the conservation of the listed species. Section 10(j) defines an "experimental population" as any population that a Service has authorized for release under that section, but only when, and at such times as, the population is wholly separate geographically from other non-experimental populations. Under section 10(j), individual members of experimental populations are treated as a threatened species, except for limited exceptions. As such, NMFS has flexibility in developing protective regulations under

ESA section 4(d) to apply limited take prohibitions to the experimental population. Therefore, management flexibility is increased, and more re-introductions are possible. Care is taken by NMFS that the experimental populations are phenotypically and genetically similar to the existing populations within the current range and will not upset the stream ecology of the reintroduction site. NMFS has designated Central Valley spring-run Chinook salmon in the San Joaquin River from Friant Dam downstream to the confluence of the Merced River as a nonessential experimental population under section 10(j) (78 FR 79622, December 31, 2013). No experimental populations are being considered for CC Chinook salmon, NC steelhead or CCC steelhead.

8.3 PACIFIC COASTAL SALMON RECOVERY FUND

The restoration of salmon and steelhead habitats has been a primary focus of Federal, State and local entities. As a means of providing funding to the states, Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Nevada, Idaho, and Alaska, and the Pacific Coastal and Columbia River tribes receive PCSRF funding from NMFS each year. The fund supplements existing state, tribal, and local programs to foster development of Federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. In California, NMFS will continue to work with CDFW to ensure the recovery strategies and priorities are considered when funding restoration projects. The State of California Fisheries Restoration Grant Program (FRGP) alone has invested over $250 million dollars and supported approximately 3,500 salmonid restoration projects. These projects include fish passage, water conservation, improving instream habitats, watershed monitoring, education, and organizational support to watershed groups. Many other entities have made investments to improve the range and habitat of salmonids. Previously, FRGP focused on projects associated with Southern Oregon/Northern California Coast coho salmon, Central California Coast coho salmon, Central California Coast steelhead, Southern California steelhead and South Central California Coast steelhead. Specific NC steelhead and CC Chinook salmon projects have been eligible for FRGP funding since the public draft of the Coastal Multispecies plan was released.

GLOSSARY

This glossary contains terms commonly used in fisheries and resource sciences and terms used throughout the National Marne Fisheries Service documents, as defined by laws, regulations, manuals, handbooks and specifications.

Abundance: Refers to the total number of individual organisms in a population or subpopulation. For the Plan, abundance refers to the total number of spawning adults within a population.

Adaptive management: An action-oriented approach to resource management that brings science and management together and allows managers to move forward in the face of uncertainty when dealing with complex ecological problems. Adaptive management tackles uncertainty about the system head-on by identifying clear objectives, developing conceptual models of the system, identifying areas of uncertainty and alternative hypotheses, learning from the system as actions are taken to manage it, updating the conceptual models, and incorporating what is learned into future actions.

Adipose fin: A small fleshy fin found on the back behind the dorsal fin, and just forward of the caudal fin.

Alevin: The larval salmonid that has hatched but has not fully absorbed its yolk sac and generally has not yet emerged from the spawning gravel.

Allele: An allele is an alternate form of a gene (the basic unit of heredity passed from parent to offspring). By convention, the "100 allele" is the most common allele in a population and is the reference for the electrophoretic mobility of other alleles of the same gene. Other genetic terms used in this document include allozymes (alternate forms of an enzyme produced by different alleles and often detected by protein electrophoresis); dendrogram (a branching diagram, sometimes resembling a tree, that provides one way of visualizing similarities between different groups or samples); gene locus (pl. loci; the site on a chromosome where a gene is found); genetic distance (D) (a quantitative measure of genetic differences between a pair of samples); and introgression (introduction of genes from one population or species into another).

Anadromous Fish: Pertaining to fish that spend part of their life cycle in the ocean and return to freshwater streams to spawn, for example salmon, trout, and shad.

Anthropogenic: Caused or produced by humans.

Artificial propagation: See hatchery.

Bacterial Kidney Disease (BKD): A bacterial kidney disease in fish caused by the bacterium *Renibacterium salmoninarum*.

Basin: Region drained by a single river system.

Benthic: Animals and plants living on or within the substrate of a water body

Biodiversity: The variability among living organisms on the earth, including the variability within and between species and within and between ecosystems.

Biological Review Team (BRT): The team of scientists from National Marine Fisheries Service formed to conduct the status review.

Biota: The combined flora and fauna of a region

Brackish Water: A combination of seawater and freshwater.

Captive Broodstock Program: A form of artificial propagation that breeds fish from local genetic stock at a conservation hatchery and releases the produced juveniles into historic streams.

Carrying Capacity: The maximum equilibrium number of a particular species that can be supported indefinitely in a given environment.

Channel: A natural or artificial waterway of perceptible extent that periodically or continuously contains moving water. It has a definite bed and banks that serve to confine water.

Channel Complexity: Measure of multiple components determining the makeup of a given waterway. Some of these would include slope, meander, bedload/substrate makeup (i.e. gravel, cobble, boulder, or combination), presence/absence of large instream woody material, thalweg, *etc***.**

Coded-wire Tag (CWT): A small piece of wire, marked with a binary code, which is normally inserted into the nasal cartilage of juvenile fish. Because the tag is not externally visible, the adipose fin of coded wire-tagged fish is removed to indicate the presence of the tag. Groups of thousands to hundreds of thousands of fish are marked with the same code number to indicate stock, place of origin, or other distinguishing traits for production releases and experimental groups.

Cohort: A group of fish that hatched during a given spawning season. When the spawning season spans portions of more than one year, the brood-year is identified by the year in which spawning began. For example, offspring of steelhead that spawned in 1996-1997 are identified as "brood-year 1996." (Synonym: Brood-year).

Conceptual Model: A qualitative model of the system and species life stages with the interrelations between the system and threats shown in diagrammatic form. Several threats are interlinked or Independent and these can be illustrated on the model of the system.

Confluence: A flowing together of two or more streams.

Connectivity: A natural pathway that provides for the movement of organisms from one habitat to another and creates a physical linkage between habitats. Spatial structure should have permanent or appropriate seasonal connectivity to allow adequate migration between spawning, rearing, and migration patches.

Conservation-Reliant Species: Species dependent on enforced protections for survival.

Conveyance: A pipeline, canal (natural or artificial), or similar conduit that transports water from one location to another.

Copepod: Small aquatic crustacean.

Critical Habitat: Specific areas designated under the ESA within the geographical area occupied by the listed species at the time it is listed, on which are found physical or biological features that are essential to the conservation of the species and which may require special management considerations or protection.

Culvert: Buried pipe structure that allows streamflow or road drainage to pass under a road.

Denil Fish Ladder (Baffle Fishway): uses a series of symmetrical close-spaced baffles in a channel to redirect the flow of water, allowing fish to swim around the barrier. Baffle fishways need not have resting areas, although pools can be included to provide a resting area or to reduce the velocity of the flow. Such fishways can be built with switchbacks to minimize the space needed for their construction. Baffles come in variety of designs. The original design for a Denil fishway was developed in 1909 by a Belgian scientist, G. Denil; it has since been adjusted and adapted in many ways.

Delisting: Removing a species from the list of threatened or endangered species under the ESA.

Deme: A local population of organisms of one species that actively interbreed with one another and share a distinct gene pool. When demes are isolated for a very long time they can become distinct subspecies or species.

Dependent Population: Populations that rely upon immigration from surrounding populations to persist. They are an "at risk" group that has a substantial likelihood of going extinct within a 100-year time period in isolation, yet receives sufficient immigration to alter their dynamics and extinction risk, and presumably increase persistence or occupancy.

Depensation: The effect where a decrease in spawning stock leads to reduced survival or production of eggs through either 1) increased predation per egg given constant predator pressure, or 2) the "Allee effect" (the positive relationship between population density and the reproduction and survival of individuals) with reduced likelihood of finding a mate.

Desiccation: To dry out thoroughly, dehydrate.

Distinct Population Segment (DPS): A subdivision of a vertebrate species that is treated as a species for purposes of listing under the Endangered Species Act (ESA). Based on FWS and NMFS "Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species Act" (61 FR 4722; February 7, 1996), two elements are considered in determining whether there is a distinct population segment: (1) discreteness of the population segment in relation to the remainder of the species to which it belongs; and (2) the significance of the population segment to the species to which it belongs.

Diversity: All the genetic and phenotypic (life history, behavioral, and morphological) variation within a population.

Diversity Strata (Recovery Unit): Populations of salmonids in the North-Central California Coast Recovery Domain are categorized into Diversity Strata based on the geographical structure described in Spence *et al.* (2008).

DNA (deoxyribonucleic acid): DNA is a complex molecule that carries an organism's heritable information. The two types of DNA commonly used to examine genetic variation are mitochondrial DNA (mtDNA), a circular molecule that is maternally inherited, and nuclear DNA, which is organized into a set of chromosomes.

Downlisting: Changing the status of a species listed under the ESA from "endangered" to "threatened" because the risk of extinction is less extreme than before, although continued protection under the ESA is still warranted.

Ecosystem: The physical and climatic features of all the living and dead organisms in an area interrelated in the transfer of energy and material.

Effective population size: Used to express information about expected rates of random genetic change due to inbreeding and/or genetic drift. Typically the effective population size is lower than the census population size.

Effluent: Discharge or emission of a liquid or gas (usually waste material).

El Nino: A warming of the ocean surface off the western coast of South America that occurs every 4 to 12 years when upwelling of cold, nutrient-rich water does not occur. It causes die-offs of plankton and fish and affects Pacific jet stream winds, altering storm tracks and creating unusual weather patterns in various parts of the world.

Endangered Species Act (ESA): Federal law (16 U.S.C. 1531 et seq.) that provides protection for species at risk of extinction. Through federal action and by encouraging the establishment of state programs, the Endangered Species Act of 1973, as amended, provides for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife, and plants depend.

Endangered Species: Any species which is in danger of extinction throughout all or a significant portion of its range

Endemic: Native to or confined to a certain region

Entrainment: To capture in a diversion by the flow of water.

Ephemeral stream: A stream that flows briefly and only in direct response to local precipitation, and whose channel is always above the water table.

Essential Fish Habitat (EFH): Under the Magnuson-Stevens Fishery Conservation and Management Act, Essential Fish Habitat is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.

Essential Population: Population selected by the recovery team to fulfill biological viability criteria per Spence *et al.* 2008.

Escapement: Adult fish that "escape" fishing gear to migrate upstream to spawning grounds. The quantity of sexually mature adult salmon (typically measured by number or biomass) that successfully pass through a fishery to reach the spawning grounds. This amount reflects losses resulting from harvest, and does not reflect natural mortality, typically partitioned between enroute and pre-spawning mortality. Thus, escaped fish do not necessarily spawn successfully.

Estuarine: Relating to an estuary.

Estuary: An area of water which joins marine and freshwater components. As such, these areas are heavily influenced by both tidal and riverine inputs.

Evolutionarily Significant Unit (ESU): According to NMFS' "Policy on Applying the Definition of Species under the Endangered Species Act to Pacific Salmon" (56 FR 58612) a stock of Pacific salmon will be considered a distinct population, and hence a "species" under the ESA, if it represents an ESU of the biological species. The stock must satisfy two criteria in order to be considered an ESU: 1) it must be substantially reproductively isolated from other conspecific population units; and 2) it must represent an important component in the evolutionary legacy of the species.

Extant: A population still existing or persistent.

Extinction: The failure of groups of organisms of varying size and inclusiveness (e.g., local geographic or temporally-defined groups to species) to have surviving descendants.

Extinction risk: In this document, the probability that a given population will become extinct within 100 years.

Extirpation: Loss of a taxon from a portion of its range.

Extirpated Species: A species that no longer survives in regions that were once part of its range, but that still exists elsewhere in the wild or in captivity.

Exotic Species (Also called Alien, Non-Indigenous or Non-Native Invasive Species): Plants and animals that originate elsewhere and migrate or are brought into an area. They may dominate the local species or have other negative impacts on the environment because they can often outcompete native species and they typically have no natural predators.

Fauna: Animals, especially the animals of a particular region or period, considered as a group

Fecundity: The number of offspring produced per female

Federal Register: The official journal of the U.S. Government, containing public notices and other routine publications. Published daily, the Federal Register includes rules, proposed rules, and notices of Federal agencies and organizations, as well as executive orders and other presidential documents.

Fine Sediment: Silts, sands and clays, which have diameters smaller than 0.0625 mm.

Fish Ladder: Structure that allows fish passage to areas upstream of obstructions (e.g. dams, locks). Fish ladders employ a series of stepped, terraced pools fed with spillover water cascading down the ladder. This allows fish to make incremental leaps upstream from pool to pool to access historical/ancestral habitat upstream.

Fish Screens: Physical exclusion structures placed at water diversion facilities to keep fish from becoming entrained, trapped and dying in a given water body.

Fishery Management Council: A regional fisheries management body established by the Magnuson-Stevens Fishery Conservation and Management Act to manage fishery resources in eight designated regions of the United States

Fishery Management Plan (FMP): A document prepared under supervision of the appropriate fishery management council for management of stocks of fish judged to be in need of management. The plan must generally be formally approved. An FMP includes data, analyses, and management measures.

Flashy Winter Flows/Flashy Streams: Streams that have a high flow rates and more rapid rises and falls in water level due to storms. The larger volume of water leads to a greater frequency of flooding and the increased velocity of water gives the stream greater erosive power. Common is areas with urbanization, where impervious surfaces keep the water from infiltrating the soil.

Floodplain: Level lowland bordering a stream onto which the stream spreads at flood stage

Flora: Plants considered as a group, especially the plants of a particular country, region, or time.

Fry: The life stage of salmonids between alevin and parr and must attain a length of at least one inch. They can typically swim and catch their own food. They are sometimes called "fingerlings."

Functionally Independent Population (FIP): Population having a high likelihood of persisting over 100-year time scales.

Fundamental Unit: A set of units for physical quantities from which every other unit can be generated. A reference unit.

Genetic Drift: The random change of the occurrence of a particular gene in a population; genetic drift is thought to be one cause of speciation when a group of organisms is separated from its parent population.

Gene(tic) Flow: The rate of entry of non-native genes into a population, measured as the proportion of the alleles at a locus in a generation that originated from outside of the population. Can be thought of as the genetically successful stray rate into a population.

Genetic Divergence: The process of one species diverging over time into more than one species.

Genetic Fitness: Generally depicted as the reproductive success of a genotype, usually measured as the number of offspring produced by an individual that survive to reproductive age relative to the average for the population.

Genetic Introgression: Introduction by interbreeding or hybridization of genes from one population or species into another.

Genetic Robustness: Demographic robustness.

Genotype: The genetic makeup, as distinguished from the physical appearance, of an organism or a group of organisms.

Gill net: With this type of gear, the fish are gilled, entangled or enmeshed in the netting. These nets can be used either alone or, as is more usual, in large numbers placed in line. According to their design, ballasting and buoyancy, these nets may be used to fish on the surface, in midwater or on the bottom.

Grilse: Salmon that have returned to their natal river.

Habitat: Areas that provide specific conditions necessary to support plant, fish, and wildlife communities. The natural abode of a plant or animal, including all biotic, climatic, and soil conditions, or other environmental influences affecting life.

Hatchery: Salmon and steelhead hatcheries typically spawn adults in captivity and raise the resulting progeny in freshwater for release into the natural environment. In some cases, fertilized eggs are out-planted (usually in "hatch-boxes"), but it is more common to release fry (young juveniles) or smolts (juveniles that are physiologically prepared to undergo the migration into salt water). This "outplanting" of fish are released either at the hatchery (on-station release) or away from the hatchery (off-station release). Releases may also be classified as within basin (occurring within the river basin in which the hatchery is located or the stock originated from) or out-of-basin (occurring in a river basin other than that in which the hatchery is located or the stock originated from). The broodstock of some hatcheries is based on adults that return to the hatchery each year; others rely on fish or eggs from other hatcheries, or capture adults in the wild each year.

Hatchery-origin Fish: Also, "hatchery fish". Fish that have spent some portion of their lives, usually their early lives, in a hatchery (see natural-origin fish.).

Headwaters: The source of a stream. Headwater streams are the small swales, creeks, and streams that are the origin of most rivers. These small streams join together to form larger streams and rivers or run directly into larger streams and lakes.

Heavy Metal: A group that includes all metallic elements with atomic numbers greater than 20, the most familiar of which are chromium, manganese, iron, cobalt, nickel, copper and zinc but that also includes arsenic, selenium, silver, cadmium, tin, antimony, mercury, and lead, among others.

Hook-and-line: A type of fishing gear consisting of a hook tied to a line. Fish are attracted by natural bait that is placed on the hook, and are impaled by the hook when biting the bait. Artificial bait (lures) with hooks are often used. Hook-and-line units may be used singly or in large numbers.

Hybridization: The process of mixing different species or varieties of organisms to create a hybrid.

Hydrologic Unit: A definitive geographical area, typically an entire watershed defined by the United States Geological Survey (USGS).

Inbreeding Depression: Reduced fitness in a given population as a result of breeding of related individuals.

Independent Population: A population that is any collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations. In other words, if one Independent population were to go extinct, it would not have much impact on the 100-year extinction risk experienced by other Independent populations. Independent populations are likely to be smaller than a whole ESU and they are likely to inhabit geographic ranges on the scale of entire river basins or major sub-basins.

Indigenous: Originating and living or occurring naturally in an area or environment.

Interbreeding: To breed with another kind or species.

Intrinsic Potential: The potential of the landscape to support a fish population.

Invasive Species: See exotic species.

Irreversibility: The trend/probability of a process to continue in only one direction once a tipping threshold has been crossed or met.

Iteroparous: A condition in which a fish may spawn multiple times. Steelhead (*Oncorhynchus mykiss*) and cutthroat trout (*O. clarkii*) display this trait routinely while other Pacific salmonids expire after spawning only once (see semelparous).

Jacks: Precocious male salmonids that return from the ocean to spawn one or more years before full-sized adults of their same cohort return.

Jeopardize: To engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing reproduction, numbers, or distribution of that species.

Jills (sometimes also called "Jennys"): Female salmonids that have spent only a year at sea but have returned to spawn. This is a relative rarity within the population.

Kelt: A post-spawning salmonid. Salmon or trout that remains in freshwater after spawning in the fall and may return to the ocean. This is extremely rare in salmon and uncommon in trout.

Large Woody Debris: Any large piece of woody material that intrudes into a stream channel, whose smallest diameter is greater than 10cm, and whose length is greater than 1 m.

Limiting Factor: An environmental factor that limits the growth or activities of an organism or that restricts the size of a population or its geographical range.

Listed Species: Any species of fish, wildlife or plant which has been determined to be endangered or threatened under the Endangered Species Act.

Magnuson-Stevens Fishery Conservation and Management Act: Federal legislation responsible for establishing the fishery management councils (FMCs) and the mandatory and discretionary guidelines for Federal fishery management plans (FMPs). This legislation was originally enacted in 1976 as the Fishery Management and Conservation Act; its name was changed to the Magnuson Fishery Conservation and Management Act in 1980, and in 1996 it was renamed the Magnuson-Stevens Fishery Conservation and Management Act.

Mass Wasting: Downslope transport of soil and rocks due to gravitational stress.

Metapopulation: A population of sub-populations which are in turn comprised of local populations or demes. Individual sub-populations can be extirpated and consequently recolonized from other sub-populations. Stability in a metapopulation is maintained by a balance between rates of sub-population extinction and colonization.

Monitoring: Scientific inquiry focused on evaluation of a program in relation to its goals (see Research).

Morphology: Refers to the form and structure of an organism, with special emphasis on external features.

Natal Stream: The stream where a salmonid was produced and hatched.

Natural-origin fish: Also, "natural or wild fish". Fish that are offspring of parents that spawned in the wild. Natural-origin fish spend their entire lives in the natural environment. (See hatchery-origin fish).

Nautical Miles: A unit of length used in sea and air navigation, based on the length of one minute of arc of a great circle. One nautical mile is equal to 1,852 meters.

Osmoregulate: The process of osmoregulation is the way by which an organism maintains suitable concentration of solutes and amount of water in the body fluids.

Otolith: A calcareous concretion in the inner ear of a vertebrate that is especially conspicuous in many bony fishes where it forms a hard body.

Pacific Northwest: A region of the northwest United States usually including the states of Washington and Oregon.

Parr: A young salmonid, in the stage between alevin and smolt, which has developed distinctive dark "parr marks" on its sides and is actively feeding in freshwater. Parr marks are vertical oval bars on the flanks of salmon fry that fade completely as the fish go through the smoltification process

Pelagic: Living in open oceans or seas rather than waters adjacent to land or inland waters.

Phenotype: The observable physical or biochemical characteristics of an organism, as determined by both genetic makeup and environmental influences.

Pinniped: Piscivorous aquatic mammals that include the seals, walrus, and similar animals having finlike flippers to use for locomotion.

Polymorphic: Having more than one form (e.g., polymorphic gene loci have more than one allele).

Pool/Riffle/Flatwater Ratio: Taken from the CAP attribute rating system. The ratio describes the percentage of the stream that is a pool, riffle or flatwater. It is determined when habitat typing is undertaken and a stream that is productive habitat for salmonids will be a mixture of the three habitat types.

Population: A group of individuals of the same species that live in the same place at the same time and exhibit some level of reproductive isolation from other such groups. In some contexts, a randomly mating group of individuals that is reproductively isolated from other groups. A population may consist of a single isolated run or more than one connected run.

Population size: In this document, is the number of adult fish in the population. Also known as census size of the population.

Potentially Independent Population (PIP): Populations having a high likelihood of persisting in isolation over 100-year time scales, but are too strongly influenced by immigration from other populations to exhibit independent dynamics.

Precocious: Early arrival of sexual maturity. Some precocious males (jacks) return after only six months of ocean residence.

Predation: The act of acquiring sustenance and nutrition by killing and consuming living animals.

Principal component analysis (**PCA**): A statistical technique that attempts to explain variation among several variables in terms of a smaller number of composite independent factors called principal components.

Progeny: An offspring or a dependent.

Proposed Rule: When one of the agencies of the United States wishes to add, remove, or modify a regulation, they inform the public through the administrative process called a proposed rulemaking. The public can comment on proposed rules. Final rules are incorporated in the Code of Federal Regulations when approved.

Recovery: NMFS (2010) describes recovery as: "…the process by which listed species and their ecosystems are restored and their future is safeguarded to the point that protections under the ESA are no longer needed."

Recovery Domain: The geographic area for which a Technical Recovery Team is responsible.

Recovery Plan: A document generally required under the ESA for the conservation and survival of listed species, which must include, to the maximum extent practicable: (1) a description of such site-specific management actions as may be necessary to achieve the plan's goal for the conservation and survival of the species; (2) objective, measurable criteria which, when met, would result in the determination that the species be removed from the list; and (3) estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal (of species recovery) and to achieve the intermediate steps toward that goal.

Recovery Supplementation: Short-term artificial propagation designed to reduce the risk of extinction of a small or chaotically fluctuating recovering population in its natural habitat by temporarily increasing population size using recovery hatchery fish, while maintaining available genetic diversity and avoiding genetic change in the natural and hatchery populations.

Redd: Nest-like depression constructed by female salmonids facilitating increased hyporheic flow for developing eggs and alevins. A type of fish-spawning area associated with running water and clean gravel.

Refugia: An area where special environment circumstances occur, enabling a species to survive in specific life stages.

Research: Scientific inquiry focused on answering original questions or increasing knowledge. May consist of experiments, systematic observations, or original descriptions of structures, relationships, and processes.

Restoration Potential: The potential for returning a damaged habitat, watershed or ecosystem to a condition or function that is (1) similar to pre-disturbance, or (2) self-sustaining and in equilibrium with the surrounding landscape and ecological processes necessary for carrying out the basic life history functions of target organisms. An area characterized as having a high restoration potential would be considered to have a high likelihood of returning to this condition or function. Conversely, an area with low restoration potential would have little to no likelihood of returning to this condition or function.

Riffle: A short, relatively shallow and coarse-bedded length of stream over which the stream flows at slower velocity but a higher turbulence than it normally does in comparison to a pool.

Riparian Area: An area with distinctive soils and vegetation between a stream or other body of water and the adjacent upland. It includes wetlands and those portions of floodplains and valley bottoms that support riparian vegetation.

Riparian Vegetation: Vegetation growing on or near the banks of a stream or other body of water in soils that exhibit some wetness characteristics during some portion of the growing season.

Rip-rap: Layer of large, durable materials (usually rock) used to protect a stream bank or lake shore from erosion.

Riverine: Habitat within or alongside a river or channel.

River kilometer (RKm): Distance, in kilometers, from the mouth of the indicated river. Usually used to identify the location of a physical feature, such as a confluence, dam, waterfall, or spawning area.

Run: The spawning adults of a given species that return to a stream during a given season (*e.g.* winter run).

Salmonid: A term used to collectively talk about both salmon and steelhead.

Salmon Fishery Management Plan: Any of a variety planning documents relating to salmon fisheries implemented or enforced by Federal or State, or local agencies.

Scope: The geographic area of the threat to the species or system. Impacts can be widespread or localized.

Scour: A negative change in stream bed or bank elevation caused by fluvial processes, particularly stream flow volume and velocity.

Sedimentary Rocks: Rocks formed by the deposition of sediment. Sediment: solid fragments of inorganic or organic material that comes from the weathering of rock and are carried and deposited by wind, water, or ice.

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

Seine: A large fishing net made to hang vertically in the water by weights at the lower edge and floats at the top.

Self-sustaining Population: A population that perpetuates itself without human intervention, without chronic decline, and in its natural ecosystem.

Semelparous: Reproducing only once in a lifetime. Most salmon are semelparous, and die after spawning (see also iteroparous).

Severity: A measure of the level of damage to species or system(s) that can reasonably be expected within 10 years under current circumstances. Severity ranges from total destruction down to slight impairment.

Smolt: (Verb) - The physiological process that prepares a juvenile anadromous fish to survive the transition from fresh water to salt water. (Noun) - A juvenile anadromous fish that has made those physiological changes.

Smoltification: Describes the process by which salmonid fish acclimate metabolically over time from fresh water to marine environments as they emigrate from their natal streams to the ocean. During this process, parr marks fade and the fish takes on a silver color.

Spawner: Adult salmonids retuning to the freshwater environment to reproduce.

Spawner surveys: Spawner surveys utilize counts of **redds** (nests dug by females in which they deposit their eggs) and fish carcasses to estimate spawner escapement and identify habitat being used by spawning fish. Annual surveys can be used to compare the relative magnitude of spawning activity between years.

Spawner-to-spawner Ratio: Several measures are employed to estimate the productivity of salmon populations. The spawner-to-spawner ratio estimates the number of spawners (those fish that reproduced or were expected to reproduce) in one generation produced by the previous generation's spawners. A spawner-to-spawner ratio of 1.0 indicates that, on average, each spawner produced one offspring that survived to spawn. The recruit-to-spawner ratio estimates the number of recruits (fish that are available for harvest in addition to those that bypass the fishery to spawn) produced by the previous generation's spawners.

Species: In general, a fundamental category of taxonomic classification, ranking below a genus or subgenus and consisting of related organisms capable of interbreeding. The ESA defines a species to include any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature.

Splash Dam: A dam built to create a head of water for driving logs downstream.

Stochastic: The term is used to describe natural events or processes that are random and unpredictable. Examples include environmental conditions such as earthquakes and severe storms, or life-cycle events, such as radically changed survival or fecundity rates.

Stock: See population.

Stock transfer: Human-caused transfer of fish from one location to another, typically in the context of out-of-basin or out-of-ESU transfers.

Stratified Random Sampling (SRS): Provides an estimate of the number of spawners in a given area based on spawner counts in both standard and supplemental surveys.

Stratification: Differing densities between salt and fresh waters create layers in the water column of estuaries and lagoons.

Straying: Occurs when some adult salmonids spawn in a stream other than the one they were produced in. Straying may be influenced by hatchery practices, water quality or water diversions.

Take: As defined by the Endangered Species Act, take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect; or attempt to engage in any such conduct.

Technical Recovery Team (TRT): An appointed group of fishery experts, led by the NMFS Southwest Fisheries Science Center for species under this document, and charged with development of technical documents providing the foundation for the development of recovery plans.

Thalweg: A line defining the deepest continuous portion of a valley, stream or waterway. Sometimes referred to as the "valley line".

Thermocline: That layer in a body of water where the temperature difference is greatest per unit of depth. It is the layer in which the drop in temperature equals or exceeds one degree C. (1.8 degrees F) per meter (39.37 inches).

Threatened Species: Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Total Maximum Daily Load: Under the Clean Water Act, the total maximum daily load is the amount of pollutant that a water body can receive and still meet water quality standards.

Tributary: A stream that flows into a larger stream or other body of water.

Trophic Levels: Hierarchical tiers within a food web system (*e.g.*, top predator or primary producer).

Turbid: Water that is not clear, having sediment or foreign particles stirred up or suspended.

Viability: The likelihood that a population will sustain itself over a 100-year time frame.

Viable Salmonid Population: An independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats for demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame

Watershed: The region draining into a river, river system, or other body of water

Weir: A notch or depression in a dam or other water barrier through which the flow of water is measured or regulated. Also, a barrier constructed across a stream to divert fish into a trap or to raise the water level or divert water flow

Wetland: An ecological community such as a marsh or swamp that is permanently or seasonally saturated with moisture.

Zooplankton: Non-photosynthetic, heterotrophic planktonic organisms, including protists, small animals, and larvae, which exist within the water column.

LITERATURE CITED

55 FR 24296. 1990. Endangered and threatened species; listing and recovery priority guidelines. June 15, 1990. Federal Register 55:24296-24298.

56 FR 58612. 1991. Policy on Applying the Definition of Species Under the Endangered Species Act to Pacific Salmon. November 20, 1991. Federal Register 56:58612-58618.

59 FR 24271. 1994. Endangered and threatened wildlife and plants: notice of interagency cooperative policy on information standards under the Endangered Species Act. July 1, 1994. Federal Register 59:24271.

61 FR 4722. 1996. Policy regarding the recognition of distinct vertebrate population segments under the Endangered Species Act. February 7, 1996. Federal Register 61:4722-4725.

61 FR 41541. 1996. Endangered and threatened species: proposed endangered status for five ESUs of steelhead and proposed threatened status for five ESUs of steelhead in Washington, Oregon, Idaho, and California. August 9, 1996. Federal Register 61:41541-41561.

62 FR 43937. 1997. Endangered and threatened species: listing of several evolutionarily significant units (ESUs) of west coast steelhead. August 18, 1997. Federal Register 62:43937-43954.

63 FR 11482. 1998. Endangered and Threatened Species: Proposed Endangered Status for Two Chinook Salmon ESUs and Proposed Threatened Status for Five Chinook Salmon ESUs; Proposed Redefinition, Threatened Status, and Revision of Critical Habitat for One Chinook Salmon ESU. Proposed Designation of Chinook Salmon Critical Habitat in California, Oregon, Washington, Idaho. March 9, 1998. Federal Register 63:11482-11520.

63 FR 13347. 1998. Endangered and threatened species: threatened status for two ESUs of steelhead in Washington, Oregon, and California. March 19, 1998. Federal Register 63:13347-13371.

64 FR 14308. 1999. Endangered and Threatened Species: threatened status for three Chinook salmon evolutionarily significant units (ESUs) in Washington and Oregon, and endangered status for one Chinook salmon ESU in Washington. March 24, 1999. Federal Register 64(56):14308-14328.

64 FR 50394. 1999. Endangered and threatened species: threatened status for two Chinook salmon evolutionarily significant units (ESUs) in California. September 16, 1999. Federal Register 64(179):50934-50415.

65 FR 6960. 2000. Endangered and Threatened Species: threatened status for one evolutionarily significant unit of steelhead in California. February 11, 2000. Federal Register 65(29):6960-6975.

65 FR 36074. 2000. Endangered and threatened species: threatened status for one steelhead evolutionarily significant unit (ESU) in California. June 7, 2000. Federal Register 65:36074-36094.

68 FR 15100. 2003. Policy for evaluation of conservation efforts when making listing decisions. March 28, 2003. Federal Register 68:15100-15115.

69 FR 33102. 2004. Endangered and threatened species: proposed listing determinations for 27 ESUs of West Coast salmonids. June 14, 2004. Federal Register 69:33102-33179.

70 FR 37160. 2005. Endangered and threatened species: final listing determinations for 16 ESUs of West Coast Salmon, and final 4(d) protective regulations for threatened salmonid ESUs. June 28, 2005. Federal Register 70:37160-37204.

70 FR 52488. 2005. Endangered and threatened species; designation of critical habitat for seven evolutionarily significant units of Pacific salmon and steelhead in California. September 2, 2005. Federal Register 70:52488-52627.

71 FR 834. 2006. Endangered and threatened species: final listing determinations for 10 distinct population segments of West coast steelhead. January 5, 2006. Federal Register 71:834-862.

79 FR 20802. 2014. Endangered and Threatened Wildlife; Final Rule To Revise the Code of Federal Regulations for Species Under the Jurisdiction of the National Marine Fisheries Service. Final rule: clarified and updated descriptions of species under NMFS' jurisdiction and that are currently listed as endangered or threatened. April 14, 2014. Federal Register 79:20802-20817.

81 FR 7414. 2016. Listing Endangered and Threatened Species and Designating Critical Habitat; Implementing Changes to the Regulations for Designating Critical Habitat. February 11, 2016. Federal Register 81:7414-7440.

81 FR 33468. 2016. Endangered and Threatened Species; 5-Year Reviews for 28 Listed Species of Pacific Salmon, Steelhead, and Eulachon. May 26, 2016. Federal Register 81:33468-33469.

Adams, P. B. 2000. Status Review Update for the Steelhead Northern California Evolutionarily Significant Unit. National Marine Fisheries Service, Southwest Fisheries Science Center, Tiburon, California.

Adams, P. B., L. B. Boydstun, S. P. Gallagher, M. K. Lacy, T. McDonald, and K. E. Shaffer. 2011. California coastal salmonid population monitoring: Strategy, design, and methods. State of California The Natural Resources Agency Department of Fish and Game.

Agrawal, A., R. S. Schick, E. P. Bjorkstedt, R. G. Szerlong, M. N. Goslin, B. C. Spence, T. H. Williams, and K. M. Burnett. 2005. Predicting the potential for historical coho, Chinook, and steelhead habitat in northern California. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-SWFSC-379.

Allen, M. A., and T. J. Hassler. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest): Chinook salmon. U.S. Fish and Wildlife Service Biological Report 82 (11.49). 36 pp.

Arnsberg, B., P. Groves, F. Mullins, D. Milks, and M. Allen. 2014. 2013 Snake River Fall Chinook Salmon Spawning Summary. Prepared for the Bonneville Power Administration. 5 pp.

Atencio, B., and M. Reichmuth. 2014. Monitoring of Adult Coho Salmon and Steelhead Trout Using Dual-frequency Identification Sonar (DIDSON) in Lagunitas Creek, California. Prepared for the California Department of Fish and Wildlife. Contract #P1130420. Point Reyes National Seashore Association, Point Reyes Station, CA.

Atkinson, K. A. 2010. Habitat conditions and steelhead abundance and growth in a California lagoon. Master's Thesis. San Jose State University, San Jose, CA.

Atkinson, K. A., M. K. Lacy, and R. J. Bellmer. 2016. Dual frequency identification sonoar (DIDSON) deployment and preliminary performance as part of the California Coastal Salmonid Monitoring Plan. California Department of Fish and Wildlife, Sacramento, California. Administrative Report 2016-01. 34 pp.

Aydin, K. Y., G. A. McFarlane, J. R. King, B. A. Megrey, and K. W. Myers. 2005. Linking oceanic food webs to coastal production and growth rates of Pacific salmon (*Oncorhynchus spp.*), using models on three scales. Deep-Sea Research Part II: Topical Studies in Oceanography 55(5-6):757-780.

Baltz, D. M., B. Vondracek, L. R. Brown, and P. B. Moyle. 1987. Influence of temperature on microhabitat choice by fishes in a California stream. Transactions of the American Fisheries Society 116:12-20.

Barnett, L. A. K., and B. C. Spence. 2011. Freshwater Survival of Stranded Steelhead Kelts in Coastal Central California Streams. North American Journal of Fisheries Management 31:757–764.

Barnhart, R. A. 1986. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Southwest), 82(11.60).

Barrowman, N. J., R. A. Myers, R. Hilborn, D. G. Kehler, and C. A. Field. 2003. The variability among populations of coho salmon in the maximum reproductive rate and depensation. Ecological Applications 13(3):784-793.

Barth, J. A., B. A. Menge, J. Lubchenco, F. Chan, J. M. Bane, A. R. Kirincich, M. A. McManus, K. J. Nielsen, S. D. Pierce, and L. Washburn. 2007. Delayed upwelling alters nearshore coastal ocean ecosystems in the northern California current. Proceedings of the National Academy of Sciences of the United States of America 104(10):3719-3724.

Battin, J., M. W. Wiley, M. H. Ruckelshaus, R. N. Palmer, E. Korb, K. K. Bartz, and H. Imaki. 2007. Projected impacts of climate change on salmon habitat restoration. Proceedings of the National Academy of Sciences of the United States of America 104(16):6720-6725.

Beakes, M. P., W. H. Satterthwaite, E. M. Collins, D. R. Swank, J. E. Merz, R. G. Titus, S. M. Sogard, and M. Mangel. 2010. Smolt Transformation in Two California Steelhead Populations: Effects of Temporal Variability in Growth. Transactions of the American Fisheries Society 139:1263–1275.

Beamish, R. J., and D. R. Bouillon. 1993. Pacific salmon production trends in relation to climate. Canadian Journal of Fisheries and Aquatic Sciences 50:1002-1016.

Beauchamp, D. A., M. F. Shepard, and G. B. Pauley. 1983. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Pacific Northwest): Chinook salmon. U. S. Fish and Wildlife Service.

Behnke, R. J. 1992. Native trout of western North America. American Fisheries Society, Fort Collins, CO.

Behrens, D. K. 2008. Inlet closure and morphological behavior in a Northern California Estuary. The case of the Russian River. Master's Thesis. University of California Davis, Davis, CA.

Bell, E., S. M. Albers, J. M. Krug, and R. Dagit. 2011. Juvenile growth in a population of southern California steelhead (*Oncorhynchus mykiss*). California Fish and Game 97(1):25-35.

Bilby, R. E., B. R. Fransen, and P. A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53:164-173.

Bilby, R. E., B. R. Fransen, P. A. Bisson, and J. K. Walter. 1998. Response of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead (*Oncorhynchus mykiss*) to the addition of salmon carcasses to two streams in southwestern Washington, U. S. A. Canadian Journal of Fisheries and Aquatic Sciences 55:1909-1918.

Bisson, P. A., R. E. Bilby, M. D. Bryant, C. A. Dolloff, G. B. Grette, R. A. House, M. L. Murphy, K. V. Koski, and J. R. Sedell. 1987. Large woody debris in forested streams in the Pacific Northwest: Past, present, and future. Pages 143-190 *in* E. O. Salo, and T. W. Cundy, editors. Streamside management: forestry and fishery interactions.

Bisson, P. A., and G. E. Davis. 1976. Production of juvenile chinook salmon, *Oncorhynchus tshawytcha*, in a heated model stream. Fishery Bulletin 74(4):763-774.

Bjorkstedt, E. P., B. C. Spence, J. C. Garza, D. G. Hankin, D. Fuller, W. E. Jones, J. J. Smith, and R. Macedo. 2005. An analysis of historical population structure for evolutionarily significant units of Chinook salmon, coho salmon, and steelhead in the north-central California coast recovery domain. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-SWFSC-382.

Bjornn, T. C., and D. W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 *in* W. R. Meehan, editor. Influences of Forest and Rangeland Management. American Fisheries Society, Bethesda, MD.

Boles, G. L. 1988. Water temperature effects on Chinook salmon (*Oncorhynchus tshawytscha*) with emphasis on the Sacramento River: a literature review. California Department of Water Resources, Northern District, Sacramento, California.

Bond, M. 2006. The Importance of Lagoon Habitat to Steelhead Survival on the Central Coast. Monterey Bay Salmon & Trout Project Newsletter.

Bond, M. H., S. A. Hayes, C. V. Hanson, and B. R. MacFarlane. 2008. Marine Survival of Steelhead (*Oncorhynchus mykiss*) enhanced by a seasonally closed estuary. Canadian Journal of Fisheries and Aquatic Sciences 65:2242-2252.

Boughton, D. A., H. Fish, J. Pope, and G. Holt. 2009. Spatial patterning of habitat for *Oncorhynchus mykiss* in a system of intermittent and perennial streams. Ecology of Freshwater Fish 18:19-105.

Boughton, D. A., M. Gibson, R. Yedor, and E. Kelley. 2007. Stream temperature and the potential growth and survival of juvenile *Oncorhynchus mykiss* in a southern California creek. Freshwater Biology 52:1353-1364.

Brewer, P. G., and J. Barry. 2008. Rising Acidity in the Ocean: The Other CO_2 Problem. Scientific American.

Brodeur, R. D., B. W. Frost, S. R. Hare, R. C. Francis, and W. J. J. Ingraham. 1996. Interannual variations in zooplankton biomass in the Gulf of Alaska, and covariation with California current zooplankton biomass. CalCOFl Rep. 37:80-99.

Bryant, M. D. 1983. The role and management of woody debris in west coast salmonid nursery streams. North American Journal of Fisheries Management 3:322-330.

Burgner, R. L., J. T. Light, L. Margolis, T. Okazaki, A. Tautz, and S. Ito. 1992. Distribution and origins of steelhead trout in offshore waters of the North Pacific Ocean. International North Pacific Fisheries Commission, Bulletin #51, Vancouver, B.C.

Burnett, K. M., G. H. Reeves, D. Miller, S. Clarke, K. Christiansen, and K. Vance-Borland. 2003. A first step toward broad-scale identification of freshwater protected areas for Pacific salmon and trout in Oregon, USA. Pages 144–154 *in* J. P. Beumer, A. Grant, and D. C. Smith, editors. Aquatic Protected Areas: what works best and how do we know? Proceedings of the 3rd World Congress on Aquatic Protected Areas. Australian Society for Fish Biology, Cairns, Australia.

Burnett, K. M., G. H. Reeves, D. J. Miller, S. Clarke, K. Vance-Borland, and K. Christiansen. 2007. Distribution of salmon-habitat potential relative to landscape characteristics and implications for conservation. Ecological Applications 17(1):66-80.

Burwen, D. L., S.J. Fleischman, and J. D. Miller. 2010. Accuracy and precision of salmon length estimates taken from DIDSON sonar images. Transactions of the American Fisheries Society 139(5):1306-1314.

Busby, M. S., and R. A. Barnhart. 1995. Potential Food Sources and Feeding Ecology of Juvenile Fall Chinook Salmon in California's Mattole River Lagoon. California Fish and Game 81(4):133-146.

Busby, P. J., T. C. R. Gustafson, R. Iwamoto, C. Mahnken, G. Matthews, J. Myers, M. Schiewe, T. C. Wainwright, R. Waples, J. Williams, P. Adams, G. Bryant, C. Wingert, and R. R. Reisenbichler. 1997. Status Review Update for West Coast Steelhead from Washington, Idaho, Oregon and California. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Largomarsino. 1996. Status review of West Coast steelhead from Washington, Idaho, Oregon, and California. National Marine Fisheries Service, Northwest Fisheries Sceince Center and Southwest Region Protected Resources Division, NOAA Technical Memorandum, NMFS-NWFSC-27.

Bustard, D. R., and D. W. Narver. 1975. Aspects of the winter ecology of junenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada 32(5):667-680.

CDFG (California Department of Fish and Game). 1965. California fish and wildlife plan. Volume III supporting data: Part B, inventory salmon-steelhead and marine resources, available from California Department of Fish and Game, 1416 Ninth St., Sacramento, CA 95814.

CDFG (California Department of Fish and Game). 1997. Eel River Salmon and Steelhead Restoration Action Plan. California Department of Fish and Game, Inland Fisheries Division, Sacramento.

CDFG (California Department of Fish and Game). 2004. Recovery strategy for California coho salmon: report to the California Fish and Game Commission. California Department of Fish and Game, Native Anadromous Fish and Watershed Branch, Sacramento, CA.

CEPA (California Environmental Protection Agency). 2006. Climate Action Team Report to Governor Schwarzenegger and the Legislature.

Cannata, S. P. 1998. Observations of steelhead trout (*Oncorhynchus mykiss*), coho salmon (*O. kisutch*) and water quality of the Navarro River estuary/lagoon May 1996 to December 1997. Humboldt State University Foundation.

Casagrande, J., and F. Watson. 2003. Hydrology and water quality of the Carmel and Salinas Lagoons, Monterey Bay, California 2002/2003. Report to the Monterey County Water Resources Agency. The Watershed Institute, California State University Monterey Bay, Seaside, CA. Report No. WI-2003-14. 128 p., WI-2003-14.

Casagrande, J. M. 2010. Distribution, abundance, growth, and habitat use of steelhead in Uvas Creek, Ca. Master's Thesis. San Jose State University, San Jose, CA.

Casola, J. H., J.E. Kay, A.K. Snover, R.A. Norheim, L.C. Whitely Binder, and Climate Impact Group. 2005. Climate impacts on Washington's hydropower, water supply, forests, fish, and agriculture. Center for Science in the Earth System, Joint Institute for the Study of the Atmosphere and Ocean, University of Washington, Seattle, Washington.

Cayan, D., E. P. Maurer, M. D. Dettinger, M. Tyree, and K. Hayhoe. 2008. Climate change scenarios for the California region. Climate change 87 (supp1):S21-S-42.

Cech, J. J., Jr, S. J. Mitchell, D. T. Castleberry, and M. McEnroe. 1990. Distribution of California Stream Fishes: Influence of Environmental Temperature and Hypoxia. Environmental Biology of Fishes 29(2):95-105.

Cederholm, C. J., M. D. Kunze, T. Murota, and A. Sibatani. 1999. Pacific Salmon Carcasses: Essential Contributions of Nutrients and Energy for Aquatic and Terrestrial Ecosystems. Fisheries 24(10):6-15.

Chapman, D. W., and T. C. Bjornn. 1969. Distribution of salmonids in streams, with special reference to food and feeding. Pages 153-176 *in* T. G. Northcote, editor Symposium on Salmon and Trout in Streams; H.R. Macmillan Lectures in Fisheries. University of British Columbia, Institute of Fisheries.

Chase, S. D., D. J. Manning, D. G. Cook, and S. K. White. 2007. Historic Accounts, Recent Abundance, and Current Distribution of Threatened Chinook Salmon in the Russian River, California. California Fish and Game 93(3):130-148.

Chen, I., J. K. Hill, R. Ohlemüller, D. B. Roy, and C. D. Thomas. 2011. Rapid range shifts of species associated with high levels of climate warming. Science 333:1024-1026.

Chilcote, M. W. 1999. Conservation Status of Lower Columbia River Coho Salmon. Information Reports 99-3. Oregon Department of Fish and Wildlife, Fish Division.

Collen, P., and R. J. Gibson. 2001. The general ecology of beavers (*Castor spp.*), as related to their influence on stream ecosystems and riparian habitats, and the subsequent effects on fish - a review. Reviews in Fish Biology and Fisheries 10:439-461.

Collins, C. 1998. Age and Growth of Steelhead Rainbow Trout (*Oncorhynchus mykiss*) in the Big Sur River. Master's Thesis. California Polytechnic State University, San Luis Obispo.

Comte, L., and G. Grenouillet. 2013. Do stream fish track climate change? Assessing distribution shifts in recent decades. Ecography 36:001–011.

Coots, M. 1973. A study of juvenile steelhead, *Salmo gairdnerii gairdnerii* Richardson in San Gregorio Creek lagoon, San Mateo County, March through August 1971. California Department of Fish and Game, Report 78-4.

Courter, I. I., D. B. Child, J. A. Hobbs, T. M. Garrison, J. G. Glessner, and S. Duery. 2013. Resident rainbow trout produce anadromous offspring in a large interior watershed. Canadian Journal of Fisheries and Aquatic Sciences 70:701-710.

Crawford, R. A., and S. Rumsey. 2011. Guidance for Monitoring Recovery of Pacific Northwest Salmon & Steelhead listed under the Federal Endangered Species Act. National Marine Fisheries Service, NW Region.

Cunjak, R. A. 1996. Winter habitat of selected stream fishes and potential impacts from land-use activity. Canadian Journal of Fisheries and Aquatic Sciences 53 (Suppl. 1):267-282.

Defenders of Wildlife v. Babbitt. 2001. 130 F. Supp. 2d 121 (D.D.C. 2001).

DeHaven, R. W. 2008. Adult and juvenile steelhead population surveys Gualala River, California, 2008. Prepared by the author, December 31, 2008, for use by agencies, groups and individuals involved in steelhead recovery efforts. 67 pp.

Dettinger, M. D., and D. R. Cayan. 1995. Large-scale atmospheric forcing of recent trends toward early snowmelt runoff in California. Journal Of Climate 8:606-623.

Devictor, V., R. Julliard, D. Couvet, and F. Jiguet. 2008. Birds are tracking climate warming, but not fast enough. Proceedings of the Royal Society Biological Sciences 275:2743–2748.

Diffenbaugh, N. S., M. A. Snyder, and L. C. Sloan. 2003. Could CO_2-induced land-cover feedbacks alter near-shore upwelling regimes? Proceedings of the National Academy of Sciences of the United States of America 101(1):27-32.

Dolloff, A. C. 1986. Effects of stream cleaning on juvenile coho salmon and dolly varden in southeast Alaska. Transactions of the American Fisheries Society 115:743-755.

Donohoe, C. J., P. B. Adams, and C. F. Royer. 2008. Influence of water chemistry and migratory distance on ability to distinguish progeny of sympatric resident and anadromous rainbow trout (*Oncorhynchus mykiss*). Canadian Journal of Fisheries and Aquatic Sciences 65:1160-1175.

Duncan, S. L. 1984. Leaving it to beaver. Environment 26:41-45.

Erman, D. C., E. D. Andrews, and M. Yoder-Williams. 1988. Effects of winter floods on fishes in the Sierra Nevada. Canadian Journal of Fisheries and Aquatic Sciences 45:2195-2200.

Everest, F. H. 1973. Ecology and management of summer steelhead in the Rogue River. Oregon State Game Commission, Fishery Research Report No. 7, Corvallis, OR.

Everest, F. H., and D. W. Chapman. 1972. Habitat selection and spatial interaction by juvenile Chinook salmon and steelhead trout. Journal of the Fisheries Research Board of Canada 29:91-100.

Fausch, K. D. 1984. Profitable Stream Positions for Salmonids: Relating Specific Growth Rate to Net Energy Gain. Canadian Journal of Zoology 62:441-451.

Fearing, D. B. 1876. The Treasures of the Deep: Or, A Descriptive Account of the Great Fisheries, and Their Products. T. Nelson and Sons, Paternoster Row, London.

Feely, R. A., C.L. Sabine, K. Lee, W. Berelson, J. Kleypas, V.J. Fabry, and F. J. Millero. 2004. Impact of anthropogenic CO_2 on the $CaCO_3$ system in the oceans. Science 305:362-366.

Fleischman, S. J., and D. L. Burwen. 2003. Mixture models for the species apportionment of hydroacoustic data, with echo-envelope length as the discriminatory variable. ICES Journal of Marine Science 60:592–598.

Francis, R. I. C. C. 1997. Comment: how should fisheries scientists and managers react to uncertainty about stock-recruit relationships? Canadian Journal of Fisheries and Aquatic Sciences 54:982-983.

Fukushima, L., and E. W. Lesh. 1998. Adult and juvenile anadromous salmonid migration timing in California streams. California Fish and Game 84(3):133-145.

Fuller, J. A. 2011. Extended residency and movement behavior of juvenile steelhead (*Oncorhynchus mykiss*) in the Russian River Estuary, California. Master's Thesis. Humboldt State University, Arcata, CA.

Fund for Animals v. Babbitt. 1995. 903 F. Supp. 96 (D.D.C. 1995).

Gallagher, S. P., and D. W. Wright. 2008. A regional approach to monitoring salmonid abundance trends: a pilot project for the application of the California coastal salmonid monitoring plan in coastal Mendocino County: Year III. 2007-08 final report to CDFG Fisheries Restoration Grant Program, Grant P0610540, Coastal Mendocino County salmonid monitoring project.

Gallagher, S. P., D. W. Wright, B. W. Collins, and P. B. Adams. 2010. A Regional Approach for Monitoring Salmonid Status and Trends: Results from a Pilot Study in Coastal Mendocino County, California. North American Journal of Fisheries Management 30:1075–1085.

Garza, J. C., E. A. Gilbert-Horvath, B. C. Spence, T. H. Williams, H. Fish, S. A. Gough, J. H. Anderson, D. Hamm, and E. C. Anderson. 2014. Population Structure of Steelhead in Coastal California. Transactions of the American Fisheries Society 143(1):134-152.

Good, T. P., R. S. Waples, and P. B. Adams. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-NWFSC-66.

Grantham, T. E., D. A. Newburn, M. A. McCarthy, A. M., and A. M. Merenlender. 2012. The Role of Streamflow and Land Use in Limiting Oversummer Survival of Juvenile Steelhead in California Streams. Transactions of the American Fisheries Society 141(3):585-598.

Grimes, C. B., R. D. Brodeur, L. J. Haldorson, and S. M. McKinnell editors. 2007. The ecology of juvenile salmon in the northeast Pacific Ocean: regional comparisons, volume Symposium 57. American Fisheries Society.

Groot, C., and L. Margolis. 1991. Pacific salmon life histories. Universtiy of British Columbia Press, Vancouver, British Columbia, Canada.

Hanson, C. V. 2008. Influence of Lagoon Habitat on Steelhead Life History Variation. Master's Thesis. University of California Santa Cruz, Santa Cruz, CA.

Hare, S. R. 1996. Low frequency climate variability and salmon production. Doctoral Dissertation. University of Washington, Seattle, WA.

Harley, C. D. G., A.R. Hughes, K.M. Hultgren, B.G. Miner, C.J.B. Sorte, C.S.Thornber, L.F. Rodriguez, L. Tomanek, and S. L. Williams. 2006. The impacts of climate change in coastal marine systems. Ecology Letters 9:228-241.

Harvey, B. C., R. J. Nakamoto, and J. L. White. 2006. Reduced streamflow lowers dry-season growth of rainbow trout in a small stream. Transactions of the American Fisheries Society 135:998–1005.

Hassler, T. J. 1987. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest): coho salmon. U.S. Fish and Wildlife Service Biological Report 82 (11.70). 28 pp.

Hayes, S. A., M. H. Bond, C. V. Hanson, E. V. Freund, J. J. Smith, E. C. Anderson, A. J. Ammann, and B. R. MacFarlane. 2008. Steelhead Growth in a Small Central California Watershed: Upstream and Estuarine Rearing Patterns. Transactions of the American Fisheries Society 137:114-128.

Hayes, S. A., M. H. Bond, C. V. Hanson, A. W. Jones, A. J. Ammann, J. A. Harding, A. L. Collins, J. Perez, and R. B. MacFarlane. 2011. Down, up, down and "smolting" twice? Seasonal movement patterns by juvenile steelhead (*Oncorhynchus mykiss*) in a coastal watershed with a bar closing estuary. Canadian Journal of Fisheries and Aquatic Sciences 68:1341-1350.

Hayes, S. A., C. V. Hanson, D. E. Pearce, M. H. Bond, J. C. Garza, and B. R. MacFarlane. 2012. Should I Stay or Should I Go? The Influence of Genetic Origin on Emigration Behavior and Physiology of Resident and Anadromous Juvenile *Oncorhynchus mykiss*. North American Journal of Fisheries Management 32(4):772-780.

Hayes, S. A., N. M. Teutschel, C. J. Michel, C. Champagne, P. W. Robinson, M. Fowler, T. Yack, D. K. Mellinger, S. Simmons, D. P. Costa, and B. R. MacFarlane. 2013. Mobile receivers: releasing the mooring to 'see' where fish go. Environmental Biology of Fishes 96:189-201.

Hayhoe, K., D. Cayan, C. B. Field, P. C. Frumhoff, E. P. Maurer, N. L. Miller, S. C. Moser, S. H. Schneider, K. N. Cahill, E. E. Cleland, L. Dale, R. Drapek, R. M. Hanemann, L. S. Kalkstein, J. Lenihan, C. K. Lunch, R. P. Neilson, S. C. Sheridan, and J. H. Verville. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences of the United States of America 101(34):12422-12427.

Healey, M. C. 1991. Life history of Chinook salmon (*Oncorhynchus tshawytscha*). Pages 311-393 *in* C. Groot, and L. Margolis, editors. Pacific salmon life histories. UBC Press, Vancouver, BC.

Healey, M. C., and F. P. Jordan. 1982. Observations on juvenile chum and chinook and spawning chinook in the Nanaimo River, British Columbia, during 1975-1981. Department of Fisheries and Oceans , Fisheries Research Branch, Pacific Biological Station, Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1659, Nanaimo.

Hendry, A. P., T. Bohlin, B. Jonsson, and O. K. Berg. 2004. To sea or not to sea? Anadromy versus non-anadromy in salmonids. Pages 93-125 *in* A. P. Hendry, and S. C. Stearns, editors. Evolution Illuminated. Oxford University Press, Oxford.

Hill, B. H., F. H. McCormick, B. C. Harvey, S. L. Johnson, M. L. Warren, and C. M. Elonen. 2010. Microbial enzyme activity, nutrient uptake and nutrient limitation in forested streams. Freshwater Biology 55:1005–1019.

Hokanson, K. E. F., C. F. Kleiner, and T. W. Thorslund. 1977. Effects of constant temperatures and diel temperature fluctuations on specific growth and mortality rates and yield of juvenile rainbow trout, *Salmo gairdneri*. Journal of the Fisheries Research Board of Canada 34:639-648.

Holecek, D. E., K. J. Cromwell, and B. P. Kennedy. 2009. Juvenile Chinook salmon summer microhabitat availability, use, and selection in a central Idaho wilderness stream. Transactions of the American Fisheries Society 138:633-644.

Hollowed, A., and W. S. Wooster. 1992. Variability of winter ocean conditions and strong year classes of northeast Pacific groundfish. ICES Mar. Sci. Symp. 195:433-444.

Holmes, J. A., G. M. W. Cronkite, H. J. Enzenhofer, and T. J. Mulligan. 2006. Accuracy and precision of fish-count data from a ''dual-frequency identification sonar'' (DIDSON) imaging system. Journal of Marine Science 63:543-555.

Holtby, L. B. 1988. Effects of logging on stream temperatures in Carnation Creek, British Columbia, and associated impacts on the coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 45:502-515.

Holtby, L. B., B. C. Anderson, and R. K. Kadowaki. 1990. Importance of smolt size and early ocean growth to interannual variability in marine survival of coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 47(11):2181-2194.

IPCC (Intergovernmental Panel on Climate Change). 2007. Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Geneva, Switzerland.

Isaak, D. J., S. Wollrab, D. Horan, and G. Chandler. 2011. Climate change effects on stream and river temperatures across the northwest U.S. from 1980-2009 and implications for salmonid fishes. Climatic Change 0165-0009: 1-26. DOI 10.1007/s10584-011-0326-z.

Jeffres, C. A., J. J. Opperman, and P. B. Moyle. 2008. Ephermeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river. Environmental Biology of Fishes 83:449-458.

Katz, J. 2012. The Knaggs Ranch Experimental Agricultural Floodplain Pilot Study 2011-2012 Year One Overview. A cooperative project of the Center for Watershed Sciences at the University of California, Davis & California Department of Water Resources, in cooperation with landowner partners Cal Marsh and Farm Ventures, LLC Knaggs Ranch, LLC. Supported by CalTrout, U.S. Bureau of Reclamation, NOAA Southwest Fisheries Science Center.

Keter, T. S. 1995. Environmental history and cultural ecology of the North Fork of the Eel River basin, California. Technical Report. R5-EM-TP-002. USDA, Forest Service, Pacific Southwest Region.

Kostow, K. 1995. Biennial report on the status of wild fish in Oregon. Oregon Department of Fish and Wildlife, Portland, OR.

Kruzic, L. M., D. L. Scarnecchia, and B. B. Roper. 2001. Comparison of midsummer survival and growth of age-0 hatchery coho salmon held in pools and riffles. Transactions of the American Fisheries Society 130:147-154.

Larson, Z. 2013. Use of dual frequency identification sonar to monitor steelhead escapement in the Smith River, California, 2012-2013. Prepared for the County of Del Norte. Zach Larson & Associates, Cresent City, California.

Le Treut, H., R. Somerville, U. Cubasch, Y. Ding, C. Mauritzen, A. Mokssit, T. Peterson, and M. Prather. 2007. Historical Overview of Climate Change. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Leidy, R. A., and G. R. Leidy. 1984. Life stage periodicities of anadromous salmonids in the Klamath River Basin, Northwestern California. U.S. Fish and Wildlife Service, Division of Ecological Services, Sacramento, CA.

Levin, P. S., J. J. Fogarty, S. A. Murawski, and D. Fluharty. 2009. Integrated ecosystem assessments: developing the scientific basis for ecosystem based management of the ocean. PLoS ONE 7:23-28.

Lindley, S. T., C. B. Grimes, M. S. Mohr, W. Peterson, J. Stein, J. T. Anderson, L.W. Botsford, D. L. Bottom, C. A. Busack, T. K. Collier, J. Ferguson, J. C. Garza, A. M. Grover, D. G. Hankin, R. G. Kope, P. W. Lawson, A. Low, R. B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F. B. Schwing, J. Smith, C. Tracy, R. Webb, B. K. Wells, and T. H. Williams. 2009. What caused the Sacramento River fall Chinook stock collapse? Pre-publication report to the Pacific Fishery Management Council.

Lindley, S. T., R. S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. R. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2007. Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science 5(1):26.

Lisle, T. E. 1989. Sediment transport and resulting deposition in spawning gravels, North Coastal California. Water Resources Research 25(6):1303-1319.

Luers, A. L., D. R. Cayan, G. Franco, M. Hanemann, and B. Croes. 2006. Our changing climate, assessing the risks to California; a summary report from the California Climate Change Center. California Climate Change Center.

Macdonald, D. W., F. H. Tattersall, E. D. Brown, and D. Balharry. 1995. Reintroducing the European beaver to Britain: nostalgic meddling or restoring biodiversity. Mammal Rev. 25:161-200.

Macdonald, J. S., C. D. Levings, C. D. McAllister, U. H. M. Fagerlund, and J. R. McBride. 1988. A Field Experiment to Test the Importance of Estuaries for Chinook Salmon (*Oncorhynchus tshawytscha*) Survival: Short-Term Results. Canadian Journal of Fisheries and Aquatic Sciences 45:1366-1377.

Magnusson, A., and R. Hilborn. 2003. Estuarine Influence on Survival Rates of Coho (*Oncorhynchus kisutch*) and Chinook Salmon (*Oncorhynchus tshawytscha*) Released from Hatcheries on the U.S. Pacific Coast. Estuaries 26:1094–1103.

Mangel, M., and W. H. Satterthwaite. 2008. Combining proximate and ultimate approaches to understanding life history variation in salmonids with application to fisheries, conservation, and aquaculture. Bulletin of Marine Science 83(1):107–130.

Mantua, N. J., and S. R. Hare. 2002. The Pacific Decadal Oscillation. Journal of Oceanography 58:35-44.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis. 1997. A pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78(6):1069-1079.

Marine, K. R., and J. J. Cech, Jr. 2004. Effects of High Water Temperature on Growth, Smoltification, and Predator Avoidance in Juvenile Sacramento River Chinook Salmon. North American Journal of Fisheries Management 24:198–210.

Martin, J. A. 1995. Food habits of some estuarine fishes in a small, seasonal central California lagoon. Master's Thesis. San Jose State University, San Jose, CA.

Martyniuk, C. J., G. M. L. Perry, H. K. Mogahadam, M. M. Ferguson, and R. G. Danzmann. 2003. The genetic architecture of correlations among growth-related traits and male age at maturation in rainbow trout. Journal of Fish Biology 63:746–764.

McCarthy, S. G., J. J. Duda, J. M. Emilen, G. R. Hodgson, and D. A. Beauchamp. 2009. Linking Habitat Quality with Trophic Performance of Steelhead along Forest Gradients in the South Fork Trinity River Watershed, California. Transactions of the American Fisheries Society 138:506–521.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-NWFSC-42.

McEwan, D., and T. A. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game, Sacramento, CA.

McMahon, T. E., and G. Hartman. 1989. Influence of cover complexity and current velocity on winter habitat use by juvenile coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 46:1551-1557.

McMahon, T. E., and L. B. Holtby. 1992. Behaviour, habitat use, and movements of coho salmon (*Oncorhynchus kisutch*) smolts during seaward migration. Canadian Journal of Fisheries and Aquatic Sciences 49:1478-1484.

Melnychuk, M. C., D. W. Welch, C. J. Walters, and V. Christensen. 2007. Riverine and early ocean migration and mortality patterns of juvenile steelhead trout (*Oncorhynchus mykiss*) from the Cheakamus River, British Columbia. Hydrobiologia 582:55-65.

Merz, J. E., and P. B. Moyle. 2006. Salmon, Wildlife, and Wine: Marine-Derived Nutrients in Human-Dominated Ecosystems of Central California. Ecological Applications 16:999–1009.

Metheny, M. D. 2012. Use of dual frequency identification sonar to estimate salmonid escapement to Redwood Creek, Humboldt County California. Master's Thesis. Master's of Science. Humboldt State University, Arcata, CA.

Michael, J. 2010. Employment Impacts of California Salmon Fishery Closures in 2008 and 2009. Business Forecasting Center, University of Pacific, Stockton, CA.

Milly, P. C. D., J. Betancourt, M. Falkenmark, R. M. Hirsch, Z. W. Kundzewicz, D. P. Lettenmaie, and R. J. Stouffer. 2008. Stationarity Is Dead: Whither Water Management? Science 319:573-574.

Monzigo, J. 2012. Pot farms take dirty toll. Los Angeles Times, December 23, 2012.

Moore, J. W., S. A. Hayes, W. Duffy, S. Gallagher, C. J. Michel, and D. Wright. 2011. Nutrient fluxes and the recent collapse of coastal California salmon populations. Canadian Journal of Fisheries and Aquatic Sciences 68:1161-1170.

Moore, M. R. 1980. Factors Influencing The Survival of Juvenile Steelhead Rainbow Trout (*Salmo gairdneri gairdneri*) in the Ventura River, California. Master's Thesis. Humboldt State University, Arcata, CA.

Moyle, P. B. 2002. Inland fishes of California. University of California Press, Berekely and Los Angeles, CA.

Moyle, P. B., J.A. Israel, and S.E. Purdy. 2008. Salmon, steelhead, and trout in California; status of an emblematic fauna. Report commissioned by California Trout. University of California Davis Center for Watershed Sciences, Davis, CA.

Moyle, P. B., J. D. Kiernan, P. K. Crain, and R. M. Quinones. 2013. Climate Change Vulnerability of Native and Alien Freshwater Fishes of California: A Systematic Assessment Approach. PLoS ONE 8(5):e63883. doi:10.1371/journal.pone.0063883.

Mueller, A. M., A.L. Burwen, K.M. Boswell, and T. Mulligan. 2010. Tail-beat patterns in dual-frequency identification sonar echograms and their potential use for species identification. Transactions of the American Fisheries Society 139(3):900-910.

Murphy, M. L., J. Keifetz, J. F. Thedinga, S. W. Johnson, and K. V. Koski. 1989. Habitat Utilization by Juvenile Pacific Salmon (*Onchorynchus*) in the Glacial Taku River, Southeast Alaska. Canadian Journal of Fisheries and Aquatic Sciences 46(10):1677-1685.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum, NMFS-NWFSC-35.

Myrick, C., and J. J. Cech, Jr. 2005. Effects of Temperature on the Growth, Food Consumption, and Thermal Tolerance of Age-0 Nimbus-Strain Steelhead. North American Journal of Aquaculture 67:324-330.

Myrick, C. A., and J. J. Cech, Jr. 2002. Growth of American River fall-run Chinook salmon in California's Central Valley: temperature and ration effects. California Fish and Game 88:35-44.

NMFS (National Marine Fisheries Service). 2006. Pacific Coastal Salmon Recovery Fund Performance Goals, Measures and Reporting Framework. December 2006. 55 pp.

NMFS (National Marine Fisheries Service). 2010. Interim endangered and threatened species recovery planning guidance. Version 1.3. National Marine Fisheries Service, Silver Spring, MD.

NMFS (National Marine Fisheries Service). 2012. Announcement of Federal Funding Opportunity: Executive Summary. Department of Commerce, National Marine Fisheries Service (NMFS).

NMFS (National Marine Fisheries Service). 2016a. 2016 5-Year Review: Summary & Evaluation of Central California Coast Steelhead. National Marine Fisheries Service, West Coast Region. April 2016. 55pp.

NMFS (National Marine Fisheries Service). 2016b. 2016 5-Year Review: Summary & Evaluation of California Coastal Chinook Salmon and Northern California Steelhead. National Marine Fisheries Service, West Coast Region. April 2016. 61 pp.

NRC (National Research Council). 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press, Washington, D.C.

Nielsen-Pincus, M., and C. Moseley. 2010. Economic and Employment Impacts of Forest and Watershed Restoration in Oregon. Ecosystem Workforce Program Working Paper Number 24. Spring 2010. Institute for a Sustainable Environment, University of Oregon, Eugene, OR.

O'Donnell, M. J., L. M. Hammond, and G. E. Hofmann. 2009. Predicted impact of ocean acidification on a marine invertebrate: elevated CO_2 alters response to thermal stress in sea urchin larvae. Marine Biology 156:439-446.

Oreskes, N. 2004. The scientific consensus on climate change. Science 306:1686.

Osgood, K. E. 2008. Climate Impacts on U.S. Living Marine Resources: National Marine Fisheries Service Concerns, Activities and Needs. National Oceanic and Atmospheric Administration, National Marine Fisheries Service. NOAA Technical Memorandum NMFS-F/SPO-89.

PFMC (Pacific Fishery Management Council). 2015. Review of 2014 Ocean Salmon Fisheries: Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan. (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

Palmer, T. N., F. J. Doblas-Reyes, A. Weisheimer, and M. J. Rodwell. 2008. Toward Seamless Prediction: Calibration of Climate Change Projections Using Seasonal Forecasts. Bulletin of the American Meteorological Society 89:459–470.

PAMRS (Panel on Adaptive Management for Resource Stewardship). 2011. Adaptive Management for Water Resource Projects. National Research Council. National Academy Press, Washington D.C.

Perry, A. L., P. J. Low, J. R. Ellis, and J. D. Reynolds. 2005. Climate change and distribution shifts in marine fishes. Science 308.

Pess, G., M. C. Liermann, M. L. McHenry, R. J. Peters, and T. R. Bennett. 2011. Juvenile salmon response to the placement of engineered log jams (ELJS) in the Elwha River, Washington State, USA. River Research and Applications 28(7):872–881.

Phillips, R. W., R. L. Lantz, E. W. Claire, and J. R. Moring. 1975. Some effects of gravel mixtures on emergence of coho salmon and steelhead trout fry. Transactions of the American Fisheries Society 104(3):461-466.

Pipal, K., M. Jessop, D. Boughton, and P. Adams. 2010. Using dual-frequency indentification sonar (DIDSON) to estimate adult escapement in the San Lorenzo River, California. California Fish and Game 96(1):90-95.

Pipal, K. A., J. J. Notch, S. A. Hayes, and P. B. Adams. 2012. Estimating Escapement for a Low-Abundance Steelhead Population Using Dual-Frequency Identification Sonar (DIDSON). North American Journal of Fisheries Management 32(5):880-893.

Pollock, M. M., G.R. Pess, T.J. Beechie, and D. R. Montgomery. 2004. The importance of beaver ponds to coho production in the Stillaguamish River basin, Washington, USA. North American Journal of Fisheries Management 24:749-760.

Pollock, M. M., J.M. Wheaton, N. Bouwes, C. Volk, N. Weber, and C. E. Jordan. 2012. Working with beaver to restore salmon habitat in the Bridge Creek intensively monitored watershed: Design rationale and hypotheses. U.S. Department of Commerce. NOAA Techncial Memo. NMFS-NWFSC-120, 47p.

Poole, G. C., and C. H. Berman. 2001. An ecological perspective on in-stream temperature: natural heat dynamics and mechanisms of human-caused thermal degradation. Environmental Management 27(6):787-802.

Quinn, T. P. 2005. The behavior and ecology of Pacific salmon and trout. American Fisheries Society, Bethesda, MD.

Quinn, T. P., and D. J. Adams. 1996. Environmental changes affecting the migratory timing of American shad and sockeye salmon. Ecology 77(4):1151-1162.

Quiñones, R. M., and T. J. Mulligan. 2005. Habitat use by juvenile salmonids in the Smith River estuary, California. Transactions of the American Fisheries Society 134:1147-1158.

Reese, C. D., and B. C. Harvey. 2002. Temperature-Dependent Interactions between Juvenile Steelhead and Sacramento Pikeminnow in Laboratory Streams. Transactions of the American Fisheries Society 131:599–606.

Reeves, G. H., F. H. Everest, and J. R. Sedell. 1993. Diversity of juvenile anadromous salmonid assemblages in Coastal Oregon basins with different levels of timber harvest. Transactions of the American Fisheries Society 122(3):309-317.

Reiser, D. W., and T. C. Bjornn. 1979. Habitat requirements of anadromous salmonids. Influence of forest and rangeland management on anadromous fish habitat in western United States and Canada. United States Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; University of Idaho, Idaho Cooperative Fishery Research Unit, PNW-96, Portland.

Richardson, J. 1836. Fauna Boreali-Americana. Part III, The Fish. London and Norwich.

Richardson, J. S., M. C. Feller, P. M. Kiffney, R. D. Moore, S. Mitchell, and S. G. Hinch. 2010. Riparian Management of Small Streams: An Experimental Trial at the Malcolm Knapp Research Forest. Streamline Watershed Managment Bulletin 13(2):16.

Robinson, M. A. 1993. The distribution and abundance of benthic and epibenthic macroinvertebrates in a small, seasonal central California lagoon. Master's Thesis. San Jose State University, San Jose, CA.

Roemmich, D., and J. McGowan. 1995. Climate warming and the decline of zooplankton in the California Current. Science 267:1324-1326.

Roni, P., and T. Beechie, (editors). 2012. Stream and Watershed Restoration: A Guide to Restoring Riverine Processes and Habitats (Advancing River Restoration and Management). Wiley-Blackwell.

Root, T. L., J. T. Price, K. R. Hall, S. H. Schneider, C. Rosenzweigk, and J. A. Pounds. 2003. Fingerprints of global warming on wild animals and plants. Nature 421:57-60.

Ruckelshaus, M. H., T. Klinger, N. Knowlton, and D. P. DeMaster. 2008. Marine Ecosystem-based Management in Practice: Scientific and Governance Challenges. BioScience 58:53-63.

Sandercock, F. K. 1991. Life history of coho salmon. Pages 397-445 *in* C. Groot, and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver, B.C.

Satterthwaite, W. H., M. P. Beakes, E. M. Collins, D. R. Swank, J. E. Merz, R. G. Titus, S. M. Sogard, and M. Mangel. 2009. Steelhead Life History on California's Central Coast: Insights from a State-Dependent Model. Transactions of the American Fisheries Society 138:532–548.

Satterthwaite, W. H., S. A. Hayes, J. E. Merz, S. M. Sogard, D. M. Frechette, and M. Mangel. 2012. State-Dependent Migration Timing and Use of Multiple Habitat Types in Anadromous Salmonids. Transactions of the American Fisheries Society 141(3):781-794.

Scavia, D., J. C. Field, B. F. Boesch, R. W. Buddemeier, V. Burkett, D. R. Cayan, M. Fogarty, M. A. Harwell, R. W. Howarth, C. Mason, D. J. Reed, T. C. Royer, A. H. Sallenger, and J. G. Titus. 2002. Climate change impacts on U.S. coastal and marine ecosystems. Estuaries 25(2):149-164.

Schneider, S. H. 2007. The unique risks to California from human-induced climate change.

Schneider, S. H., and T. L. Root, editors. 2002. Wildlife Responses to Climate Change: North American Case Studies. Island Press, Washington D.C.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Bulletin 184. Fisheries Research Board of Canada, Ottawa, Canada.

Scruton, D. A., T. C. Anderson, and L. W. King. 1998. Pamehac Brook: a case study of the restoration of a Newfoundland, Canada, river impacted by flow diversion for pulpwood transportation. Aquatic Conservation: Marine & Freshwater Ecosystems 8:145-157.

Seghesio, E. E. 2011. The Influence of an Intermittently Closed, Northern California Estuary on the Feeding Ecology of Juvenile Steelhead (*Oncorhynchus mykiss*) and Chinook Salmon (*Oncorhynchus tshawytscha*). Master's Thesis. University of Washington, Seattle, WA.

Shapovalov, L., and A. C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. Fish Bulletin 98.

Sharr, S., C. Melcher, T. Nickelson, P. Lawson, R. Kope, and J. Coon. 2000. 2000 review of Amendment 13 to the Pacific Coast Salmon Plan. Pacific Fisheries Management Council, Portland, OR.

Simenstad, C. A., K. L. Fresh, and E. O. Salo. 1982. The role of Puget Sound and Washington coastal estuaries in the life history of Pacific salmon: an unappreciated function. Pages 343-364 *in* V. S. Kennedy, editor. Estuarine Comparisons. Academic Press, New York, NY.

Sloat, M. R., and A. K. Osterback. 2013. Maximum stream temperature and the occurrence, abundance, and behavior of steelhead trout (*Oncorhynchus mykiss*) in a southern California stream. Canadian Journal of Fisheries and Aquatic Sciences 70:64-73.

Smith, G. R., and R. F. Stearley. 1989. The classification and scientific names of rainbow and cutthroat trouts. Fisheries 14:4-10.

Smith, J. J. 1990. The effects of sandbar formation and inflows on aquatic habitat and fish utilization in Pescadero, San Gregorio, Waddell, and Pomponio crek estuary/lagoon systems, 1985-1989. Prepared for California Department of Parks and Recreation. Report Interagency Agreement 84-04-324, San Jose State University.

Smith, J. J., and H. Li, W. 1983. Energetic factors influencing foraging tactics of juvenile steelhead trout, *Salmo gairdneri*. Pages 173-180 in D. L. G. Noakes, D. G. Lingquist, G. S. Helfman, and J. A. Ward, editors. Predators and prey in fishes. Dr. W. Junk, The Hague, The Netherlands.

Sogard, S. M., J. E. Merz, W. H. Satterthwaite, M. P. Beakes, D. R. Swank, E. M. Collins, R. G. Titus, and M. Mangel. 2012. Contrasts in Habitat Characteristics and Life History Patterns of *Oncorhynchus mykiss* in California's Central Coast and Central Valley. Transactions of the American Fisheries Society 141:747–760.

Sogard, S. M., T. H. Williams, and H. Fish. 2009. Seasonal Patterns of Abundance, Growth, and Site Fidelity of Juvenile Steelhead in a Small Coastal California Stream. Transactions of the American Fisheries Society 138:549–563.

Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer. 2001. Floodplain rearing of juvenile chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58:325-333.

Southwick Associates. 2009. Calculation of the Projected Economics and Jobs Impact of Salmon Recovery in California.

Sparkman, M. D. 2002a. Upper Redwood Creek juvenile salmonid downstream migration study. 2000-2001 Annual Report, Project 2a5. California Department of Fish and Game, Arcata, CA.

Sparkman, M. D. 2002b. Juvenile steelhead downstream migration study in the Mad River, Humboldt County, California, Spring 2001. 2000-2001 Annual Report, Project 2a3. California Department of Fish and Game, Arcata, CA.

Spence, B. C., E. P. Bjorkstedt, J. C. Garza, J. J. Smith, D. G. Hankin, D. Fuller, W. E. Jones, R. Macedo, T. H. Williams, and E. Mora. 2008. A Framework for Assessing the Viability of Threatened and Endangered Salmon and Steelhead in the North-Central California Coast Recovery Domain. U.S. Department of Commerce. NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-423.

Spence, B. C., E. P. Bjorkstedt, S. Paddock, and L. Nanus. 2012. Updates to biological viability criteria for threatened steelhead populations in the North-Central California Coast Recovery Domain. National Marine Fisheries Service, Southwest Fisheries Science Center, Fisheries Ecology Division, Santa Cruz, CA.

Spina, A. P. 2007. Thermal ecology of juvenile steelhead in a warm-water environment. Environmental Biology of Fishes 80:23–34.

Swales, S., F. Caron, J. R. Irvine, and C. D. Levings. 1988. Overwintering habitats of coho salmon (*Oncorhynchus kisutch*) and other juvenile salmonids in the Keogh River system, British Columbia. Canadian Journal of Zoology 66:254–261.

Swales, S., and C. D. Levings. 1989. Role of off-channel ponds in the life cycle of coho salmon (*Oncorhynchus kisutch*) and other juvenile salmonids in the Coldwater River, British Columbia. Canadian Journal of Fisheries and Aquatic Sciences 46:232-242.

Tallis, H., P. S. Levin, M. H. Ruckelshaus, S. E. Lester, K. L. McLeod, D. Fluharty, and B. S. Halpren. 2010. The many faces of ecosystem-based management: Making the process work today in real places. Marine Policy 34:340–348.

Tennessee Valley Auth. v. Hill. 1978. U.S. Supreme Court Cases & Opinions 437(113):153-213.

TNC (The Nature Conservancy). 2007. Conservation Action Planning: Developing Strategies, Taking Action, and Measuring Success at Any Scale. Overview of Basic Practices Version.

Thomas, L. P., M. D. DeBacker, J. R. Boetsch, and D. G. Petiz. 2001. Conceptual Framework, Monitoring Components And Implementation Of A NPS Long-Term Ecological Monitoring Program Prairie Cluster Prototype Program Status Report. Prairie Cluster Prototype LTEM Program National Park Service Wilson's Creek National Battlefield., Republic, MO.

Thompson, K. 1972. Determining stream flows for fish life. Pages 31-50 *in* Pacific Northwest River Basins Commission, Instream Flow Requirement Workshop, Portland, Oregon.

Thorpe, J. E. 2007. Maturation responses of salmonids to changing developmental opportunities. Marine Ecology Progress Series 335:285-288.

Tipping, J. M. 1991. Management Briefs: Heritability of Age at Maturity in Steelhead. North American Journal of Fisheries Management 11(1):105-108.

Turley, C. 2008. Impacts of changing ocean chemistry in a high-CO2 world. Mineralogical Magazine 72(1):359-362.

USFWS and NMFS (United States Fish and Wildlife Service, and National Marine Fisheries Service). 2006. 5-Year Guidance: Procedures for Conducting 5-Year Reviews under the Endangered Species Act. July 2006. 74 pp.

USGAO (United States Government Accountability Office). 2006. Endangered species: time and costs required to recover species are largely unknown. U.S. Government Accountability Office, GAO-06-463R.

Venrick, E. L. 1992. Phytoplankton species structure in the central North Pacific: Is the edge like the center? Journal of Plankton Research 14(5):665-680.

Vondracek, B., and D. R. Longanecker. 1993. Habitat selection by rainbow trout, *Oncorhynchus mykiss*, in a California stream: implifications for the Instream Flow Incremental Methodology. Ecology of Freshwater Fish 2:173-186.

Wainwright, T. C., M.W. Chilcote, P.W. Lawson, T.E. Nickelson, C.W. Huntington, J.S. Mills, K.M.S. Moore, G.H. Reeves, H.A. Stout, and L. A. Weitkamp. 2008. Biological recovery criteria for the Oregon Coast coho salmon evolutionarily significant unit. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-91, 199 p.

Walbaum, J. J. 1792. Petri Artedi renovati, i.e., bibliotheca et philosophia ichthyologica. Ichthyologiae pars III. Grywewaldiae. A. E Roese. 723 pp.

Walther, G., E. Post, P. Convey, A. Menzel, C. Parmesan, T. J. C. Beebee, J. Fromentin, O. Hoegh-Guldberg, and F. Bairlein. 2002. Ecological responses to recent climate change. Nature 416:389-395.

Ward, B. R., and P. A. Slaney. 1988. Life history and smolt-to-adult survival of Keough River steelhead trout and the relationship to smolt size. Canadian Journal of Fisheries and Aquatic Sciences 45:1110-1122.

Watson, F., and J. Casagrande. 2004. Potential Effects of Groundwater Extractions on Carmel Lagoon. Watershed Institute, California State University Monterey Bay, Seaside, CA.

Whiteway, S. L., P. M. Biron, A. Zimmermann, O. Venter, and J. W. A. Grant. 2010. Do in-stream restoration structures enhance salmonid abundance? A meta-analysis. Canadian Journal of Fisheries and Aquatic Sciences 67:831–841.

Williams, T. H., S. T. Lindley, B. C. Spence, and D. A. Boughton. 2011. Status Review Update For Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest. NOAA's National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA.

Williams, T. H., B. C. Spence, D. A. Boughton, R. C. Johnson, L. Crozier, N. Mantua, M. O'Farrell, and S. T. Lindley. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. 2 February 2016 Report to National Marine Fisheries Service – West Coast Region from Southwest Fisheries Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California 95060.

Wilzbach, M. A., M. J. Ashenfelter, and S. J. Ricker. 2012. Movement of Resident Rainbow Trout Transplanted below a Barrier to Anadromy. Transactions of the American Fisheries Society 141:294–304.

Wurtsbaugh, W. A., and G. E. Davis. 1977. Effects of temperature and ration level on the growth and food conversion efficiency of *Salmo gairdneri*, Richardson. Journal of Fish Biology 11:87-98.

Zedonis, P. 1992. The Biology of the steelhead (*Onchorynchus mykiss*) in the Mattole River Estuary/Lagoon, California. Master's Thesis. Humboldt State University, Arcata, California.

Zedonis, P. A., and T. J. Newcomb. 1997. An evaluation of flow and water temperatures during the spring for protection of salmon and steelhead smolts in the Trinity River, California. United States Fish and Wildlife Service, Arcata, CA.

Zimmerman, C. E., and G. H. Reeves. 2000. Population structure of sympatric anadromous and nonanadromous *Oncorhynchus mykiss*: evidence from spawning surveys and otolith microchemistry. Canadian Journal of Fisheries and Aquatic Sciences 57:2152–2162.

Zimmerman, C. E., and G. H. Reeves. 2002. Identification of Steelhead and Resident Rainbow Trout Progeny in the Deschutes River, Oregon, Revealed with Otolith Microchemistry. Transactions of the American Fisheries Society 131:986-993.

Zwiers, F. W., and X. Zhang. 2003. Toward regional scale climate change detection. Journal Of Climate 16:793–797.