Chapter 7
Biological Resources – Fisheries

Introduction

This chapter describes fish and aquatic resources in the study area and potential changes that could occur as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect these resources as a result of augmenting flows in the lower Klamath River in an effort to reduce the likelihood, and potentially reduce the severity, of any *Ichthyophthirius multifiliis* (Ich) epizootic event that could lead to an associated fish die-off in future years.

Regulatory Environment and Compliance Requirements

Federal or State regulations relevant to implementation of the alternatives evaluated in this EIS for fisheries resources include:

- **Endangered Species Act** – The Federal Endangered Species Act (ESA) applies to proposed Federal, State, and local projects that may result in the "take" of a fish or wildlife species that is Federally listed as threatened or endangered and to actions that are proposed to be authorized, funded, or undertaken by a Federal agency and that may jeopardize the continued existence of any Federally-listed fish, wildlife, or plant species or which may adversely modify or destroy designated critical habitat for such species.

- **Magnuson-Stevens Fishery Conservation and Management Act** – The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act (Public Law 104-297), requires that all Federal agencies consult with National Marine Fisheries Service (NMFS) on activities or proposed activities authorized, funded, or undertaken by that agency that may adversely affect Essential Fish Habitat (EFH) for commercially managed marine and anadromous fish species.

Affected Environment

This section describes fish and aquatic resources that could be affected by the implementation of the alternatives considered in this EIS. Changes in fish and aquatic resources may occur in the Lower Klamath and Trinity River Region and in the Central Valley and Bay-Delta Region because of the changes in Trinity River Division (TRD) operations to provide increased flows in the lower Klamath River during the late-summer. The purpose of the flow augmentation is to protect the returning adult salmon population as they migrate and hold in the Klamath River below the Trinity River confluence.

This section is organized by geographic area, generally in an upstream to downstream direction. This format does not imply any particular use by fish and aquatic species, which can move among geographic areas either seasonally or during different phases of their life history.

Fish Species Evaluated

Many fish and aquatic species use the project area during all or some portion of their lives; however, certain fish and aquatic species were selected to be the focus of the analysis of alternatives considered in this EIS based on their sensitivity and their potential to be affected by augmenting flows in the lower Klamath River through operational changes of the TRD, as summarized in Table 7-1. Fish are evaluated both at the species level, and at the Evolutionarily Significant Unit (ESU) or distinct population segment (DPS), where relevant. An ESU is “a population (or group of populations) that (1) is substantially reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species (Waples 1995). A DPS is a population (or group of populations) that is discrete from other populations of the species, and significant in relation to the entire species.

While many of the species identified in Table 7-1 also occur in tributaries to the major rivers, the focus of this EIS is on the lower Klamath River and the waterbodies influenced by operational changes of the Central Valley Project (CVP). TRD and CVP operations would not directly affect ocean conditions; however, operations have the potential to affect Southern Resident Killer Whales indirectly by influencing the number of Chinook Salmon (produced in the Klamath River and the Sacramento-San Joaquin River and associated tributaries) that enter the Pacific Ocean and become available as a food supply for the whales.

The purpose of the proposed action is to reduce the likelihood, and potentially reduce the severity, of any Ich epizootic that could lead to an associated fish die-off in future years. Of the fish that did not survive in the 2002 die-off, 96 percent were fall-run Chinook Salmon, nearly 2 percent were steelhead, and 1 percent were Coho Salmon (DFG 2004). These species and other focal species are evaluated in this chapter. Focal species are fish listed as threatened or endangered, or at risk of being listed as endangered or threatened, and are legally protected, or are otherwise considered sensitive by the U.S. Fish and Wildlife Service (USFWS), NMFS, or California Department of Fish and Wildlife (CDFW) (previously known as Department of Fish and Game (DFG)) and fish that have tribal, commercial or recreational importance.

Table 7-1. Focal Fish Species Evaluated by Region of Occurrence

Species or Population[a]	Federal Status	State Status[b]	Tribal, Commercial, or Recreational Importance	Occurrence within Area of Analysis
Lower Klamath and Trinity River Region				
Coho Salmon *Southern Oregon/Northern California Coast ESU*	Threatened	Threatened	Yes	Trinity River, Klamath River
Chinook Salmon *Southern Oregon/Northern California Coasts ESU*	None	None	Yes	Klamath River
Chinook Salmon *Upper Klamath-Trinity River ESU*	None	Species of Special Concern[c]	Yes	Trinity River, Klamath River
Steelhead (winter- and summer-run) *Klamath Mountains Province DPS*	None	Species of Special Concern[d]	Yes	Trinity River, Klamath River
Green Sturgeon *Southern DPS*	Threatened	Species of Special Concern	Yes	Lower Klamath River and Estuary
Green Sturgeon *Northern DPS*	None	Species of Special Concern	Yes	Trinity River, Klamath River
Eulachon *Southern DPS*	Threatened	None	Yes	Klamath River
Pacific Lamprey	None	Species of Special Concern	Yes	Trinity River, Klamath River
Black Bass (Largemouth, Smallmouth, Spotted)	None	None	Yes	Trinity Lake, Lewiston Reservoir
Central Valley and Bay-Delta Region				
Winter-run Chinook Salmon *Sacramento River ESU*	Endangered	Endangered	Yes	Sacramento River[e], Bay-Delta
Spring-run Chinook Salmon *Central Valley ESU*	Threatened	Threatened	Yes	Clear Creek, Sacramento River, Feather River, and Bay-Delta
Steelhead *Central Valley DPS*	Threatened	None	Yes	Clear Creek, Sacramento River; Feather River, American River, and Bay-Delta
Green Sturgeon *Southern DPS*	Threatened	Species of Special Concern	Yes	Sacramento River, Feather River, and Bay-Delta
Delta Smelt	Threatened	Endangered	No	Sacramento River and Bay-Delta

Table 7-1. Focal Fish Species Evaluated by Region of Occurrence (contd.)

Species or Population[a]	Federal Status	State Status[b]	Tribal, Commercial, or Recreational Importance	Occurrence within Area of Analysis
Central Valley and Bay-Delta Region (contd.)				
Longfin Smelt *Bay Delta DPS*	Candidate	Endangered	No	Bay-Delta
Fall-/Late Fall-run Chinook Salmon *Central Valley ESU*	None	Species of Special Concern	Yes	Clear Creek, Sacramento River, Feather River, American River, and Bay-Delta
Black Bass (Largemouth, Smallmouth, Spotted)	None	None	Yes	Whiskeytown Lake, Shasta Lake, Oroville Lake, Folsom Lake

Notes:

a. The term population refers to the listed ESU or Distinct Population Segment DPS for that species.

b. Includes species listed by the State of California as threatened, endangered, or considered a Species of Special Concern.

c. The California Species of Special Concern designation refers only to the spring-run of the upper Klamath-Trinity River ESU Chinook Salmon population.

d. The California Species of Special Concern designation refers only to the summer-run of the Klamath Mountains Province DPS steelhead population.

Key:

DPS = Distinct Population Segment

ESU = Evolutionarily Significant Unit

The level of detail presented in the *Affected Environment* section is tailored to correspond with the level of resolution of the analysis, which relies on modeling tools that broadly characterize the changes in flows in the lower Klamath River and changes in CVP operations on reservoir storage and flows. This level of detail is intended to support an understanding of the resources potentially affected and the context within which the project is evaluated.

Critical Habitat and Primary Constituent Elements

Critical habitat are areas designated by USFWS or NMFS for the conservation of their jurisdictional species listed as threatened or endangered under the ESA. When a species is proposed for listing under the ESA, USFWS or NMFS considers whether there are certain areas essential to the conservation of the species. The conservation value of listed species critical habitat is determined by the conservation value of the watersheds that make up the designated area. In turn, the conservation value of the elements that make up the habitat is the sum of the value of the primary constituent elements (PCE) within the area. PCEs are physical and biological features essential to the conservation of the species including space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; and sites for breeding, reproduction, and rearing of offspring. The conservation value of the PCEs is the sum of the quantity, quality, and availability of the essential features of that PCE. [1]

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[1] The U.S. Fish and Wildlife Service and National Marine Fisheries Service have proposed discontinuing the use of the term “Primary Constituent Elements” to simplify and clarify the critical habitat process and to provide consistency with the language contained in the Endangered Species Act, which uses the term “physical or biological features.”

Critical habitat and specific PCEs identified for salmonids, Green Sturgeon, Delta Smelt, and Eulachon are described below.

Southern Oregon/Northern California Coastal Coho Salmon ESU Critical Habitat The Southern Oregon/Northern California Coast Coho Salmon ESU consists of populations from Cape Blanco, Oregon, to Punta Gorda, California, including Coho Salmon inhabiting the Klamath and Trinity Rivers. In the Trinity River Region, all Trinity River reaches downstream from Lewiston Dam, the South Fork Trinity River, and the entire lower Klamath River are designated as critical habitat with the exception of tribal lands (64 Federal Register (FR) 24049).

Sacramento River Winter-run Chinook Salmon ESU Critical Habitat The Sacramento River winter-run Chinook Salmon ESU consists of only one population confined to the upper Sacramento River. This ESU includes all fish spawning naturally in the Sacramento River and its tributaries, as well as fish that are propagated at the Livingston Stone National Fish Hatchery (NFH), operated by USFWS (NMFS 2005a). Critical habitat was delineated as the Sacramento River from Keswick Dam to Chipps Island at the westward margin of the Sacramento-SanJaoquin River Delta (Delta); all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Bay (north of the San Francisco-Oakland Bay Bridge) to the Golden Gate Bridge (58 FR 33212).

Central Valley Spring-run Chinook Salmon ESU Critical Habitat This ESU consists of spring-run Chinook Salmon in the Sacramento River Basin, including spring-run Chinook Salmon from the Feather River Hatchery. Designated critical habitat for Central Valley spring-run Chinook Salmon includes stream reaches of the American, Feather, Yuba, and Bear Rivers; tributaries of the Sacramento River, including Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear Creeks; and the main stem of the Sacramento River from Keswick Dam through the Delta. Designated critical habitat in the Delta includes portions of the Delta Cross Channel (DCC); Yolo Bypass; and portions of the network of channels in the northern Delta. Critical habitat for spring-run Chinook Salmon was not designated for the Stanislaus or San Joaquin River.

Central Valley Steelhead DPS Critical Habitat The California Central Valley steelhead DPS includes all naturally-spawned populations of steelhead in the Sacramento and San Joaquin Rivers and their tributaries, excluding steelhead from San Francisco and San Pablo Bays and their tributaries. Two artificial propagation programs, the Coleman NFH and Feather River Hatchery steelhead hatchery programs, are considered to be part of the DPS. Critical habitat for Central Valley steelhead includes stream reaches of the American, Feather, Yuba, and Bear Rivers and their tributaries, and tributaries of the Sacramento River including Deer, Mill, Battle, Antelope, and Clear Creeks in the Sacramento River Basin; the Mokelumne, Calaveras, Stanislaus, Tuolumne, and Merced Rivers in the San Joaquin River Basin; and portions of the Sacramento and San Joaquin Rivers. Designated critical habitat in the Delta includes portions of the DCC, Yolo Bypass, and portions of the network of channels in the Sacramento River portion of the Delta; and portions of the San Joaquin, Cosumnes, and Mokelumne Rivers and portions of the network of channels in the San Joaquin portion of the Delta.

Anadromous Salmonids PCE In designating critical habitat for anadromous salmonids (70 FR 52536), NMFS defined the PCEs essential to the conservation of the listed salmonids to include:

- Spawning sites with water quantity and quality conditions and substrate to support spawning, incubation, and larval development.
- Freshwater rearing sites with:
  - Water quantity and floodplain connectivity to form and maintain physical habitat conditions to support juvenile growth and mobility
  - Water quality and forage to support juvenile development
  - Natural cover (e.g., shade, submerged and overhanging large wood, aquatic vegetation, large rocks, and undercut banks)
- Freshwater migration corridors free of obstruction and excessive predation and having water quantity and quality conditions and natural cover to support juvenile and adult mobility and survival.
- Estuarine areas free of obstruction and excessive predation with:
  - Water quality, water quantity, and salinity conditions to support juvenile and adult physiological transitions between fresh water and salt water
  - Natural cover
  - Juvenile and adult forage, including aquatic invertebrates and fishes, to support growth and maturation

Southern DPS of the North American Green Sturgeon PCE and Critical Habitat

The southern DPS of the North American Green Sturgeon consists of populations occurring in the Central Valley and coastal systems south of the Eel River. The only known spawning population is in the Sacramento River system. In designating critical habitat, NMFS identified PCEs essential to the conservation of the southern DPS in freshwater riverine systems, estuarine areas, and nearshore marine waters (74 FR 52345). The PCEs for each area largely overlap and include the following items:

- Abundant prey items for larval, juvenile, subadult, and adult life stages
- Substrates suitable for egg deposition and development, larval development, and subadults and adults
- A flow regime (i.e., the magnitude, frequency, duration, seasonality, and rate-of-change of fresh water discharge over time) necessary for normal behavior, growth, and survival of all life stages
- Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages

- A migratory pathway suitable for safe and timely passage in riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for safe and timely passage)

- Deep (greater than 5 meters) holding pools for both upstream and downstream holding of adult or subadult fish, with adequate water quality and flow to maintain the physiological needs of the holding adult or subadult fish

- Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages

Within the study area, critical habitat for the southern DPS Green Sturgeon encompasses the Sacramento River from the I-Street Bridge upstream to Keswick Dam, including areas in the Yolo Bypass and the Sutter Bypass and the lower American River from its confluence with the Sacramento River upstream to the State Route 160 bridge over the American River; the lower Feather River from its confluence with the Sacramento River upstream to the Fish Barrier Dam; and the lower Yuba River from its confluence with the Feather River upstream to Daguerre Dam. Critical habitat also includes all waterways of the Delta up to the elevation of mean higher high water except for certain excluded areas and all tidally-influenced areas of San Francisco Bay, San Pablo Bay, and Suisun Bay up to the elevation of mean higher high water (74 FR 52300).

Delta Smelt PCE and Critical Habitat

In designating critical habitat for Delta Smelt (59 FR 65256), USFWS identified the following PCEs essential to their conservation:

- Suitable substrate for spawning

- Water of suitable quality and depth to support survival and reproduction (e.g., temperature, turbidity, lack of contaminants)

- Sufficient Delta flow to facilitate spawning migrations and transport of larval Delta Smelt to appropriate rearing habitats

- Salinity, which influences the extent and location of the low-salinity zone where Delta Smelt rear. The location of the low-salinity zone (or X2) is described in terms of the average distance of the two practical salinity units isohaline from the Golden Gate Bridge

Critical habitat for Delta Smelt includes all water and submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma Sloughs; and the existing contiguous waters contained in the legal Delta (as defined in Section 12220 of the California Water Code) (59 FR 65256).

Eulachon Southern DPS Critical Habitat

In designating critical habitat for Eulachon, NMFS (76 FR 65323) identified the following physical or biological features essential to the conservation of the Eulachon Southern DPS reflecting key life history phases of Eulachon:

- Freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate to support spawning and incubation, and with migratory access for adults and juveniles

- Freshwater and estuarine migration corridors associated with spawning and incubation sites that are free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted

- Nearshore and offshore marine foraging habitat with water quality and available prey, supporting juvenile and adult survival

Within the study area, critical habitat for Eulachon includes the Klamath River from its mouth upstream to the confluence with Omogar Creek. The critical habitat designation specifically excludes all lands of the Yurok Tribe and Resighini Rancheria, based upon a determination that the benefits of exclusion outweigh the benefits of designation (NMFS 2011). Exclusion of these areas will not result in the extinction of the Southern DPS because the overall percentage of critical habitat on Indian lands is so small (approximately 5 percent of the total are designated), and it is likely that Eulachon production on these lands represents a small percentile of the total annual production for the DPS (NMFS 2011).

Essential Fish Habitat

In response to growing concern about the status of United States fisheries, Congress passed the Sustainable Fisheries Act of 1996 (Public Law 104-297) to amend the Magnuson-Stevens Fishery Conservation and Management Act (Public Law 94-265), the primary law governing marine fisheries management in the Federal waters of the United States. Under the Sustainable Fisheries Act, consultation is required by NMFS on any activity that might adversely affect essential fish habitat (EFH). EFH includes those habitats on which fish rely throughout their life cycles, including waters and substrate necessary for spawning, feeding, and growth to maturity. It encompasses habitats necessary to allow sufficient production of commercially valuable aquatic species to support a long-term sustainable fishery and contribute to a healthy ecosystem. EFH for Pacific salmon includes fresh water systems currently or historically accessible to salmon, and nearshore and marine environments up to 200 miles offshore.

Klamath and Trinity River Region

For this EIS, the Klamath and Trinity River Region includes Trinity Lake, Lewiston Reservoir, and the Trinity River from Lewiston Reservoir to the confluence with the Klamath River; and the portion of the lower Klamath River watershed from its confluence with the Trinity River to the Pacific Ocean. The Trinity River flows approximately 112 miles from Lewiston Reservoir to its confluence with the Klamath River, traversing through the Hoopa Valley Indian Reservation. The Trinity River is the largest tributary of the Klamath River (DOI and DFG 2012).

The lower Klamath River flows 43.5 miles from its confluence with the Trinity River to the Pacific Ocean (USFWS and Hoopa Valley Tribe 1999). Downstream from the Trinity River confluence, the Klamath River flows through the Yurok Indian Reservation and Resighini Rancheria (DOI and DFG 2012). There are no dams located in the Klamath River watershed downstream of its confluence with the Trinity River. The Klamath River estuary extends approximately 5 miles upstream of the Pacific Ocean. This area is generally under tidal effects, and salt water can occur up to 4 miles upriver from the coastline during high tides in summer and fall when Klamath River flows are low.

Trinity Lake and Lewiston Reservoir

Trinity Lake is created by Trinity Dam and is considered relatively unproductive with low-standing crops of phytoplankton and zooplankton (USFWS et al. 2004). The fish in Trinity Lake include cold-water and warm-water species. Trinity Lake supports a trophy Smallmouth Bass fishery and provides substantial sport fishing for Largemouth Bass, Rainbow and Brown Trout, and Kokanee Salmon (landlocked Sockeye Salmon). Other fish species in Trinity Lake include Speckled Dace, Klamath Smallscale Sucker, Coast Range Sculpin, and the nonnative Green Sunfish, Yellow Perch, and Brown Bullhead.

Lewiston Reservoir is a re-regulating reservoir for Trinity Lake. The water surface elevation is relatively constant. The reservoir contains Rainbow, Brown, and Brook Trout and Kokanee Salmon. Other fish species present include Pacific Lamprey, Speckled Dace, Klamath Smallscale Sucker, Coastrange Sculpin, and Smallmouth Bass (USFWS et al. 2004).

Trinity River from Lewiston Reservoir to Klamath River

The Trinity River flows out of Trinity Lake and Lewiston Reservoir. Native anadromous salmonids in the mainstem Trinity River and its tributaries downstream of Lewiston Dam are spring- and fall-run Chinook Salmon, Coho Salmon, and steelhead (NCRWQCB et al. 2009). Native non-salmonid anadromous species that inhabit the Trinity River Basin include Green Sturgeon, White Sturgeon and Pacific Lamprey.

The hydrologic and geomorphic changes following construction of the Trinity and Lewiston Dams changed the character of the river channel substantially and altered the quantity and quality of aquatic habitat. Riparian vegetation encroached on areas that had previously been scoured by flood flows, resulting in the formation of a riparian berm that armored and anchored the river banks and prevented meandering of the river channel (USFWS and Hoopa Valley Tribe 1999).

The ongoing Trinity River Restoration Program includes specific dedicated instream water volumes that vary by water year type (as described in Chapter 4, “Surface Water Supply and Management”); mechanical channel rehabilitation; fine and coarse sediment management; watershed restoration; infrastructure improvement; and adaptive management components (NCRWQCB et al. 2009, USFWS and Hoopa Valley Tribe 1999). The mechanical channel rehabilitation includes construction of bar surfaces, floodplain lowering and reconnection, side channel construction, and removal of fossilized riparian berms that had been anchored by extensive woody-vegetation root systems that confined the river. Following mechanical rehabilitation, the altered areas have been re-vegetated to support native vegetation. Sediment management activities include introduction of coarse sediment at locations to support spawning and other aquatic life stages. In areas closer to Lewiston Dam with limited gravel supply, gravel/cobble point bars are being rebuilt to increase gravel storage and improve channel dynamics. Riparian vegetation is planted on restored floodplains and flows are managed to encourage natural riparian growth on the floodplain and limit encroachment on the newly formed gravel bars. Some improvement projects have been completed and others are under construction or in the planning phase. These restoration actions are occurring in the 40-mile restoration reach between Lewiston Dam and the confluence with the North Fork Trinity River (TRRP 2014).

Lower Klamath River from Trinity River to Pacific Ocean

The lower Klamath River begins where the Trinity River flows into it near Weitchpec, located about 43 miles upstream from the Pacific Ocean. The Trinity River is the largest tributary of the Klamath River and makes a substantial contribution to the flows in the lower Klamath River. This section of the Klamath River serves primarily as a migration corridor for salmonids, with most spawning and rearing upstream of its confluence with the Trinity River or in the larger tributaries (e.g., Blue Creek) to the mainstem Klamath River.

Fish Species in the Klamath and Trinity River Region The focal fish species that occur in the Klamath and Trinity River Region are identified in Table 7-1, and detail of their life histories are provided below.

Southern Oregon/Northern California Coast Coho Salmon Coho Salmon (*Oncorhynchus kisutch*) in the Trinity River are in the Southern Oregon/Northern California Coast (SONCC) Coho Salmon ESU, and were listed as threatened under the ESA in 1997 (62 FR 24588, May 6, 1997) and threatened under the California Endangered Species Act in 2002. This ESU includes naturally-spawning populations between Punta Gorda, California, and Cape Blanco, Oregon, which encompasses the Klamath River Basin (which includes the Trinity River) (62 FR 24588, May 6, 1997). This ESU includes three artificially-propagated stocks. Additionally, Coho Salmon in the Klamath Basin have been listed by the California Fish and Game Commission as threatened under the California Endangered Species Act.

Coho Salmon in the Trinity River are thought to be primarily 3-year lifecycle fish, living a full year in the river as juveniles before migrating to the ocean. Most returning adult Coho Salmon enter rivers between August and January. Spawning in the Trinity River and tributaries occurs primarily in November and December. Most of the spawning by Coho Salmon in the mainstem Trinity River occurs from Lewiston Dam downstream to the North Fork Trinity River confluence (NMFS 2014a). After emergence, fry move into areas out of the main current, and as they grow, they spread out from the areas where they were spawned. During summer, juveniles prefer pools and riffles with adequate cover such as large woody debris with smaller branches, undercut banks, and overhanging vegetation and roots.

Because juvenile Coho Salmon remain in their spawning stream for a full year after emerging from the gravel, they are exposed to a broad range of freshwater conditions. The smolts[2] typically migrate to the ocean between March and June, with most leaving in April and May.

Passage for Coho Salmon and other anadromous salmonids is now blocked by Lewiston Dam, preventing access to roughly 109 miles of upstream historical habitat for Coho Salmon (DOI and Hoopa Valley Tribe 2000). The Trinity River Hatchery produces Coho Salmon with an annual production goal of 300,000 yearlings to mitigate the upstream habitat loss (CHSRG 2012, USDC 2014).

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[2] The term *smolt* refers to young salmon prior to entering the ocean that have undergone the physiological changes necessary for life in salt water

The run-size estimates have ranged from 852 fish in 1994 to 59,079 fish in 1987. Both intra- and inter-specific redd superimposition on the spawning grounds can affect salmon reproductive success and the spawning areas downstream of Lewiston Dam are likely near carrying capacity (NMFS 2014a).

Upper Klamath and Trinity Rivers Spring-Run Chinook Salmon The Upper Klamath and Trinity Rivers ESU includes fall- and spring-runs of Chinook Salmon (*O. tshawytscha*) that spawn in the Klamath and Trinity Rivers upstream of the Trinity River's confluence with the Klamath. Although wild spring-run Chinook Salmon in the Klamath River system differ to a degree from fall-run Chinook Salmon genetically, and in life history and habitat requirements (NRC 2004), both are included within this ESU (Myers et al. 1998). A petition to list the Upper Klamath and Trinity Rivers ESU was submitted to NMFS in January 2011 (CBD et al. 2011); in April 2011, NMFS announced that listing was not warranted. Of primary importance in their decision was their conclusion that the spring-run and fall-run Chinook Salmon in the basin constitute a single ESU (77 FR 19597). Three hatchery stocks from the Iron Gate (fallrun) and Trinity River (spring and fall runs) Hatcheries are considered part of the ESU because they were founded using native, local stock in the watershed where fish are released (77 FR 19597).

Adult spring-run Chinook Salmon migrate upstream in the Trinity River from April through September, with most fish arriving at the mouth of the North Fork Trinity by the end of July. These fish remain in deep pools until the onset of the spawning season, which typically begins in early September, peaks in October, and continues through November. The distribution of spawning extends upstream to Lewiston Dam, and is concentrated in the reaches immediately downstream of the dam to the mouth of the North Fork Trinity River.

Emergence of spring-run Chinook Salmon fry in the Trinity River begins in December and continues into mid-April. Juvenile spring-run Chinook Salmon exhibit both ocean-type and stream-type rearing. That is, they may rear for a short period in the Trinity River and outmigrate to sea in the spring or fall after hatching (ocean-type), or rear in the Trinity River for a year and outmigrate to sea after a year of growth in the Trinity River. Outmigration from the lower Trinity River, as indicated by monitoring near Willow Creek, peaks in May and June.

Williams et al. (2011) concluded that although abundance is low compared with historical abundance, the current spring-run Chinook Salmon population (which includes hatchery fish) appears to have been fairly stable for the past 30 years. This run-size estimate is approximately 51 percent of the 34-year average spring-run Chinook Salmon run-size of 17,402, which has ranged from 2,381 fish in 1991 to 62,692 fish in 1988 (CDFW 2014).

Upper Klamath and Trinity Rivers Fall-run Chinook Salmon The adult fall-run Chinook Salmon migration in the Trinity River begins in August and continues into December, with spawning beginning in early October. Spawning activity peaks in late October, and continues through December. Fall-run Chinook Salmon spawning occurs throughout the mainstem Trinity River from Lewiston Dam to the Hoopa Valley (Myers et al. 1998).

Trinity River fall-run Chinook Salmon fry begin emerging from the spawning beds in January and continue into mid-April. Juvenile fall-run Chinook Salmon typically outmigrate after a few months of growth in the Trinity River. Outmigration from the upper river, as indicated by monitoring near Junction City, begins in March and peaks in early May, ending by late May or early June. Outmigration of fall-run Chinook Salmon fry in the lower Trinity River occurs over approximately the same time period described above for the spring run.

Southern Oregon/Northern California Coast Chinook Salmon The SONCC Chinook Salmon ESU includes all naturally-spawned Chinook salmon in the lower Klamath River downstream from its confluence with the Trinity River. In 1999, NMFS determined that this ESU did not warrant listing, nor did they identify the SONCC Chinook Salmon as a species of concern. Their life history traits are similar to the Upper Klamath and Trinity River Chinook Salmon. They are principally a late fall-run Chinook Salmon, entering the rivers to spawn between September and December. Spawning takes place between October and February. These ocean-type fish remain in fresh water for four to six months before migrating back out to sea.

Klamath Mountains Province Steelhead Steelhead (*O. mykiss*) in the Trinity River exhibit two primary life history strategies: a summer-run that is stream maturing and a winter-run that is ocean maturing. The winter-run is considered by some to be composed of a fall-run and a winter-run based upon the timing of the adult migration. Summer-run steelhead occur in the north and south forks of the Trinity River and in the New River and Canyon Creek tributaries (BLM 1995).

Adult summer-run steelhead enter the Trinity River from April through September and over-summer in deep pools in the mainstem and large tributaries. Some enter the smaller tributary streams of the Trinity River during the first November rains (Hill 2010), with most fish spawning in both the mainstem and tributaries from February through April (USFWS et al. 2004). Summer-run steelhead spawner escapements for the Trinity River upstream of Lewiston Dam prior to its construction were estimated to average 8,000 adults annually. Comprehensive synoptic, post-dam surveys of Trinty basin-wide summer steelhead populations have not been regularly compiled; however, numbers of over-summering adult steelhead in the North Fork Trinity River from 1990-97 ranged from 20 to 1,037 (Everest 1997). Additionally, redd surveys (during and after spawning by both summer and fall runs) in a number of other tributaries of the Trinity River, including the South Fork Trinity River, suggests populations within the same range for populations in other tributaries (Hill 2008, 2010).

Juvenile summer-run steelhead may rear in fresh water for up to three years before outmigrating, and freshwater rearing histories of Trinity River steelhead are highly variable (Scheiff et al. 2001, Pinnix and Quinn 2009, Pinnix et al. 2013, Hodge et al. 2016). For juveniles that rear at least a year in fresh water, survival appears to be higher for those that outmigrate to the ocean at age 2+ (DFG 1998a). Juveniles outmigrating from the tributaries as 0+ or age 1+ may rear in the mainstem or in nonnatal tributaries (particularly during periods of poor water quality) for one or more years before smolting. Juvenile outmigration can occur from spring through fall, with three peak migration periods including March, May/June, and October/November (USFWS et al. 2004).

Fall-run and winter-run steelhead also are widely distributed throughout the Trinity River. Adult fall-run steelhead enter the Klamath River system in September and October (Hill 2010) and likely spawn in tributaries such as the Trinity River from January through April. Adult winter-run steelhead begin their upstream migration in the Klamath River from November through March (USFWS 1997). Winter-run steelhead primarily spawn in Klamath River tributaries (including the Trinity River) from January through April (USFWS 1997), with peak spawn timing in February and March (NRC 2004). Since 1980, run-size estimates have ranged from 2,972 in 1998 to 53,885 in 2007. The estimated abundance of steelhead in 2013 was 8.4 percent above the average since 1980 (CDFW 2014).

Green Sturgeon Limited Green Sturgeon (*Acipenser medirostris*) data has been collected in the Trinity River, so most information on life history characteristics for Green Sturgeon in the Trinity River is based on data from the Klamath River. Green Sturgeon in the Klamath River sampled during their spawning migration ranged in age from 16 to 40 years (Van Eenennaam et al. 2006). Green Sturgeon are generally believed to have a life span of at least 50 years and spawn every four years on average after around age 16 (Klimley et al. 2007).

The northern DPS of Green Sturgeon enter the Trinity and Klamath Rivers to spawn from February through July, and most spawning occurs from the middle of April to the middle of June (NRC 2004). After spawning, around 25 percent migrate directly back to the ocean (Benson et al. 2007), and the remainder hold in mainstem pools through November. During the onset of fall rainstorms and increased river flow, adult sturgeon move downstream and leave the river system (Benson et al. 2007). Juveniles may rear for one to three years in the Klamath River system before they migrate to the estuary and Pacific Ocean (NRC 2004, FERC 2007a), usually during summer and fall (Emmett et al. 1991, Hardy and Addley 2001).

In the Trinity River Basin, the northern DPS of Green Sturgeon are known to spawn in the mainstem from the confluence with the Klamath River to as far upstream as Gray’s Falls near Burnt Ranch. Juveniles are captured in rotary screw traps at Willow Creek on the Trinity River (Scheiff et al. 2001, Pinnix and Quinn 2009). The southern DPS of Green Sturgeon may use the lower Klamath River and estuary periodically for juvenile and adult rearing.

Pacific Lamprey Pacific Lamprey (*Entosphenus tridentatus*) are the only anadromous lamprey species in the Trinity River Basin. This species is important to local tribes and supports subsistence fisheries on the Klamath River and lower Trinity River. Although no systematic distribution surveys are available for the Trinity River Basin, they are expected to have a distribution similar to anadromous salmonids that use the mainstem Trinity River and accessible reaches of larger tributaries. No current status assessments are available for Pacific Lamprey in the Trinity River, but information from tribal fishermen who catch lampreys in the lower Klamath River suggests a decline that mirrors what has been observed across the species’ range (Petersen Lewis 2009).

Adult Pacific Lampreys have been documented entering the Klamath River from the ocean during all months of the year, with peak upstream migration to holding areas from December through June (Larson and Belchik 1998, Petersen Lewis 2009). Migration up the Trinity River is expected to begin slightly later. After entering fresh water as sexually immature adults and undergoing an initial migration, Pacific Lampreys hold through summer and most of winter before spawning the following spring when they reach sexual maturity (Robinson and Bayer 2005, Clemens et al. 2012). After the holding period, individuals undergo a secondary migration in the late winter or early spring from holding areas to spawning grounds (Robinson and Bayer 2005, Clemens et al. 2012, Lampman 2011). Thus, adult Pacific Lampreys with varying levels of sexual maturity may be in the Trinity River throughout the year. Ammocoetes (the larval stage of lamprey) inhabit fine substrates in depositional areas, rearing in the Trinity River and tributaries year-round for up to 7 years before outmigrating to the ocean (Moyle 2002, Reclamation and Trinity County 2006).

Eulachon Eulachon (*Thaleichthys pacificus*) is a smelt species in the Klamath River system found upstream of the estuary. Eulachon are anadromous broadcast spawners that spawn in the lower reaches of rivers and tributaries and usually die after spawning. Most Eulachon are sexually mature at 3 years though some spawn at ages 4 or 5. A few fish may spawn again the following year, but most die after their first spawn (Moyle 2002). Timing of the spawning migration in the Klamath River is similar to other known runs of Eulachon, beginning in December and continuing until May, with a peak in March and April (YTFP 1998, Larson and Belchik 1998).

In the Klamath River, adult Eulachon generally migrate as far upstream as Brooks Riffle, about 24 miles upstream of the mouth, but they have been observed as high as Pecwan Creek and even Weitchpec during exceptional years (YTFP 1998); yet specific spawning areas are unknown. Eggs hatch in 20 to 40 days depending on water temperature, taking longer at cooler temperatures. After hatching, the larvae stay near the bottom and are then washed out to the ocean (Moyle 2002).

This species was historically important to local tribes and supported a subsistence fishery on the lower Klamath River. According to accounts of Yurok Tribal elders, there were annual runs so large that one had no problem catching “as many as you wanted”; however, the last noticeable runs of Eulachon were observed in 1988 and 1989 by Tribal fishers (Larson and Belchik 1998). In 1996, Yurok Tribal Fisheries Program (YTFP) sampling efforts to capture Eulachon were unsuccessful, although a Yurok Tribal member gave the YTFP a Eulachon he had caught while fishing for lamprey at the mouth of the river (Larson and Belchik 1998). However, it is likely that the Eulachon has been extirpated or nearly so on the lower Klamath River (NMFS 2015).

Current Understanding of Fish Disease Processes in the Lower Klamath River

A number of important fish pathogens, which can cause disease, occur in the Klamath River basin, including Ich, the protozoan causative agent of white spot disease; *Ceratonova shasta* and *Parvicapsula minibicornis*, both myxosporean parasites of salmon that have a polychaete worm (*Manayunkia speciosa*) intermediate host prior to infecting juvenile salmonids; and *Flavobacterium columnare*, bacterial causative agent of columnaris disease (Foott 2003, Guillen 2003, DFG 2004, NRC 2004, Nichols et al. 2003 and 2008, Bartholomew and Foott 2010, True and Foott 2012, Foott et al. 2016).

Ceratomyxosis, caused by *C. shasta* infections, has been the most significant disease for juvenile salmon in the Klamath River Basin (Bartholomew and Foott 2010). This pathogen is particularly abundant in the Klamath River from Iron Gate Dam to Seiad Creek (river mile [RM] 190 – 141). Favorable conditions for its intermediate host polychaete worm occur in this reach of the Klamath River, including relatively low-velocity habitats with a silty, detrital river bottom and abundant filamentous green algae that supports dense and persistent populations of *M. speciosa* (Bartholomew and Foott 2010). Additionally, relatively high densities of returning adult salmon in this reach and high abundance of juveniles released from Iron Gate Hatchery are thought to facilitate the parasite’s life cycle and contribute to particularly high concentrations of infective stages of both *C. shasta* and *P. minibicornus* (True et al. 2012). Despite the resistance to *C. shasta* exhibited by native sympatric salmonid populations, juvenile salmon exposed to high levels of the parasite, particularly at high temperatures, appear to be more susceptible to the disease (Bartholomew and Foott 2010). Many juvenile salmonids originating in upstream reaches of the Klamath River pass through the reach favoring the *C. shasta* life cycle during their spring outmigration at a time when *C. shasta* infectivity appears to be high and are reported to have a high incidence of infection by *C. shasta* and *P. minibicornis* (10 to 70 percent), with disease-related mortality rates as high as 35 to 70 percent (Nichols and Foott 2005, Beeman et al. 2008).

The nature and agents of disease in adult salmon returning to the Klamath River Basin are different than that described for juvenile salmon, and disease outbreaks and mortality have generally been less frequent in adult salmon (DFG 2004). Ich and columnaris disease are commonly reported diseases in adult salmon returning to the Klamath River and other rivers along the Pacific Coast and are often associated with pre-spawning mortality of salmon (Fagerlund et al. 1995, DFG 2004). The two pathogens that cause these diseases are widespread, regularly occur on healthy fish (though not at levels causing disease), and typically become lethal only when fish experience high degrees of stress[3] (Fagerlund et al. 1995, Winton 2001, DFG 2004). Crowding may be considered one factor that elicits a stress response in fish and contributes to efficient transmission of pathogens from one fish to another (Guillen 2003, DFG 2004).

As described and reviewed by DFG (2004) and Strange (2010a, 2015), the life cycle of the Ich pathogen, *I. multifilii*s, is direct (with no intermediate host). The parasitic stage of Ich is called the trophont and resides on the fish. After feeding, the parasite drops off the fish as a tomont, attaches to substrate where it encysts, and replicates many tomites. The cyst bursts and releases many short lived theronts which must successfully invade and attach to fish host tissue to continue the life cycle. The rate of infection is temperature dependent and increases at temperatures from 55 degrees Fahrenheit (°F) and warmer (Traxler et al. 1998, Winton 2001, DFG 2004). At optimal temperatures of 68 to 73.4°F, which are common in the lower Klamath River during the late summer, the entire Ich life cycle may take from four to seven days, with the trophonts residing on fish for three to five days, tomonts drop off and divide into many tomites in less than one to two days, and the released free-swimming, infectious theronts must find a fish host within about 24 hours. The cycle can be completed more quickly at warmer temperatures, but requires two weeks at 59°F, more than five weeks at 50°F, and months at lower temperatures (Post 1987, Winton 2001).

The pathogenicity of Ich disease is related to the fish immune response primarily at infection sites on gill and skin tissues (Post 1987, Fagerlund et al. 1995). The very thin walled epithelial cells of the gills facilitate oxygen and carbon dioxide gas exchange between the blood and oxygen-supplying water. When the Ich parasite infects this tissue—a preferred site because of the blood rich nutrient supply accessible to the parasite—an inflammatory immune response of the fish can result in fluid edema and hyperplasia (a thickening and proliferation of cells) of the gill tissue (Post 1987). This reduces the efficiency of gas exchange across the gills, reducing the ability of fish to obtain necessary oxygen and disrupting blood pH regulation. Infections of the

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[3] Stress as used here refers to a state produced by any environmental factor that alters the normal behavioral and physiological adaptive responses of an animal to such an extent that the chances of survival are significantly reduced.

skin integument can lead to leaky cells and disruption of osmoregulatory function (Post 1987, Winton 2001, DFG 2004). Columnaris infections are usually secondary to Ich infections and other injuries that expose tissues vulnerable to bacterial infection (Post 1987, Fagerlund et al. 1995, Winton 2001, Foott 2003).

The primary factors currently thought to contribute to infection dynamics and outbreaks of Ich disease in adult salmon returning to the Klamath River are:

- A background presence and reservoir of Ich parasites carried by the resident freshwater fishes of the lower Klamath River, primarily Speckled Dace (*Rhinichthys osculus*) and, perhaps other fish species including Klamath Smallscale Sucker (*Catostomous rimiculus*), with background levels varying from year-to-year but may be higher in years following large-scale outbreaks of Ich, even when disease or pre-spawning mortality of salmon does not result (Belchik 2015, Strange 2015, Foott et al. 2016).

- High water temperatures in the lower Klamath River, ≥73.4°F, during late summer into early fall that can result in thermal barriers that slow or delay migration of adult salmon. Salmon that arrive from the ocean and encounter these elevated temperatures can congregate in limited thermal refuge habitats, slowing migration through the lower Klamath River as they experience elevated physiological stress, contributing to high replication rates of the Ich parasites (Guillen 2003, DFG 2004, Strange 2010a, 2010b and 2012, USFWS and NMFS 2013, Belchik 2015).

- Low-flow conditions, which are often associated with high water temperatures, can result in limited areas of holding habitat and slowed migration for adult salmon in the lower Klamath River, where they stage until conditions for continuing migration improve, leading to abundant congregations of fish in these limited staging areas, especially near cooler temperature refuges at the mouths of tributaries (DFG 2004, Strange 2012, Belchik 2015).

- Presence of adult salmon in the lower Klamath River. In particular, large run size and high abundance of fall-run Chinook Salmon in the lower Klamath River generally increases the density of holding fish in the lower river that, in turn, can favor transmission and infectivity of the Ich parasite due to the close proximity of fish in limited holding habitats, leading to outbreaks of infection. However, adult salmon tend to congregate in close proximity to each other (schooling behavior) even with smaller runs or low fish abundance, and outbreaks can still occur during smaller run sizes if other variables are favorable to Ich transmission (Foott 2003, DFG 2004, Belchik 2015, Strange 2015).

The combination and convergence of these factors contribute to prime conditions for infections and transmission of the Ich parasite between fish. When densities of the host fish are high, the likelihood of the infectious tomite stage finding a host is high. When the temperature is high, parasite reproduction rate is increased and heavy parasite loads and burdens in fish can result. This may or may not result in fish mortality; for example, in 2014, infection rates were reported to be relatively high, without significant adult moratlity (Belchik 2015). Gill epithelia damaged by heavy parasite loads exacerbates the fishes' ability to obtain oxygen from water that may already be depressed in oxygen by warm water temperature and crowded holding pools where dissolved oxygen levels can be reduced due to respiration by the mass of fish inhabiting the pools (CDFW 2004). Accordingly, management measures that have been applied since the 2002 fish die-off in the lower Klamath River, as described in Chapter 1 “Introduction” and that are further considered and evaluated in this Draft EIS, focus on alleviating one or more of the contributing factors and disrupting the life cycle of the Ich parasite that may cause disease and potentially lead to pre-spawning mortality of adult salmon (USFWS and NMFS 2013, Reclamation 2016).

Central Valley and Bay-Delta Region

Fish and aquatic resources in the Central Valley Region are described in this section in accordance with the following major waterbodies:

- Shasta Lake
- Whiskeytown Lake
- Clear Creek
- Sacramento River, from Keswick Reservoir to the Delta
- Feather River
- American River
- Bay-Delta

Shasta Lake

Shasta Lake is formed by Shasta Dam, which is located on the Sacramento River just downstream of the confluence of the Sacramento, McCloud, and Pit Rivers. Keswick Dam reregulates releases from Shasta Dam to the Sacramento River and has no fish passage facilities; however, Keswick Dam has a fish trapping facility that operates in conjunction with Livingston Stone National Fish Hatchery, which is located below Shasta Dam.

Shasta Lake fish species include native and introduced warm-water and cold-water species. Major nonfish aquatic animal species assemblages in Shasta Lake include benthic macroinvertebrates and zooplankton (Reclamation 2014). Shasta Lake is typically thermally stratified from April through November, during which time the upper layer (epilimnion) can reach a peak water temperature of 80°F (Reclamation 2014). The upper layer of Shasta Lake supports warm-water game fish, and the lower layers (metalimnion and hypolimnion) support cold-water fishes. Nonnative, warm-water fish species in Shasta Lake include Smallmouth Bass, Largemouth Bass, Spotted Bass, Black Crappie, Bluegill, Green Sunfish, Channel Catfish, White Catfish, and Brown Bullhead (DWR et al. 2013). Cold-water species include Rainbow Trout, Brown Trout, landlocked White Sturgeon, landlocked Coho Salmon (Reclamation et al. 2003), and landlocked Chinook Salmon (Reclamation 2014). Other fish species in Shasta Lake include Golden Shiner, Threadfin Shad, Common Carp, and the native Hardhead, Sacramento Sucker, and Sacramento Pikeminnow (DWR et al. 2013, Reclamation 2014).

Warm-water fish habitat in Shasta Lake is influenced primarily by fluctuations in the lake level and the availability of shoreline cover (Reclamation 2014). Water surface elevations in Shasta

Lake can fluctuate approximately 55 feet annually as a result of operation of Shasta and Sacramento River diversions (Reclamation 2014). Reservoir surface elevation fluctuations can disturb shallow, nearshore habitats, including spawning and rearing habitat for warm-water fish species. The shoreline of Shasta Lake is generally steep, which limits shallow, warm-water fish habitat, and is not conducive to the establishment of vegetation or other shoreline cover (Reclamation 2014).

Whiskeytown Lake

Water is diverted from the Trinity River at Lewiston Dam and discharged via the Clear Creek Tunnel into Whiskeytown Lake on Clear Creek. From Whiskeytown Lake, water is released into the lower portion of Clear Creek via Whiskeytown Dam and into Keswick Reservoir through the Spring Creek Tunnel. There are two temperature control curtains in Whiskeytown Lake: Oak Bottom and Spring Creek (Reclamation 2008a). The Oak Bottom temperature control curtain was replaced in 2016 and serves as a barrier to prevent warm water in the reservoir from mixing with cold water from Lewiston Lake entering through the Carr Powerhouse. The Spring Creek temperature control curtain was replaced in 2011 and aids cold-water movement into the underwater intake for the Spring Creek Tunnel.

The fish assemblage in Whiskeytown Lake includes cold-water and warm-water species. Common fishes known to occur in Whiskeytown Lake include Rainbow Trout, Brook Trout, Brown Trout, Kokanee Salmon, Largemouth Bass, crappie, sunfish, catfish, and bullhead (USFWS et al. 2004).

Clear Creek

The project area includes the reach of Clear Creek extending from Whiskeytown Dam to the confluence with the Sacramento River. Since 1995, extensive habitat and flow restoration in Clear Creek has occurred under the Central Valley Project Improvement Act (CVPIA) and CALFED programs and in accordance with the NMFS 2009 BO (NMFS 2009). The Clear Creek Technical Team has been working since 1996 to facilitate implementation of CVPIA anadromous salmonid restoration actions (Brown et al. 2012). Restoration efforts have resulted in increased stocks of fall-run Chinook Salmon and re-established populations of spring-run Chinook Salmon and steelhead.

Extent and Status of Aquatic Habitat Whiskeytown Dam limits the contribution of coarse sediment for transport downstream in Clear Creek, which NMFS (2009) reported has resulted in riffle coarsening, fossilization of alluvial features, loss of fine sediments available for overbank deposition, and considerable loss of spawning gravels. These conditions affect spawning and rearing habitat on Clear Creek. Water flows and temperature conditions on Clear Creek are presented in Chapters 4 and 5, “Surface Water Supply and Management,” and “Surface Water Quality,” respectively.

Spawning Habitat An unpublished study conducted by USFWS (as cited in Brown 2011) suggested that gravel transport blocked by the construction of Whiskeytown Dam reduced spawning habitat in Clear Creek by 92 percent. Plans developed under CVPIA implementation included a goal to create and maintain 347,288 square feet of usable spawning habitat between Whiskeytown Dam to the former McCormick-Saeltzer Dam by 2020. This area is equivalent to the spawning habitat that existed before construction of Whiskeytown Dam (CVPIA 2014).

Brown (2011) noted that much of the degraded habitat has been restored by gravel augmentation, but continued augmentation will be required. Spawning gravel is annually augmented in Clear Creek downstream of Whiskeytown Dam, pursuant to CVPIA implementation and Action of I.1.3 of the 2009 NMFS BO Reasonable and Prudent Alternative (RPA). The CVPIA annual spawning gravel target is 25,000 tons per year; however, an average of 9,574 tons has been placed annually since 1996.

These gravel addition projects have successfully created habitat suitable for spring-run Chinook Salmon spawning, as evidenced by the number of redds directly observed in supplemental gravel or in supplemental gravel integrated into native gravel (USFWS 2007a). Spawning area mapping (performed annually since 2000) indicates the overall amount of area used by spawning fall-run Chinook Salmon has been increasing, despite the adult population abundance remaining stable. Gravel augmentation also has increased the amount of steelhead spawning habitat available in the lower reaches of Clear Creek, and NMFS (2009a) has indicated that this directly relates to higher fish abundance in recent years. In most locations, gravel additions created spawning habitat that did not exist or had limited prior use.

Studies to estimate the availability of fish habitat, expressed as Weighted Usable Area (WUA), have been conducted by USFWS for Clear Creek (USFWS 2007b). Over the range of flow evaluated, from 50 to 900 cubic feet per second (cfs), WUA for spring-run Chinook Salmon spawning was highest at 900 cfs in the upstream alluvial segment from Whiskeytown Dam to the NEED Camp Bridge. In the canyon segment downstream (NEED Camp Bridge to the Clear Creek Road Bridge), estimated spawning habitat WUA peaked at 650 cfs. The WUA estimates for steelhead/Rainbow Trout spawning habitat peaked at 350 cfs and 600 cfs in these segments, respectively (USFWS 2007b). In the lower reach downstream of the Clear Creek Road Bridge, estimated WUA for both fall-run Chinook Salmon and steelhead/Rainbow Trout spawning habitat peaked at 300 cfs (USFWS 2011a).

USFWS (2007) concluded that at all flows evaluated, the estimated amount of spawning habitat present in Clear Creek was less than that needed to accomodate an an average escapement of 833 spring-run Chinook Salmon, an escapement that meets “low risk of extinction criteria” (NMFS 2014b). However, the increased spawning habitat availability (due to gravel additions since 2003) suggests that spawning habitat for spring-run Chinook Salmon is now more than sufficient to support the recovery goal at all flows. At flows greater than 50 cfs, the amount of spawning habitat present in Clear Creek was greater than the amount of spawning habitat needed to accomodate 833 spawning adults for steelhead. The amount of spawning habitat present in Clear Creek was less than the amount of spawning habitat needed to support the 2005 to 2013 avererage escapement of 7,920 adult fall-run Chinook Salmon in Clear Creek (USFWS 2015a).

Rearing Habitat The WUA estimate for spring-run Chinook Salmon fry rearing peaked at 600 cfs in the upstream alluvial segment from Whiskeytown Dam to the NEED Camp Bridge. In the canyon segment downstream (NEED Camp Bridge to Clear Creek Road Bridge), estimated fry rearing habitat WUA peaked at the highest modeled flow of 900 cfs. The WUA for steelhead/Rainbow Trout fry rearing habitat peaked at 700 cfs and 900 cfs (the maximum flow modeled) in these segments, respectively (USFWS 2011b). The WUA for spring-run Chinook Salmon and steelhead/Rainbow Trout juvenile rearing habitat peaked at the highest modeled flow (900 cfs) in the upper alluvial segment, and 650 cfs in the canyon segment downstream. In the lower reach downstream of the Clear Creek Road Bridge, WUA for both fall-run Chinook Salmon and steelhead/Rainbow Trout fry rearing habitat peaked at 50 cfs; fry rearing habitat for spring-run Chinook Salmon peaked at 900 cfs. Spring-run Chinook Salmon and steelhead/Rainbow Trout juvenile rearing habitat peaked at 850 cfs, while fall-run Chinook Salmon juvenile rearing habitat peaked at 350 cfs (USFWS 2013).

USFWS (2015) compared the total amount of rearing habitat available for spring-run Chinook Salmon and steelhead/Rainbow Trout to the amount of rearing habitat needed to support an annual escapement of 833 adults for each species. The total amount of rearing habitat available for fall-run Chinook Salmon was compared to the amount of habitat needed to support an average escapement of 7,920 fall-run Chinook Salmon. At all flows, the amount of rearing habitat present in Clear Creek was greater than the amount needed to achieve the abundance recovery goal for spring-run Chinook Salmon and steelhead. In contrast, the amount of rearing habitat present in Clear Creek was less than the amount needed to support the the 2005 to 2013 average annual excapement of 7,920 adult fall-run Chinook Salmon in Clear Creek.

Fish Passage Whiskeytown Dam blocks access to 25 miles of historical spring-run Chinook Salmon and steelhead spawning and rearing habitat (Yoshiyama et al. 1996). Until 2000, the McCormick-Saeltzer Dam was an almost complete barrier to upstream migration for anadromous salmonids. After its removal, anadromous salmonids recolonized an additional 12 miles of habitat upstream to Whiskeytown Dam. Stream surveys and juvenile monitoring results also suggest that dam removal has allowed reestablishment of spring-run Chinook Salmon and steelhead. NMFS (2009a) reported that compared to fall-run Chinook Salmon, spring-run Chinook Salmon historically spawned earlier and at locations farther upstream in Clear Creek. However, NMFS (2009a) concluded that the construction of Whiskeytown Dam likely caused a high degree of spatial overlap between the fall-run and spring-run fish during spawning, resulting in a higher probability of hybridization. To address this concern, USFWS has been separating adult fall-run fish from the spring-run fish holding in the upper reaches of Clear Creek by operating a segregation weir from late August to November 1. After November 1, fall-run Chinook Salmon have access to the entire river for spawning.

Sacramento River from Keswick Dam to the Delta Near Freeport

Aquatic resources in the Sacramento River are affected by the habitat along the river and along the tributaries that connect to the river. Habitat along the river ranges from artificial structures used for water supply and flood management to ones that provide more natural types of habitat. The flow regime in the Sacramento River is managed for water supply, flood risk reduction, and fish and wildlife resources as described in Chapter 4, “Surface Water Supply and Management.” The following discussion focuses on the fish in the Sacramento River and aquatic habitat conditions.

Aquatic Habitat The mainstem Sacramento River provides habitat for native and introduced fish and other aquatic species. The diversity of aquatic habitats ranges from fast-water riffles and glides in the upper reaches to tidally influenced slow-water pools and glides in the lower reaches.

A few miles downstream of Keswick Dam, near Redding, the valley and floodplain broadens. Historically, this area likely had wide expanses of riparian forests, but much of the river’s riparian zone is subject to urban encroachment, particularly in the Anderson/Redding area. In the

Sacramento River between Red Bluff and Chico Landing, the mainstem channel is flanked by broad floodplains. In the lower reaches downstream of Verona, much of the Sacramento River is constrained by levees. Dredging, dams, levee construction, urban encroachment, and other human activities in the Sacramento River have modified aquatic habitat, altered sediment dynamics, simplified stream bank and riparian habitat, reduced floodplain connectivity, and modified hydrology (NMFS 2009). However, some complex floodplain habitats remain in the system such as reaches with setback levees and the Yolo and Sutter Bypasses.

Holding Habitat An abundance of deep, cold-water pools in the mainstem Sacramento River provide habitat for holding adult anadromous salmonids during all months of the year (Vogel 2011). Green Sturgeon also use deep pools for holding but can tolerate warmer water temperatures than salmon and, therefore, can hold farther downstream. Large numbers of adult Green Sturgeon have been observed holding during summer in deep pools in the Sacramento River near Hamilton City (Vogel 2011).

Spawning Habitat Spawning habitat on the Sacramento River is affected by lack of sediment, and by flow patterns that are dominated by the operations of the CVP and local water diverters.

Sediment Conditions Shasta and Keswick Dams substantially influence sediment transport in the upper Sacramento River because they block sediment that would normally have been transported downstream. The result has been a net loss of coarse sediment, including gravel particle sizes suitable for salmon spawning, in the Sacramento River downstream of Keswick Dam (Reclamation 2014). To address the issue of spawning gravel loss downstream of Keswick Dam, the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) has placed an average of approximately 5,000 tons of washed spawning gravel into the Sacramento River downstream of Keswick about every other year since 1997 (Reclamation 2010). Gravel placements of higher quantities sometimes occur after years when high flows have evacuated gravel from the injection sites. Flows as high as 20,000 cfs were released from Keswick Dam in March 2016, and created room to inject 20,000 tons of gravel that were placed just downstream of Keswick Dam in September 2016.

Spawning Habitat Availability Winter-run Chinook Salmon spawning in the upper reaches of the Sacramento River is affected by the operations of the seasonal Anderson-Cottonwood Irrigation District (ACID) diversion dam, which involves placement of flashboards in the river between April and May. Flows in the river vary with the operation of the diversion dam and releases of water from Shasta Lake into the river.

The WUA for winter-run Chinook Salmon spawning peaked at around 10,000 cfs in the reach upstream of the ACID intake when the dam flashboards were in place. With the boards out, the peak was around 5,500 cfs. Between ACID intake and Cow Creek, spawning WUA also peaked at around 10,000 cfs. Between Cow Creek to Battle Creek, WUA spawning habitat peaked at around 5,250 cfs, but there was low variability in spawning WUA from 3,250 to 8,000 cfs (USFWS 2005a).

Overall, spawning habitat WUA values differed for fall-run and late fall-run Chinook Salmon, but the shapes of their flow versus habitat relationships were about the same for the two runs. Upstream of the ACID intake, estimated spawning habitat WUA for fall- and late fall-run

Chinook Salmon was highest at the lowest flow analyzed (3,250 cfs) with the dam flashboards out, and at about 6,000 cfs with the flashboards in. Between the ACID intake and Cow Creek, spawning habitat WUA peaked at around 5,000 cfs for both runs. Between Cow Creek and Battle Creek, spawning habitat WUA for both runs peaked at about 3,500 cfs. The highest density of redds for fall- and late fall-run Chinook Salmon occur in the ACID intake to Cow Creek reach.

The estimated spawning habitat WUA value for steelhead were highest at the lowest river flow analyzed (3,250 cfs) in the reach upstream of the ACID intake. This habitat relationship held regardless of whether the flashboards were in or out. In the reach between the ACID intake and Cow Creek, spawning habitat WUA peaked at river flows around 6,000 cfs. In the lower reach, from Cow Creek to Battle Creek, spawning habitat WUA also peaked at river flows of about 6,500 cfs, but did not vary substantially over the flow range from about 4,000 to 8,000 cfs.

USFWS (2005a) conducted limiting life-stage analyses for winter-, fall- and latefall-run Chinook Salmon in the Sacramento River upstream of the Battle Creek confluence and found that in most cases, juvenile habitat was limiting. In some cases (fall- and late fall-run in between the ACID intake and Cow Creek), spawning habitat may have been limiting at higher flows.

USFWS (2005b) developed spawning flow-habitat relationships for fall-run Chinook Salmon spawning habitat in the Sacramento River between Battle Creek and Deer Creek. Between Battle Creek and the Red Bluff Pumping Plant (RBPP), spawning habitat WUA values for fall-run Chinook Salmon peaked at approximately 3,750 cfs, but showed little variation over flows from 3,250 cfs (the lowest flow evaluated) and 6,000 cfs, then declined substantially at higher flows. Between the Red Bluff Pumping Plant and Deer Creek, spawning habitat WUA values for fall-run Chinook Salmon peaked at 5,500 cfs, with little variation at flows from 4,250 to 8,000 cfs (USFWS 2005b).

Rearing Habitat In the Sacramento River between Red Bluff and Chico Landing, the mainstem channel is flanked by broad floodplains. Ongoing sediment deposition in these areas provides evidence of continued inundation of floodplains in this reach (DWR 1994). Between Chico Landing and Colusa, the Sacramento River is bounded by levees that provide flood protection for cities and agricultural areas. However, the levees in this portion of the Sacramento River are for the most part, set back from the mainstem channel such that floodplain processes can be significant within the river corridor (TNC 2007).

Fry rearing habitat WUA for winter-run Chinook Salmon fry rearing habitat peaked at around 5,500 cfs in the reach upstream of the ACID intake when the dam flashboards were in. With the boards out, the peak was around 6,500 cfs. Between ACID intake and Cow Creek, fry rearing habitat WUA for winter-run Chinook Salmon was highest at around 31,000 cfs (the highest flow evaluated). From Cow Creek to Battle Creek, fry rearing habitat WUA for winter-run Chinook Salmon also peaked at around 31,000 cfs, but there was little relationship between WUA and flows.

The fry rearing habitat WUA values differed for fall-run and late fall-run Chinook Salmon, but the shapes of the flow versus habitat relationships were similar for the two runs. Upstream of the ACID intake, fry rearing habitat WUA for fall- and late fall-run Chinook Salmon was highest at the lowest flow analyzed (3,250 cfs) with the dam flashboards in. With the flashboards out, fry rearing habitat WUA peaked at around 23,000 cfs for both species. Between the ACID intake and Cow Creek, fry rearing habitat WUA for fall- and late fall-run Chinook Salmon peaked at around 3,750 cfs for both runs, with little variation from 3,250 cfs to 6,000 cfs and only slightly lower WUA values at flows greater than 21,000 cfs. Between Cow Creek and Battle Creek, fry rearing habitat WUA for both runs was highest at 3,250 cfs (the lowest flow evaluated) and declined as flows increased.

Juvenile rearing habitat WUA for winter-run Chinook Salmon peaked at around 8,000 cfs in the upstream reach above the ACID intake when the dam flashboards were in. With the boards out, the peak was around 9,000 cfs. However, there was little variation in juvenile winter-run Chinook Salmon rearing habitat WUA from around 5,500 to 11,000 cfs in this reach. In the next reach downstream between the ACID intake to Cow Creek, juvenile rearing habitat WUA for winter-run Chinook Salmon was highest at around 31,000 cfs (the highest flow evaluated). From Cow Creek to Battle Creek, juvenile rearing habitat WUA for winter-run Chinook Salmon peaked at around 3,500 cfs but showed only moderate (less than 50 percent) reductions in WUA over the entire range of flows evaluated.

The juvenile rearing habitat WUA values differed for fall-run and late fall-run Chinook Salmon, but the shapes of their flow versus habitat relationships were similar. Upstream of the ACID intake, juvenile rearing habitat WUA for fall- and late fall-run Chinook Salmon peaked in the 5,000- to 6,000-cfs range with the dam flashboards in or out; there were only moderate (less than 50 percent) reductions in juvenile rearing WUA over the entire range of flows evaluated. Between the ACID intake and Cow Creek, fry rearing WUA was highest at 3,250 cfs (the lowest flow evaluated) for both runs, declining to a minimum at around 15,000 cfs and increasing to around 70 percent of the maximum at flows above 21,000 cfs. Between Cow Creek and Battle Creek, fry rearing WUA for both runs was highest at 3,250 cfs (the lowest flow evaluated) and declined as flow increased.

Vogel (2011) suggested that the mainstem Sacramento River may not provide adequate rearing areas for fry-stage anadromous salmonids, as evidenced by rapid displacement of fry from upstream to downstream areas and into nonnatal tributaries during increased flow events. Underwater observations of salmon fry in the mainstem Sacramento River suggest that optimal habitats for rearing may be limited at higher flows (Vogel 2011). USFWS (2005a) conducted limiting life-stage analyses for winter-, fall-, and latefall-run Chinook Salmon in the Sacramento River above Battle Creek and found that in most cases, juvenile habitat was limiting. An important limitation of this analysis was that it did not take into account fry and juvenile rearing habitat below Battle Creek or in the Delta.

The minimum required Sacramento River flow from Keswick Dam is 3,250 cfs from September through February in all but critical water years in accordance with State Water Resources Control Board water rights order 90-05. Flows during summer generally exceed 3,250 cfs. The water temperature requirements established for winter-run Chinook Salmon result in water temperatures also suitable for year-round rearing of steelhead in the upper Sacramento River.

Fish Passage and Entrainment Historically, anadromous salmonids had access to a minimum of approximately 493 miles of habitat in the Sacramento River (Yoshiyama et al. 1996). Access to approximately 207 miles was blocked with completion of Shasta Dam in 1945. Keswick Dam, just downstream of Shasta Dam, is now the upstream extent of available habitat for anadromous fish in the Sacramento River.

Until recently, three large-scale, upper Sacramento River diversions, including the ACID and Glen-Colusa Irrigation District (GCID) intakes and the Red Bluff Diversion Dam (RBDD), were of particular concern as potential passage or entrainment problems for Chinook Salmon, steelhead, and other migratory fish species (NRC 2012, NMFS 2009). Recently, the RBDD was replaced by the more passage-friendly RBPP, the GCID fish screens were installed, and fish passage at the ACID intake was improved (NRC 2012). At the ACID intake, new fish ladders and fish screens were installed around the diversion and were operated starting in the summer 2001 diversion period. However, adult Green Sturgeon that migrate upstream in April, May, and June are completely blocked by the ACID intake (NMFS 2009), rendering approximately 3 miles of spawning habitat upstream of the diversion dam inaccessible. Numerous other diversions are located on the Sacramento River. Herren and Kawasaki (2001) documented up to 431 diversions from the Sacramento River between Shasta Dam and the City of Sacramento. Hanson (2001) studied juvenile Chinook Salmon entrainment at unscreened diversions at the Princeton Pumping Plant and documented the entrainment of approximately 0.05 percent of juvenile Chinook Salmon passing the diversion. Vogel (2014) found that juvenile salmon were entrained in a much lower proportion than the proportion of flow diverted, similar to results noted by Hanson (2001). Mussen et al. (2014) examined the risk to Green Sturgeon from unscreened water diversions and found that juvenile Green Sturgeon entrainment susceptibility (in a laboratory setting) was high relative to that estimated for Chinook Salmon, suggesting that unscreened diversions could be a contributing mortality source for threatened Southern DPS Green Sturgeon.

Predation On the mainstem Sacramento River, high rates of predation have been known to occur at the diversion facilities and areas where rock revetment has replaced natural river bank vegetation (NMFS 2009). Chinook Salmon fry, juveniles, and smolts are more susceptible to predation at these locations because Sacramento Pikeminnow and Striped Bass congregate in areas that provide predator refuge (Williams 2006, Tucker et al. 2003).

Feather River from Lake Oroville and the Thermalito Complex to the Sacramento River

The Feather River is a major tributary to the Sacramento River, providing approximately 25 percent of the flow in the Sacramento River (FERC 2007b). The lower Feather River extends downstream from the Fish Barrier Dam to its confluence with the Sacramento River near Verona. The Fish Barrier Dam is located downstream of the Thermalito Diversion Dam and immediately upstream of the Feather River Fish Hatchery (FERC 2007b).

Most Chinook Salmon and steelhead spawning is concentrated in the uppermost three miles of accessible habitat in the lower Feather River downstream of the Feather River Fish Hatchery (FERC 2007b). As a result, salmonid spawning is concentrated to unnaturally high levels in the low-flow channel of the lower Feather River directly downstream of Oroville Dam and the Fish Barrier Dam. A physical habitat simulation analysis conducted by the California Department of Water Resources (DWR) in 2002 indicated that Chinook Salmon spawning habitat suitability in the low-flow channel reached a maximum between 800 and 825 cfs, and in the high-flow channel, it reached a maximum at 1,200 cfs. The steelhead spawning habitat index in the low-flow channel had no distinct optimum over the range of flow between 150 and 1,000 cfs. In the high-flow channel, spawning habitat suitability was maximized at a flow just under 1,000 cfs (DWR 2004).

Lower American River Between Lake Natoma and the Sacramento River

The lower American River extends approximately 23 miles from the Nimbus Dam downstream to its confluence with the Sacramento River. Access to the upper reaches of the river by anadromous fish is blocked at Nimbus Dam. During higher flows, channel geomorphology in the lower American River is characterized by bar complexes and side channel areas, which may become limited at lower flows (NMFS 2009). In 2008, Reclamation began implementing floodplain and spawning habitat restoration projects in the American River, and has continued to do so nearly every year since from Nimbus Dam down to River Bend Park.

Bay-Delta

Ecologically, the Delta consists of three major landscapes and geographic regions: (1) the north Delta freshwater flood basins composed primarily of freshwater inflow from the Sacramento River system; (2) the south Delta distributary channels composed of predominantly San Joaquin River system inflow; and (3) the central Delta tidal islands landscape wherein the Sacramento River, San Joaquin River, and east side tributary flows converge and tidal influences from San Francisco Bay are greater.

Aquatic Habitat Flow management in the Delta has created stress on aquatic resources by (1) changing aspects of the historical flow regime (i.e., timing, magnitude, duration) that supported life history traits of native species; (2) limiting access to habitat or degrading habitat quality; (3) contributing to conditions better suited to invasive, nonnative species (through reduced spring flows, increased summer inflows and exports, and low and less-variable interior Delta salinity [Moyle and Bennett 2008]); and (4) causing reverse flows in channels leading to project export facilities that can entrain fish (Mount et al. 2012). Native species of the Delta are adapted to and depend upon variable flow conditions at multiple scales as influenced by the region’s dramatic seasonal and interannual climatic variation. In particular, most native fishes evolved reproductive or outmigration timing associated with historical peak flows during spring.

Water temperatures in the Delta follow a seasonal pattern of winter cold-water conditions and summer warm-water conditions with alternating cool-wet and hot-dry seasons. Currently in the Delta, the most significant changes in water temperatures have been in the form of increased summer water temperatures over large areas of the Delta because of high summer ambient air temperatures, the increased temperature of river inflows, and to a lesser extent, reduced quantities of freshwater inflow and modified tidal and groundwater hydraulics (Mount et al. 2012, NRC 2012, Wagner et al. 2011). Water temperatures in summer now approach or exceed the upper thermal tolerances for cold-water fish species such as salmonids and Delta-dependent species such as Delta Smelt (NRC 2012).

Landscape-scale changes resulting from flood management infrastructure, along with flow modification, have eliminated most of the historical hydrologic connectivity of floodplains and aquatic ecosystems in the Delta and its tributaries, thereby degrading and diminishing Delta habitat for native plant and animal communities (Mount et al. 2012). The large reduction of hydrologic variability and landscape complexity, coupled with degradation of water quality, has supported invasive aquatic species that have further degraded conditions for native species. Due to the combination of these factors, the Delta appears to have undergone an ecological regime shift unfavorable to many native species (Moyle and Bennett 2008, Baxter et al. 2010).

Salinity is a critical factor influencing plant and animal communities in the Delta. Although estuarine fish species are generally tolerant of a range of salinity, the tolerance varies by species and lifestage. Some species can be highly sensitive to excessively low or high salinity during physiologically vulnerable periods, such as reproductive and early life history stages. Although the Delta is tidally influenced, most of the Delta is freshwater year-round, due to inflows from rivers. The south Delta can have low salinity because of agricultural return water. The tidally influenced low-salinity zone can move upstream into the central Delta.

An important measure of the spatial geography of salinity in the western Delta is X2. The X2 has also been correlated with the amount of suitable habitat for Delta Smelt in fall (Feyrer et al. 2007, 2010). It also helps define the extent of habitat available for oligohaline pelagic organisms and their prey. The abiotic habitat of Delta Smelt can be defined as a specific envelope of salinity and turbidity that changes over the course of the species' life cycle (Feyrer et al. 2007). CVP and State Water Project (SWP) operations and other potential factors (e.g., lower outflows) have shifted the X2 position in fall farther upstream out of the wide expanse of Suisun Bay into the much narrower channels near the confluence of the Sacramento and San Joaquin Rivers (near Collinsville), reducing the spatial extent of low-salinity habitat important for relevant species such as Delta Smelt (Kimmerer et al. 2009, Baxter et al. 2010).

Nutrients and Food Web Support Nutrients provide a resource base for primary producers. Typically in freshwater aquatic environments, phosphorous is the primary limiting macronutrient, whereas in marine aquatic environments, nitrogen tends to be limiting. A balanced range of abundant nutrients provides optimal conditions for maximum primary production, a robust food web, and productive fish populations. However, changes in nutrient loadings and forms, excessive amounts of nutrients, and altered nutrient ratios can lead to eutrophication and a suite of problems in aquatic ecosystems, such as low dissolved oxygen concentrations, un-ionized ammonia, excessive growth of toxic forms of cyanobacteria, and changes in components of the food web.

Estuaries are commonly characterized as highly productive nursery areas for numerous aquatic organisms. Compared to other estuaries, pelagic primary productivity in the upper San Francisco Estuary is relatively poor, and a relatively low fish yield is expected (Wilkerson et al. 2006). There has been a significant long-term decline in phytoplankton biomass (chlorophyll a) and primary productivity at low levels in the Suisun Bay region and the Delta (Jassby et al. 2002). Shifts in nutrient concentrations such as a high level of ammonium and nitrogen to phosphorus ratio may contribute to the phytoplankton reduction and to changes in algal species composition in the San Francisco Estuary (Wilkerson et al. 2006, Dugdale et al. 2007, Glibert 2010, Glibert et al. 2014). Low and declining primary productivity in the estuary may be contributing to the long-term pattern of relatively low and declining biomass of pelagic fishes (Jassby et al. 2002).

The introductions of two clams from Asia have led to major alterations in the food web in the Delta. These filter feeders significantly reduce the phytoplankton and zooplankton concentrations in the water column, reducing food availability for native fishes, such as Delta Smelt and young Chinook Salmon (Feyrer et al. 2007). Additionally, the introduced clams caused the decline of higher-food-quality native copepods and the establishment of poorer quality nonnative copepods. Reductions in food availability and food quality have led to lower fish foraging efficiency and reduced growth rates (Moyle 2002).

Turbidity Turbidity is important in the Delta because it affects physical habitat through sedimentation and food web dynamics through attenuation of light in the water column. Light attenuation, in turn, affects the extent of the photic zone where primary production can occur, and impacts the ability of predators to locate prey and for prey to escape predation.

Turbidity has been declining in the Delta, as indicated by sediment data collected by the U.S. Geological Survey since the 1950s (Wright and Schoellhamer 2004), with important implications for food web dynamics and predation. Higher water clarity is at least partially caused by increased water filtration and plankton grazing by highly abundant overbite clams (*Potamocorbula amurensis*) and other benthic organisms (Kimmerer 2004, Greene et al. 2011). High nutrient loads, coupled with reduced sediment loads and higher water clarity, could contribute to plankton and algal blooms and overall increased eutrophic conditions in some areas (Kimmerer 2004).

The first high-flow events of winter create turbid conditions in the Delta, which can be drawn into the south Delta during reverse flow conditions in the Old and Middle Rivers. Delta Smelt may follow turbid waters into the southern Delta, increasing their proximity to project export facilities and, therefore, their entrainment risk (USFWS 2008).

Contaminants Contaminants can change ecosystem functions and productivity through numerous pathways. Trends in contaminant loadings and their ecosystem effects are not well understood. Efforts are underway to evaluate direct and indirect toxic effects on the Delta fishes of manmade contaminants and natural toxins associated with blooms of *Microcystis aeruginosa*, a cyanobacterium or blue-green alga that releases a potent toxin known as microcystin. Toxic microcystins cause food web impacts at multiple trophic levels, and histopathological studies of fish liver tissue suggest that fish exposed to elevated concentrations of microcystins have developed liver damage and tumors (Lehman et al. 2005, 2008, 2010).

Baxter et al. (2008) prepared a 2007 synthesis of results as part of a Pelagic Organism Decline Progress Report, including a summary of prior studies of contaminants in the Delta. The summary included studies that suggested that phytoplankton growth rates may be inhibited by localized high concentrations of herbicides (Edmunds et al. 1999).

Toxicity to invertebrates has been noted in water and sediments from the Delta and associated watersheds (Kuivila and Foe 1995, Weston et al. 2004). The 2004 study of sediment toxicity recommended additional study of the effects of the pyrethroid insecticides on benthic organisms (Weston et al. 2004). Undiluted drainwater from agricultural drains in the San Joaquin River watershed can be acutely toxic (quickly lethal) to fish (Chinook Salmon and Striped Bass) and have chronic effects on growth, likely because of high concentrations of major ions (e.g., sodium and sulfates) and trace elements (e.g., chromium, mercury and selenium) (Saiki et al. 1992).

Fish Passage and Entrainment The Delta presents a challenge for anadromous and resident fish during upstream and downstream migration, with its complex network of channels, low eastern and southern tributary inflows, and reverse currents created by pumping for water exports. These complex conditions can lead to straying, extended exposure to predators, and entrainment during outmigration. Tidal elevations, salinity, turbidity, in-flow, meteorological conditions, season, habitat conditions, and project exports all have the potential to influence fish movement, currents, and ultimately the level of entrainment and fish passage success and survival, which is the subject of extensive research and adaptive management efforts (IRP 2010, 2011). Michel et al. (2010, 2015) used acoustic telemetry to examine survival of late fall-run Chinook Salmon smolts outmigrating from the Sacramento River through the Bay-Delta. Survival was lowest in the freshwater portion (Delta) and the brackish portion of the estuary relative to survival in the riverine portion of the migration route.

Juvenile fish moving down the mainstem Sacramento River can enter the DCC when the gates are open and travel through the Delta via the Mokelumne and San Joaquin Rivers' channels. In the case of juvenile salmonids, this shifted route from the north Delta to the central Delta increases their mortality rate (Brandes and McLain 2001, Newman and Brandes 2010, Perry et al. 2010, 2012). Closing the DCC gates redirects the migratory path of outmigrating fish into Sutter and Steamboat Sloughs and away from Georgiana Slough, resulting in higher survival rates (NMFS 2009).

The south Delta intake facilities include the CVP and SWP export facilities; local agency intakes, and agricultural intakes. Water flow patterns in the south Delta are influenced by the water diversion actions and operations of the south Delta seasonal temporary barriers and tides and river inflows to the Delta. Delta diversions can create reverse flows, drawing fish toward project facilities (Arthur et al. 1996, Kimmerer 2008, Grimaldo et al. 2009).

A portion of fish that enter the CVP C.W. Jones Pumping Plant approach channel and the SWP Clifton Court Forebay are salvaged at screening and fish salvage facilities, transported downstream by trucks, and released. NMFS (2009a) estimates that the direct loss of fish from the screening and salvage process is in the range of 65 to 83.5 percent for fish from the point they enter Clifton Court Forebay or encounter the trash racks at the CVP facilities. Additionally, mark-recapture experiments indicate that most fish are probably subject to predation prior to reaching the fish salvage facilities (e.g., in Clifton Court Forebay) (Gingras 1997, Castillo et al. 2012). Aquatic organisms (e.g., phytoplankton and zooplankton) that serve as food for fish also are entrained and removed from the Delta (Jassby et al. 2002, Kimmerer et al. 2008).

Salvage estimates reflect the number of fish entrained by project exports, but these numbers alone do not account for other sources of mortality related to the export facilities. These numbers do not include prescreen losses that occur in the waterways leading to the diversion facilities, which may in some cases reduce the number of salvageable fish (Gingras 1997, Castillo et al. 2012). For Delta Smelt, prescreen losses appear to be where most mortality occurs (Castillo et al. 2012). In addition, actual salvage numbers do not include the entrainment of fish larvae, which cannot be collected by the fish screens. The number of fish salvaged also does not include losses of fish that pass through the louvers intended to guide fish into the fish collection facilities or the losses during collection, handling, transport, and release back into the Delta.

Research conducted during 2010 and 2011 showed that upriver movements of adult Delta Smelt are achieved through a form of tidal rectification or active tidal transport by using lateral movement to shallow edges of channels on ebb tides to maintain their position (IRP 2010, 2011). Turbidity gradients could be involved in the lateral positioning of Delta Smelt within the channels, but large-scale turbidity pulses through the system may not be necessary to trigger upriver migrations of Delta Smelt if they are already occupying sufficiently turbid water (IRP 2011). The new understanding of potential tidal and turbidity effects on Delta Smelt behavior may have important implications for the Delta Smelt monitoring programs that are the basis for biological triggers for Biological Opinion RPA Actions 1 and 2 by understanding the catch efficiency of mid-water trawl data in relation to the lateral positioning of Delta Smelt within channels (USFWS 2008).

Disease Preliminary results of several histopathological studies have found evidence of significant disease in Delta fish species (Reclamation 2008a). For example, massive intestinal infections with an unidentified myxosporean were found in yellowfin goby collected from Suisun Marsh (Baxa et al. 2013). Studies by Bennett (2005) and Bennett et al. (2008) show that exposure to toxic chemicals may cause liver abnormalities and cancerous cells in Delta Smelt, and stressful summer conditions, warm water, and lack of food may result in liver glycogen depletion and liver damage. Studies of Sacramento Splittail suggest that liver abnormalities in this species are more linked to health and nutritional status than to pollutant exposure (Greenfield et al. 2008).

Nonnative Invasive Species Nonnative invasive species influence the Delta ecosystem by increasing competition and predation on native species, reducing habitat quality (as result of invasive aquatic macrophyte growth), and reducing food supplies by altering the aquatic food web. Not all nonnative species are considered invasive.[4] Some introduced species have minimal ability to spread or increase in abundance. Others have commercial or recreational value (e.g., Striped Bass, American Shad and Largemouth Bass).

Because of invasive species and other environmental stressors, native fishes have declined in abundance throughout the region during the period of monitoring (Matern et al. 2002, Brown and Michniuk 2007, Sommer et al. 2007, Mount et al. 2012). Habitat degradation, changes in hydrology and water quality, and stabilization of natural environmental variability are all factors that generally favor nonnative, invasive species (Mount et al. 2012, Moyle et al. 2012).

Predation Predation is an important factor that influences the behavior, distribution, and abundance of prey species in aquatic communities to varying degrees. Predation can have differing effects on a population of fish depending on the size or age selectivity, mode of capture, mortality rates, and other factors. Predation is a part of every food web, and native Delta fishes were part of the historical Delta food web. Because of the magnitude of change in the Delta from historical times and the introduction of nonnative predators, it is logical to conclude that predation may have increased in importance as a mortality factor for Delta fishes, with some observers suggesting that it is likely the primary source of mortality for juvenile salmonids in the Delta (Vogel 2011). Predation occurs by fish, birds, and mammals, including sea lions. The

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[4] DFG (2008) defines *invasive species* as "species that establish and reproduce rapidly outside of their native range and may threaten the diversity or abundance of native species through competition for resources, predation, parasitism, hybridization with native populations, introduction of pathogens, or physical or chemical alteration of the invaded habitat."

alternatives considered in this EIS are not anticipated to modify predatory actions of birds and mammals on the focal species. Therefore, the predation discussion is focused on fish predators.

A panel of experts recently convened to review data on predation in the Delta and draw preliminary conclusions on the effects of predation on salmonids. The panel acknowledged that the system supports large populations of fish predators that consume juvenile salmonids (Grossman et al. 2013). However, the panel concluded that because of extensive flow modification, altered habitat conditions, native and nonnative fish and avian predators, temperature and dissolved oxygen limitations, and the overall reduction in salmon population size, it was unclear what proportion of the juvenile salmonid mortality could be attributed to predation. The panel further indicated that predation, while the proximate cause of mortality, may be influenced by a combination of other stressors that make fish more vulnerable to predation.

Aquatic Macrophytes Aquatic macrophytes are an important component of the biotic community of Delta wetlands and can provide habitat for aquatic species, serve as food, produce detritus, and influence water quality through nutrient cycling and dissolved oxygen fluctuations. Whipple et al. (2012) described likely historical conditions in the Delta, which have been modified extensively, with major impacts on the aquatic macrophyte community composition and distribution. The primary change has been a shift from a high percentage of emergent aquatic macrophyte wetlands to open water and hardened channels.

The introduction of two nonnative invasive aquatic plants, water hyacinth and Brazilian waterweed, has reduced habitat quantity and value for many native fishes. Water hyacinth forms floating mats that greatly reduce light penetration into the water column, which can significantly reduce primary productivity and available food for fish in the underlying water column. Brazilian waterweed grows along the margins of channels in dense stands that prohibit access for native juvenile fish to shallow water habitat. Additionally, the thick cover of these two invasive plants provides excellent habitat for nonnative ambush predators, such as bass, which prey on native fish species. Studies indicate low abundance of native fish, such as Delta Smelt, Chinook Salmon, and Sacramento Splittail, in areas of the Delta where submerged aquatic vegetation infestations are thick (Grimaldo et al. 2004, 2012, Nobriga et al. 2005).

Invasive aquatic macrophytes are still equilibrating within the Delta and resulting habitat changes are ongoing, with negative impacts on habitats and food webs of native fish species (Toft et al. 2003, Grimaldo et al. 2009). Concerns about invasive aquatic macrophytes are centered on their ability to form large, dense growth that can clog waterways, block fish passage, increase water clarity, provide cover for predatory fish, and cause high biological oxygen demand.

Fish Species in the Central Valley and Bay-Delta Region

The focal fish species that occur in the Central Valley and Bay-Delta Region are identified in Table 7-1, and detail of their life histories are provided below.

Fish in the CVP and SWP Reservoirs Fish in the CVP and SWP reservoirs consist of two basic types – warm-water and cold-water species. Warm-water fishes include the black bass, consisting of Largemouth Bass, Smallmouth Bass and Spotted Bass. Cold-water fishes include salmonid species, including Rainbow Trout and in some cases, landlocked Chinook Salmon.

Largemouth Bass Largemouth Bass (*Micropterus salmoides*), native to the Mississippi River drainage and the southeastern United States, were first introduced into California in 1891 and have since spread to most suitable habitats in the State (Moyle 2002).

Largemouth Bass begin spawning in March or April and may spawn through June (Mitchell 1982, Moyle 2002). They typically build their nests on sand, gravel, or debris-littered substrates, often selecting sites next to logs or boulders that provide cover (Moyle 2002). Largemouth Bass generally spawn at depths between about 3 and 6 feet. The larvae rise from the nest and begin exogenous feeding about 5 to 8 days after hatching (Emig 1966). The males guard the nests and newly hatched larvae from predators, including Bluegill and Threadfin Shad (Mitchell 1982). Their optimal water temperatures for growth range from 77°F to 86°F (Moyle 2002). Juveniles prefer somewhat higher water temperatures than adults.

Smallmouth Bass Smallmouth Bass (*M. dolomieui*) are native to the upper and middle Mississippi River drainage. They were first introduced into California in 1874 and have since been widely distributed throughout the State (Moyle 2002). They have become established in many reservoirs and are normally found in cool waters, often near the upstream end of the impoundments. They also concentrate in narrow bays or areas along shores where rocky shelves project under water (Moyle 2002).

Spawning activity usually begins in spring when water temperatures reach 59°F to 61°F and ceases when temperatures reach about 78°F (Wang 1986, Cooke et al. 2003). The male guards the nest until the eggs hatch, which occurs between 3 and 10 days, depending on water temperature. The male herds and guards the fry for an additional 1 to 3 weeks until the fry disperse into shallower water. Fluctuations in reservoir water levels often interfere with success of Smallmouth Bass nests. Although Smallmouth Bass are typically found in cooler water than Largemouth and Spotted Bass, optimum temperatures for growth and survival are similar, approximately 77°F to 81°F (Moyle 2002).

Spotted Bass Alabama Spotted Bass (*M. punctulatus*) are native to the southeastern United States, but have been widely introduced into reservoirs because of their ability to spawn successfully in highly fluctuating water levels.

Spotted Bass begin spawning as early as late March, when the water temperature rises to 59°F to 65°F, and continues until temperatures reach 71°F to 73°F (Moyle 2002), with peak spawning occuring in late May and early June (Wang 1986). Males construct nests in colonies at depths of 3 to 20 feet (Wang 1986). The males guard the nests and newly-hatched larvae from predators such as bluegills (Aasen and Henry 1980). The larvae typically disperse from the nest 8 days after hatching (Vogele 1975). Growth is maximized at about 75°F (McMahon et al. 1984).

Fish in the Rivers Downstream from the CVP and SWP Reservoirs This section includes descriptions of the riverine fishes that occur downstream from the CVP and SWP reservoirs.

Sacramento River Winter-Run Chinook Salmon In 1989, Sacramento River winter-run Chinook Salmon escapement was estimated at 695 adults. Escapement continued to decline, ranging between 185 and 1,240 fish between 1989 and 1994, with an average of 525 adults. The decline in escapement during the late 1980s and early 1990s prompted listing winter-run Chinook Salmon as endangered under ESA (59 FR 440, January 4, 1994) and the California Endangered Species Act (CESA). Immediately following the listing, the numbers slowly began to increase. Construction of the temperature control device at Shasta Dam in 1999 helped provide the necessary cold water for winter-run Chinook Salmon. Winter-run Chinook Salmon, because they have a single population, have a higher risk to their population from long-term droughts, climate change, and other catastrophic events that affect flow and water temperature in the Sacramento River.

Adult winter-run Chinook Salmon return to fresh water during winter but delay spawning until spring and summer. Adults enter fresh water in an immature reproductive state, similar to spring-run Chinook Salmon, but winter-run Chinook Salmon move upstream much more quickly and then hold in the cool waters downstream of Keswick Dam for an extended period before spawning. Juveniles spend about 5 to 9 months in the river and estuary systems before entering the ocean. This life-history pattern differentiates the winter-run Chinook Salmon from other Sacramento River Chinook Salmon runs and from all other populations within the range of Chinook Salmon (DFG 1985, 1998b).

Adults migrate upstream past the RBPP beginning in mid-December and continue into early August, with most passing between January and May, peaking in mid-March (DFG 1985). Winter-run Chinook Salmon spawn only in the Sacramento River, almost exclusively above RBPP, with the majority spawning upstream from Balls Ferry, based on aerial redd survey data. Aerial redd surveys have indicated that the winter-run Chinook Salmon spawning distribution has shifted upstream since gravel introductions began in the upper river near Keswick Dam (USFWS and Reclamation 2008). They spawn from May through July, with the peak in early June. Fry emergence occurs from mid-June through mid-October and fry disperse to areas downstream for rearing. Juvenile migration past RBPP may begin in late July, generally peaks in September, and can continue until mid-March in drier years (Vogel and Marine 1991). The majority of winter-run Chinook Salmon outmigrate past RBPP as fry (Martin et al. 2001) and rear in the Sacramento River downstream before outmigrating to the Delta primarily in December through April. Between 44 and 81 percent (mean 65 percent) of juvenile winter-run Chinook Salmon used areas downstream of RBPP for rearing habitat, and the relative usage of rearing habitat upstream and downstream of RBPP appeared to be influenced by river flow during fry emergence (Martin et al. 2001). Winter-run Chinook Salmon usually migrate past Knight’s Landing once flows at Wilkins Slough rise to about 14,000 cfs; most juvenile winter-run Chinook Salmon outmigrate past Chipps Island by the end of March (del Rosario et al. 2013).

Central Valley Spring-Run Chinook Salmon On September 16, 1999, the Central Valley spring-run Chinook Salmon ESU was listed as threatened under the ESA by NMFS. The Central Valley spring-run Chinook Salmon ESU includes all naturally-spawned populations of spring-run Chinook Salmon in the Sacramento River and its tributaries, as well as artificially propagated Feather River spring-run Chinook Salmon (70 FR 37177). Naturally-spawning populations of spring-run Chinook Salmon currently are restricted to accessible reaches of the upper Sacramento River; Antelope, Battle, Beegum, Big Chico, Butte, Clear, Deer, and Mill Creeks; and the Feather and Yuba Rivers (DFG 1998b).

Spring-run Chinook Salmon display both stream-type and ocean-type life history strategies. Adults migrate upstream while sexually immature, hold in deep cold pools over the summer, and spawn in late summer and early fall. Juvenile outmigration is highly variable, with some juveniles outmigrating in winter and spring (ocean-type), and others oversummering and then emigrating as yearlings (stream-type).

Adult spring-run Chinook Salmon begin their upstream migation in late January and early February, and continue to their natal streams through June. They hold in cool, deep pools until they spawn in late August to October. Egg incubation continues through March, depending on water temperatures.

In fresh water, juvenile spring-run Chinook Salmon rear in natal tributaries, the Sacramento River mainstem, and nonnatal tributaries to the Sacramento River (DFG 1998b). Outmigration timing is highly variable, as they may migrate downstream as the young-of-year (YOY) or as juveniles or yearlings. The outmigration period for spring-run Chinook Salmon extends from November to early May, with up to 69 percent of the YOY fish outmigrating through the lower Sacramento River and Delta during this period (DFG 1998b). Migratory cues, such as increased flows, increasing turbidity from runoff, changes in day length, or intraspecific competition from other fish in their natal streams, may spur outmigration of juveniles from the upper Sacramento River basin when they have reached the appropriate stage of maturation (NMFS 2009).

Central Valley Fall-/Late Fall-run Chinook Salmon On March 9, 1998 (63 FR 11481), NMFS issued a proposed rule to list fall-run Chinook Salmon as threatened, but determined the species did not warrant listing, and identified it as a candidate species (64 FR 50393). It was then changed to a species of concern in 2004. NMFS also determined that both late fall-run and fall-run comprise a single ESU, but because they are separate in timing and effects, they are distinguished separately for the purposes of this document.

Fall-run Chinook Salmon are the most abundant and widely distributed of the Chinook Salmon runs in the Central Valley, occurring in nearly all anadromous salmonid bearing rivers and streams in the Sacramento and San Joaquin River systems. Historically, the summer water temperature regime in the Sacramento River was a key variable that influenced the life-history timing and strategy of the different salmonids that occur in the basin. Fall-run Chinook Salmon avoid stressful summer conditions by migrating upstream in the fall (September to November) when both air and water temperatures begin to cool. Because they arrive at spawning grounds with fully developed gonads, adult fall-run can spawn immediately (October to November), which allows their progeny to emerge in time to emigrate from the Sacramento River as fry in the subsequent spring (February to May) before water temperatures become too high.

The fall-run Chinook Salmon is an ocean-maturing type of salmon adapted for spawning in lowland reaches of big rivers, including the mainstem Sacramento River; the late fall-run Chinook Salmon is mostly a stream-maturing type (Moyle 2002). Similar to spring-run, adult late fall-run Chinook Salmon typically hold in the river for 1 to 3 months before spawning, while fall-run Chinook Salmon generally spawn shortly after entering freshwater.

Adult fall-run Chinook Salmon migrate into the Sacramento River and its tributaries from June through December in mature condition, with upstream migration peaking in September and

October. Adults spawn soon after arriving at their spawning grounds between late September and December, with peak spawning activity in late October and early November.

Adult late fall-run Chinook Salmon migrate up the Sacramento River between mid-October and mid-April, with peak migration occurring in December (Reclamation 1991). Adults spawn soon after reaching spawning areas between January and April. Fisher reports that peak spawning in the Sacramento River occurs in early February (1994), but carcass surveys conducted in the late 1990s suggest that peak spawning may occur in January (Snider et al. 1998, 1999, 2000).

Fall-run and late fall-run Chinook Salmon are generally able to spawn in deeper water with higher velocities than Chinook Salmon in other runs because of their larger size (Healey 1991). Late fall-run salmon tend to be the largest individuals of the Chinook Salmon species that occur in the Sacramento River basin (USFWS 1996).

Fall-run Chinook Salmon fry emergence occurs from December through March, and fry rear in freshwater for only a few months before migrating downstream to the ocean as smolts between March and July (Yoshiyama et al. 1998). Late fall-run fry emerge from redds between April and June (Vogel and Marine 1991).

Fall-run Chinook Salmon in the Sacramento River generally exhibit two rearing strategies: migrating to the lower reaches of the river or Delta as fry, or remaining to rear in the gravel-bedded reach for about 3 months and then smolting and outmigrating. The highest abundances of fry in the Delta are observed in wet years (Brandes and McLain 2001). Fall-run Chinook Salmon fry rear during a time and in a location where floodplain inundation is most likely to occur, thereby expanding the amount of rearing habitat available. Relative survival of fry appears to be higher in the upper Sacramento River than in the Bay-Delta, especially in wet years (Brandes and McClain 2001).

Water temperatures in the lower Sacramento River are often too high in May and June to support late fall-run Chinook Salmon fry survival, so later-emerging fry that migrate downstream likely suffer high rates of mortality and contribute little to the population. This suggests that a significant fraction of late fall-run juveniles rear in the upper Sacramento River throughout the summer before emigrating in the following fall and early winter as large subyearlings (Fisher 1994). Summer rearing is made possible by the cold water releases from the Shasta-Trinity divisions of the CVP. Late fall-run juveniles generally leave the Sacramento River by December (Vogel and Marine 1991), with peak emigration of smolts in October.

Central Valley Steelhead NMFS listed the Central Valley Steelhead ESU as threatened in 1998 (63 FR 13347). In 2004, NMFS proposed that all west coast steelhead ESUs be reclassified to DPSs and proposed to retain Central Valley Steelhead as threatened. In January 2006, after a status review (Good et al. 2005), NMFS issued its final decision to retain the status of Central Valley Steelhead as threatened (71 FR 834). Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River. Populations may exist in other tributaries, and a few naturally-spawning steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996).

Steelhead generally exhibit a more flexible life-history strategy than Chinook Salmon, and the habitat requirements of juvenile steelhead differ from those of juvenile Chinook Salmon. Unlike Chinook Salmon, steelhead can be iteroparous—that is, they can survive spawning, return to the ocean, and migrate into fresh water to spawn again. Post-spawning adults are known as kelts. In general, there are two types of steelhead: winter steelhead and summer steelhead. Winter steelhead are of the ocean-maturing reproductive ecotype, becoming sexually mature during their ocean phase and spawning soon after their arrival at the spawning grounds. Adult summer steelhead are of the stream-maturing type, which enter their natal streams and spend several months holding and maturing in fresh water before spawning. Central Valley Steelhead are predominantly winter steelhead, and this section describes the life history and habitat requirements of winter steelhead.

Central Valley steelhead generally leave the ocean and migrate upstream from August through March (Busby et al. 1996), In the Sacramento River, steelhead migrate upstream nearly every month of the year, with the bulk of migration from August through November and the peak in late September (Bailey 1954, Hallock et al. 1961, McEwan 2001). Spawning in the upper Sacramento River generally occurs from December through April (Newton and Stafford 2011).

Spawning typically begins in December and continues through early March. Peak spawning occurs from late January to early February. Embryos of various state of development are in the spawning gravel from December through April.

Unlike salmon, steelhead may live to spawn more than once and generally rear in freshwater streams for 1 to 3 years before outmigrating to the ocean. Most returning adults in the Central Valley spent 2 years in freshwater before emigrating. For steelhead, the Sacramento River functions primarily as a migration channel, although some rearing habitat remains in areas with setback levees (primarily upstream of Colusa) and flood bypasses (e.g., Yolo Bypass) (NMFS 2009). Juvenile emigration from the upper Sacramento River occurs between November and late June, with a peak between early January and late March (Reclamation 2008).

Southern DPS of the North American Green Sturgeon The Sacramento River provides habitat for Green Sturgeon spawning, adult holding, foraging, and juvenile rearing. Suitable spawning temperatures and spawning substrate exist for Green Sturgeon in the Sacramento River upstream and downstream of RBPP (Reclamation 2008a, Poytress et al. 2015). Although the upstream extent of historical Green Sturgeon spawning in the Sacramento River is unknown, the observed distribution of sturgeon eggs, larvae, and juveniles indicates that spawning occurs from Hamilton City to as far upstream as Ink’s Creek confluence (between Jellys Ferry and Bend Bridge) and possibly up to the Cow Creek confluence (Brown 2007, Poytress et al. 2015). Based on the distribution of sturgeon eggs, larvae, and juveniles in the Sacramento River, DFG (2002) indicated that Green Sturgeon spawn in late spring and early summer. Peak spawning is believed to occur between April and June.

Spawning migrations and spawning by Green Sturgeon in the Sacramento River mainstem have been well documented (Beamesderfer et al. 2004, Seesholtz et al. 2014, Poytress et al. 2015). Anglers fishing for White Sturgeon or salmon commonly report catches of Green Sturgeon from the Sacramento River as far upstream as Hamilton City (Beamesderfer et al. 2004). Eggs and YOY Green Sturgeon have been observed at Red Bluff and the GCID intake (Beamesderfer et al.

2004, Poytress et al. 2015). Adult Green Sturgeon that migrate upstream in April, May, and June are completely blocked by the ACID diversion dam (74 FR 52300), rendering approximately 3 miles of spawning habitat upstream of the diversion dam inaccessible.

Green Sturgeon from the Sacramento River are genetically distinct from their northern counterparts, indicating a spawning fidelity to their natal rivers (Israel et al. 2004), even though individuals can range widely (Lindley et al. 2008). Eggs have been observed upstream from the RBPP (Poytress et al., 2015), and larval Green Sturgeon have been captured during their dispersal stage at about 2 weeks of age (24 to 34 mm fork length) in rotary screw traps at RBPP (DFG 2002) and at about 3 weeks old when captured at the GCID intake (Van Eenennaam et al. 2001).

Young Green Sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (DFG 2002, Poytress et al. 2015). Rearing habitat condition and function may be affected by variation in annual and seasonal river flow and temperature characteristics.

Empirical estimates of Green Sturgeon abundance are not available for the Sacramento River population or any west coast population (Reclamation 2008a), and the current population status is unknown (Beamesderfer et al. 2007, Adams et al. 2007). NMFS (2009b) noted that, similar to winter-run Chinook Salmon, the restriction of spawning habitat for Green Sturgeon (to only one reach of the Sacramento River) increases the vulnerability of this spawning population to catastrophic events. This was one of the primary reasons that the Southern DPS of Green Sturgeon was Federally listed as a threatened species in 2006.

Fish in the Delta The Delta provides unique and, in some places, highly productive habitats for a variety of fish species, including euryhaline and oligohaline resident species and anadromous species. For anadromous species, the Delta is used by adult fish during upstream migration and by rearing juvenile fish that are feeding and growing as they migrate downstream to the ocean. Conditions in the Delta influence the abundance and productivity of all fish populations that use the system. Fish communities currently in the Delta include a mix of native species, some with low abundance, and a variety of introduced fish, some with high abundance (Matern et al. 2002, Feyrer and Healey 2003, Nobriga et al. 2005, Brown and May 2006, Moyle and Bennett 2008, Grimaldo et al. 2012).

Sacramento River Winter-Run Chinook Salmon Winter-run Chinook Salmon use the Delta for upstream migration as adults and for downstream migration and rearing as juveniles (del Rosario et al. 2013). Adults migrate through the Delta during winter and into late spring (May/June), enroute to their spawning grounds in the mainstem Sacramento River downstream of Keswick Dam (USFWS 2001). After entry into the Delta, the juveniles remain and rear in the Delta until they are 5 to 10 months of age (Fisher 1994, Myers et al. 1998). Although the duration of residence in the Delta is not precisely known, del Rosario et al. (2013) suggested that it can be up to several months. Winter-run juveniles have been documented in the north Delta (e.g., Sacramento River, Steamboat Slough, Sutter Slough, Miner Slough, Yolo Bypass, and Cache Slough complex); the central Delta (e.g., Georgiana Slough, DCC, Snodgrass Slough, and Mokelumne River complex below Dead Horse Island); south Delta channels, including Old and Middle Rivers, and the joining waterways between Old and Middle Rivers (e.g., Victoria Canal, Woodward Canal, and Connection Slough); and the western central Delta, including the mainstem channels of the Sacramento and San Joaquin Rivers and Threemile Slough (NMFS 2009).

Sampling at Chipps Island in the western Delta suggests that winter-run Chinook Salmon exit the Delta as early as December and as late as May, with a peak in March (Brandes and McLain 2001, del Rosario et al. 2013). The peak timing of the outmigration of juvenile winter-run Chinook Salmon through the Delta is corroborated by recoveries of winter-run-sized juvenile Chinook Salmon from the SWP Skinner Delta Fish Protection Facility and the CVP Tracy Fish Collection Facility in the south Delta (NMFS 2009).

Central Valley Spring-Run Chinook Salmon The Delta is an important migratory route for all remaining populations of spring-run Chinook Salmon. Like all salmonids migrating up through the Delta, adult spring-run Chinook Salmon must navigate the many channels and avoid direct sources of mortality (e.g., fishing and predation), but also must minimize exposure to sources of nonlethal stress (e.g., high temperatures) that can contribute to prespawn mortality in adult salmonids (Naughton et al. 2005, Cooke et al. 2006). Habitat degradation in the Delta caused by factors such as channelization and changes in water quality can present challenges for outmigrating juveniles. Additionally, outmigrating juveniles are subjected to predation and entrainment in the project export facilities and smaller diversions (NMFS 2009). Further detail is provided later in this section.

Spring-run Chinook Salmon returning to spawn in the Sacramento River system enter the San Francisco Estuary from the ocean in January to late February, and move through the Delta prior to entering the Sacramento River. Several populations of spring-run Chinook Salmon occur in the Sacramento River Basin. The Sacramento River channel is the main spring-run Chinook Salmon migration route through the Delta. However, adult spring-run Chinook Salmon may stray into the San Joaquin River side of the Delta in response to water from the Sacramento River Basin flowing into the interconnecting waterways that join the San Joaquin River channel through the DCC, Georgiana Slough, and Threemile Slough. Closure of the DCC radial gates is intended to minimize straying, but some southward net flow still occurs naturally in Georgiana and Threemile Sloughs.

YOY spring-run Chinook Salmon presence in the Delta peaks during April and May, as suggested by the recoveries of Chinook Salmon of a size consistent with the predicted size of spring-run fish at that time of year in the CVP and SWP salvage operations and the Chipps Island trawls. However, it is difficult to distinguish the YOY spring-run Chinook Salmon outmigration from that of the fall-run due to the similarity in their spawning and emergence times and size. Together, these two runs generate an extended pulse of Chinook Salmon smolts outmigrating through the Delta throughout spring, frequently lasting into June. Spring-run Chinook Salmon juveniles also overlap spatially with juvenile winter-run Chinook Salmon in the Delta (NMFS 2009). Typically, juvenile spring-run Chinook Salmon are not found in the channels of the eastern side of the Delta or the mainstem of the San Joaquin River upstream of Columbia and Turner Cuts.

Central Valley Fall-/Late fall-run Chinook Salmon Central Valley fall- and late fall-run Chinook Salmon pass through the Delta as adults migrating upstream and juveniles outmigrating downstream. Adult fall- and late fall-run Chinook Salmon migrating through the Delta must navigate the many channels and avoid direct sources of mortality and minimize exposure to sources of nonlethal stress. Additionally, outmigrating juveniles are subject to predation and entrainment in the project export facilities and smaller diversions.

Adult fall-run Chinook Salmon migrate through the Delta and into Central Valley rivers from June through December. Adult late fall-run Chinook Salmon migrate through the Delta and into the Sacramento River from October through April. Adult Central Valley fall- and late fall-run Chinook Salmon migrating into the Sacramento River and its tributaries primarily use the western and northern portions of the Delta, whereas adults entering the San Joaquin River system to spawn use the western, central, and southern Delta as a migration pathway.

In general, fall-run Chinook Salmon fry abundance in the Delta increases following high winter flows. Smolts that arrive in the estuary after rearing upstream migrate quickly through the Delta and Suisun and San Pablo Bays. A small number of juvenile fall-run Chinook Salmon spend over a year in freshwater and outmigrate as yearling smolts the following November through April. Late fall-run fry rear in freshwater from April through the following April. and outmigrate as smolts from October through February (Snider and Titus 2000a, b, and c).

Juvenile fall- and late fall-run Chinook Salmon migrating through the Delta toward the Pacific Ocean use the Delta, Suisun Marsh, and the Yolo Bypass for rearing to varying degrees, depending on their life stage (fry versus juvenile), size, river flows, and time of year. Movement of juvenile Chinook Salmon in the estuarine environment is driven by the interaction between tidally-influenced saltwater intrusion through San Francisco Bay and freshwater outflow from the Sacramento and San Joaquin Rivers (Healey 1991).

In the Delta, tidal and floodplain habitat areas provide important rearing habitat for foraging juvenile salmonids, including fall-run Chinook Salmon. Studies have shown that juvenile salmon may spend 2 to 3 months rearing in these habitat areas, and losses resulting from land reclamation and levee construction are considered to be major stressors (Williams 2010). The channeled, leveed, and riprapped river reaches and sloughs common in the Delta typically have low habitat diversity and complexity, have low abundance of food organisms, and offer little protection from predation by fish and birds.

Central Valley Steelhead Upstream migration of steelhead begins with estuarine entry from the ocean as early as July and continues through February or March in most years (McEwan and Jackson 1996, NMFS 2009). Populations of steelhead occur primarily within the watersheds of the Sacramento River Basin, although not exclusively. Steelhead can spawn more than once, with postspawn adults (typically females) potentially moving back downstream through the Delta after completion of spawning in their natal streams.

Juvenile steelhead can be found in all waterways of the Delta, but particularly in the main channels leading from their natal river systems (NMFS 2009). Juvenile steelhead are recovered in trawls from October through July at Chipps Island and at Mossdale. Chipps Island catch data indicate there is a difference in the outmigration timing between wild and hatchery-reared steelhead smolts from the Sacramento and eastside tributaries. Hatchery fish are typically recovered at Chipps Island from January through March, with a peak in February and March corresponding to the schedule of hatchery releases of steelhead smolts from the Central Valley hatcheries (Nobriga and Cadrett 2001, Reclamation 2008a). The timing of wild (unmarked) steelhead outmigration is more spread out, and based on salvage records at the CVP and SWP fish collection facilities, outmigration occurs over approximately 6 months with the highest levels of recovery in February through June (Aasen 2011, 2012).

Southern DPS of the North American Green Sturgeon Adult Green Sturgeon move through the Delta from February through April, arriving at holding and spawning locations in the upper Sacramento River between April and June (Heublein 2006, Kelly et al. 2007). Following their initial spawning run upriver, adults may hold for a few weeks to months in the upper river before moving back downstream in fall (Vogel 2008, Heublein et al. 2009), or they may migrate immediately back downstream through the Delta. Radio-tagged adult Green Sturgeon have been tracked moving downstream past Knights Landing during summer and fall, typically in association with pulses of flow in the river (Heublein et al. 2009).

Similar to other estuaries along the west coast of North America, adult and sub-adult Green Sturgeon frequently congregate in the San Francisco Estuary during summer and fall (Lindley et al. 2008). Specifically, adults and subadults may reside for extended periods in the central Delta as well as in Suisun and San Pablo Bays, presumably for feeding, because bays and estuaries are preferred feeding habitat rich in benthic invertebrates (e.g., amphipods, bivalves, and insect larvae). In part because of their bottom-oriented feeding habits, sturgeon are at risk for harmful accumulations of toxic pollutants in their tissues, especially pesticides such as pyrethroids and heavy metals such as selenium and mercury (Israel and Klimley 2008, Stewart et al. 2004).

After hatching, larvae and juveniles migrate downstream toward the Delta. Juveniles are believed to use the Delta for rearing for the first 1 to 3 years of their lives before moving out to the ocean and are likely to be found in the main channels of the Delta and the larger interconnecting sloughs and waterways, especially within the central Delta and Suisun Bay/Marsh.

When the DCC is open, there is no passage delay for adults, but juveniles could be diverted from the Sacramento River into the interior Delta. This has been shown to reduce the survival of juvenile Chinook Salmon (Brandes and McLain 2001, Newman and Brandes 2010, Perry et al. 2012), but it is unknown whether it has similar effects on Green Sturgeon.

Delta Smelt Delta Smelt was Federally listed as threatened (58 FR 12854, March 5, 1993). Recent monitoring results indicate that the Delta Smelt population continues to remain at an all-time low. In 2006, the USFWS was petitioned to upgrade the status of Delta Smelt to endangered. In 2010 and 2015, the USFWS conducted their 5-year review and found Delta Smelt warranted the upgrade in status, however, the listing was precluded by other higher priority-listing actions. The status of Delta Smelt under CESA was upgraded to endangered in January 2010 (DFG 2011).

Delta Smelt are endemic to the Delta (Moyle et al. 1992, Bennett 2005). Delta Smelt were once regarded as one of the most common pelagic fish in the Delta, but declines in their population led to their listing under the ESA as threatened in 1993 (58 FR 12854, March 5 1993). Delta Smelt are one of four pelagic fish species (including Longfin Smelt, Threadfin Shad, and juvenile Striped Bass) documented to be in decline based on fall midwater trawl abundance indices

(Sommer et al. 2007). The causes of the declines have been extensively studied and are thought to include a combination of factors, such as decreased habitat quantity and quality, increased mortality rates, and reduced food availability (Baxter et al. 2010, Rose et al. 2013a, b, Sommer and Mejia 2013).

The status of the Delta Smelt is uncertain, as indicators of Delta Smelt abundance have continued to decline and the number of fish collected in sampling programs, such as the trawl surveys conducted by the IEP, have dropped even lower in recent years. Fewer than 10 Delta Smelt were collected in surveys in 2014; the 2014 Delta Smelt index was 9, making it the lowest in Fall Midwater Trawl Survey (FMWT) history (Smelt Working Group 2015). Results for Delta Smelt from the 2015 spring Kodiak trawl, 20-mm survey, and summer townet survey—reported in the June 2015 Smelt Working Group meeting summary—were similarly low (Smelt Working Group 2015).

Delta Smelt have been documented throughout their geographic range during much of the year (Merz et al. 2011, Sommer and Mejia 2013, Brown et al. 2014). Studies indicate that in fall, prior to spawning, Delta Smelt are found in the Delta, Suisun and San Pablo Bays, the Sacramento River and San Joaquin River confluence, Cache Slough, and the lower Sacramento River (Murphy and Hamilton 2013). By spring, they move to freshwater areas of the Delta region, including the Sacramento River and San Joaquin River confluence, the Upper Sacramento River, and Cache Slough (Brown et al. 2014, Murphy and Hamilton 2013).

Sommer et al. (2011) described that during winter, adult Delta Smelt initiate upstream spawning migrations in association with “first flush” freshets. Others report this seasonal change as a multi-directional and more circumscribed dispersal movement to freshwater areas throughout the Delta region (Murphy and Hamilton 2013). After arriving in freshwater staging habitats, adult Delta Smelt hold until spawning commences during favorable water temperatures in the late winter-spring (Bennett 2005, Grimaldo et al. 2009, Sommer et al. 2011). Delta Smelt spawn over a wide area throughout much of the Delta, including some areas downstream and upstream as conditions allow. Although the specific substrates or habitats used for spawning by Delta Smelt are not known, spawning habitat preferences of closely-related species (Bennett 2005) suggest that spawning may occur in shallow areas over sandy substrates. The nonpelagic habitats used by larval Delta Smelt before they move into the pelagic areas also are not known (Swanson et al. 1998, Sommer et al. 2011).

During and after larval rearing in freshwater, many young Delta Smelt move with river and tidal currents to remain in favorable rearing habitats, often moving increasingly into the low-salinity zone to avoid seasonally warm and highly transparent waters that typify many areas in the central Delta (Nobriga et al. 2008).

During summer and fall, the distribution of juvenile Delta Smelt rearing is influenced by the position of the low-salinity zone (as indexed by the position of X2), although their distribution can also be influenced by temperature and turbidity (Bennett 2005, Feyrer et al. 2007 and 2010, Kimmerer et al. 2009, Sommer and Mejia 2013). The geographical position of the low-salinity zone varies primarily as a function of freshwater outflow; thus, X2 typically lies farther east in summer and fall during low outflow conditions and drier water years and farther west during high outflow conditions (Jassby et al. 1995).

Entrainment and salvage-related mortality of Delta Smelt associated with water pumping and CVP/SWP exports from the Delta occur primarily from December to July (Kimmerer 2008, Grimaldo et al. 2009, Baxter et al. 2010). Entrainment occurs when migrating and spawning adult Delta Smelt and their larvae overlap in time and space with reverse (southward, or upstream) flows in the Old and Middle Rivers' channels (Kimmerer 2008, Grimaldo et al. 2009, Baxter et al. 2010).

Longfin Smelt Longfin Smelt is a State-listed threatened species throughout its range in California (DFG 2009). USFWS denied a petition for Federal listing because the population in California (and specifically the San Francisco Bay) was not believed to be sufficiently genetically isolated from other populations (74 FR 16169). The Center for Biological Diversity challenged the merits of this determination. In 2011, USFWS entered into a settlement agreement with the Center for Biological Diversity and agreed to conduct a rangewide status review and prepare a 12-month finding to be published by September 30, 2011. After completing the 12-month findings, USFWS determined that listing the Longfin Smelt rangewide was not warranted at the time, but that listing the Bay-Delta DPS of Longfin Smelt was warranted. This was, however, precluded by other higher-priority listing actions (77 FR 19756).

Longfin Smelt are anadromous and spawn in freshwater in the Delta, generally at 2 years of age (Moyle 2002). They migrate upstream to spawn during late fall through winter, with most spawning from November through April (DFG 2009). Spawning in the Sacramento River is believed to occur from just downstream of its confluence with the San Joaquin River upstream to about Rio Vista. Spawning on the San Joaquin River extends from the confluence upstream to about Medford Island (Moyle 2002). Spawning likely also occurs in Suisun Marsh and the Napa River (DFG 2009).

Longfin Smelt larvae are most abundant in the water column usually from January through April (Reclamation 2008a). In the Bay-Delta, the geographic distribution of Longfin Smelt larvae is closely associated with the position of X2; the center of distribution varies with outflow conditions, but not with respect to X2 (Dege and Brown 2004). This pattern is consistent with juveniles migrating downstream to low-salinity, brackish habitats for growth and rearing. Larger Longfin Smelt feed primarily on opossum shrimps and other invertebrates (Feyrer et al. 2003). Copepods and other crustaceans also can be important food items, especially for smaller fish (Reclamation 2008a).

The abundance of Longfin Smelt in the estuary has fluctuated over time but has exhibited statistically-significant declines around 1989 to 1991 and in 2004 (Thomson et al. 2010). Increased Delta outflow in winter and spring is the largest factor possibly affecting Longfin Smelt abundance (77 FR 19756).

Habitat for Longfin Smelt is open water, largely away from shorelines and vegetated inshore areas except perhaps during spawning. This includes all of the large embayments in the estuary and the deeper areas of many of the larger channels in the western Delta; habitat suitability in these areas for Longfin Smelt can be strongly influenced by variation in freshwater flow (Jassby et al. 1995, Kimmerer 2004, Kimmerer et al. 2009).

Entrainment of Longfin Smelt in CVP and SWP export facilities mainly occurs from December to May, with peak adult entrainment from December to February (Grimaldo et al. 2009). In water year 2011, Aasen (2012) reported four adult Longfin Smelt were salvaged at the project export facilities, compared with much higher numbers in the early 2000s and late 1980s. The entrainment of Longfin Smelt in recent years has been reduced likely because of changes in export operations and a decline in abundance.

Impact Analysis

Potential Mechanisms for Change in Fisheries and Analytical Methods

The impact analysis considers changes in the ecological attributes that affect fish and aquatic resources related to changes in flows in the lower Klamath River and CVP operations under the alternatives as compared to the No Action Alternative. Most evaluations are based on water year type. The Trinity water year classification system is used for locations in the Lower Klamath and Trinity River Region. Locations in the Central Valley and Bay-Delta Region use the Sacramento water year classification system.

Changes in Fish Habitat in CVP and SWP Reservoirs

Changes in CVP operations under the alternatives could result in changes in reservoir storage volumes, elevations, and water temperatures in the primary water supply reservoirs (i.e., Trinity Lake, Shasta Lake, Lake Oroville, and Folsom Lake). Variation in reservoir storage, elevation, and temperature is a function of water demand, water quality requirements, and inflow; these attributes also change based on the water year type. Because no changes occur in the San Joaquin reservoirs, they are not evaluated in this EIS.

The downstream reservoirs (i.e., Lewiston Lake, Keswick Reservoir, Thermalito Forebay and Afterbay, and Lake Natoma) are operated to maintain relatively stable water elevations. These types of operations would result in similar conditions between the No Action Alternative and the action alternatives. Therefore, changes at these reservoirs are not evaluated in this EIS.

Changes in CVP Reservoir Elevation Seasonal temperature stratification is a dominant feature of these reservoirs. There are relatively distinct fish assemblages within the upper (warm water) and lower (cold water) habitat zones, with different feeding and reproductive behaviors. Flood control, water storage, and water delivery operations typically result in declining water elevations during the summer through the fall months, rising or stable elevations during the winter months, and rising elevations during the spring months, while storing precipitation and snowmelt runoff. During summer months, the relatively warm surface layer favors warm-water fishes such as black bass (e.g., Largemouth and Spotted Bass) and catfish.

Reservoir surface water elevations from the CalSim II model were used to analyze potential effects on black bass species (Largemouth, Smallmouth, and Spotted Bass). Water surface elevation in each reservoir was calculated from storage values and is presented as average end-of-month elevation by water year type.

Warm-water fish species that inhabit the upper layer of these reservoirs may be affected by fluctuations in storage through changes in reservoir water surface elevations (WSELs). Stable or increasing WSEL during spring months (March through June) can contribute to increased reproductive success, young-of-the-year production, and juvenile growth rate of several warm-water species, including the black basses. Conversely, reduced or variable WSEL due to reservoir drawdown during spring spawning months can cause reduced spawning success for warm-water fishes through nest dewatering, egg desiccation, and physical disruption of spawning or nest guarding behaviors. Increases in WSEL are not thought to result in adverse effects on these species unless there is a corresponding decrease in water temperatures that can result in nest abandonment.

A conceptual approach was used to evaluate the effects of water surface elevation fluctuations on black bass nests, based upon a relationship between nest success and water surface elevation reductions developed by CDFW (Lee 1999) from research conducted on five California reservoirs. Lee (1999) examined the relationship between water surface elevation fluctuation rates and nesting success for black bass, and developed nest survival curves for Largemouth, Smallmouth, and Spotted Bass. The equations corresponding to the curves are the following:

Largemouth Bass $Y = -56.378*\ln(X)-102.59$

Smallmouth Bass $Y = -46.466*\ln(X)-83.34$

Spotted Bass $Y = -79.095*\ln(X)-94.162$

Where: X is the drawdown rate (m/day) and Y is the percentage of successful nests.

Based on the work by Lee (1999), the maximum receding water level rate providing 100 percent successful nesting varied among species, with receding water level rates of <0.02, <0.01, and <0.09 meters per day providing successful nesting of 100 percent of the Largemouth, Smallmouth, and Spotted Bass nests, respectively. For this analysis, water surface elevations at the end of each month from the CalSim II model were used to calculate the monthly fluctuation rates, and derive the daily fluctuation rates used to compute the percentage of successful nests using the equations from Lee (1999).

CalSim II reports end-of-month (EOM) water surface elevations; therefore, water surface elevations from February to June were used in this analysis (i.e., March fluctuation rate = March EOM elevation – February EOM elevation). It was further assumed that the monthly change in elevation divided by the number of days in that month reflected the average daily fluctuation rate that was used as “X” in the above equations to compute the percentage of successful nests during that month. The percentages of successful bass nests were computed based on the equations from Lee (1999) for each month of the potential spawning season for these species.

Review of the available literature suggests that bass nest failure is highly variable between water bodies and between years, but it is not uncommon to have up to 40 percent of bass nests fail (approximately 60 percent survival). Many self-sustaining black bass populations in North America experience nest success (i.e., the nest produces swim-up fry) rates of 21 to 96 percent, with reported survival rates in the 40 to 60 percent range (Hunt and Annett 2002). Based on the literature review, bass nest survival probability in excess of 40 percent is assumed to be sufficient to provide for a self-sustaining bass fishery. For this analysis, differences between alternatives were evaluated using the exceedance probability corresponding to the 40 percent level of survival, based on the probability of exceedance over the 82-year CalSim II modeling time period.

Changes in CVP and SWP Reservoir Storage Volume To evaluate changes in operation, changes in reservoir storage were estimated based upon modeled monthly average storage and reservoir elevation output from CalSim II under the operations defined for each alternative, as described in the Analytical Tools Technical Appendix. The output of CalSim II served as input to the quantitative procedures described below for evaluation of changes in fish habitat and bass nesting success in CVP reservoirs.

The effects analysis in Chapter 4, "Surface Water Supply and Management," includes a summary of the monthly storage in each major upstream reservoir in combination with a frequency of exceedance analysis for each month. Reservoir storage values are characterized based on results of CalSim II hydrologic modeling, and are presented as average monthly storage by water year type. Although aquatic habitat within the CVP water supply reservoirs is not thought to be limiting, storage volume is used as an indicator of how much habitat is available to fish species inhabiting these reservoirs.

Changes in Fish Habitat Conditions in Rivers Downstream from CVP and SWP Reservoirs

By altering reservoir storage and releases, changes in CVP operations under the alternatives would change flow and temperature regimes in downstream waterways. In turn, these alterations could affect aquatic and fish resources and important ecological processes on which the fish community depends.

The portions of the Sacramento River, Trinity River, and lower Klamath River that could be affected by the proposed action alternatives are part of designated critical habitats for the fish species listed under the ESA inhabiting these rivers, as well as being recognized as providing EFH for Pacific salmon under the Magnuson-Stevens Fishery Conservation and Management Act. The effects on habitat for each of these Federally-listed fish species inhabiting the Sacramento, Trinity and Klamath Rivers described in the following sections, applies to the effects of the proposed action alternatives on designated critical habitat for the Federally-listed fish species, and on EFH for Pacific salmon in each of these rivers.

Changes in Flows Changes in flows, in and of themselves, do not constitute an effect on aquatic resources. However, changes in flow can affect the quantity and quality of aquatic habitats in rivers and have direct effects on fish species through stranding or dewatering events that occur when flows are reduced. In addition, changes in flows can result in a reduction in ecologically-important geomorphic processes resulting from reduced frequency and magnitude of intermediate to high flows. Changes in flow can also influence the frequency and duration of inundated floodplains (e.g., Yolo Bypass) that support salmonid rearing and conditions for other native fish species.

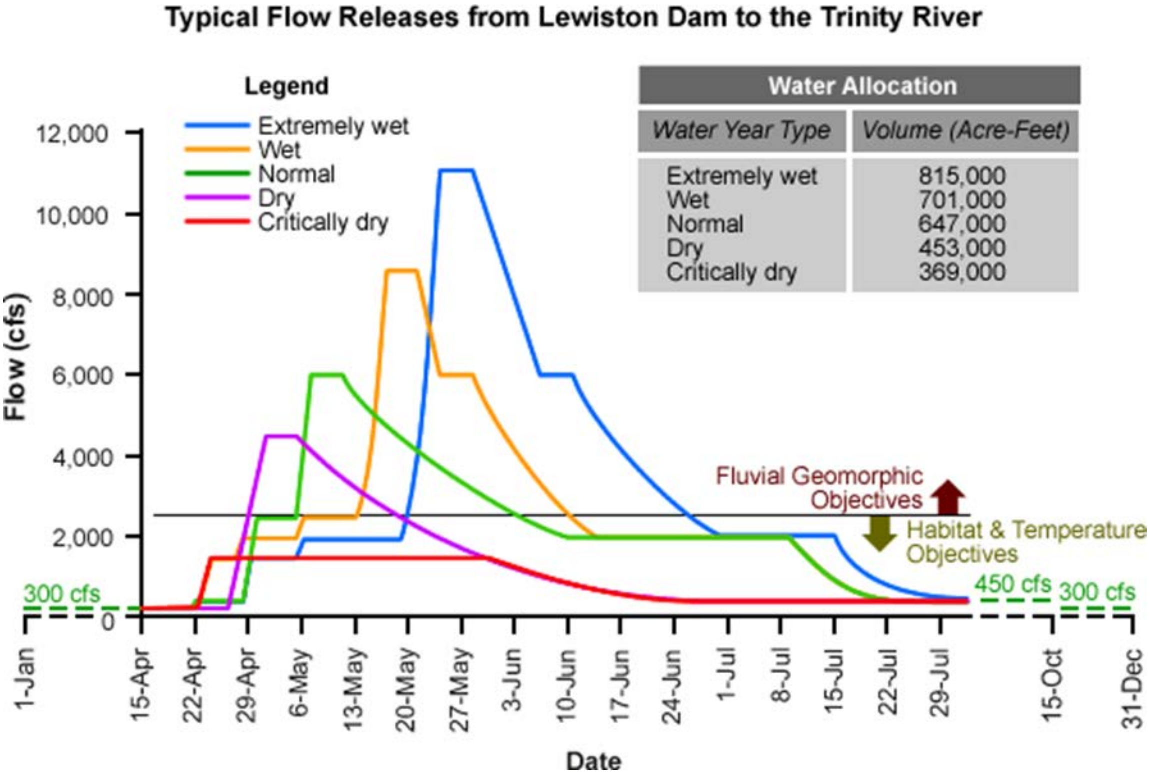
The effects analysis in Chapter 4, "Surface Water Supply and Management," includes a summary of the monthly flows (at various points downstream of the reservoirs) in each major stream affected by project operations. Instream flows are characterized based on results of CalSim II hydrologic modeling, and are presented as both average monthly flows by month and water year type to allow examination of the entire range of simulation results for each of the alternatives, as a means of evaluating differences among alternatives. The CalSim II model uses a monthly time step, and it was determined that incremental changes of 5 percent or less were within the range of uncertainty in the model processing. Therefore, flow changes of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis.

Comparison of Flow-Habitat Relationships To compare the operational flow regime and evaluate the potential effects on habitat for anadromous species inhabiting streams, it was necessary to determine the relationships between streamflow and habitat availability or key flow thresholds affecting habitat attributes for each life stage of these species in the rivers in which flows may be altered by CVP operations.

A number of studies have been conducted using the models and techniques contained within the Instream Flow Incremental Methodology (IFIM) to establish these relationships in streams within the study area. The analytic variable provided by the IFIM is total habitat, in units of WUA for each life stage (fry, juvenile and spawning) of each evaluation species (or race as applied to Chinook Salmon). Habitat (WUA) incorporates both macro and microhabitat features. Macrohabitat features include longitudinal attributes like water quality, and microhabitat features include the hydraulic and structural conditions (depth, velocity, substrate or cover) affected by flow which define the actual living space of the organisms. The total habitat available to a species/life stage at any streamflow is the area of overlap between available microhabitat and macrohabitat conditions. Because the combination of depths, velocities, and substrates preferred by species and life stages varies, WUA values at a given flow differ substantially for the species and life stages evaluated.

WUA-flow relationships were available only for some rivers for which simulated flows were available. Therefore, flow-dependent habitat availability was evaluated quantitatively only for Clear Creek and the Sacramento, Feather, and American Rivers, and was not reported for other rivers evaluated in this EIS. Tables of the spawning habitat-discharge relationships used in the calculations of spawning WUA for these rivers are provided in Appendix 9E, Weighted Useable Area Analysis in the *Coordinated Long-Term Operation of the Central Valley Project and State Water Project EIS* (Reclamation 2015). Differences between the alternatives and the No Action Alternative are used to identify the effects of each alternative on habitat availability (WUA) for each species and life stage in each river.

Comparison to the Trinity River Functional Flow-Habitat Criteria Because CalSim II produces flows on a monthly time step, the model outputs were downscaled to a daily time step (simulated or approximated hydrology) for use in HEC-5Q and RBM 10 water quality and temperature models. These approximated daily flow patterns were also used to compare the two alternatives and the No Action Alternative operational scenarios for the frequencies of flow levels associated with functional flow criteria specified for the Trinity River fishery restoration program (Figure 7-1). Flow exceedance plots—for specific time periods when operations of the alternatives may differ from the No Action Alternative—are used to compare the performance of the alternatives and No Action Alternative relative to functional flow-habitat criteria. The late-summer (August to September) and late-spring (May to June) months are the seasonal periods when flow patterns in the Trinity River could be altered to conduct the proposed action under either of the alternatives. Accordingly, recommended Lewiston Dam release levels, intended hydrographic patterns, management targets and biological purposes—adopted by the *Trinity River Mainstem Fishery Restoration Final EIS/Environmental Impact Report Record of Decision* (ROD) (DOI and Hoopa Valley Tribe 2000) during select seasons (see Table 7-2)—were compared to projected flow releases from Lewiston Dam (for the alternatives and the No Action Alternative) during those periods when the releases for the proposed action alternatives could deviate from these criteria.



Water Allocation	
Water Year Type	*Volume (Acre-Feet)*
Extremely wet	815,000
Wet	701,000
Normal	647,000
Dry	453,000
Critically dry	369,000

Source: http://www.trrp.net/ restore/flows/typical/

Note: Water allocations are those specified in the 2000 Record of Decision for the Trinity River Mainstem Fishery Restoration Program (DOI and Hoopa Valley Tribe 2000)

Figure 7-1. Fishery Restoration Seasonal Flow Release Patterns from Lewiston Dam for the Five Trinity Basin Water Year Types, Showing Functional Flow Objective Levels

Table 7-2. Excerpts From the Recommended Lewiston Dam Releases, Management Targets, Purposes, and Benefits, for Seasonal Periods Potentially Affected by the Proposed Action Alternatives

Seasonal Period	Release (cfs)	Hydrograph Component	Management Target	Purpose	Intended Benefit
Extremely Wet					
Jun 10-Jun 30	6,000 to 2,000	Descending limb	Descent rate to mimic pre-TRD	Inundate point bar Minimize river stage change to preserve egg masses of yellow-legged frogs Maintain seasonally variable water surface in side channels and off-channel wetlands	Prevent riparian vegetation initiation along low water channel margins Reduce fine sediment (<5/16 inch) storage within surface channelbed Improve juvenile salmonid growth Increase riparian vegetation and future LWD recruitment
Wet					
May 28-Jun14	6,000 to 2,000	Descending limb	Descent rate to mimic pre-TRD Descent rate < 0.1 ft/day	Inundate point bars Minimize river stage change to preserve egg masses of yellow-legged frogs Maintain seasonally variable water surface in side channels and off-channel wetlands	Prevent riparian vegetation initiation along low water channel margins Reduce fine sediment (<5/16 inch) storage within surface channelbed Improve juvenile salmonid growth
Normal					
May 11-Jun10	6,000 to 2,000	Descending limb	Descent rate to mimic pre-TRD Descent rate < 0.1 ft/day	Inundate point bars Minimize river stage change to preserve egg masses of yellow-legged frogs Maintain seasonally variable water surface in side channels and off-channel wetlands	Reduce fine sediment (<5/16 inch) storage within surface channelbed Improve juvenile salmonid growth Increase riparian vegetation and future LWD recruitment

Table 7-2. Excerpts From the Recommended Lewiston Dam Releases, Management Targets, Purposes, and Benefits, for Seasonal Periods Potentially Affected by the Proposed Action Alternatives (contd.)

Seasonal Period	**Release (cfs)**	**Hydrograph Component**	**Management Target**	**Purpose**	**Intended Benefit**
Dry					
May 5 - Jun 26	4,500 to 450	Descending limb		Inundate point bars Minimize river stage change to preserve egg masses of yellow-legged frogs Maintain seasonally variable water surface in side channels and off-channel wetlands Improve salmonid smolt production by providing temperatures necessary for survival of steelhead, Coho Salmon, and Chinook Salmon smolts	Prevent riparian initiation along channel margins Reduce fine sediment (<5/16 inch) storage within surface channelbed Improve juvenile Chinook Salmon growth Increase survival of steelhead fry Provide outmigration cues for Chinook Salmon smolts
Critically Dry					
May 29-Jun 26	1,500 to 450	Descending limb	Descent rate to mimic pre-TRD Provide non-lethal water temperatures to Weitchpec for Coho Salmon smolts (≤ 62.6°F) until June 4, and for Chinook Salmon smolts (≤ 68°F) until mid-June	Minimize river stage change to preserve egg masses of yellow-legged frogs Inundate point bars Improve salmonid smolt production by providing temperatuers necessary for survival of steelhead, Coho Salmon, and Chinook Salmon smolts	Prevent riparian initiation along low water channel margins Reduce fine sediment (<5/16 inch) storage within surface channelbed Maintain seasonal variable water levels in side channel and off-channel wetlands Sustain juvenile salmonid smolt production Provide outmigration cues for Chinook Salmon smolts

Table 7-2. Excerpts From the Recommended Lewiston Dam Releases, Management Targets, Purposes, and Benefits, for Seasonal Periods Potentially Affected by the Proposed Action Alternatives (contd.)

Seasonal Period	Release (cfs)	Hydrograph Component	Management Target	Purpose	Intended Benefit
All Water Year Types					
Jul 22-Sept 30	450	Summer baseflow	Provide water temperatures ≤ 60°F to Douglas City through Sept 14 Provide water tempertures ≤ 56°F to Douglas City from Sept 15 through Sept 30	Increase survival of holding adult spring-run Chinook Salmon by providing optimal thermal refugia	Increase production of Coho Salmon and steelhead by providing water temperatures conducive to growth

Key:
°F = degrees Fahrenheit
< = less than
cfs = cubic feet per second
LWD = large woody debris
TRD = Trinity River Division

Changes in Water Temperatures Water temperatures in the rivers and streams downstream of the CVP reservoirs are influenced by factors such as reservoir cold water pools, elevation of reservoir release outlets, and seasonal atmospheric conditions. The level of water storage in a reservoir has a strong effect on the volume of cold water (cold water pool) in the reservoir and, in combination with the elevation of reservoir release outlets, the temperature of water released downstream. Storage levels are often lowest in the late summer and early fall, resulting in warmer water releases from the reservoir. During this time of year, ambient air temperatures contribute substantially to warming instream flows downstream of reservoirs. Summer and early fall are the times of year when river temperatures are most likely to rise above tolerance thresholds for steelhead and salmon.

The analysis of the effects of water temperature changes on fish was conducted using three approaches: (1) a comparison of average monthly water temperatures between the alternatives and the No Action Alternative, (2) a comparison of average monthly water temperatures to established temperature objectives intended to be protective of fish, and (3) a comparison of daily average water temperature statistics for the Trinity and lower Klamath Rivers to established temperature objectives and biologically-relevant temperature criteria for various key periods between the alternatives and the No Action Alternative. These approaches are described below.

Comparison of Average Monthly Water Temperatures Between Alternatives The analysis uses average water monthly temperatures to provide a comparison of the ability of operations considered under alternatives to meet water temperature objectives for various species. Water temperature modeling is subsequent to CalSim II modeling that simulates operations on a monthly basis; there are certain components in the temperature models that are downscaled to a daily time step (simulated or approximated hydrology). The results of those daily conditions are averaged to a monthly time step.

The effects analysis in Chapter 5, “Surface Water Quality,” includes a summary of the average monthly water temperature in each major stream downstream of CVP reservoirs. Water temperatures at various locations in each river were compared to determine whether mean monthly temperatures by water-year type were different between the alternatives and the No Action Alternative. Because the temperature models use inputs from the monthly time step CalSim II model, effects of real-time daily temperature management cannot be captured, even though the temperature models are capable of simulating on a sub-monthly time step. Therefore, the analysis is based on monthly average temperature results for all water years and by water year type (as defined in Chapter 4, “Surface Water Supply and Management”). For this monthly analysis that uses two cascading models, incremental changes of 0.5°F or less in mean monthly water temperatures would be within the model uncertainty. Therefore, changes of 0.5°F or less are considered to be not substantially different, or “similar” in this comparative analysis.

Comparison of Daily Water Temperature Statistics for the Trinity River and Lower Klamath River This analysis is based on the one-dimensional daily averaged water-temperature outputs from the RBM 10 water temperature models for the Trinity and Klamath Rivers, the analytic procedures for which are described in Chapter 5, “Surface Water Quality,” and in the Analytical Tools Technical Appendix. These water-temperature models were used to simulate the daily average temperatures (DAT) along the Trinity River below Lewiston Dam and in the lower Klamath River below the Trinity River confluence for the two action alternatives and No Action Alternative operational scenarios for a hydrologically representative 24-year period (1980 to 2003). Seven day moving averages of daily maximum (7DADM) temperatures were also estimated for some analyses based on a statistical derivation of 95 percentile exceedance probabilities of daily fluctuations in water temperature at Lewiston Dam (see the Analytical Tools Technical Appendix for details on computation of estimated 7DADM temperature values). Descriptive statistics for daily water temperatures were compiled for several locations along the Trinity and Klamath Rivers, over the course of key biologically-relevant periods, to compare the ability of operations considered under the alternatives to meet water temperature objectives and temperature management criteria for various fish species.

Comparison to Established Water Temperature Thresholds The average monthly water temperature output from CalSim II does not have the resolution to allow a direct comparison to the average daily temperature objectives identified in Table 7.3. Nonetheless, the average monthly water temperatures provide the basis for a coarse evaluation of the likelihood that temperature objectives (Table 7-3) would be exceeded. These objectives are used as thresholds in the temperature exceedance analysis where the frequency of exceedance (percent of years) is calculated. Because average monthly water temperatures likely mask daily temperatures that could exceed important thresholds, any difference in the frequency of threshold exceedance was considered important, and could be indicative of a biological effect on the species/life stage for which the objective was established. While likely effects from temperature on early life stages occur at a shorter temporal scale than can be captured in these models, comparative analyses are useful for looking at long-term impacts over numerous water years and types.

Water temperatures in the Feather and American Rivers were not modeled. However, minimal changes in storage and flows under the action alternatives would result in similar water temperatures under the action alternatives relative to the No Action Alternative. Therefore, there was no further evaluation conducted on these system for water temperature thresholds.

Table 7-3. Water Temperature Objectives

Compliance Location	Year Types	Dates	Temperature Objective (°F)[a]	Purpose
Trinity River				
Lewiston Dam to Douglas City[1,2]	All Year Types	July 1 – September 15	< 60	Spring-run Chinook Salmon holding
		September 16 – September 30	≤ 56	Spring-run Chinook Salmon spawning
Lewiston Dam to North Fork Trinity River Confluence[2]	All Year Types	October 1 – December 31	< 56	Spring-run and fall-run Chinook Salmon spawning
Lewiston Dam to Weitchpec[3]	Normal, Wet, Extremely Wet	April 15 – May 22 May 23 – June 4 June 5 – July 9	≤ 55.4 ≤ 59 ≤ 62.6	Salmonid smolt outmigration
	Dry, Critically Dry	April 15 – May 22 May 23 – June 4 June 5 – June 15	≤ 59 ≤ 62.6 ≤ 68	Salmonid smolt outmigration[b]
Clear Creek				
Igo[4]	All Year Types	June 1 – September 15	60	Spring-run Chinook Salmon holding and rearing
		September 15 – October	56	Spring-run and fall-run Chinook Salmon spawning and egg incubation
Sacramento River				
Clear Creek[2] Balls Ferry[2] Jellys Ferry[2]	All Year Types	May – October	56	Winter- and spring-run Chinook Salmon spawning and egg incubation
Bend Bridge[2]	All Year Types	May – October	56	Winter- and spring-run Chinook Salmon spawning and egg incubation
			63	Green Sturgeon spawning, incubation, and rearing
Feather River				
Robinson Riffle[2]	All Year Types	September – April	56	Spring-run Chinook Salmon and steelhead spawning and incubation
		May – August	63	Spring-run Chinook Salmon and steelhead rearing
American River				
Watt Avenue Bridge[2]	All Year Types	May – October	65	Juvenile steelhead rearing

Source:
[1] NCRWQCB 2011
[2] SWRCB Water Rights Order 90-5
[3] DOI and Hoopa Valley 2000; USFWS et al. 2000
[4] NMFS 2009

Notes:
[a] Criteria are daily average temperatures
[b] Facilitate early outmigration by allowing gradual warming toat least marginal temperatures throughout smolt outmigration for juvenile salmonids

Key:
°F = degrees Fahrenheit
< = less than
≤ = less than or equal to

Changes in Salmonid Production Collectively, factors such as flow, temperature, and habitat availability affect the population dynamics of anadromous fish species during their freshwater life stages. Two different models were used to assess changes in salmonid production potential: (1) SALMOD, and (2) the Interactive Object-Oriented Simulation (IOS) model for winter-run Chinook Salmon. In the modeling simulations, in certain critical years, the reservoirs approach *dead-pool volume* when cold water availability is limited. Modeling results likely represent the worst-case conditions in critical years, but do not account for real-time operations.

Comparison of Annual Production Using SALMOD The SALMOD model was used to assess changes in the annual production potential of four runs of Chinook Salmon in the Sacramento River between Keswick Dam and the RBPP (see Analytical Tools Technical Appendix for additional information on SALMOD). The primary assumption of the model is that egg and fish mortality is directly proportional to spatially and temporally variable habitat limitations, such as water temperatures, which themselves are functions of operational variables (timing and quantity of flow) and meteorological variables, such as air temperature. SALMOD is a spatially explicit model that characterizes habitat value and carrying capacity using the hydraulic and thermal properties of individual habitat units. Inputs to SALMOD include flow, water temperature, spawning distributions, spawn timing by salmon race, and the number of spawners provided by the user (e.g., recent average escapement).

Annual production potential or the number of outmigrants, annual mortality, length, and weight of the smolts are some of the reporting metrics available from SALMOD. The production numbers obtained from SALMOD are best used as an index in comparing to a specified baseline condition rather than absolute values. Differences between alternatives are assessed based on changes in the annual production potential for each species by river by water year type. SALMOD uses flows and output from the water temperature models that are downscaled from the monthly time step CalSim II model, and differences in production of 5 percent or less were considered to be within the uncertainty of the model processing. Therefore, production estimates within 5 percent or less of each other are considered to be not substantially different, or “similar” in this comparative analysis.

While steelhead are not directly evaluated in SALMOD, effects for late fall-run Chinook Salmon are considered representative for steelhead since NMFS, in their 2009 BO, assumed late fall-run Chinook Salmon could be used as a surrogate for steelhead because they have similar life history stages, including spawning at the same time of the year (NMFS 2009).

Comparison of Annual Winter-run Chinook Salmon Escapement Using IOS IOS is a stochastic life cycle simulation model for winter-run Chinook Salmon in the Sacramento River (see Analytical Tools Technical Appendix for additional information on IOS). The IOS model is composed of six model stages that are arranged sequentially to account for the entire life cycle of winter run, from eggs to returning spawners. The primary output from the IOS model is escapement, the total number of winter-run Chinook Salmon that leave the ocean and return to the Sacramento River to spawn. Differences between alternatives are assessed based on changes in the average annual escapement and the average escapement by water year type over the 82-year CalSim II simulation period. The IOS model also provides survival at various life stages and locations, including eggs, fry-to-smolt, smolt production, smolts between RBPP and the Delta, and smolts in the Delta. The IOS model uses scenario-specific daily DSM2, CalSim II, and Sacramento River Basin Water Temperature Model (HEC-5Q) data as model input. IOS uses output from the monthly time step CalSim II model or other models downscaled from CalSim II as input, and differences in production of 5 percent or less were considered to be within the uncertainty of the model processing. Therefore, changes in escapment of 5 percent or less are considered to be not substantially different, or “similar” in this comparative analysis.

Changes in Fish Habitat Conditions in the Bay-Delta

Changes in CVP operations under the alternatives would affect the Bay-Delta conditions primarily through changes in volume and timing of upstream storage releases and diversions, Delta exports and diversions, and DCC operations. Environmental conditions such as water temperature, predation, food production and availability, competition with introduced exotic fish and invertebrate species, and pollutant concentrations all contribute to interactive, cumulative conditions that have substantial effects on aquatic resources in the Delta.

Changes in Delta Hydrodynamics Operations of the CVP and intake facilities owned by the CVP, SWP, local agencies, and private parties affect Delta hydrologic flow regimes. The largest effects of flow management in the Delta related to aquatic resources are the modification of winter and spring inflows and outflows of the Delta, and the introduction of net cross-Delta and net reverse flows in Delta channels that can alter fish movement patterns (Moyle and Bennett 2008).

In addition, changes in Delta outflow influence the abundance and distribution of fish and invertebrates in the Bay through changes in salinity, currents, nutrient levels, and pollutant concentrations. Altered flows through the Delta affect water residence time, an important physical property that can influence the ability of phytoplankton biomass to build up over time, with implications for higher trophic level consumers such as fish. Turbidity is an important water quality component in the Delta that could be affected by changes in operation. Changes in turbidity affect food web dynamics through attenuation of light in the water column, altering predation success.

Old and Middle River (OMR) reverse flows occur as the rate of water diverted at the CVP and SWP export facilities exceeds tidal and downstream flows within the central region of the Delta. These reverse flows have been identified as a potential cause of fish mortality at the CVP and SWP fish facilities (USFWS 2008, Mount et al. 2012). The most biologically sensitive period when the effects of reverse flows could affect multiple Delta species, including Chinook Salmon and Delta Smelt, extends from late winter through early summer (December through June) (USFWS 2008, Zeug and Cavallo 2014). Changes in OMR flows to exceed -5,000 are used as an indicator of project effects.[5]

Changes in CVP operations can affect through-Delta survival of migratory (e.g., salmonids) and resident (e.g., Delta Smelt and Longfin Smelt) fish species through changes in the level of entrainment at CVP export pumping facilities (USFWS 2008, Zeug and Cavallo 2014). The south Delta CVP facilities are the largest water diversions in the Delta and in the past, have entrained large numbers of Delta fish species. Tides, salinity, turbidity, freshwater inflow to the Delta, meteorological conditions, season, habitat conditions, and project exports all have the potential to influence fish movement, currents, and ultimately the level of entrainment and fish

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[5] Results of analyses of the relationship between the magnitude of reverse flows in OMR and salvage of adult Delta Smelt in the late winter shows a substantial increase in salvage as reverse flows increase (i.e., become more negative), and exceed approximately -5,000 cfs.

passage success and survival. Entrainment risk for fish also tends to increase with increased reverse flows in Old and Middle Rivers.

Larvae and early juvenile Delta Smelt are most prevalent in the Delta in the spring months of March through June. Evaluation of changes in the Delta hydrodymanics, such as changes in exports, Delta outflow, and OMR reverse flows were used to characterize potentical changes in entrainment.

Changes in X2 Location Changes in CVP operations under the alternatives could change the location of Fall X2 position (in September through December). The predicted location of Fall X2 position (in September through December) is used as an indicator of the fall abiotic habitat index for Delta Smelt. Feyrer et al. (2010) used X2 location as an indicator of the extent of habitat available with suitable salinity for the rearing of older juvenile Delta Smelt. Feyrer et al. (2010) concluded that when X2 is located downstream (west) of the confluence of the Sacramento and San Joaquin Rivers, at a distance of 70 to 80 kilometers (km) from the Golden Gate Bridge, there is a larger area of suitable habitat. The overlap of the low-salinity zone (or X2) with the Suisun Bay/Marsh results in a two-fold increase in the habitat index (Feyrer et al. 2010). The average September through December X2 position in km was used to evaluate the fall abiotic habitat availability for Delta Smelt under the alternatives. X2 values simulated in the CalSim II model for each alternative were averaged over September through December and compared.

To evaluate fall abiotic habitat availability for Delta Smelt under the alternatives, X2 values simulated in the CalSim II model for each alternative were averaged over September to December, and compared for differences. There are uncertainties and limitations associated with this approach. For example, it does not evaluate other factors that influence the quality or quantity of habitat available for Delta Smelt (e.g., turbidity, temperature, food availability), nor does it take into account the relative abundance of Delta Smelt that might benefit from the available habitat in the simulated X2 areas in any given year. In this study, simulated fall X2 values are used as a tool to compare the alternatives, as one of the factors that would indicate available suitable habitat to benefit Delta Smelt.

Evaluation of Alternatives

The impact analysis in this EIS is based upon the comparison of the alternatives to the No Action Alternative projected in the year 2030.

No Action Alternative

Under the No Action Alternative, fisheries resources would be comparable to the conditions described in the *Affected Environment* section of this chapter. Conditions in 2030 would be different than existing conditions primarily due to climate change and sea-level rise, general plan development throughout California, and implementation of reasonable and foreseeable water resource management projects to provide water supplies. It is anticipated that climate change would result in more short-duration high-rainfall events and less snowpack in the winter and early spring months. For unregulated rivers, reduced snowpack would shift flow patterns to an earlier and shorter spring runoff period. For regulated rivers, reservoirs would be full more frequently by the end of April or May by the year 2030 than they would be in recent historical conditions. However, as the water is released in the spring, there would be less snowpack to refill the reservoirs. This condition would reduce reservoir storage and result in reduced flows and increased water temperatures in the summer and early fall. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and non-SWP reservoirs. In addition, average air temperatures are expected to increase, further contributing to warmer water temperatures in rivers during summer and fall.

Klamath and Trinity River Watershed

Trinity River Watershed Under the No Action Alternative, Reclamation would not release additional flows from Lewiston Dam in August and September as a measure to reduce the potential and severity of fish disease outbreaks that could lead to large-scale pre-spawning mortality of adult anadromous salmonids. Late-summer releases from Lewiston Dam would remain at 450 cfs, as prescribed in the Trinity River ROD (DOI and Hoopa Valley Tribe 2000). Accordingly, no changes, other than those associated with climate change, would be expected to occur in 1) the annual patterns of Trinity Lake water storage and surface elevation fluctuations, 2) late-summer flow and water temperature patterns in the Trinity River below Lewiston Dam, and 3) spring-summer flow and water temperature patterns in the Trinity River, all of which could affect fish and other aquatic resources within the Trinity River watershed.

The ongoing implementation of the Trinity River Restoration Program (TRRP) would be expected to continue to pursue long-term improvements to habitat conditions for anadromous salmonids and resident native freshwater fish, other aquatic organisms, and riverine and riparian-dependent wildlife and plant species. It is anticipated that these continuing restoration activities in tandem with the variable annual flow releases from Lewiston Dam on the Trinity River will increase floodplain connectivity, reactivate channel migration across floodplains (especially within rehabilitation sites), and improve riparian and aquatic habitat diversity and quality for anadromous salmonids and riparian-dependent species throughout the Trinity River, from Lewiston Dam to the Klamath River confluence.

Although the potential risk, frequency, and magnitude of future fish die-offs occurring in the lower Klamath River during the late-summer under the No Action Alternative cannot be predicted with certainty, at this time, it is currently thought that low flows and warm water temperatures in the lower Klamath River—combined with high densities of adult salmon and steelhead in the river during August and September—contributes to the risk of disease outbreaks that could cause large-scale mortality of salmon (DFG 2004, Strange 2010a and 2015, USFWS and NMFS 2013). It is more certain that a large level of pre-spawning salmon mortality can potentially have a disproportionate effect on sub-basin stocks, which, in fact, occurred for Trinity River Hatchery fall-run Chinook Salmon in the 2002 event (DFG 2004). High levels of pre-spawning mortality, including that caused by disease epizootics, can affect salmon reproduction levels and, consequently, the age-class structure of subsequent generations for a number of years beyond the year in which the mortality event occurs. Any disproportionate effects of future fish die-offs, from any cause, on Trinity River salmon stocks would impact natural and hatchery spawning escapement goals for the TRRP, as well as commercial, sport, and tribal harvest allocations.

Lower Klamath River from Trinity River to the Pacific Ocean Fishery conditions in the lower Klamath River, downstream from the Trinty River confluence, under the No Action Alternative are the same as the description of fish management and habitat conditions and the status of key fish species provided in the *Affected Environment* section. Under the No Action Alternative, Reclamation would not release additional flows from Lewiston Dam in August and September to augment flows in the lower Klamath River as a measure to reduce the potential for and severity of fish disease outbreaks that could lead to large-scale pre-spawning mortality of adult anadromous salmonids. Late-summer flows could continue to periodically fall to levels that were associated with the 2002 fish die-off and to levels reported in more recent Ich infection incidents in 2014 and 2015 (Belchick 2015, USFWS 2015b).

Large-scale fish die-offs, similar to the one that occurred in 2002, were, up to that time, unprecedented in the Klamath River Basin (DFG 2004). Although the proximate causative factor of the 2002 die-off is known, a primary epizootic of the Ich parasite, and secondary infection by the columaris bacterium, and other factors, are thought to contribute to the virulence and outbreaks of Ich infection in the lower Klamath River. The potential frequency for future fish die-offs under the No Action Alternative cannot be predicted with certainty at this time.

The pathogens involved in the 2002 fish die-off are always present in the lower Klamath River, and water temperatures are normally very warm (≥ 70°F) and at optimal levels for high rates of pathogen replication in the late-summer when fall-run Chinook Salmon begin spawning migrations into the river. Therefore, a disease outbreak could occur anytime conditions exist that facilitate pathogen infection and transmissivity. High densities of adult salmon staging in the lower Klamath River for an extended period of time is thought to be an important primary risk factor contributing to Ich disease outbreaks (Guillen 2002, DFG 2004, USFWS and NMFS 2013, USFWS 2015b). High densities of adult salmon staging in the lower Klamath River can result from moderate to large annual run sizes, low river flows that restrict holding habitat areas, and high water temperatures (≥ 73.4°F) that cause a thermal behavioral barrier to migrating adult salmon. Low water velocities are also thought to contribute to the successful transmissivity and infection of host fish by the free-swimming infectious life stage of the Ich parasite (Strange 2015). So, it is thought that in years with higher late-summer river flows (and associated higher water velocities) in the lower Klamath River, transmissivity and infection rates of Ich may be reduced.

Because future salmon run sizes cannot be predicted with certainty, a flow exceedance probability for the months of August and September was used to provide one measure of the potential risk of occurance of disease outbreaks among adult anadromous salmonids in the lower Klamath River under the No Action Alternative. The projected average montly flows under the No Action Alternative—for current and foreseeable future conditions during the late-summer period when adult salmon are susceptible to disease outbreaks that could cause large-scale fish die-offs—could fall to levels associated with the 2002 fish die-off and more recent reported Ich infections (≤ 2,000 cfs) about 4 percent of the time, and to levels below the 2,800 cfs preventative baseflow level of the proposed action alternatives about 21 percent of the time (Figure 7-2).

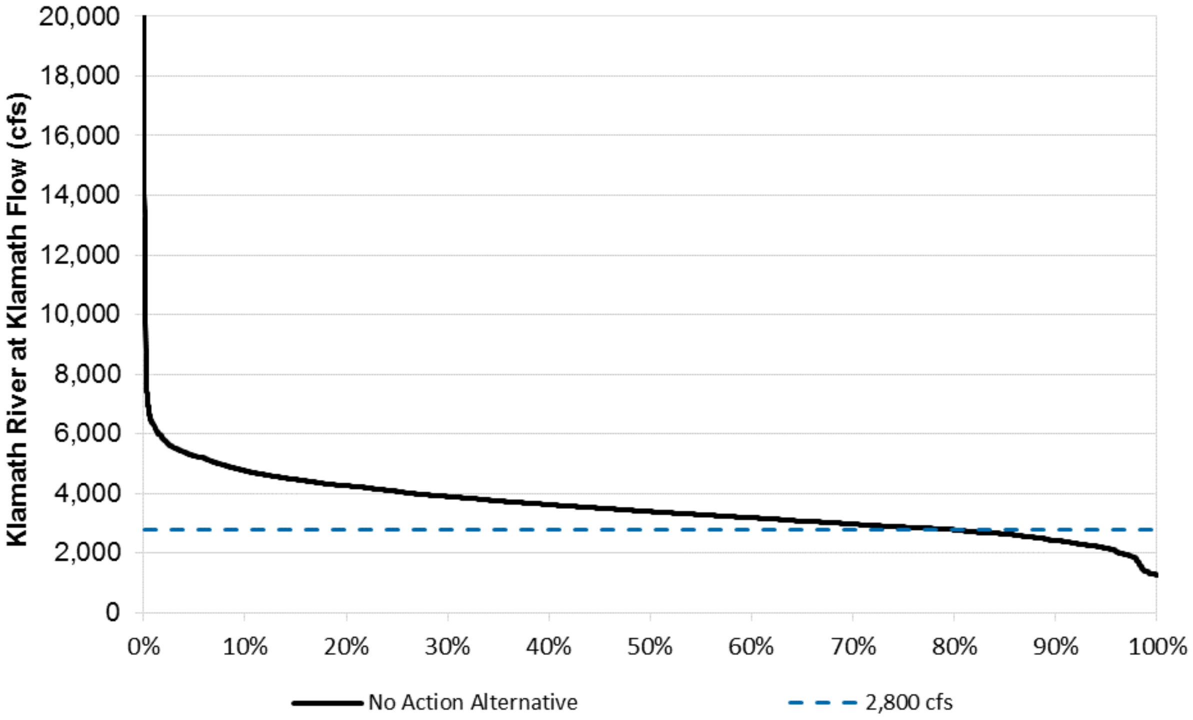


Figure 7-2. August Through September Flow Exceedance Probability for the Klamath River at Klamath, California Under the No Action Alternative

Proposed Action (Alternative 1)

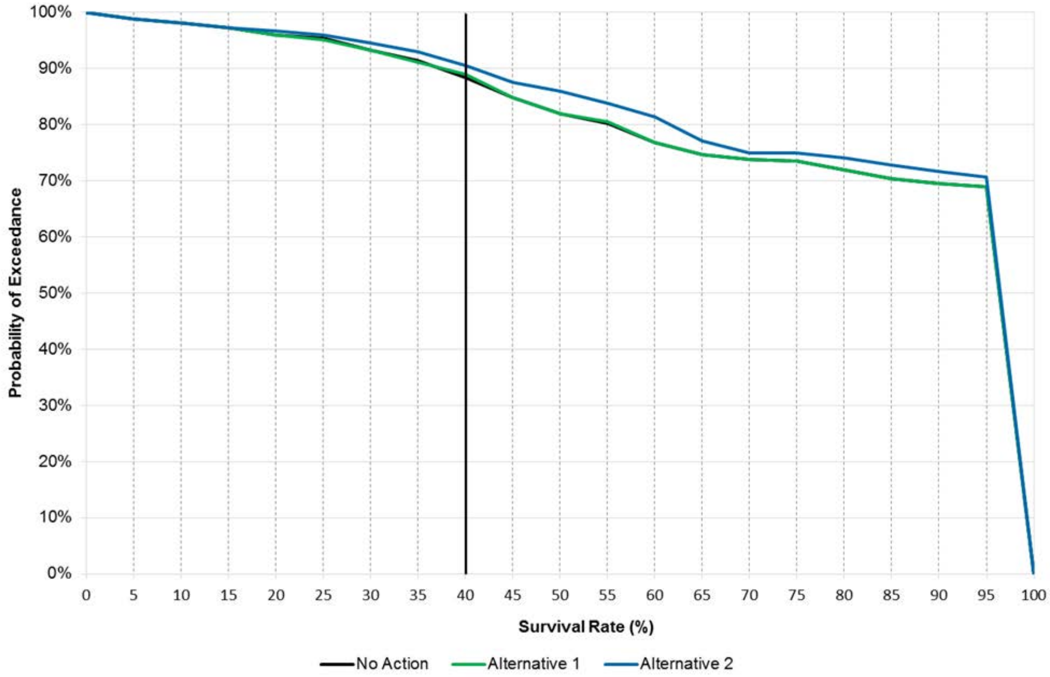
As described in Chapter 3, "Considerations for Describing Affected Environment and Enviromental Consequences," the effects under Alternative 1 are compared to the effects under the No Action Alternative.

Lower Klamath and Trinity River Region

Fish Habitat Conditions in the CVP Reservoir

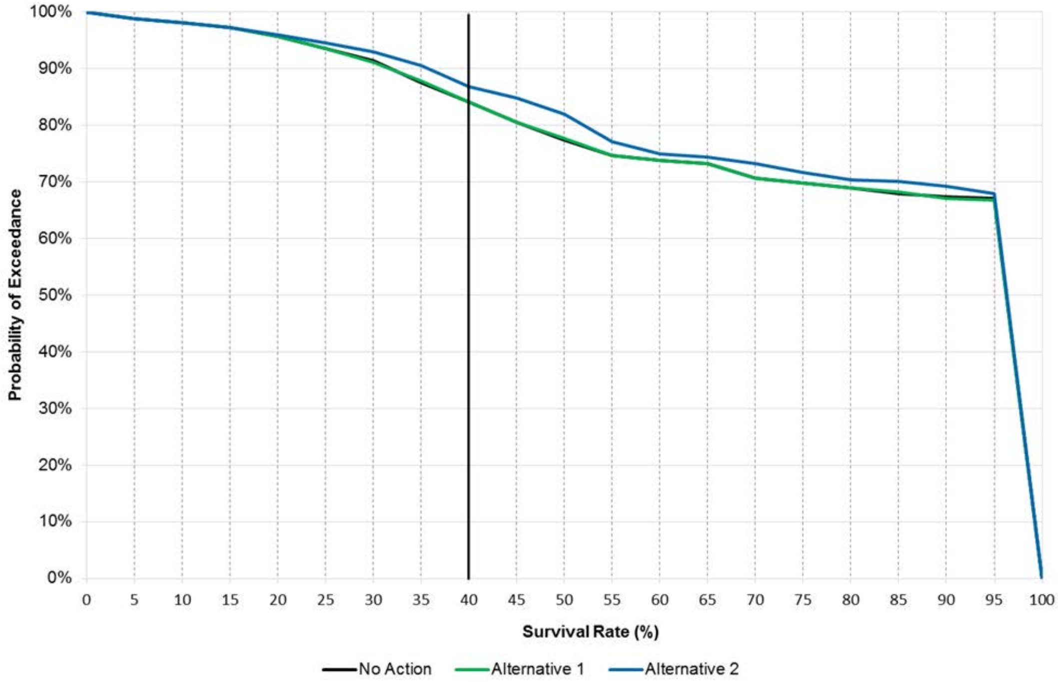
Changes in Black Bass Nesting Success As shown in Figures 7-3 through 7-5, nest survival for all the three black bass species in Trinity Lake would be essentially the same under Alternative 1 as compared to the No Action Alternative, differing by less than 1 percent. Largemouth Bass and Smallmouth Bass would exhibit likelihoods of nest survival of 40 percent or greater nearly 85 to 90 percent of the time. Spotted Bass nesting success would be 40 percent or greater nearly 100 percent of the time under both Alternative 1 and the No Action Alternative.

Overall, the comparison of storage and the analysis of nesting suggest that effects of Alternative 1 on reservoir fishes in Trinity Lake would be similar to those under the No Action Alternative.



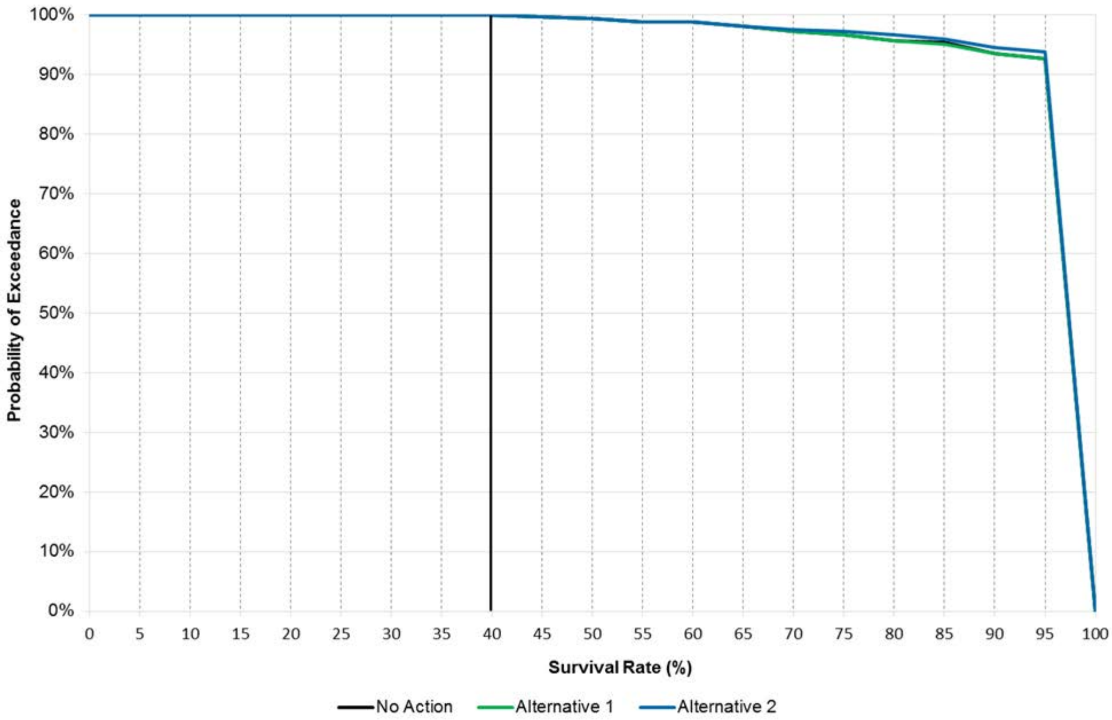
Note: Vertical line indicates typical nest survival rate in California reservoirs.

Figure 7-3. Comparison of Largemouth Bass Nesting Success Probabilities From March Through June in Trinity Lake for the No Action Alternative, Alternative 1 and Alternative 2



Note: Vertical line indicates typical nest survival rate in California reservoirs.

Figure 7-4. Comparison of Smallmouth Bass Nesting Success Probabilities From March Through June in Trinity Lake for the No Action Alternative, Alternative 1 and Alternative 2



Note: Vertical line indicates typical nest survival rate in California reservoirs.

Figure 7-5. Comparison of Spotted Bass Nesting Success Probabilities From March Through June in Trinity Lake for the No Action Alternative, Alternative 1 and Alternative 2

Changes in Cold-Water Fish Habitat The analysis of effects associated with changes in operation to provide additional late-summer flow releases from Lewiston Dam on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP water supplies and operations under Alternative 1, as compared to the No Action Alternative, would be similar, resulting in lower end-of-year reservoir storage in Trinity Lake, the only CVP storage reservoir in the Klamath-Trinity Basin. End-of-year storage in Trinity Lake would decrease by no more than 4 percent in any water year type (see Chapter 4 “Surface Water Resources and Water Supply”). Trinity Lake storage would decrease by no more than 2 percent in any month of extremely wet water years.

Using Trinity Lake storage as an indicator of habitat available to fish species inhabiting the reservoir, the amount of habitat for reservoir fishes would generally be similar, except in September of dry water years, when storage could differ by 4 percent compared to the No Action Alternative, and most months of extremely wet water years when storage could be 1 to 2 percent less, under Alternative 1 relative to the No Action Alternative.

Aquatic Habitat Conditions in the Lower Klamath and Trinity Rivers

Changes in Trinity River Flows during the Late Summer

Chinook Salmon, Coho Salmon, and Steelhead Potential effects associated with changes in operation to provide additional late-summer flow releases from Lewiston Dam, on the functional flow-habitat criteria and objectives specified by the Trinity River ROD for anadromous salmonids in the Trinity River downstream of Lewiston Dam, were evaluated by examining changes in monthly flows and probability of exceedance curves for daily flows during August and September. Overall, average monthly flows would increase by 20 percent in August and 42 percent in September (see Chapter 4 "Surface Water Resources and Water Supply"). The amount of additional flows released from Lewiston Dam to the Trinity River would vary, depending on the amount needed to augment Klamath River baseflows and the detection and severity of Ich infections of adult salmon, and would range from 2 percent (extremely wet years) to 55 percent (critically dry years) in August, and from 6 percent (extremely wet years) to 115 percent (critically dry years) in September.

The Trinity River summer baseflow release from Lewiston Dam of 450 cfs prescribed by the Trinity River ROD is intended to provide suitable water temperatures and conditions for adult spring-run Chinook Salmon holding habitat, juvenile Coho Salmon and steelhead rearing habitat, and suitable temperatures and spawning habitat for spring-run Chinook Salmon through September. Additional Lewiston Dam releases above 450 cfs during August and September to augment flows in the lower Klamath River—according to the trigger conditions described in the *Draft Long-Term Plan for Protecting Late Summer Adult Salmon in the Lower Klamath River*—could:

- Extend suitable water temperatures for rearing juvenile Coho Salmon and steelhead further downriver
- Overtop berms along the river channel at higher release flows associated with the proposed preventative and emergency pulse flows, potentially increasing risk of stranding juvenile salmon upon reduction of the pulse flows back to the baseflow
- Interrupt or dewater redds of spring-run Chinook Salmon, which may begin spawning in early- to mid-September before releases are returned to baseflow

Figure 7-6 shows that Lewiston Dam releases under Alternative 1 will be at the 450 cfs base flow for more than 75 percent of the time. When late-summer augmentation flow releases are necessary, more than 50 percent of the additional releases would likely be less than 1,000 cfs, 90 percent would be less than 1,500 cfs, with only about 5 percent excceding 2,000 cfs up to a maximum of 3,800 cfs. The flows greater than 1,500 cfs are levels mostly associated with preventative and emergency pulse flows that would be conducted over a short time frame for one day and five days (plus ramping), respectively.

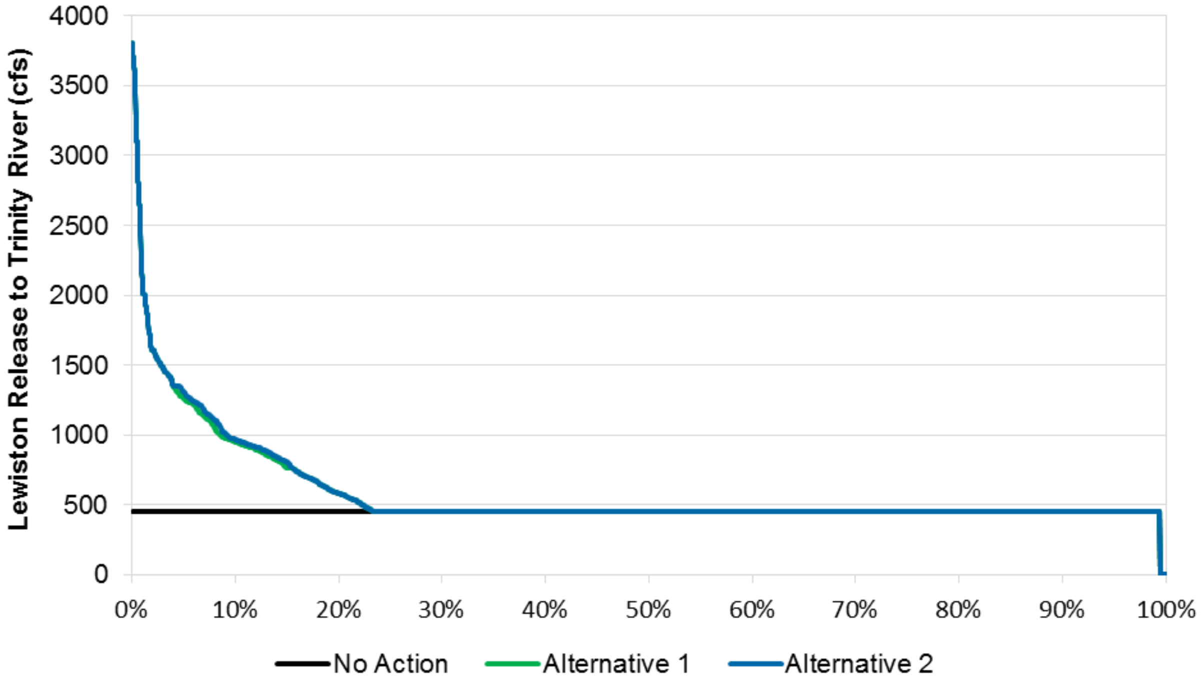


Figure 7-6. Comparison of the Exceedance Probabilities of Predicted Daily Trinity River Flows Below Lewiston Dam for the No Action Alternative, Alternative 1, and Alternative 2

Flow rates less than 1,000 cfs typically would not be expected to overtop berms, many of which have been removed by the Trinity River Restoration Program in the last decade as part of extensive channel rehabilitation projects (Hoopa Valley Tribe et al. 2011, TRRP SAB 2013, TRRP 2014)[6]. Some high-flow side channels and floodplain areas adjacent to the summer baseflow channel, that get inundated by the additional late-summer augmentation release flows, would allow juvenile fish to temporarily distribute along and use these areas for rearing until flows are returned to summer baseflow, when they will move with receding flows back to summer flow channel habitat. However, most juvenile Coho Salmon, Chinook Salmon, and steelhead rearing in the Trinity River during August and September are at a larger parr or pre-smolt size and generally prefer deeper, swifter habitats than fry-sized fish, which would likely minimize numbers of salmon and steelhead parr moving up onto shallower areas inundated at the higher stage extents of augmentation flows.

Flows greater than about 2,000 cfs associated with preventative and emergency pulse flow components of the proposed action alternatives have the potential to minimally affect juvenile Coho Salmon and steelhead rearing in the river in August and September by stranding them in side- and off-channel areas inundated by the high pulse flows once flows are reduced back to the summer baseflow of 450 cfs. Ramping rates for both the ascending and receding flows associated with these pulse flows are designed to minimize public and environmental impacts, including stranding fish. Given that channel rehabilitation over the last decade has reduced the

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[6] More than half of the 44 original channel rehabilitation sites (nearly 15 miles of the 40 mile upper Trinity River Restoration reach) have had channel rehabilitation treatments (TRRP SAB 2013; TRRP 2014).

number of areas in the upper Trinity River where stranding is likely to occur and the conservative ramping rates that would be implemented for the proposed action (Chamberlain 2003)[7], the proportion of rearing juvenile salmonids that may be vulnerable to stranding is anticipated to be small and would not be expected to impact overall production.

Trinity River spring-run Chinook Salmon begin spawning by about the third week in September in most years (USFWS and Hoopa Valley Tribe 1999). However, the timing and down-ramping pattern of late-summer augmentation releases during the third week of September is designed to avoid and minimize effects on spawning spring run salmon. Chamberlain and Hetrick (2013) reported that reduction of flows in September 2013 from 900 cfs to 450 cfs did not dewater up to 65 spring-run Chinook Salmon redds completed through September 19 that year. In the case where an emergency pulse flow action is required at the end of the preventative baseflow period, a small number of spring-run Chinook Salmon that begin to construct redds and spawn during this period may experience a disruption of spawning activites or, in the worst case, completed or partially-completed redds could be dewatered (Gaeuman, pers. com. 2016). However, this effect is expected to be infrequent and minimal.

Pacific Lamprey Adult Pacific Lamprey and River Lamprey immigrate into the Klamath-Trinity River basin tributaries from spring through summer before spawning the following winter and spring. Juvenile lamprey larvae (ammocoetes) rear year-round in the mainstem Trinity River and its tributaries in low-velocity pools and channel margins with a dominant substrate of fine silt, sand, or small gravels (Moyle 2002, USFWS 2010). Increased late-summer augmentation flows may cause increased water velocities and disturbance of fine sediments along the summer baseflow channel where lamprey ammocoetes are living. Because the range of augmentation flows under Alternative 1 would be within the typical range of annual fluctuations in the upper Trinity River, which lampreys experience over their freshwater juvenile life stage, it is expected that juvenile lampreys will redistribute to other areas of suitable habitat over the course of the augmentation flow cycle, if disturbed by higher water velocities.

Changes in Trinity River Water Temperatures during the Late Summer through Fall

Chinook Salmon, Coho Salmon, and Steelhead Potential effects associated with changes in operation to provide additional late-summer flow releases from Lewiston Dam on the water temperature criteria and objectives specified by the Trinity River ROD for anadromous salmonids in the Trinity River downstream of Lewiston Dam were evaluated by examining changes in DAT statistics at key temperature objective/compliance locations during July through December. Consideration of changes in water temperatures through the fall months after completion of the late-summer augmentation releases is important because of the potential latent effect that additional flow releases in August and September may have on reducing cold water storage in Trinity Lake and, therefore, on dam release and river temperatures in subsequent fall months (see Chapter 5, “Surface Water Quality”), and the ability of operations to achieve water temperature compliance objectives and temperature management criteria for spawning salmon. Differences in DAT of 1°F or less are considered to be similar given the typical accuracy and

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[7] Chamberlain (2003) reported that stranding potential juvenile salmonids was less at pilot channel restoration sites than at sites with riparian encroachment berms.

precision of temperature measurement devices (± 0.5°F) and resolution of the CalSim II, HEC-5Q, and RBM10 models used for analysis (see Analytical Tools Appendix).

The mean and range of DATs during the July through September period at Douglas City are similar between Alternative 1 and the No Action Alternative, with a potential minor risk of exceeding optimal temperature thresholds by less than 1°F up to 3°F for up to four additional days in any one year for pre-spawning adult spring-run Chinook Salmon. During the latter half of September as spawning begins, some additional minor exceedances of optimal spawning temperatures of up to 2°F for one to nine days at Douglas City could occur primarily during extended drought periods and critically dry years, as occurred in the early 1990s (Table 7-4); although, in such instances, much of the river upstream of Douglas City would experience temperatures closer to the optimal spawning temperature threshold of ≤ 56°F. After October 1 through the end of December, when spring- and fall-run Chinook Salmon and Coho Salmon are spawning in the upper Trinity River, the mean and range of DATs down to the North Fork Trinity River confluence are similar between Alternative 1 and the No Action Alternative, with a minor increase in the number of days exceeding optimal spawning temperatures in dry and and critically dry years (Table 7-5); however, in such instances, much of the reach upstream of the North Fork Trinty River would likely experience cooler temperatures approaching and meeting the objective of ≤ 56°F.

Pacific Lamprey The temperature requirements and preferences of Pacific Lamprey and other lamprey species inhabiting the Klamath-Trinity River basin tributaries overlaps that of the sympatric anadromous salmonid species, but they are tolerant of somewhat warmer temperatures during the freshwater and reproductive lifestages (Moyle 2002). Given the relative similarity of the water temperatures, with minor differences in magnitude of the ranges in DATs, it is likely that the effects on Pacific Lampreys and other lamprey species would be similar between Alternative 1 and the No Action Alternative.

Table 7-4. Changes in Daily Average Water Temperatures Compared to NCRWQCB Temperature Objectives for Lewiston Dam to Douglas City Under the No Action Alternative and Alternative 1

Year	Water Year Type	7/1 to 9/14 ≤ 60°F (15.5°C) Average; (Range); [# days]		9/15 to 9/30 ≤ 56°F (13.3°C) Average; (Range); [# days]	
		No Action	**Alternative 1**	**No Action**	**Alternative 1**
1980	W	52 (49-55) [0]	52 (49-55) [0]	50 (49-51) [0]	50 (49-51) [0]
1981	**D**	**52 (51-55) [0]**	**52 (51-54) [0]**	**51 (51-53) [0]**	**52 (51-52) [0]**
1982	EW	52 (49-54) [0]	52 (49-54) [0]	50 (48-50) [0]	50 (48-50) [0]
1983	EW	53 (50-56) [0]	53 (50-56) [0]	52 (52-53) [0]	52 (52-53) [0]
1984	W	54 (52-56) [0]	54 (52-56) [0]	52 (51-54) [0]	52 (51-54) [0]
1985	**D**	**53 (52-54) [0]**	**53 (52-54) [0]**	**53 (52-53) [0]**	**53 (52-54) [0]**
1986	**W**	**51 (50-53) [0]**	**51 (50-53) [0]**	**50 (49-50) [0]**	**50 (49-50) [0]**
1987	**D**	**53 (51-55) [0]**	**53 (51-55) [0]**	**54 (54-55) [0]**	**55 (54-56) [0]**
1988	**D**	**54 (53-56) [0]**	**54 (52-55) [0]**	**53 (52-55) [0]**	**53 (53-55) [0]**
1989	**N**	**54 (51-56) [0]**	**54 (52-56) [0]**	**55 (54-56) [0]**	**55 (54-55) [0]**
1990	**D**	**56 (55-58) [0]**	**56 (55-58) [0]**	**56 (56-57) [7]**	**56 (55-56) [2]**
1991	**CD**	**59 (55-62) [33]**	**59 (56-63) [37]**	**59 (58-60) [15]**	**58 (56-60) [15]**
1992	**D**	**55 (53-57) [0]**	**55 (53-59) [0]**	**56 (55-56) [5]**	**57 (56-58) [14]**
1993	W	55 (51-61) [1]	56 (52-63) [2]	53 (53-55) [0]	55 (54-56) [0]
1994	**CD**	**55 (54-56) [0]**	**55 (53-56) [0]**	**55 (55-56) [0]**	**55 (54-56) [0]**
1995	**EW**	**56 (50-61) [6]**	**55 (50-60) [6]**	**50 (49-51) [0]**	**51 (50-52) [0]**
1996	**W**	**54 (51-57) [0]**	**54 (51-57) [0]**	**52 (52-53) [0]**	**52 (52-53) [0]**
1997	**W**	**53 (50-54) [0]**	**53 (50-54) [0]**	**52 (51-53) [0]**	**52 (51-53) [0]**
1998	EW	53 (50-56) [0]	53 (50-56) [0]	51 (50-52) [0]	51 (50-52) [0]
1999	W	54 (50-59) [0]	54 (50-60) [1]	52 (52-53) [0]	52 (52-53) [0]
2000	**W**	**53 (51-55) [0]**	**53 (51-55) [0]**	**53 (52-54) [0]**	**53 (52-54) [0]**
2001	**D**	**55 (54-56) [0]**	**54 (53-56) [0]**	**55 (54-55) [0]**	**55 (54-55) [0]**
2002	**N**	**53 (51-54) [0]**	**52 (50-54) [0]**	**52 (51-53) [0]**	**52 (51-52) [0]**
2003	**EW**	**53 (51-57) [0]**	**53 (50-57) [0]**	**51 (51-52) [0]**	**51 (51-52) [0]**
Summary of Differences		**Difference in DAT Mean (range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (range)**	**Difference in Number of Exceedances**
Flow Augmentation		-0.1°F (0.4 to -0.4°F)	+5	0°F (1.6 to -1.2°F)	+4
No Flow Augmentation		0.1°F (0.7 to 0°F)	+2	0.2°F (1.5 to 0°F)	0

Notes:

Averages are calculated for a 24-year period for the critical summer and fall reproductive periods for Trinity River spring- and fall-run Chinook Salmon and Coho Salmon

Water temperature management objectives for the Trinity River at Douglas City for protection of anadromous salmon freshwater life stages are shown for each period.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 1.

Key:

CD = critically dry
D = dry
DAT = daily average temperature
EW = extremely wet
N = normal
NCRWQCB = North Coast Regional Water Quality Control Board
W = wet

Table 7-5. Changes in Daily Average Water Temperatures Compared to NCRWQCB Temperature Objectives for Lewiston Dam to North Fork Trinity River Confluence Under the No Action Alternative and Alternative 1

		10/1 to 12/31 ≤ 56°F (13.3°C) Average; (Range); [# days]	**10/1 to 12/31 ≤ 56°F (13.3°C) Average; (Range); [# days]**
Year	**Water Year Type**	**No Action**	**Alternative 1**
1980	W	49 (42-59) [10]	49 (42-59) [10]
1981	**D**	**49 (42-57) [1]**	**49 (42-57) [4]**
1982	EW	47 (41-56) [1]	47 (41-56) [1]
1983	EW	49 (42-56) [7]	49 (42-56) [7]
1984	W	46 (40-57) [1]	46 (40-57) [1]
1985	**D**	**49 (43-61) [9]**	**49 (43-61) [9]**
1986	**W**	**49 (44-56) [2]**	**49 (44-56) [2]**
1987	**D**	**50 (41-62) [23]**	**51 (41-62) [28]**
1988	**D**	**50 (40-60) [22]**	**50 (40-60) [24]**
1989	**N**	**51 (44-59) [20]**	**50 (44-59) [20]**
1990	**D**	**50 (42-62) [11]**	**50 (42-62) [11]**
1991	**CD**	**51 (44-65) [22]**	**50 (43-65) [22]**
1992	**D**	**51 (40-61) [26]**	**51 (40-62) [26]**
1993	W	49 (42-61) [10]	49 (42-61) [14]
1994	**CD**	**49 (41-61) [14]**	**49 (41-61) [18]**
1995	**EW**	**49 (41-55) [0]**	**49 (41-56) [0]**
1996	**W**	**49 (42-59) [11]**	**49 (42-59) [11]**
1997	**W**	**48 (41-57) [1]**	**48 (41-57) [1]**
1998	EW	47 (39-57) [1]	47 (39-57) [1]
1999	W	49 (43-57) [8]	49 (43-57) [8]
2000	**W**	**49 (44-58) [9]**	**49 (44-58) [9]**
2001	**D**	**50 (41-61) [19]**	**50 (41-63) [22]**
2002	**N**	**49 (41-58) [6]**	**50 (41-60) [15]**
2003	**EW**	**NA**	**NA**
Summary of Differences		**Difference in DAT Mean (range)**	**Difference in Number of Exceedances**
Flow Augmentation		0.1°F (0.6 to -0.4°F)	+26
No Flow Augmentation		0°F (0.1 to 0°F)	+4

Notes:

Averages are calculated for a 24-year period for the critical summer and fall reproductive periods for Trinity River spring- and fall-run Chinook Salmon and Coho Salmon

Water temperature management objective for the Trinity River at the North Fork Trinity River confluence for protection of anadromous salmon freshwater life stages is shown for each period.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 1.

Key:
CD = critically dry
D = dry
DAT = daily average temperature
EW = extremely wet
N = normal
NCRWQCB = North Coast Regional Water Quality Control Board
W = wet

Changes in Trinity River Spring Flow Release Patterns Under Alternative 1, Lewiston Dam would operate releases to conform to the Trinity River ROD flow management release schedules in all water year types; therefore, no change to the functional flow related fish habitat management objectives for anadromous salmonids and other fish species in the Trinity River would occur compared to the No Action Alternative.

Changes in Trinity River Water Temperatures During Spring Flow Releases

Chinook Salmon, Coho Salmon, and Steelhead Consideration of changes in water temperatures through the spring and early summer months, following years when late-summer augmentation releases would occur, is important because of the potential latent effect that additional flow releases may have on reducing overall storage or cold water reserves in Trinity Lake and, therefore, on the ability of operations to achieve temperature management criteria for fish habitat throughout the following year (see Chapter 5, "Surface Water Quality"). Potential effects associated with changes in operation to provide additional late-summer flow releases from Lewiston Dam on the spring/early-summer water temperature management criteria were evaluated by examining changes in DAT statistics during mid-May to early-July. Differences in DAT of 1°F or less are considered to be similar given the typical accuracy and precision of temperature measurement devices (± 0.5°F) and resolution of the CalSim II, HEC-5Q, and RBM10 models used for analysis (see Analytical Tools Technical Appendix).

The mean and range of DATs during the spring/early-summer period at the North Fork Trinity River confluence (downstream to Weitchpec) are similar between Alternative 1 and the No Action Alternative (Tables 7-6 and 7-7), with a potential for only a minor increase of one or two days additional exceedances of temperature criteria in June and July, primarily during multiple consecutive dry water years. Given the similarity in spring/early-summer flows and water temperatures throughout the Trinity River between Alternative 1 and the No Action Alternative, habitat conditions for juvenile Chinook Salmon, Coho Salmon, and steelhead growth and outmigration survival would be expected to be similar.

Changes in Late Summer Flows in the Lower Klamath River Below the Trinity River Confluence

Chinook Salmon, Coho Salmon, and Steelhead The proposed action alternatives, including Alternative 1 compared to the No Action Alternative, would release additional flows from Lewiston Dam on the Trinity River to augment the late-summer baseflow in the lower Klamath River, below the Trinity River confluence, to a minimum of 2,800 cfs, in any year when flows may otherwise be less than this level. Furthermore, Alternative 1 would provide additional releases from Lewiston Dam for preventative and emergency pulse flows of 5,000 cfs in the lower Klamath River, for one and five days, respectively, as described in Chapter 2, "Description of Alternatives," to reduce the severity of Ich infections of adult salmon, when fish health monitoring detects infection levels that may merit additional flow to ameliorate conditions thought to contribute to virulence of the Ich parasite, which can cause an epizootic leading to fish die-offs.

As described under the impacts of the No Action Alternative, high densities of salmon in the lower Klamath River during the late-summer, resulting from any combination of high run-sizes, early shifts in run-timing of fall-run Chinook Salmon, thermal barriers to migration causing slowed migration, congregation, and extended residence time of adult salmon in restricted thermal refuges along the lower river; low seasonal flow levels (generally at or below the 90-percentile historic flow— see Figure 7-2); and warm water temperatures, can potentially trigger epizootic outbreaks of the fish diseases Ich and columnaris.

The potential effects of increases in the late-summer flows in lower Klamath River under Alternative 1 include an increase in average cross-sectional area of inundated river channel, increases in average water velocities in the channel, and changes in water temperature— all thought to be important in the disruption of infectivity and virulence of the Ich parasite. Increases in the baseflow would have varying effects on increasing habitat areas, dispersal opportunity, and migration cues for adult salmon to move upstream, depending on year and salmon abundance, which could reduce densities of fish in holding habitat.

Table 7-6. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives Near the North Fork Trinity River Confluence Under the No Action Alternative and Alternative 1

		4/15 to 5/22 ≤ 55.4° for N, W, & EW ≤ 59°F for D & CD WYs Average; (Range); [# days]		**5/23 to 6/4 ≤ 59°F for N, W, & EW ≤ 62.6°F for D, CD Average; (Range); [# days]**		**6/5 to 7/9 ≤ 62.6°F for N, W, & EW Average; (Range); [# days]**	**6/5 to 6/15 ≤ 62.6°F for D, CD**
Year	**Water Year Type**	**No Action**	**Alternative 1**	**No Action**	**Alternative 1**	**No Action**	**Alternative 1**
1980	W	51 (47-56) [2]	51 (47-56) [2]	48 (46-51) [0]	48 (46-51) [0]	55 (49-57) [0]	55 (49-57) [0]
1981	**D**	**52 (49-57) [0]**	**52 (49-57) [0]**	**58 (54-60) [0]**	**58 (54-60) [0]**	**60 (57-62) [1]**	**60 (57-62) [1]**
1982	EW	51 (45-53) [0]	51 (45-53) [0]	47 (46-48) [0]	47 (46-48) [0]	52 (47-56) [0]	52 (47-56) [0]
1983	EW	49 (45-56) [1]	49 (45-56) [1]	53 (51-55) [0]	53 (51-54) [0]	55 (52-58) [0]	55 (52-58) [0]
1984	W	51 (47-54) [0]	51 (47-54) [0]	51 (49-53) [0]	51 (49-53) [0]	57 (51-60) [0]	57 (51-60) [0]
1985	**D**	**53 (50-57) [0]**	**53 (50-57) [0]**	**55 (52-57) [0]**	**55 (52-57) [0]**	**61 (56-65) [0]**	**61 (56-65) [0]**
1986	**W**	**50 (46-55) [0]**	**50 (46-55) [0]**	**51 (48-55) [0]**	**51 (48-55) [0]**	**56 (53-58) [0]**	**56 (53-58) [0]**
1987	**D**	**54 (49-60) [1]**	**54 (49-60) [1]**	**56 (53-59) [0]**	**56 (53-59) [0]**	**60 (58-62) [0]**	**60 (58-62) [0]**
1988	**D**	**52 (47-57) [0]**	**52 (47-57) [0]**	**56 (53-58) [0]**	**56 (53-58) [0]**	**55 (51-62) [2]**	**55 (51-62) [2]**
1989	**N**	**52 (49-59) [7]**	**52 (49-59) [7]**	**52 (48-56) [0]**	**52 (48-56) [0]**	**58 (53-59) [0]**	**58 (53-59) [0]**
1990	**D**	**53 (50-58) [0]**	**53 (50-58) [0]**	**52 (49-56) [0]**	**52 (49-56) [0]**	**60 (56-62) [0]**	**60 (56-62) [0]**
1991	**CD**	**54 (49-58) [0]**	**54 (49-58) [0]**	**58 (53-60) [0]**	**58 (53-61) [0]**	**63 (60-65) [0]**	**63 (60-65) [0]**
1992	**D**	**53 (50-58) [0]**	**53 (50-58) [0]**	**59 (55-63) [1]**	**59 (55-63) [1]**	**61 (55-63) [3]**	**61 (55-63) [3]**
1993	W	50 (47-53) [0]	50 (47-53) [0]	49 (48-50) [0]	49 (48-50) [0]	56 (49-59) [0]	56 (49-59) [0]
1994	**CD**	**56 (50-60) [7]**	**56 (50-60) [7]**	**59 (58-61) [0]**	**59 (58-61) [0]**	**60 (56-63) [0]**	**60 (55-63) [0]**
1995	**EW**	**49 (45-53) [0]**	**49 (45-53) [0]**	**48 (48-50) [0]**	**48 (47-49) [0]**	**53 (48-59) [0]**	**53 (48-59) [0]**
1996	**W**	**51 (47-55) [0]**	**51 (47-55) [0]**	**51 (47-54) [0]**	**51 (47-54) [0]**	**57 (53-60) [0]**	**57 (53-60) [0]**
1997	**W**	**52 (47-55) [0]**	**52 (47-55) [0]**	**50 (47-54) [0]**	**50 (47-53) [0]**	**56 (53-58) [0]**	**56 (53-58) [0]**
1998	EW	51 (46-55) [0]	51 (46-55) [0]	48 (45-53) [0]	48 (45-53) [0]	55 (52-57) [0]	55 (52-57) [0]
1999	W	51 (48-56) [3]	51 (48-56) [3]	52 (50-53) [0]	52 (50-53) [0]	56 (52-60) [0]	56 (52-60) [0]
2000	**W**	**51 (47-55) [0]**	**51 (47-55) [0]**	**52 (51-53) [0]**	**52 (51-53) [0]**	**57 (52-60) [0]**	**57 (52-60) [0]**
2001	**D**	**55 (49-60) [3]**	**55 (49-60) [3]**	**59 (57-63) [0]**	**59 (57-63) [0]**	**60 (58-62) [0]**	**60 (58-62) [0]**
2002	**N**	**51 (47-57) [3]**	**51 (47-57) [3]**	**53 (50-57) [0]**	**53 (50-57) [0]**	**57 (55-59) [0]**	**57 (55-59) [0]**
2003	**EW**	**50 (46-53) [0]**	**50 (46-53) [0]**	**49 (48-51) [0]**	**49 (48-51) [0]**	**54 (50-58) [0]**	**54 (50-58) [0]**

Table 7-6. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives Near the North Fork Trinity River Confluence Under the No Action Alternative and Alternative 1 (contd.)

	4/15 to 5/22		**5/23 to 6/4**		**6/5 to 7/9**	
Summary of Differences	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**
Flow Augmentation Years	0°F (0 to -0.1°F)	0	0°F (0 to -0.2°F)	0	0°F (0.1 to -0.1°F)	0
Non-Augmentation Years	0°F (0 to -0.1°F)	0	0°F (0 to -0.1°F)	0	0°F (0.1 to 0°F)	0

Notes:

Averages are calculated for a 24-year period for the critical spring and early summer rearing and outmigration periods for Trinity River anadromous salmonids

Water temperature management objectives for the Trinity River from Lewiston Dam to Weitchpec for protection of anadromous salmon freshwater life stages are shown for each period.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 1

Key:
CD = critically dry water year
D = dry water year
DAT = daily average temperature
EW = extremely wet water year
N = normal water year
W = wet

Table 7-7. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives for Lewiston Dam to Weitchpec Under the No Action Alternative and Alternative 1

Year	**Water Year Type**	**4/15 to 5/22** **≤ 55.4° for N, W, & EW** **≤ 59°F for D & CD WYs** **Average; (Range); [# days]**		**5/23 to 6/4** **≤ 59°F for N, W, & EW** **≤ 62.6°F for D, CD** **Average; (Range); [# days]**		**6/5 to 7/9** **≤ 62.6°F for N, W, & EW** **Average; (Range); [# days]**	**6/5 to 6/15** **≤ 62.6°F for D, CD**
		No Action	**Alternative 1**	**No Action**	**Alternative 1**	**No Action**	**Alternative 1**
1980	W	55 (51-60) [24]	55 (51-60) [24]	52 (49-55) [0]	52 (49-55) [0]	61 (54-64) [10]	61 (54-64) [10]
1981	**D**	**56 (52-60) [4]**	**56 (52-60) [4]**	**63 (58-66) [8]**	**63 (58-66) [8]**	**65 (62-67) [0]**	**65 (62-67) [0]**
1982	EW	55 (47-58) [23]	55 (47-58) [23]	52 (50-54) [0]	52 (50-54) [0]	59 (51-63) [1]	59 (51-63) [1]
1983	EW	52 (47-61) [7]	52 (47-61) [7]	59 (57-61) [8]	59 (57-61) [7]	61 (58-64) [3]	61 (58-64) [3]
1984	W	53 (50-59) [4]	53 (50-59) [4]	56 (53-59) [0]	56 (53-59) [0]	63 (55-68) [24]	63 (55-68) [24]
1985	**D**	**56 (51-62) [4]**	**56 (51-62) [4]**	**60 (57-62) [0]**	**60 (57-62) [0]**	**67 (61-72) [5]**	**67 (61-72) [5]**
1986	**W**	**53 (50-58) [7]**	**53 (50-58) [7]**	**57 (51-61) [4]**	**57 (51-61) [4]**	**63 (60-65) [20]**	**63 (60-65) [20]**
1987	**D**	**59 (53-64) [18]**	**59 (53-64) [18]**	**61 (57-67) [3]**	**61 (57-67) [3]**	**68 (66-70) [4]**	**68 (66-70) [4]**
1988	**D**	**55 (49-62) [3]**	**55 (49-62) [3]**	**60 (57-64) [2]**	**60 (57-64) [2]**	**58 (55-66) [0]**	**58 (55-66) [0]**
1989	**N**	**57 (52-64) [19]**	**57 (52-64) [19]**	**57 (52-63) [3]**	**56 (52-63) [3]**	**64 (58-66) [30]**	**64 (58-66) [32]**
1990	**D**	**57 (53-62) [9]**	**57 (53-62) [9]**	**54 (53-58) [0]**	**54 (53-58) [0]**	**64 (58-65) [0]**	**64 (58-65) [0]**
1991	**CD**	**56 (52-60) [1]**	**56 (52-60) [1]**	**61 (58-63) [2]**	**61 (58-63) [2]**	**67 (63-69) [4]**	**67 (63-69) [5]**
1992	**D**	**58 (56-62) [10]**	**58 (56-62) [10]**	**65 (60-70) [12]**	**65 (60-70) [12]**	**67 (60-70) [7]**	**67 (60-70) [7]**
1993	W	54 (51-57) [10]	54 (51-57) [10]	55 (54-57) [0]	55 (54-57) [0]	63 (54-66) [23]	63 (54-67) [23]
1994	**CD**	**59 (53-65) [18]**	**59 (53-65) [18]**	**65 (61-66) [12]**	**65 (61-66) [12]**	**66 (62-70) [4]**	**66 (62-70) [4]**
1995	**EW**	**53 (47-58) [5]**	**53 (47-58) [5]**	**54 (53-55) [0]**	**54 (52-55) [0]**	**59 (53-67) [14]**	**59 (52-67) [14]**
1996	**W**	**54 (49-59) [14]**	**54 (49-59) [14]**	**55 (52-60) [1]**	**55 (52-60) [1]**	**63 (59-67) [20]**	**63 (59-67) [20]**
1997	**W**	**57 (52-62) [28]**	**57 (52-62) [29]**	**54 (51-59) [1]**	**54 (51-59) [0]**	**62 (57-65) [16]**	**62 (57-65) [16]**
1998	EW	55 (47-60) [18]	55 (47-60) [18]	51 (47-57) [0]	51 (47-57) [0]	61 (57-65) [5]	61 (57-65) [5]
1999	W	54 (49-60) [10]	54 (49-60) [10]	58 (55-59) [2]	58 (55-59) [2]	62 (55-66) [20]	62 (55-66) [20]
2000	**W**	**54 (50-57) [8]**	**54 (50-57) [8]**	**57 (55-58) [0]**	**57 (55-58) [0]**	**63 (58-67)[20]**	**63 (58-67) [20]**
2001	**D**	**58 (52-65) [13]**	**58 (52-65) [13]**	**65 (63-67) [13]**	**65 (63-67) [13]**	**65 (63-68) [0]**	**65 (63-68) [0]**
2002	**N**	**54 (51-60) [12]**	**54 (51-60) [12]**	**59 (54-62) [6]**	**59 (54-62) [6]**	**64 (61-66) [30]**	**64 (61-66) [30]**
2003	**EW**	**52 (48-55) [0]**	**52 (48-55) [0]**	**54 (52-56) [0]**	**54 (52-56) [0]**	**60 (55-65) [12]**	**60 (55-65) [12]**

Table 7-7. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives for Lewiston Dam to Weitchpec Under the No Action Alternative and Alternative 1 (contd.)

Summary of Differences	**4/15 to 5/22**		**5/23 to 6/4**		**6/5 to 7/9**	
	Difference in DAT Mean (Range)	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**
Flow Augmentation Years	0°F (--)	+1	0°F (0 to -0.1°F)	0	0°F (0.1 to -0.1°F)	+3
Non-Augmentation Years	0°F (0 to -0.1°F)	0	0°F (--)	-1	0°F (0.1 to 0°F)	0

Notes:

Averages are calculated for a 24-year period for the critical spring and early summer rearing and outmigration periods for Trinity River anadromous salmonids

Water temperature management objectives for the Trinity River from Lewiston Dam to Weitchpec for protection of anadromous salmon freshwater life stages are shown for each period.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 1

Key:
CD = critically dry water year
D = dry water year
DAT = daily average temperature
EW = extremely wet water year
N = normal water year
W = wet

The effect of increased water velocities on disrupting and reducing the ability of the free-swimming infectious life-stage of the Ich parasite has been reported as being an important function of late-summer flow augmentation in the lower Klamath River (Strange 2015, USFWS 2015, USFWS and YTFP 2016). In-channel water velocities in the lower Klamath River, near Blue Creek, were modeled in a recent investigation and current speeds were reported to increase by an average of 0.21 feet per second faster when flows increased from 2,000 cfs to 2,800 cfs (USFWS and YTFP 2016). Additionally, USFWS and YTFP (2016) reported that modeled mean channel velocities also increased by 0.68 feet per second, with increasing discharge from 2,800 cfs to 5,000 cfs.

Current understanding of the mechanisms of the factors discussed above—that interact to result in Ich infection and epizootics that can lead to fish die-offs—is incomplete, and it is not possible to accurately quantify the reduced risk of disease that can be attributed to increased flows. However, given the potential of the proposed action's preventative base flow of 2,800 cfs, and the preventative and emergency pulse flows of 5,000 cfs, to affect increases in cross-sectional channel area to expand habitat space to some degree, increase water velocities that can reduce efficacy of Ich parasites from finding and attaching to adult salmon hosts, and potentially provide migration cues to further disperse adult salmon and reduce densities in the lower Klamath River, conditions under Alternative 1 would be expected to result in some level of reduced risk of Ich infection, epizootic outbreaks and consequent fish die-offs. In addition, reduction in the frequency of year-to-year parasite carryover effect may be reduced.

Pacific Lamprey Although, Pacific Lamprey may immigrate into the Klamath River from spring through summer, few are thought to reside in the lower Klamath River during the late-summer. No lamprey were reported among the fish that died in the 2002 mass fish mortality event (DFG 2004). The effects on lamprey of Alternative 1 compared to the No Action Alternative are thought to be similar as that for anadromous salmonids.

Green Sturgeon Green Sturgeon, including both northern DPS that spawn in the Klamath and Trinity Rivers, and southern DPS that may move into the Klamath River estuary to forage, may occur in the lower Klamath River during the late-summer. Some Green Sturgeon were reported among the fish that died in the 2002 mass fish mortality event (DFG 2004). The effects on Green Sturgeon of Alternative 1 compared to the No Action Alternative are thought to be of potentially similar benefit as for the anadromous salmonids.

Eulachon It is unclear whether this species has been extirpated from the Klamath River. However, Eulachon are reported to spawn in the lower Klamath River, up to 7 miles inland, during March through May, with the larvae washing out through the estuary to the ocean by June. Therefore, increased late-summer flows in the lower Klamath River would not affect Eulachon.

Changes in Late Summer Water Temperatures in the Lower Klamath River Below the Trinity River Confluence

<u>Chinook Salmon, Coho Salmon, and Steelhead</u> Reduction of water temperatures in the lower Klamath River is one of the intended benefits of the late-summer augmentation flow releases from Lewiston Dam. Effects on water temperatures in the lower Klamath River were evaluated by examining changes in DAT and 7DADM temperature statistics at RM 5.7, near the

head of the estuary, and at RM 16.5, near the Blue Creek confluence, during August 22 to September 22, when augmentation flows would occur. Differences in DAT and 7DADM of 1°F or less are considered to be similar given the typical accuracy and precision of temperature measurement devices (± 0.5°F) and resolution of the CalSim II, HEC-5Q, and RBM10 models used for analysis (see Analytical Tools Technical Appendix). Modeled temperature statistics were also compared for exceedances of 73.4°F, which is a temperature of particular importance because it is a thermal threshold known to inhibit migration of adult salmon (Strange 201b, 2012).

During late-summer flow augmentation operations, the DAT at the head of the estuary (RM 5.7) and near Blue Creek (RM 16.5) would be reduced by up to nearly 6°F in some years, averaging around 2°F, under Alternative 1 compared to the No Action Alternative (Tables 7-8 and 7-9), with a potential for a frequent reduction in the total number of days when DATs exceed the critical 73.4°F thermal migration barrier threshold. Similarly, the 7DADM at both locations would be reduced by up to nearly 5°F in some years, when flow augmentation occurs, averaging reductions of 1.3°F (RM 5.7) and 1.4°F (RM 16.5). The reduction in this metric under Alternative 1 also reflects that daily maximum temperatures would exhibt less frequent exccedance of the thermal migration barrier threshold.

Given the reduction in number of days when modeled DATs would exceed the thermal barrier threshold temperature, and the reduction in 7DADM, during late-summer flow augmentation in the lower Klamath River, thermal risk factors contributing to the potential for and severity of Ich infection would be reduced to some degree under Alternative 1 compared to the No Action Alternative.

Table 7-8. Changes in Maximum 7-Day Average of Daily Maximum Water Temperatures on the Lower Klamath River Near Klamath, California, Under the No Action Alternative and Alternative 1

Year	Water Year Type	No Action		Alternative 1	
		DAT Statistics Average; (Range); [# days]	Maximum 7DADM (°F)	DAT Statistics Average; (Range); [# days]	Maximum 7DADM (°F)
1980	W	68 (63-71) [0]	73	68 (63-71) [0]	73
1981	**D**	**70 (62-73) [0]**	**74**	**67 (62-71) [0]**	**73**
1982	EW	68 (62-74) [3]	75	68 (62-74) [3]	75
1983	EW	68 (64-70) [0]	74	68 (64-70) [0]	74
1984	W	69 (62-72) [0]	74	69 (62-72) [0]	74
1985	**D**	**66 (62-73) [0]**	**74**	**66 (62-73) [0]**	**74**
1986	**W**	**67 (58-74) [1]**	**75**	**67 (58-74) [1]**	**74**
1987	**D**	**68 (64-77) [5]**	**76**	**66 (62-71) [0]**	**72**
1988	**D**	**70 (62-75) [12]**	**76**	**66 (61-72) [0]**	**74**
1989	**N**	**68 (63-71) [0]**	**75**	**67 (63-69) [0]**	**74**
1990	**D**	**69 (66-71) [0]**	**73**	**68 (65-70) [0]**	**73**
1991	**CD**	**72 (68-76) [10]**	**76**	**68 (65-71) [0]**	**74**
1992	**D**	**70 (67-74) [1]**	**76**	**66 (62-69) [0]**	**74**
1993	W	69 (63-72) [0]	73	69 (63-72) [0]	73
1994	**CD**	**70 (66-74) [3]**	**76**	**64 (60-67) [0]**	**72**
1995	**EW**	**69 (67-71) [0]**	**73**	**69 (67-71) [0]**	**73**
1996	**W**	**68 (63-74) [1]**	**75**	**68 (63-74) [1]**	**75**
1997	**W**	**69 (64-72) [0]**	**74**	**69 (64-72) [0]**	**74**
1998	EW	70 (64-75) [4]	75	70 (64-75) [4]	75
1999	W	69 (66-74) [5]	75	69 (66-74) [5]	75
2000	**W**	**68 (64-73) [0]**	**74**	**68 (64-73) [0]**	**74**
2001	**D**	**70 (66-72) [0]**	**74**	**66 (63-69) [0]**	**73**
2002	**N**	**69 (65-74) [3]**	**75**	**64 (58-69) [0]**	**71**
2003	**EW**	**69 (63-73) [4]**	**76**	**67 (62-73) [1]**	**75**

Summary of Differences	Difference in DAT Mean (Range)	Difference in 7DADM Mean (Range)	Difference in Number of Exceedances
Flow Augmentation	-2.1°F (0 to -5.8°F)	-1.3°F (0 to -4.5°F)	-37
Non-Augmentation	0°F (0.1 to 0°F)	0°F (0.1 to 0°F)	0

Notes:

Averages are calculated for a 24-year period during the flow augmentation period, August 22 to September 22

Daily average water temperatures ≥ 73.4°F have been reported to inhibit migratory behavior of adult salmon.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 1.

Key:
7DADM = 7-day average daily maximum
CD = critically dry
D = dry
DAT = daily average temperature
EW = extremely wet
N = normal
W = wet

Table 7-9. Changes in Maximum 7-Day Average of Daily Maximum Water Temperatures on the Lower Klamath River Near Blue Creek Under the No Action Alternative and Alternative 1

Year	**Water Year Type**	**No Action**		**Alternative 1**	
		DAT Statistics Average; (Range); [# days]	**Maximum 7DADM (°F)**	**DAT Statistics Average; (Range); [# days]**	**Maximum 7DADM (°F)**
1980	W	67 (62-70) [0]	72	67 (62-70) [0]	72
1981	**D**	**69 (62-72) [0]**	**74**	**66 (62-70) [0]**	**73**
1982	EW	68 (62-74) [4]	75	68 (62-74) [4]	75
1983	EW	67 (64-70) [0]	74	67 (64-70) [0]	74
1984	W	69 (61-72) [0]	74	69 (61-72) [0]	74
1985	**D**	**66 (61-73) [1]**	**74**	**66 (61-73) [0]**	**74**
1986	**W**	**67 (58-73) [0]**	**74**	**66 (58-73) [0]**	**73**
1987	**D**	**68 (64-77) [5]**	**76**	**66 (61-72) [0]**	**71**
1988	**D**	**69 (61-74) [3]**	**75**	**66 (60-71) [0]**	**73**
1989	**N**	**68 (62-71) [0]**	**74**	**66 (62-69) [0]**	**73**
1990	**D**	**68 (66-71) [0]**	**73**	**67 (65-70) [0]**	**73**
1991	**CD**	**71 (68-75) [9]**	**76**	**67 (65-70) [0]**	**73**
1992	**D**	**69 (66-74) [3]**	**76**	**66 (62-69) [0]**	**73**
1993	W	68 (62-73) [0]	73	69 (62-73) [0]	73
1994	**CD**	**70 (65-73) [1]**	**75**	**64 (60-67) [0]**	**72**
1995	**EW**	**69 (67-71) [0]**	**73**	**69 (67-71) [0]**	**73**
1996	**W**	**68 (62-74) [1]**	**74**	**68 (62-74) [1]**	**74**
1997	**W**	**68 (63-71) [0]**	**74**	**68 (63-71) [0]**	**74**
1998	EW	70 (64-75) [4]	75	70 (64-75) [4]	75
1999	W	69 (66-74) [3]	75	69 (66-74) [3]	75
2000	**W**	**68 (64-72) [0]**	**73**	**68 (64-72) [0]**	**73**
2001	**D**	**69 (66-72) [0]**	**73**	**66 (62-68) [0]**	**72**
2002	**N**	**69 (65-73) [0]**	**74**	**63 (58-67) [0]**	**71**
2003	**EW**	**69 (63-74) [4]**	**76**	**67 (62-72) [1]**	**75**
Summary of Differences	**Difference in DAT Mean (Range)**		**Difference in 7DADM Mean (Range)**		**Difference in Number of Exceedances**
Flow Augmentation Years	-2.2°F (0 to -6.2°F)		-1.4°F (0 to -4.8°F)		-25
Non-Augmentation Years	0°F (0.1 to 0°F)		0°F (--)		0

Notes:

Averages are calculated for a 24-year period during the flow augmentation period, August 22 to September 22

Daily average water temperatures ≥ 73.4°F have been reported to inhibit migratory behavior of adult salmon.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 1.

Key:
7DADM = 7-day average daily maximum
CD = critically dry
D = dry
DAT = daily average temperature
EW = extremely wet
N = normal
W = wet

Pacific Lamprey Similar to the previous discussion of effects of late-summer augmentation flows, the effects of water temperatures associated with late-summer augmentation flows in the lower Klamath River under Alternative 1, compared to the No Action Alternative, are thought to be negligible for Pacific Lamprey.

Green Sturgeon Similar to the previous discussion of effects of late-summer augmentation flows, water temperatures associated with late-summer augmentation flows in the lower Klamath River under Alternative 1, compared to the No Action Alternative, are thought to be of potentially similar benefit to Green Sturgeon as for the anadromous salmonids.

Eulachon Similar to the previous discussion of effects of late-summer augmentation flows, water temperatures associated with late-summer augmentation flows in the lower Klamath River under Alternative 1, compared to the No Action Alternative, would not affect Eulachon.

Central Valley and Bay-Delta Region

Fish Habitat Conditions in the CVP and SWP Reservoirs

Changes in Black Bass Nesting Success The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir elevations) and anticipated changes in black bass nesting success.

Under Alternative 1, reservoir elevations would be similar (less than 1 percent difference) compared to the No Action Alternative. Therefore, there would be minimal changes in nesting success for Largemouth Bass, Smallmouth Bass, and Spotted Bass in Shasta Lake, Oroville Lake, and Folsom Lake (Tables 7-10 through 7-12). Whiskeytown Reservoir has 100 percent nesting success under all alternatives in all months for all species for both the No Action Alternative and Alternative 1.

Table 7-10. Black Bass Nesting Success in Percent Survival in Shasta Reservoir for the No Action Alternative and Alternative 1

Water Year Type	**March**		**April**		**May**		**June**	
	No Action	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**
Largemouth Bass								
Wet	100	0	100	0	100	0	41	0
AN	100	0	100	0	100	0	8	0
BN	100	0	100	0	100	0	7	0
Dry	100	0	100	0	100	0	1	0
Critical	100	0	85	2	50	1	0	0
All Years	100	0	100	0	100	0	8	0
Smallmouth Bass								
Wet	100	0	100	0	100	0	36	1
AN	100	0	100	0	100	0	10	0
BN	100	0	100	0	86	0	8	0
Dry	100	0	100	0	85	0	3	0
Critical	100	0	73	1	43	0	0	0
All Years	100	0	100	0	100	0	9	0
Spotted Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	61	0
BN	100	0	100	0	100	0	59	3
Dry	100	0	100	0	100	0	51	-5
Critical	100	0	100	0	100	0	18	2
All Years	100	0	100	0	100	0	61	0

Key:
Alt = Alternative
AN = Above Normal
BN = Below Normal

Table 7-11. Black Bass Nesting Success in Percent Survival in Oroville Reservoir for the No Action Alternative and Alternative 1

Water Year Type	**March**		**April**		**May**		**June**	
	No Action	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**
Largemouth Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	27	0
BN	100	0	100	0	100	0	0	0
Dry	100	0	100	0	100	0	0	0
Critical	100	0	100	0	100	0	0	0
All Years	100	0	100	0	100	0	9	0
Smallmouth Bass								
Wet	100	0	100	0	100	0	85	0
AN	100	0	100	0	100	0	25	0
BN	100	0	100	0	100	0	3	0
Dry	100	0	100	0	100	0	0	0
Critical	100	0	100	0	92	1	0	0
All Years	100	0	100	0	100	0	10	0
Spotted Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	87	0
BN	100	0	100	0	100	0	50	0
Dry	100	0	100	0	100	0	13	0
Critical	100	0	100	0	100	0	34	-4
All Years	100	0	100	0	100	0	62	0

Key:
Alt = Alternative
AN = Above Normal
BN = Below Normal

Table 7-12. Black Bass Nesting Success in Percent Survival in Folsom Reservoir for the No Action Alternative and Alternative 1

	March		**April**		**May**		**June**	
Water Year Type	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**	**No Action**	**Alt 1 (Difference from No Action)**
Largemouth Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	61	0
BN	100	0	100	0	100	0	50	0
Dry	100	0	100	0	100	0	20	0
Critical	100	0	100	0	100	0	22	-1
All Years	100	0	100	0	100	0	52	-1
Smallmouth Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	53	0
BN	100	0	100	0	100	0	44	0
Dry	100	0	100	0	100	0	19	0
Critical	100	0	100	0	100	0	21	-1
All Years	100	0	100	0	100	0	45	0
Spotted Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	100	0
BN	100	0	100	0	100	0	100	0
Dry	100	0	100	0	100	0	78	0
Critical	100	0	100	0	100	0	81	-1
All Years	100	0	100	0	100	0	100	0

Key:
Alt = Alternative
AN = Above Normal
BN = Below Normal

Changes in Cold Water Fish Habitat Changes in CVP and SWP water supplies and operations under Alternative 1, as compared to the No Action Alternative, generally would result in similar reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Changes in storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be less than 2 percent under Alternative 1 compared to the No Action Alternative, as summarized in Chapter 4, “Surface Water Supply and Management.” These minimal differences in reservoir storage in all water year types would result in minor, if any, changes to cold water fish habitat under Alternative 1 compared to the No Action Alternative.

Aquatic Habitat Conditions in Rivers Downstream from the CVP and SWP Reservoirs

Changes in Juvenile Chinook Salmon Production - SALMOD Output SALMOD results indicate that potential juvenile production under Alternative 1 would be the similar (less than 3 percent difference) to the No Action Alternative in all water year types for all runs of Chinook Salmon except for fall-run Chinook Salmon (Table 7-13).

There are 4 out of 12 critical water years in which production is decreased by more than 16 percent for fall-run Chinook Salmon. The overall average change in critical water years are over

5 percent, however the overall production in all water years decreased by less than 1 percent compared with the No Action Alternative.

Late fall-run Chinook Salmon, and steelhead through their similarity, experience production decreases by more than 10 percent in 2 out of 12 critical years and 2 out of 18 dry years. The overall average for critical and dry water years is less than 3 percent and 1 percent, respectively, and the overall change in production for all water year types is less than 1 percent compared to the No Action Alternative.

Winter-run Chinook Salmon experience a decrease in production by more than 7 percent in 3 of 12 critical water years, but experience a greater than 7 percent increase in production in 1 critical water year. The overall average decrease in critical water years is less than 2 percent, and the overall change in production for all water year types is less than 1 percent compared to the No Action Alternative.

Spring-run Chinook Salmon, which have a very low spawning population in the Sacramento River, could experience 100 percent mortality in 2 critical water years, however, that is compared with No Action Alternative productions of 10 and 32 juveniles. In 4 other critical water years, they could experience a decrease in production ranging from 7 to 64 percent relative to the No Action Alternative. In one critical year, they could experience an increase in production of nearly 24 percent compared to the No Action Alternative. Populations of 500 or more spawning Chinook Salmon are considered necessary for accurate results using SALMOD because it is a deterministic model that relies on the “law of large numbers.” When populations are *low* (an arbitrary term), mean responses are quickly affected by environmental stochasticity and individual variability.

Table 7-13. Juvenile Chinook Salmon Production Based on SALMOD Results for Alternative 1

Water Year Type	No Action Alternative (Average Production)	Alternative 1 (Difference from No Action)	Alternative 1 (Percent Change)
Fall-Run Chinook Salmon			
Critical	13,058,552	-745,197	-5.7
Dry	29,967,217	36,551	0.1
Below Normal	30,112,903	-194,033	-0.6
Above Normal	30,324,698	45,599	0.2
Wet	29,159,993	66,118	0.2
All Water Years	27,275,865	-99,746	-0.4
Late Fall-Run Chinook Salmon			
Critical	5,245,425	-114,999	-2.2
Dry	5,648,977	-42,391	-0.8
Below Normal	5,787,938	-5,749	-0.1
Above Normal	5,929,655	-22,349	-0.4
Wet	5,868,372	-11,305	0.0
All Water Years	5,720,957	-35,135	-0.2
Winter-Run Chinook Salmon			
Critical	2,382,579	-44,027	-1.8
Dry	3,327,324	-522	0.0
Below Normal	3,250,781	2,641	0.1
Above Normal	3,149,290	11,693	0.4
Wet	3,139,415	371	0.0
All Water Years	3,090,275	-4,441	-0.1
Spring-Run Chinook Salmon			
Critical	68,168	3,499	5.1
Dry	416,959	1,725	0.4
Below Normal	447,950	-1,628	-0.4
Above Normal	465,691	-574	-0.1
Wet	467,027	-739	-0.2
All Water Years	392,786	401	0.1

Changes in Winter-Run Chinook Salmon Production - Interactive Object-Oriented Simulation Output The IOS model predicted adult escapement trajectories for winter-run Chinook Salmon across the simulated water years. Under Alternative 1, average adult escapement was 6,513, and under the No Action Alternative, average escapement was 6,610. Adult escapement estimates were based on the water year type in the third year previous to the adult return, the assumed time for spawning, rearing and outmigration. Three of 11 critical, 2 of 19 dry, 1 out of 10 below normal, 2 out of 11 above normal, and 3 out of 25 wet water years would experience decreases greater than 6 percent under Alternative 1 relative to the No Action Alternative.

Similar to adult escapement, the IOS model predicted similar (less than 2 percent difference) egg survival, smolt production, and survival downstream from RBPP and in the Delta for winter-run Chinook Salmon between Alternative 1 and the No Action Alternative across the 81 water years (Table 7-14). However, Under Alternative 1, during critical years, fry-to-smolt survival would be affected, showing an average of 9 percent decrease in survival relative to the No Action Alternative, caused by 5 of the 12 years with significantly decreased survival.

Smolt production would be decreased by over 5 percent in critical years, but the overall smolt production for all simulated years would be less than 2 percent, less than production under the No Action Alternative. Most years in which the decreased survival occurred were years in which overall production was low (typically less than 1 million smolts).

Table 7-14. IOS Model Results for Winter-Run Chinook Salmon for Alternative 1

Water Year Type	No Action	Alternative 1	Alternative 1 (Percent Change)
Adult Escapement			
Critical	4,806	4,741	-1
Dry	6,772	6,697	-1
Below Normal	5,249	5,229	0
Above Normal	5,426	5,304	-2
Wet	8,887	8,728	-2
All Water Years	6,793	6,691	-1
Egg Survival			
Critical	0.55	0.54	-1.8
Dry	0.99	0.99	0
Below Normal	0.98	0.98	0
Above Normal	0.99	0.99	0
Wet	0.99	0.99	-0.1
All Water Years	0.92	0.92	0
Fry-to-Smolt Survival			
Critical	0.48	0.44	-8.6
Dry	0.93	0.93	0.1
Below Normal	0.93	0.93	0
Above Normal	0.94	0.94	0
Wet	0.93	0.93	0
All Water Years	0.87	0.86	-0.7
Smolt Production			
Critical	3,568,552	3,384,779	-5.1
Dry	6,143,220	6,103,382	-0.6
Below Normal	5,329,551	5,326,125	-0.1
Above Normal	4,466,911	4,339,296	-2.9
Wet	6,916,239	6,789,627	-1.8
All Water Years	5,600,444	5,504,896	-1.7
Red Bluff Pumping Plant to Delta Survival			
Critical	0.24	0.24	0.1
Dry	0.24	0.24	0.0
Below Normal	0.23	0.23	0.0
Above Normal	0.24	0.24	0.0
Wet	0.23	0.23	0.0
All Water Years	0.23	0.23	0.0
Delta Survival			
Critical	0.32	0.32	0.1
Dry	0.40	0.40	0.0
Below Normal	0.41	0.41	0.0
Above Normal	0.38	0.38	0.0
Wet	0.40	0.40	0.0
All Water Years	0.39	0.39	0.0

Changes in Water Temperature Long-term daily average monthly water temperature in Clear Creek at Igo and in the Sacramento River downstream from Clear Creek, at Balls Ferry, Jellys Ferry, and Bend Bridge under Alternative 1 would generally be similar to (less than 0.5°F difference) to water temperatures under the No Action Alternative (See Chapter 5, "Surface Water Quality"). The exception to this would occur in September of critical water years on the Sacramento River downstream from Clear Creek, Balls Ferry, and Jellys Ferry, where average water temperatures could increase by 0.5 ºF to 0.6ºF.

Changes in Exceedances of Water Temperature Thresholds Average monthly water temperatures from May through October under both the No Action Alternative and Alternative 1 exceed the water temperature threshold of 56°F in the Sacramento River below Clear Creek less than 14 percent of the time. In the Sacramento River at Balls Ferry for winter-run and spring-run Chinook Salmon spawning and egg incubation, the water temperature threshold would be exceeded by 22 percent of the time under both the No Action Alternative and Alternative 1. Water temperature thresholds would be exceeded nearly 40 percent of the months with designated thresholds under the No Action Alternative and Alternative 1 at Jellys Ferry. At Bend Bridge, the frequency of exceedances would be similar under Alternative 1 (62 percent) to the No Action Alternative (61 percent). The difference between the No Action Alternative and Alternative 1 is less than 1 percent. While there are minimal differences in meeting the water temperature thresholds, the slight increase in water tempareture exceedence is sufficient to result in the differences shown for the modeling results in SALMOD and IOS.

Average monthly water temperatures in Clear Creek at Igo between June and September exceed the 60°F threshold under both the No Action Alternative and Alternative 1, less than 1 percent of the time. The September to October threshold of 56°F would be exceeded by 12 percent under the No Action Alternative, and less than 10 percent under Alternative 1.

Changes in Weighted Usable Area As described above for the assessment methodology, WUA is a function of flow, but the relationship is not linear due to differences in depths and velocities present in the wetted channel at different flows. Because the combination of depths, velocities, and substrates preferred by species and life stages varies, WUA values at a given flow can differ substantially for the life stages evaluated.

As an indicator of the amount of suitable habitat for winter-run Chinook Salmon, fall-run Chinook Salmon, late fall-run Chinook Salmon, and steelhead between Keswick Dam and Battle Creek, flows in the Sacramento River below Keswick Dam indicate that, in general, there would be similar amounts of spawning habitat, suitable fry rearing habitat, and suitable juvenile rearing habitat under Alternative 1 and the No Action Alternative (less than 1 percent difference).

Based on the simulated flows, WUA values for spring-run Chinook Salmon, fall-run Chinook Salmon, and steelhead in Clear Creek are similar, with a less than 1 percent difference in WUA between Alternative 1 and the No Action Alternative, for spawning, fry rearing, and juvenile rearing habitat.

The amount of suitable spawning habitat, fry rearing habitat, and juvenile rearing habitat would be similar, less than 1 percent difference, between Alternative 1 and the No Action Alternative for fall-run Chinook Salmon and steelhead in the lower Feather River and the lower American River.

Fish Habitat Conditions in Bay-Delta

Changes in Delta Hydrodynamics Under Alternative 1, Delta outflow would be similar (less than 1 percent difference) to the No Action Alternative (See Chapter 4, "Surface Water Supply and Management").

The OMR flows would be similar in almost all months between Alternative 1 and the No Action Alternative, with the long-term average ranging from -6,219 to 914 cfs (compared with -6,217 to 914 cfs under the No Action Alternative) from December through June under Alternative 1 (See Chapter 4, "Surface Water Supply and Management"). In June of critical water years, there was a 7 percent increase in negative flows (a change from -1,414 cfs under No Action Alternative to -1,512 cfs under Alternative 1). This change, however, is substantially below the -5,000 cfs criteria, and therefore, does not result in an adverse effect to Delta fishes.

As a result, Delta fishes, including Delta Smelt, Longfin Smelt, all runs of Chinook Salmon, steelhead, and Green Sturgeon would not be affected by the implementation of the action resulting from a change in Delta hydrodynamics.

Changes in X2 Location Overall, the quantitative results from the numerical models suggest that operation under the Alternative 1 would result in a less than 1 percent change in the X2 location, relative to the No Action Alternative in all months and all water year types. Implementing Alternative 1 would not affect fish habitat resulting from the placement of X2.

Trinity River Record of Decision Flow Rescheduling Alternative (Alternative 2)

As described in Chapter 3, "Considerations for Describing Affected Environment and Enviromental Consequences," Alternative 2 is compared to the No Action Alternative.

Lower Klamath and Trinity River Region

Changes in CVP Reservoir Storage and Surface Elevations Alternative 2 would reschedule a portion of the spring/early-summer component of the Trinity River ROD flows for release in the late-summer, as compared to the No Action Alternative. This would result in some lower end-of-year reservoir storage in Trinity Lake, (see Chapter 4, "Surface Water Supply"). However, end-of-year storage in Trinity Lake would decrease by no more than 2 percent in any water year type compared to the No Action Alternative. Monthly storage in Trinity Lake would increase during the spring and early summer months from May to July by up to 1 to 4 percent, except in extremely wet years when it could be 1 to 2 percent less than the No Action Alternative. Additional information related to the CalSim II and DSM2 modeling used to generate monthly reservoir elevations is provided in the Analytical Tools Technical Appendix.

Using Trinity Lake storage as an indicator of habitat available to fish species inhabiting the reservoir, the amount of habitat for reservoir fishes would generally be similar in most months, except for increases in May through July of normal and drier water years, decreases of up to 2 percent in September of dry water years, and decreases of up to 2 percent in most months of extremely wet water years, under Alternative 2 as compared to the No Action Alternative.

As shown in Figures 7-3 through 7-5, nest survival for all the three black bass species in Trinity Lake would be somewhat greater under Alternative 2 as compared to the No Action or Alternative 1. The likelihood of nest survival of 40 percent or greater for Largemouth Bass and Smallmouth Bass could increase by up to 2 percent. Spotted Bass nesting success would be 40 percent or greater nearly 100 percent of the time under all alternatives.

Overall, the comparison of storage and the analysis of nesting suggest that effects of Alternative 2 on reservoir fishes in Trinity Lake would be largely similar to those under the No Action Alternative, with a potential for modestly higher springtime nesting success rates for Largemouth and Smallmouth Bass.

Aquatic Habitat Conditions in the Lower Klamath and Trinity Rivers

Changes in Trinity River Flows During the Late Summer

<u>Chinook Salmon, Coho Salmon, and Steelhead</u> The Lewiston Dam late-summer augmentation flow releases under Alternative 2 are the same as described for Alternative 1. Accordingly, similar changes compared to the No Action Alternative, would be expected under Alternative 2 in terms of (1) the extent of the river downstream of Lewiston Dam providing suitable habitat and water temperatures for rearing juvenile salmonids, (2) the potential risks of overtopping riverside riparian berms and subsequent stranding of juvenile salmonids during downramping after the augmentation flow period, and (3) the potential for interrupting spawning and dewatering redds of spring-run Chinook Salmon.

<u>Pacific Lamprey</u> Adult Pacific Lamprey migrate into the Klamath-Trinity River basin tributaries from spring through summer before spawning the following winter and spring. Juvenile lamprey larvae (ammocoetes) rear year-round in the mainstem Trinity River and its tributaries in low-velocity pools and channel margins with a dominant substrate of fine silt, sand, or small gravels (USFWS 2010). Increased late-summer augmentation flows may cause increased water velocities and disturbance of fine sediments along the summer baseflow channel where lamprey ammocoetes are living. Because the range of augmentation flows under Alternative 2 would be within the typical range of annual fluctuations in the upper Trinity River, which lampreys experience over their freshwater juvenile life stage, it is expected that juvenile lampreys will redistribute to other areas of suitable habitat over the course of the augmentation flow cycle, if disturbed by higher water velocities.

Changes in Trinity River Water Temperatures in Late Summer through Fall

<u>Chinook Salmon, Coho Salmon, and Steelhead</u> The potential changes to water temperatures during the late-summer and fall in the upper Trinity River under Alternative 2 compared to the No Action Alternative would be different from that of Alternative 1 because Alternative 2 would reschedule the spring/early summer component of the Trinity River ROD flow release schedule to provide additional late-summer flow releases from Lewiston Dam.

The mean and range of DATs during the July through September period at Douglas City would be generally similar, with a reduction in potential number of days exceeding optimal temperature thresholds in any one year for pre-spawning adult spring-run Chinook Salmon under Alternative 2. During the latter half of September as spawning begins, DATs would be similar between Alternative 2 and the No Action Alternative, with potentially fewer exceedances under Alternative 2 in dry and critically dry years (Table 7-15). After October 1 through the end of

December, when spring- and fall-run Chinook Salmon and Coho Salmon are spawning in the upper Trinity River, the mean and range of DATs down to the North Fork Trinity River confluence are similar between Alternative 2 and the No Action Alternative, with a minor increase in the number of days exceeding optimal spawning temperatures in dry and and critically dry years (Table 7-16); however, in such instances, much of the reach upstream of the North Fork Trinty River would likely experience cooler temperatures approaching and meeting the objective of ≤ 56°F.

Table 7-15. Changes in Daily Average Water Temperatures Compared to NCRWQCB Temperature Objectives for Lewiston Dam to Douglas City Under the No Action Alternative and Alternative 2

Year	**Water Year Type**	**7/1 to 9/14** **≤ 60°F Average; (Range); [# days]**		**9/15 to 9/30** **≤ 56°F Average; (Range); [# days]**	
		No Action	**Alternative 2**	**No Action**	**Alternative 2**
1980	W	52 (49-55) [0]	52 (49-55) [0]	50 (49-51) [0]	50 (49-51) [0]
1981	**D**	**52 (51-55) [0]**	**52 (51-54) [0]**	**51 (51-53) [0]**	**52 (51-52) [0]**
1982	EW	52 (49-54) [0]	52 (49-54) [0]	50 (48-50) [0]	50 (48-50) [0]
1983	EW	53 (50-56) [0]	53 (50-56) [0]	52 (52-53) [0]	52 (52-53) [0]
1984	W	54 (52-56) [0]	54 (52-56) [0]	52 (51-54) [0]	52 (51-54) [0]
1985	**D**	**53 (52-54) [0]**	**53 (52-54) [0]**	**53 (52-53) [0]**	**53 (52-53) [0]**
1986	**W**	**51 (50-53) [0]**	**51 (50-53) [0]**	**50 (49-50) [0]**	**50 (49-50) [0]**
1987	**D**	**53 (51-55) [0]**	**53 (51-54) [0]**	**54 (54-55) [0]**	**54 (53-55) [0]**
1988	**D**	**54 (53-56) [0]**	**54 (52-55) [0]**	**53 (52-55) [0]**	**53 (52-54) [0]**
1989	**N**	**54 (51-56) [0]**	**54 (52-56) [0]**	**55 (54-56) [0]**	**54 (54-55) [0]**
1990	**D**	**56 (55-58) [0]**	**56 (55-58) [0]**	**56 (56-57) [7]**	**56 (55-57) [6]**
1991	**CD**	**59 (55-62) [33]**	**58 (55-61) [12]**	**59 (58-60) [15]**	**58 (56-59) [15]**
1992	**D**	**55 (53-57) [0]**	**55 (53-57) [0]**	**56 (55-56) [5]**	**55 (55-56) [1]**
1993	W	55 (51-61) [1]	55 (51-61) [2]	53 (53-55) [0]	54 (53-55) [0]
1994	**CD**	**55 (54-56) [0]**	**54 (53-56) [0]**	**55 (55-56) [0]**	**55 (54-56) [0]**
1995	**EW**	**56 (50-61) [6]**	**55 (50-60) [6]**	**50 (49-51) [0]**	**51 (50-52) [0]**
1996	**W**	**54 (51-57) [0]**	**54 (51-56) [0]**	**52 (52-53) [0]**	**52 (52-53) [0]**
1997	**W**	**53 (50-54) [0]**	**53 (50-54) [0]**	**52 (51-53) [0]**	**52 (51-53) [0]**
1998	EW	53 (50-56) [0]	53 (50-56) [0]	51 (50-52) [0]	51 (50-52) [0]
1999	W	54 (50-59) [0]	53 (51-55) [0]	52 (52-53) [0]	52 (52-53) [0]
2000	**W**	**53 (51-55) [0]**	**53 (51-55) [0]**	**53 (52-54) [0]**	**53 (52-54) [0]**
2001	**D**	**55 (54-56) [0]**	**54 (53-56) [0]**	**55 (54-55) [0]**	**55 (54-56) [0]**
2002	**N**	**53 (51-54) [0]**	**52 (50-54) [0]**	**52 (51-53) [0]**	**52 (51-52) [0]**
2003	**EW**	**53 (51-57) [0]**	**53 (50-57) [0]**	**51 (51-52) [0]**	**51 (51-52) [0]**
Summary of Differences		**Difference in DAT Mean (range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (range)**	**Difference in Number of Exceedances**
Flow Augmentation		-0.3°F (0 to -1.4°F)	-21	-0.2°F (0.5 to -1.3°F)	-5
No Flow Augmentation		0°F (0.1 to 0°F)	+1	0°F (0.2 to 0°F)	0

Notes:

Averages are calculated for a 24-year period for the critical summer and fall reproductive periods for Trinity River spring- and fall-run Chinook Salmon and Coho Salmon

Water temperature management objectives for the Trinity River at Douglas City for protection of anadromous salmon freshwater life stages are shown for each period.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 2.

Key:

CD = critically dry
D = dry
DAT = daily average temperature
EW = extremely wet
N = normal
NCRWQCB = North Coast Regional Water Quality Control Board
W = wet

Table 7-16. Changes in Daily Average Water Temperatures Compared to NCRWQCB Temperature Objectives for Lewiston Dam to North Fork Trinity River Confluence Under the No Action Alternative and Alternative 2

Year	**Water Year Type**	**10/1 to 12/31** **≤ 56°F Average; (Range); [# days]**	**10/1 to 12/31** **≤ 56°F Average; (Range); [# days]**
		No Action	**Alternative 2**
1980	W	49 (42-59) [10]	49 (42-59) [10]
1981	**D**	**49 (42-57) [1]**	**49 (42-57) [3]**
1982	EW	47 (41-56) [1]	47 (41-56) [1]
1983	EW	49 (42-56) [7]	49 (42-56) [7]
1984	W	46 (40-57) [1]	46 (40-57) [1]
1985	**D**	**49 (43-61) [9]**	**49 (43-61) [9]**
1986	**W**	**49 (44-56) [2]**	**49 (44-56) [2]**
1987	**D**	**50 (41-62) [23]**	**51 (41-62) [27]**
1988	**D**	**50 (40-60) [22]**	**50 (40-60) [24]**
1989	**N**	**51 (44-59) [20]**	**50 (44-59) [20]**
1990	**D**	**50 (42-62) [11]**	**50 (42-62) [12]**
1991	**CD**	**51 (44-65) [22]**	**50 (43-65) [22]**
1992	**D**	**51 (40-61) [26]**	**51 (40-60) [19]**
1993	W	49 (42-61) [10]	49 (42-61) [12]
1994	**CD**	**49 (41-61) [14]**	**49 (41-61) [15]**
1995	**EW**	**49 (41-55) [0]**	**49 (41-56) [0]**
1996	**W**	**49 (42-59) [11]**	**49 (42-59) [11]**
1997	**W**	**48 (41-57) [1]**	**48 (41-57) [1]**
1998	EW	47 (39-57) [1]	47 (39-57) [1]
1999	W	49 (43-57) [8]	49 (43-57) [8]
2000	**W**	**49 (44-58) [9]**	**49 (44-58) [9]**
2001	**D**	**50 (41-61) [19]**	**50 (41-62) [21]**
2002	**N**	**49 (41-58) [6]**	**50 (41-60) [15]**
2003	**EW**	**NA**	**NA**
Summary of Differences		**Difference in DAT Mean (Range)**	**Difference in No. Exceedances**
Flow Augmentation Years		0.1°F (0.6 to -0.4°F)	+14
Non-Augmentation Years		0°F (0.1 to 0°F)	+2

Notes:

Averages are calculated for a 24-year period for the critical summer and fall reproductive periods for Trinity River spring- and fall-run Chinook Salmon and Coho Salmon

Water temperature management objective for the Trinity River at the North Fork Trinity River confluence for protection of anadromous salmon freshwater life stages is shown for each period.

Years in bold font indicate representative years modeled with augmentation of late-summer flows for Alternative 2.

Key:
CD = critically dry
D = dry
DAT = daily average temperature
EW = extremely wet
N = normal
NCRWQCB = North Coast Regional Water Quality Control Board
W = wet

Pacific Lamprey The temperature requirements and preferences of Pacific Lamprey and other lamprey species inhabiting the Klamath-Trinity River basin tributaries overlaps that of the sympatric anadromous salmonid species, but they are tolerant of somewhat warmer temperatures during the freshwater and reproductive lifestages (Moyle 2002). Given the relative similarity of the water temperatures, with minor differences in magnitude of the ranges in DATs, it is likely that the effects on Pacific Lampreys and other lamprey species would be similar for Alternative 2 and the No Action Alternative.

Changes in Trinity River Spring Flow Release Patterns

Chinook Salmon, Coho Salmon, and Steelhead Alternative 2 would operate Lewiston Dam releases according to a rescheduling of the Trinity River ROD flow release schedules in all water year types, as described in Chapter 2, "Description of Alternatives." The primary effect of rescheduling Trinity River ROD releases would be an acceleration of the descending limb component of the managed hydrograph in May and June of all water year types, and a reduction in duration of the critically dry year peak flow by about 14 days.

The functional flow-related fish habitat management objectives of the descending limb of the hydrograph vary by water year, but are primarily intended to provide optimal water temperatures (during normal and wetter water years) or suitable to marginal water temperatures (during dry and critically dry water years) for juvenile salmonid growth and survival and a gradual seasonal warming cue, as flows recede, for outmigrating smolts (see Table 7-2). The critically dry year peak flow is intended to inundate the flanks and high ends of alluvial bars and provide non-lethal water temperatures for steelhead and Coho Salmon until the latter half of May. Flow recession rates are intended to provide for a gradual warming of the river and minimize risk of stranding of salmon fry in side-channels and upper bar and floodplain areas.

Habitat availability high up on alluvial bars that is used by juvenile salmonids for rearing, particularly fry, would be reduced under Alternative 2 compared to the No Action Alternative, for about two weeks in critically dry years. Flow recession rates during the descending limb of the hydrograph would be somewhat faster in all years, but would remain gradual enough to allow for fish to move from side-channels and off-channel areas into the main river channel as flow declines.

Changes in Trinity River Water Temperatures During Spring Flow Releases

Chinook Salmon, Coho Salmon, and Steelhead The potential changes to water temperatures during the spring/early-summer in the Trinity River, below Lewiston Dam to its confluence with the Klamath River at Weitchpec, under Alternative 2 compared to the No Action Alternative would be different from that of Alternative 1, because Alternative 2 includes rescheduling the spring/early summer component of the Trinity River ROD flow release schedule to provide additional late-summer flow releases from Lewiston Dam. This operation would reduce flows more rapidly in the spring and early summer, which could affect water temperatures throughout the length of the river.

The mean and range of DATs during the spring/early-summer period at the North Fork Trinity River confluence (on downstream to Weitchpec) are somewhat higher for Alternative 2 compared to the No Action Alternative (Tables 7-17 and 7-18), particularly during critically dry years, when the greatest differences from the Trinity River ROD flow schedule would occur. The number of days of additional exceedances of temperature management criteria would increase at the North Fork Trinty River confluence in late May and June, and from mid-April through early-July at Weitchpec, though most of the additional exceedances occur during dry and critically dry years. Maximum differences in DATs between Alternative 2 and the No Action Alternative during periods when exceedances occur could be up to about 3°F at the North Fork Trinity confluence, and about 2°F at Weitchpec. Optimal and marginally-suitable temperature conditions for juvenile Chinook Salmon, Coho Salmon, and steelhead growth and outmigration survival would be of shorter duration, especially in the lower reaches of the Trinity River during dry and critically dry water years.

Table 7-17. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives Near the North Fork Trinity River Confluence Under the No Action Alternative and Alternative 2

		4/15 to 5/22 **≤ 55.4° for N, W, & EW** **≤ 59°F for D & CD WYs** **Average; (Range); [# days]**		**5/23 to 6/4** **≤ 59°F for N, W, & EW** **≤ 62.6°F for D, CD** **Average; (Range); [# days]**		**6/5 to 7/9** **≤ 62.6°F for N, W, & EW** **Average; (Range); [# days]**	**6/5 to 6/15** **≤ 62.6°F for D, CD**
Year	**Water Year Type**	**No Action**	**Alternative 2**	**No Action**	**Alternative 2**	**No Action**	**Alternative 2**
1980	W	51 (47-56) [2]	51 (47-56) [2]	48 (46-51) [0]	48 (46-51) [0]	55 (49-57) [0]	55 (51-57) [0]
1981	**D**	**52 (49-57) [0]**	**53 (49-57) [0]**	**58 (54-60) [0]**	**58 (54-61) [0]**	**60 (57-62) [1]**	**60 (58-62) [1]**
1982	EW	51 (45-53) [0]	51 (45-53) [0]	47 (46-48) [0]	47 (46-48) [0]	52 (47-56) [0]	52 (47-56) [0]
1983	EW	49 (45-56) [1]	49 (45-56) [1]	53 (51-55) [0]	53 (51-54) [0]	55 (52-58) [0]	55 (51-58) [0]
1984	W	51 (47-54) [0]	51 (47-54) [0]	51 (49-53) [0]	51 (49-53) [0]	57 (51-60) [0]	57 (51-60) [0]
1985	**D**	**53 (50-57) [0]**	**53 (50-58) [0]**	**55 (52-57) [0]**	**56 (52-58) [0]**	**61 (56-65) [0]**	**61 (56-66) [1]**
1986	**W**	**50 (46-55) [0]**	**50 (46-55) [0]**	**51 (48-55) [0]**	**51 (48-55) [0]**	**56 (53-58) [0]**	**56 (53-58) [0]**
1987	**D**	**54 (49-60) [1]**	**55 (49-60) [1]**	**56 (53-59) [0]**	**56 (53-59) [0]**	**60 (58-62) [0]**	**60 (58-63) [0]**
1988	**D**	**52 (47-57) [0]**	**52 (47-58) [0]**	**56 (53-58) [0]**	**56 (53-58) [0]**	**55 (51-62) [2]**	**55 (51-62) [3]**
1989	**N**	**52 (49-59) [7]**	**52 (49-59) [7]**	**52 (48-56) [0]**	**53 (48-57) [0]**	**58 (53-59) [0]**	**58 (53-59) [0]**
1990	**D**	**53 (50-58) [0]**	**54 (50-58) [0]**	**52 (49-56) [0]**	**52 (49-56) [0]**	**60 (56-62) [0]**	**60 (56-62) [0]**
1991	**CD**	**54 (49-58) [0]**	**54 (49-59) [0]**	**58 (53-60) [0]**	**60 (55-62) [0]**	**63 (60-65) [0]**	**66 (62-68) [0]**
1992	**D**	**53 (50-58) [0]**	**54 (50-58) [0]**	**59 (55-63) [1]**	**60 (56-64) [2]**	**61 (55-63) [3]**	**61 (56-64) [5]**
1993	W	50 (47-53) [0]	50 (47-53) [0]	49 (48-50) [0]	49 (48-51) [0]	56 (49-59) [0]	56 (49-59) [0]
1994	**CD**	**56 (50-60) [7]**	**56 (50-60) [7]**	**59 (58-61) [0]**	**62 (59-65) [5]**	**60 (56-63) [0]**	**63 (57-66) [0]**
1995	**EW**	**49 (45-53) [0]**	**49 (45-53) [0]**	**48 (48-50) [0]**	**48 (47-49) [0]**	**53 (48-59) [0]**	**53 (48-59) [0]**
1996	**W**	**51 (47-55) [0]**	**51 (47-55) [0]**	**51 (47-54) [0]**	**51 (47-55) [0]**	**57 (53-60) [0]**	**57 (53-60) [0]**
1997	**W**	**52 (47-55) [0]**	**52 (47-55) [0]**	**50 (47-54) [0]**	**50 (47-54) [0]**	**56 (53-58) [0]**	**56 (53-58) [0]**
1998	EW	51 (46-55) [0]	51 (46-55) [0]	48 (45-53) [0]	48 (45-53) [0]	55 (52-57) [0]	55 (53-57) [0]
1999	W	51 (48-56) [3]	51 (48-56) [3]	52 (50-53) [0]	52 (50-53) [0]	56 (52-60) [0]	57 (52-60) [0]
2000	**W**	**51 (47-55) [0]**	**51 (47-55) [0]**	**52 (51-53) [0]**	**52 (51-53) [0]**	**57 (52-60) [0]**	**57 (52-60) [0]**
2001	**D**	**55 (49-60) [3]**	**55 (49-60) [3]**	**59 (57-63) [0]**	**60 (57-63) [1]**	**60 (58-62) [0]**	**60 (58-63) [0]**
2002	**N**	**51 (47-57) [3]**	**51 (47-57) [3]**	**53 (50-57) [0]**	**54 (50-58) [0]**	**57 (55-59) [0]**	**57 (55-59) [0]**
2003	**EW**	**50 (46-53) [0]**	**50 (46-53) [0]**	**49 (48-51) [0]**	**49 (48-51) [0]**	**54 (50-58) [0]**	**54 (51-58) [0]**

Table 7-17. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives Near the North Fork Trinity River Confluence Under the No Action Alternative and Alternative 2 (contd.)

Summary of Differences	**4/15 to 5/22** **Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**5/23 to 6/4** **Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**6/5 to 7/9** **Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**
Flow Augmentation	0.2°F (0.5 to 0°F)	0	0.6°F (2.8 to -0.1°F)	+7	0.5°F (2.5 to 0°F)	+4
No Flow Augmentation	0°F (--)	0	0.1°F (0.2 to 0°F)	0	0°F (03 to -0.3°F)	0

Notes:

Averages are calculated for a 24-year period for the critical spring and early summer rearing and outmigration periods for Trinity River anadromous salmonids

Water temperature management objectives for the Trinity River from Lewiston Dam to Weitchpec for protection of anadromous salmon freshwater life stages are shown for each period.

Years in **bold** font indicate representative years modeled with augmentation of late-summer flows for Alternative 1

Key:

CD = critically dry water year
D = dry water year
DAT = daily average temperature
EW = extremely wet water year
N = normal water year
W = wet

Table 7-18. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives for Lewiston Dam to Weitchpec Under the No Action Alternative and Alternative 2

		4/15 to 5/22 ≤ 55.4° for N, W, & EW ≤ 59°F for D & CD WYs Average; (Range); [# days]		**5/23 to 6/4 ≤ 59°F for N, W, & EW ≤ 62.6°F for D, CD Average; (Range); [# days]**		**6/5 to 7/9 ≤ 62.6°F for N, W, & EW Average; (Range); [# days]**	**6/5 to 6/15 ≤ 62.6°F for D, CD**
Year	**Water Year Type**	**No Action**	**Alternative 2**	**No Action**	**Alternative 2**	**No Action**	**Alternative 2**
1980	W	55 (51-60) [24]	55 (51-60) [24]	52 (49-55) [0]	52 (49-56) [0]	61 (54-64) [10]	61 (55-64) [10]
1981	**D**	**56 (52-60) [4]**	**56 (53-60) [4]**	**63 (58-66) [8]**	**64 (59-67) [9]**	**65 (62-67) [0]**	**66 (62-67) [0]**
1982	EW	55 (47-58) [23]	55 (47-58) [23]	52 (50-54) [0]	52 (50-54) [0]	59 (51-63) [1]	59 (51-63) [1]
1983	EW	52 (47-61) [7]	52 (47-61) [7]	59 (57-61) [8]	59 (57-61) [8]	61 (58-64) [3]	61 (57-64) [3]
1984	W	53 (50-59) [4]	53 (50-59) [4]	56 (53-59) [0]	57 (53-59) [1]	63 (55-68) [24]	63 (55-68) [24]
1985	**D**	**56 (51-62) [4]**	**56 (51-63) [6]**	**60 (57-62) [0]**	**61 (57-64) [5]**	**67 (61-72) [5]**	**68 (61-72) [5]**
1986	**W**	**53 (50-58) [7]**	**53 (50-58) [7]**	**57 (51-61) [4]**	**57 (51-62) [5]**	**63 (60-65) [20]**	**63 (60-65) [20]**
1987	**D**	**59 (53-64) [18]**	**60 (53-64) [19]**	**61 (57-67) [3]**	**61 (58-67) [3]**	**68 (66-70) [4]**	**69 (67-71) [6]**
1988	**D**	**55 (49-62) [3]**	**56 (49-63) [3]**	**60 (57-64) [2]**	**61 (57-64) [5]**	**58 (55-66) [0]**	**59 (55-65) [0]**
1989	**N**	**57 (52-64) [19]**	**57 (52-64) [19]**	**57 (52-63) [3]**	**57 (52-63) [3]**	**64 (58-66) [30]**	**64 (58-66) [32]**
1990	**D**	**57 (53-62) [9]**	**57 (53-62) [9]**	**54 (53-58) [0]**	**54 (53-58) [0]**	**64 (58-65) [0]**	**64 (58-66) [0]**
1991	**CD**	**56 (52-60) [1]**	**56 (52-61) [1]**	**61 (58-63) [2]**	**62 (60-64) [3]**	**67 (63-69) [4]**	**69 (64-71) [7]**
1992	**D**	**58 (56-62) [10]**	**59 (56-62) [17]**	**65 (60-70) [12]**	**66 (61-70) [12]**	**67 (60-70) [7]**	**68 (61-71) [7]**
1993	W	54 (51-57) [10]	54 (51-57) [10]	55 (54-57) [0]	55 (54-57) [0]	63 (54-66) [23]	63 (54-66) [23]
1994	**CD**	**59 (53-65) [18]**	**60 (53-65) [19]**	**65 (61-66) [12]**	**67 (62-69) [12]**	**66 (62-70) [4]**	**69 (64-72) [7]**
1995	**EW**	**53 (47-58) [5]**	**53 (47-58) [5]**	**54 (53-55) [0]**	**54 (53-55) [0]**	**59 (53-67) [14]**	**59 (53-67) [14]**
1996	**W**	**54 (49-59) [14]**	**54 (49-59) [14]**	**55 (52-60) [1]**	**55 (52-60) [1]**	**63 (59-67) [20]**	**63 (59-67) [20]**
1997	**W**	**57 (52-62) [28]**	**57 (52-62) [28]**	**54 (51-59) [1]**	**55 (51-59) [1]**	**62 (57-65) [16]**	**62 (58-65) [16]**
1998	EW	55 (47-60) [18]	55 (47-60) [18]	51 (47-57) [0]	51 (47-57) [0]	61 (57-65) [5]	61 (57-65) [6]
1999	W	54 (49-60) [10]	54 (49-60) [10]	58 (55-59) [2]	58 (56-59) [3]	62 (55-66) [20]	62 (55-66) [23]
2000	**W**	**54 (50-57) [8]**	**54 (50-57) [8]**	**57 (55-58) [0]**	**57 (55-58) [0]**	**63 (58-67)[20]**	**63 (58-67) [20]**
2001	**D**	**58 (52-65) [13]**	**58 (52-66) [15]**	**65 (63-67) [13]**	**66 (64-68) [13]**	**65 (63-68) [0]**	**66 (64-69) [0]**
2002	**N**	**54 (51-60) [12]**	**54 (51-60) [12]**	**59 (54-62) [6]**	**59 (54-63) [6]**	**64 (61-66) [30]**	**64 (61-66) [32]**
2003	**EW**	**52 (48-55) [0]**	**52 (48-55) [0]**	**54 (52-56) [0]**	**54 (52-56) [0]**	**60 (55-65) [12]**	**60 (56-65) [13]**

Table 7-18. Change in Daily Average Water Temperatures Compared to Spring-Time Temperature Objectives for Lewiston Dam to Weitchpec under the No Action Alternative and Alternative 2 (contd.)

	4/15 to 5/22		**5/23 to 6/4**		**6/5 to 7/9**	
Summary of Differences	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**	**Difference in DAT Mean (Range)**	**Difference in Number of Exceedances**
Flow Augmentation	0.2°F (0.5 to 0°F)	+13	0.5°F (2.2 to 0°F)	+10	0.5°F (2.4 to 0°F)	+13
No Flow Augmentation	0°F (--)	0	0.1°F (0.2 to 0°F)	+2	0.1°F (0.2 to -0.2°F)	+4

Notes:

Averages are calculated for a 24-year period for the critical spring and early summer rearing and outmigration periods for Trinity River anadromous salmonids

Water temperature management objectives for the Trinity River from Lewiston Dam to Weitchpec for protection of anadromous salmon freshwater life stages are shown for each period.

Years in **bold** font indicate representative years modeled with augmentation of late-summer flows for Alternative 1

Key:

CD = critically dry water year	EW = extremely wet water year
D = dry water year	N = normal water year
DAT = daily average temperature	W = wet

Pacific Lamprey The temperature requirements and preferences of Pacific Lamprey and other lamprey species inhabiting the Klamath-Trinity River basin tributaries overlaps that of the sympatric anadromous salmonid species, but is generally somewhat broader during the freshwater and reproductive lifestages (Moyle 2002). Therfore, effects of Alternative 2 on lamprey compared to the No Action Alternative would be similar or less than those described for anadromous salmonids.

Changes in Late Summer Flows in the Lower Klamath River Below the Trinity River Confluence

Chinook Salmon, Coho Salmon, and Steelhead Alternative 2 would release additional late-summer flows from Lewiston Dam on the Trinity River to augment flows in the lower Klamath River, to reduce the potential risk and severity of Ich infection and epizootics that could lead to fish die-offs, in a manner similar to that described for Alternative 1. The same preventative base flow of 2,800 cfs, and the preventative and emergency pulse flows of 5,000 cfs, would be achieved under Alternative 2. Accordingly, the same potential to affect conditions that result in some level of reduced risk of Ich infection, epizootic outbreaks and consequent fish die-offs could occur under Alternative 2. These include: increases in cross-sectional channel area to expand habitat space, increased water velocities that can reduce efficacy of Ich parasites from finding and attaching to adult salmon hosts, and potentially provide migration cues to further disperse adult salmon and reduce densities in the lower Klamath River. In addition, reduction in the frequency of year-to-year parasite carryover effect may be reduced.

Pacific Lamprey Although, Pacific Lamprey may migrate into the Klamath River from spring through summer, few are thought to reside in the lower Klamath River during the late-summer. No lampreys were reported among the fish that died in the 2002 mass fish mortality event (DFG 2004). The effects on Pacific Lamprey of Alternative 2, compared to the No Action Alternative, are thought to be negligible.

Green Sturgeon Green Sturgeon, including both northern DPS that spawn in the Klamath and Trinity Rivers, and southern DPS that may move into the Klamath River estuary to forage, may occur in the lower Klamath River during the late-summer. Some Green Sturgeon were reported among the fish that died in the 2002 mass fish mortality event (DFG 2004). The effects on Green Sturgeon of Alternative 2, compared to the No Action Alternative, are thought to be of potentially similar benefit as for the anadromous salmonids.

Eulachon It is unclear whether this species has been extirpated from the Klamath River. However, Eulachon are reported to spawn in the lower Klamath River, up to 7 miles inland, during March through May, with the larvae washing out through the estuary to the ocean by June. Therefore, increased late-summer flows in the lower Klamath River would not affect Eulachon.

Changes in Late Summer Water Temperatures in the Lower Klamath River Below the Trinity River Confluence

Chinook Salmon, Coho Salmon, and Steelhead Alternative 2 would result in similar reductions in the mean and range of DAT and 7DADM during the late-summer flow augmentation releases from Lewiston Dam over the period from August 22 to September 22 in the lower Klamath River at the head of estuary (RM 5.7) and near the Blue Creek confluence (RM 16.5) (Tables 7-19 and

7-20). Given the reduction in number of days when modeled DATs would exceed the thermal barrier threshold temperature, and the reduction in 7DADM during late-summer flow augmentation in the lower Klamath River, thermal risk factors contributing to the potential for and severity of Ich infection would be reduced to some degree under Alternative 2 similar to Alternative 1, as compared to the No Action Alternative.

Table 7-19. Changes in Maximum 7-Day Average of Daily Maximum Water Temperatures on the Lower Klamath River near Klamath, California, Under the No Action Alternative and Alternative 2

		No Action		**Alternative 2**	
Year	**Water Year Type**	**DAT Statistics Average; (Range); [# days]**	**Maximum 7DADM (°F)**	**DAT Statistics Average; (Range); [# days]**	**Maximum 7DADM (°F)**
1980	W	68 (63-71) [0]	73	68 (63-71) [0]	73
1981	**D**	**70 (62-73) [0]**	**74**	**67 (62-70) [0]**	**73**
1982	EW	68 (62-74) [3]	75	68 (62-74) [3]	75
1983	EW	68 (64-70) [0]	74	68 (64-70) [0]	74
1984	W	69 (62-72) [0]	74	69 (62-72) [0]	74
1985	**D**	**66 (62-73) [0]**	**74**	**66 (62-73) [0]**	**74**
1986	**W**	**67 (58-74) [1]**	**75**	**67 (58-74) [1]**	**74**
1987	**D**	**68 (64-77) [5]**	**76**	**66 (61-71) [0]**	**72**
1988	**D**	**70 (62-75) [12]**	**76**	**66 (61-72) [0]**	**74**
1989	**N**	**68 (63-71) [0]**	**75**	**67 (63-69) [0]**	**74**
1990	**D**	**69 (66-71) [0]**	**73**	**68 (65-70) [0]**	**73**
1991	**CD**	**72 (68-76) [10]**	**76**	**68 (65-71) [0]**	**74**
1992	**D**	**70 (67-74) [1]**	**76**	**66 (61-69) [0]**	**73**
1993	W	69 (63-72) [0]	73	69 (63-72) [0]	73
1994	**CD**	**70 (66-74) [3]**	**76**	**64 (60-67) [0]**	**72**
1995	**EW**	**69 (67-71) [0]**	**73**	**69 (67-71) [0]**	**73**
1996	**W**	**68 (63-74) [1]**	**75**	**68 (63-74) [1]**	**75**
1997	**W**	**69 (64-72) [0]**	**74**	**69 (64-72) [0]**	**74**
1998	EW	70 (64-75) [4]	75	70 (64-75) [4]	75
1999	W	69 (66-74) [5]	75	69 (66-74) [5]	75
2000	**W**	**68 (64-73) [0]**	**74**	**68 (64-73) [0]**	**74**
2001	**D**	**70 (66-72) [0]**	**74**	**66 (63-69) [0]**	**73**
2002	**N**	**69 (65-74) [3]**	**75**	**64 (58-69) [0]**	**71**
2003	**EW**	**69 (63-73) [4]**	**76**	**67 (62-73) [1]**	**75**

Summary of Differences	**Difference in DAT Mean (Range)**	**Difference in 7DADM Mean (Range)**	**Difference in Number of Exceedances**
Flow Augmentation Years	-2.1°F (0 to -5.8°F)	-1.4°F (0 to -4.6°F)	-37
Non-Augmentation Years	0°F (--)	0°F (0.1 to 0°F)	0

Notes:
Averages are calculated for a 24-year period during the flow augmentation period, August 22 to September 22.
Daily average water temperatures ≥ 73.4°F have been reported to inhibit migratory behavior of adult salmon.
Years in **bold** font indicate representative years modeled with augmentation of late-summer flows for Alternative 1.
Key:7DADM = 7-day average daily maximum D = dry N = normal W = wet
CD = critically dry EW = extremely wet POR = period of record

Table 7-20. Changes in Maximum 7-Day Average of Daily Maximum Water Temperatures on the Lower Klamath River near Blue Creek Under the No Action Alternative and Alternative 2

		No Action		**Alternative 2**	
Year	**Water Year Type**	**DAT statistics Average; (Range); [# days]**	**Maximum 7DADM (°F)**	**DAT statistics Average; (Range); [# days]**	**Maximum 7DADM (°F)**
1980	W	67 (62-70) [0]	72	67 (62-70) [0]	72
1981	**D**	**69 (62-72) [0]**	**74**	**66 (62-70) [0]**	**73**
1982	EW	68 (62-74) [4]	75	68 (62-74) [4]	75
1983	EW	67 (64-70) [0]	74	67 (64-70) [0]	74
1984	W	69 (61-72) [0]	74	69 (61-72) [0]	74
1985	**D**	**66 (61-73) [1]**	**74**	**66 (61-73) [0]**	**74**
1986	**W**	**67 (58-73) [0]**	**74**	**66 (58-73) [0]**	**73**
1987	**D**	**68 (64-77) [5]**	**76**	**66 (61-72) [0]**	**71**
1988	**D**	**69 (61-74) [3]**	**75**	**65 (60-71) [0]**	**73**
1989	**N**	**68 (62-71) [0]**	**74**	**66 (62-69) [0]**	**73**
1990	**D**	**68 (66-71) [0]**	**73**	**67 (65-70) [0]**	**73**
1991	**CD**	**71 (68-75) [9]**	**76**	**67 (65-70) [0]**	**74**
1992	**D**	**69 (66-74) [3]**	**76**	**65 (60-69) [0]**	**73**
1993	W	68 (62-73) [0]	73	68 (62-73) [0]	73
1994	**CD**	**70 (65-73) [1]**	**75**	**64 (60-67) [0]**	**72**
1995	**EW**	**69 (67-71) [0]**	**73**	**69 (67-71) [0]**	**73**
1996	**W**	**68 (62-74) [1]**	**74**	**68 (62-74) [1]**	**74**
1997	**W**	**68 (63-71) [0]**	**74**	**68 (63-71) [0]**	**74**
1998	EW	70 (64-75) [4]	75	70 (64-75) [4]	75
1999	W	69 (66-74) [3]	75	69 (66-74) [4]	75
2000	**W**	**68 (64-72) [0]**	**73**	**68 (64-72) [0]**	**73**
2001	**D**	**69 (66-72) [0]**	**73**	**66 (62-68) [0]**	**72**
2002	**N**	**69 (65-73) [0]**	**74**	**63 (58-67) [0]**	**71**
2003	**EW**	**69 (63-74) [4]**	**76**	**67 (62-72) [1]**	**75**
Summary of Differences	**Difference in DAT Mean (Range)**		**Difference in 7DADM Mean (Range)**		**Difference in Number of Exceedances**
Flow Augmentation Years	-2.3°F (0 to -6.3°F)		-1.4°F (0 to -4.9°F)		-25
Non-Augmentation Years	0°F (0.1 to 0°F)		0°F (0.1 to 0°F)		+1

Notes:
Averages are calculated for a 24-year period during the flow augmentation period, August 22 to September 22.
Daily average water temperatures ≥ 73.4°F have been reported to inhibit migratory behavior of adult salmon.
Years in **bold** font indicate representative years modeled with augmentation of late-summer flows for Alternative 1.
Key:
7DADM = 7-day average daily maximum
CD = critically dry
D = dry
EW = extremely wet
N = normal
POR = period of record
W = wet

Pacific Lamprey Similar to the previous discussion of effects of late-summer augmentation flows, water temperatures associated with late-summer augmentation flows in the lower Klamath River under Alternative 2, compared to the No Action Alternative, are thought to be negligible for Pacific Lamprey.

Green Sturgeon Similar to the previous discussion of effects of late-summer augmentation flows, water temperatures associated with late-summer augmentation flows in the lower Klamath River under Alternative 2, compared to the No Action Alternative, are thought to be of potentially similar benefit to Green Sturgeon as for anadromous salmonids.

Eulachon Similar to the previous discussion of effects of late-summer augmentation flows, water temperatures associated with late-summer augmentation flows in the lower Klamath River under Alternative 2, compared to the No Action Alternative, would not affect Eulachon.

Central Valleyand Bay-Delta Region

Fish Habitat Conditions in the CVP and SWP Reservoirs

Changes in Black Bass Nesting Success The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir elevations) and anticipated changes in black bass nesting success.

Under Alternative 2, reservoir elevations would be similar compared to the No Action Alternative (less than 1 percent difference). Therefore, there would be no change in nesting success for Largemouth Bass, Smallmouth Bass, and Spotted Bass in Whiskeytown Lake, Shasta Lake, Oroville Lake, and Folsom Lake (Tables 7-21 through 7-23). Whiskeytown Reservoir has 100 percent nesting success under all alternatives, in all months for all species, for both the No Action Alternative and Alternative 2.

Table 7-21. Black Bass Nesting Success in Percent Survival in Shasta Reservoir for the No Action Alternative and Alternative 2

	March		**April**		**May**		**June**	
Water Year Type	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**
Largemouth Bass								
Wet	100	0	100	0	100	0	41	0
AN	100	0	100	0	100	0	8	0
BN	100	0	100	0	100	0	7	0
Dry	100	0	100	0	100	0	1	0
Critical	100	0	85	1	50	1	0	0
All Years	100	0	100	0	100	0	9	0
Smallmouth Bass								
Wet	100	0	100	0	100	0	36	0
AN	100	0	100	0	100	0	10	0
BN	100	0	100	0	86	1	8	1
Dry	100	0	100	0	85	0	3	1
Critical	100	0	73	1	43	0	0	0
All Years	100	0	100	0	100	0	9	0
Spotted Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	61	0
BN	100	0	100	0	100	0	59	1
Dry	100	0	100	0	100	0	51	0
Critical	100	0	100	0	100	0	18	1
All Years	100	0	100	0	100	0	61	0

Key: Alt = Alternative AN = Above Normal BN = Below Normal

Table 7-22. Black Bass Nesting Success in Percent Survival in Oroville Reservoir for the No Action Alternative and Alternative 2

Water Year Type	**March**		**April**		**May**		**June**	
	No Action	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**
Largemouth Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	27	0
BN	100	0	100	0	100	0	0	0
Dry	100	0	100	0	100	0	0	0
Critical	100	0	100	0	100	0	0	0
All Years	100	0	100	0	100	0	9	0
Smallmouth Bass								
Wet	100	0	100	0	100	0	85	0
AN	100	0	100	0	100	0	25	0
BN	100	0	100	0	100	0	3	0
Dry	100	0	100	0	100	0	0	0
Critical	100	0	100	0	92	0	0	0
All Years	100	0	100	0	100	0	10	0
Spotted Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	87	0
BN	100	0	100	0	100	0	50	0
Dry	100	0	100	0	100	0	13	0
Critical	100	0	100	0	100	0	34	-4
All Years	100	0	100	0	100	0	62	0

Key:
Alt = Alternative
AN = Above Normal
BN = Below Normal

Table 7-23. Black Bass Nesting Success in Percent Survival in Folsom Reservoir for the No Action Alternative and Alternative 2

	March		**April**		**May**		**June**	
Water Year Type	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**	**No Action**	**Alt 2 (Difference from No Action)**
Largemouth Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	61	0
BN	100	0	100	0	100	0	50	0
Dry	100	0	100	0	100	0	20	0
Critical	100	0	100	0	100	0	22	-1
All Years	100	0	100	0	100	0	52	-1
Smallmouth Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	53	0
BN	100	0	100	0	100	0	44	0
Dry	100	0	100	0	100	0	19	0
Critical	100	0	100	0	100	0	21	-1
All Years	100	0	100	0	100	0	45	0
Spotted Bass								
Wet	100	0	100	0	100	0	100	0
AN	100	0	100	0	100	0	100	0
BN	100	0	100	0	100	0	100	0
Dry	100	0	100	0	100	0	78	0
Critical	100	0	100	0	100	0	81	-1
All Years	100	0	100	0	100	0	100	0

Key:
Alt = Alternative
AN = Above Normal
BN = Below Normal

Changes in Cold Water Fish Habitat Changes in CVP and SWP water supplies and operations under Alternative 2, as compared to the No Action Alternative, generally would result in similar reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Changes in storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be less than 1 percent under Alternative 1 compared to the No Action Alternative, as summarized in Chapter 4, "Surface Water Supply and Management." These minimal differences in reservoir storage in all water year types would not result in changes to cold-water fish habitat under Alternative 2 compared to the No Action Alternative.

Aquatic Habitat Conditions in Rivers Downstream from the CVP and SWP Reservoirs

Changes in Juvenile Chinook Salmon Production - SALMOD Output SALMOD results indicate that potential juvenile production under Alternative 1 would be the similar (less than 4 percent difference) to the No Action Alternative in all water year types (Table 7-24).

There are *2* out of 12 critical water years in which production under Alternative 2 decreased by more than 20 percent for fall-run Chinook Salmon relative to the No Action Alternative. The overall average change in critical water years were less than 2 percent, and had an increase in production by more than 10 percent in 1 critical water year. The overall average smolt production in all water years was just over 2 percent.

Late fall-run Chinook Salmon—and through their similarity, steelhead—experience production decreases by more than 7 percent in 1 out of 12 critical years, and 2 out of 18 dry years, but also increased by more than 5 percent in 1 critical water year. The overall average for critical and dry water years was less than 1 percent, and smolt production in all years averaged less than 1 percent difference from the No Action Alternative

Winter-run Chinook Salmon experience an increase in production by more than 20 percent in 1 critical water year. The overall average difference in critical water years, as well as for all water years, was less than 1 percent compared to the No Action Alternative.

Spring-run Chinook Salmon, which have a very low spawning population in the Sacramento River could experience 100 percent mortality in 1 critical water year, and greater than 25 percent decrease in 2 additional critical years, relative to the No Action Alternative. The modeled production in those years under the No Action Alternative, in two of those three years, consisted of only only 10 and 115 juvenile fish. In 4 critical water years, spring-run Chinook Salmon could experience an increase in production ranging from 11 to 147 percent. Populations of 500 or more spawning Chinook Salmon are considered necessary for accurate results using SALMOD because it is a deterministic model that relies on the “law of large numbers.” When populations are *low* (an arbitrary term), mean responses are quickly affected by environmental stochasticity and individual variability. The overall average difference in smolt production relative to the No Action Alternative was less than 1 percent.

Table 7-24. Juvenile Chinook Salmon Production Based on SALMOD Results for Alternative 2

Water Year Type	No Action Alternative (Average Production)	Alternative 2 (Difference from No Action)	Alternative 2 (Percent Change)
Fall-Run Chinook Salmon			
Critical	13,058,552	-309,976	-2.4
Dry	29,967,217	6,406	0.0
Below Normal	30,112,903	5,401	0.0
Above Normal	30,324,698	-10,254	0.0
Wet	29,159,993	-3,425	0.0
All Water Years	27,275,865	-46,226	-0.2
Late Fall-Run Chinook Salmon			
Critical	5,245,425	-17,793	-0.3
Dry	5,648,977	-31,007	-0.5
Below Normal	5,787,938	-3,483	-0.1
Above Normal	5,929,655	-20,597	-0.3
Wet	5,868,372	1,558	0.0
All Water Years	5,720,957	-13,095	-0.2
Winter-Run Chinook Salmon			
Critical	2,382,579	19,855	0.8
Dry	3,327,324	-2,652	-0.1
Below Normal	3,250,781	-461	0.0
Above Normal	3,149,290	9,195	0.3
Wet	3,139,415	-396	0.0
All Water Years	3,090,275	3,459	-0.1
Spring-Run Chinook Salmon			
Critical	68,168	-83	-0.1
Dry	416,959	1,040	0.2
Below Normal	447,950	-1,818	-0.4
Above Normal	465,691	-453	-0.1
Wet	467,027	-605	-0.1
All Water Years	392,786	-264	-0.1

Changes in Winter-Run Chinook Salmon Production - Interactive Object-Oriented Simulation Output The IOS model predicted adult escapement trajectories for winter-run Chinook Salmon across the 81 simulated years. Under Alternative 2, average adult escapement was 6,729 and under the No Action Alternative, average escapement was 6,793 (Table 7-25). Adult escapement estimates were based on the water year type in the third year previous to the adult return, the assumed time for spawning, rearing and outmigration. Two of 11 critical, 1 of 19 dry, 2 out of 11 above normal, and 4 out of 25 wet water years would experience decreases greater than 5 percent under Alternative 1 relative to the No Action Alternative.

Similar to adult escapement, the IOS model predicted similar (less than 3 percent difference) egg survival, fry-to-smolt survival, smolt production, and survival downstream from RBPP and in the Delta for winter-run Chinook Salmon between Alternative 2 and the No Action Alternative, across the 81 water years (Table 7-25).

Table 7-25. IOS Model Results for Winter-Run Chinook Salmon for Alternative 2

Water Year Type	No Action	Alternative 2	Alternative 2 (Percent Change)
Adult Escapement			
Critical	4,806	4,911	2
Dry	6,772	6,699	-1
Below Normal	5,249	5,274	0
Above Normal	5,426	5,368	-1
Wet	8,887	8,787	-1
All Water Years	6,793	6729	-1
Egg Survival			
Critical	0.55	0.56	0.3
Dry	0.99	0.98	-0.3
Below Normal	0.98	0.98	0.3
Above Normal	0.99	0.99	0.1
Wet	0.99	0.99	-0.1
All Water Years	0.92	0.92	0
Fry-to-Smolt Survival			
Critical	0.48	0.47	-3.0
Dry	0.93	0.93	0.1
Below Normal	0.93	0.93	0.1
Above Normal	0.94	0.94	0.0
Wet	0.93	0.93	0.0
All Water Years	0.87	0.86	-0.2
Smolt Production			
Critical	3,568,552	3,452,638	-3.2
Dry	6,143,220	6,114,900	-0.5
Below Normal	5,329,551	5,360,342	0.6
Above Normal	4,466,911	4,400,987	-1.5
Wet	6,916,239	6,835,961	-1.2
All Water Years	5,600,444	5,545,919	-1.0
Red Bluff Pumping Plant to Delta Survival			
Critical	0.24	0.24	0.0
Dry	0.24	0.24	0.0
Below Normal	0.23	0.23	0.0
Above Normal	0.24	0.24	0.0
Wet	0.23	0.23	0.0
All Water Years	0.23	0.23	0.0
Delta Survival			
Critical	0.32	0.32	0.1
Dry	0.40	0.40	0.0
Below Normal	0.41	0.41	0.1
Above Normal	0.38	0.38	0.0
Wet	0.40	0.40	0.0
All Water Years	0.39	0.39	0.0

Changes in Water Temperature Long-term daily average monthly water temperature in Clear Creek at Igo and in the Sacramento River downstream from Clear Creek, at Balls Ferry, Jellys Ferry, and Bend Bridge under Alternative 2 would generally be similar (less than 0.2°F difference) to water temperatures under the No Action Alternative (See Chapter 5, "Surface Water Quality").

Overall, the minimal temperature differences between Alternative 2 and the No Action Alternative would have similar effects on all runs of Chinook Salmon, steelhead, and Green Sturgeon in the Sacramento River.

Changes in Exceedances of Water Temperature Thresholds Average monthly water temperatures from April through October under both the No Action Alternative and Alternative 2 exceed the water temperature threshold of 56°F in the Sacramento River below Clear Creek less than 14 percent of the time. In the Sacramento River at Balls Ferry, for winter-run and spring-run Chinook Salmon spawning and egg incubation, the water temperature threshold would be exceeded by 22 percent of the time under both the No Action Alternative and Alternative 2. Water temperature thresholds would be exceeded nearly 40 percent of the critical months under the No Action Alternative and Alternative 2 at Jellys Ferry. At Bend Bridge, the frequency of exceedances would be similar under Alternative 2 and the No Action Alternative (61 percent) of the simulated years. The differences between the No Action Alternative and Alternative 2 are less than 1 percent.

Average monthly water temperatures in Clear Creek at Igo between June and September exceed the 60°F threshold under both the No Action Alternative and Alternative 2 less than 1 percent of the time. The September to October threshold of 56°F would be exceeded by 12 percent under both the No Action Alternative and Alternative 2.

Changes in Weighted Usable Area As described above for the assessment methodology, WUA is a function of flow, but the relationship is not linear due to differences in depths and velocities present in the wetted channel at different flows. Because the combination of depths, velocities, and substrates preferred by species and life stages varies, WUA values at a given flow can differ substantially for the life stages evaluated.

As an indicator of the amount of suitable habitat for winter-run Chinook Salmon, fall-run Chinook Salmon, late fall-run Chinook Salmon, and steelhead between Keswick Dam and Battle Creek, flows in the Sacramento River below Keswick Dam indicate that there is little difference in the amounts of spawning habitat, suitable fry rearing habitat, and suitable juvenile rearing habitat under Alternative 2 and the No Action Alternative (less than 5 percent difference).

Based on the simulated flows, WUA values for spring-run Chinook Salmon, fall-run Chinook Salmon, and steelhead in Clear Creek are similar, with a less than 5 percent difference between Alternative 2 and the No Action Alternative, for spawning habitat, suitable fry rearing habitat, and suitable juvenile rearing habitat.

The amount of suitable spawning habitat, fry rearing habitat, and juvenile rearing habitat would be similar, less than 5 percent difference, between Alternative 1 and the No Action Alternative for fall-run Chinook Salmon and steelhead in the lower Feather River and the lower American River.

Fish Habitat Conditions in Bay-Delta

Changes in Delta Hydrodynamics Under Alternative 2, Delta outflow would be similar (less than 1 percent difference) to the No Action Alternative (See Chapter 4, “Surface Water Supply and Management”).

The OMR flows would be similar in all almost all months between Alternative 2 and the No Action Alternative, with the long-term average ranging from -6,219 to 914 cfs (compared with -6,217,385 to 914 cfs under the No Action Alternative) from December through June under Alternative 2 (See Chapter 4, "Surface Water Supply and Management"). In June of critical water years, there was a 7 percent increase in negative flows (a change from -1,414 cfs under No Action Alternative to -1,514 cfs under Alternative 2). This change, however, is substantially below the -5,000 cfs criteria, and therefore, does not result in an adverse effect to Delta fishes.

As a result, Delta fishes, including Delta Smelt, Longfin Smelt, all runs of Chinook Salmon, steelhead, and Green Sturgeon would not be affected by the implementation of Alternative 2 resulting from a change in Delta hydrodynamics.

Changes in X2 Location Overall, the quantitative results from the numerical models suggest that operations under Alternative 2 would result in a less-than-1 percent change in the X2 location relative to the No Action Alternative in all months and all water year types. Implementing Alternative 2 would not affect fish habitat resulting from the placement of X2.

Summary of Environmental Consequences

Table 7-26 presents the results of the environmental consequences analysis for implementing the action alternatives compared to the No Action Alternative.

Table 7-26. Comparison of Action Alternatives to No Action Alternative

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	**Klamath and Trinity River Region**	
	Trinity River	
	Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead *Late Summer Augmentation: Spring-run Chinook Salmon* Late-summer augmentation release operations could interrupt or dewater redds of spring-run Chinook Salmon, which may begin spawning in early- to mid-September, before releases are returned to baseflow.	Coordination with resource agencies as part of annual flow augmentation implementation process
	Pulse Flows: Coho Salmon, Spring-run Chinook Salmon, Steelhead Late-summer preventive and emergency pulse flows may be high enough to overtop berms along the river channel, potentially increasing risk of stranding juvenile salmon upon reduction of the pulse flows back to the baseflow. Gradual ramping rates are intended to minimize this risk.	Coordination with resource agencies as part of annual flow augmentation implementation process
	Fall Temperature Objectives: Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead Water temperatures meet the temperature objectives in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives at less than 2%. Spawning and adult migration would not be affected by changes in fall temperatures under Alternative 1.	None needed

Table 7-26. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1 (contd.)	*Spring Temperature Objectives: Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead* Water temperatures in the spring/early-summer (May-June) meet the temperature objectives at all locations in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives at less than 5%. Juvenile rearing and outmigration would not be affected by changes in the spring water temperatures under Alternative 1. *Alluvial Bar Habitat in the Spring: Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead* Rearing habitat availability high up on alluvial bars would be similar to the No Action Alternative *July to September Temperature Objectives: Spring-run Chinook Salmon* Water temperatures between July and mid-September meet the temperature objectives at all locations in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives less than 1% of the time. Adult holding would not be affected by changes in the spring water temperatures under Alternative 1. *Late Summer Flow Release: Coho Salmon, Steelhead* Additional Lewiston Dam late-summer flow releases, which will extend cooler water temperatures to the confluence, are expected to provide suitable water temperatures for rearing juveniles	None needed
	Pacific Lamprey Increased late-summer augmentation flows may cause increased water velocities and disturbance of fine sediments along the summer baseflow channel where lamprey ammocoetes are living. Because the range of augmentation flows would be within the typical range of annual fluctuations in the upper Trinity River, which lampreys experience over their freshwater juvenile life stage, it is expected that juvenile lampreys will redistribute to other areas of suitable habitat over the course of the augmentation flow cycle, if disturbed by higher water velocities.	None needed
	Reservoir Fishes Reservoir fish habitat for both cold and warm water (e.g., black bass) fishes in Trinity Lake would be similar to the No Action Alternative.	None needed

Table 7-26. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1 (contd.)	***Lower Klamath River*** Coho Salmon, Spring-run and Fall-run Chinook Salmon, Steelhead, Pacific Lamprey The risk of Ich infection epizootic events, and fish die-offs would be reduced compared to the No Action Alternative through increased habitat area, increased water velocities, improved migration cues, and a decrease in frequency of water temperatures exceeding 73.4°F.	None needed
	Eulachon Effects to flows in the lower Klamath River and Estuary would be similar between Alternative 1 and the No Action Alternative.	None needed
	Central Valley and Bay-Delta Region	
	Chinook Salmon and Steelhead SALMOD results indicate some critical years may result in decreased production of Chinook compared with the No Action Alternative. Overall averages show similar production levels (less than 3%) for all runs of Chinook Salmon (and through similar life stages, steelhead), except for fall-run Chinook which experience a higher potential mortality rate in critical water years, averaging 6% reduced survival and spring-run, which experience a greater than 5% increase in survival in critical water years.	Reclamation will consult with fisheries agencies consistent with the 2009 NMFS BO RPAs and coordinate with resource agencies
	IOS results indicate winter-run Chinook Salmon would experience reduced survival during several critical water years, resulting in a less than 1% average reduction in spawning escapement, a 9% reduction in fry-to-smolt survival and 5% reduction in smolt production under Alternative 1. However, the average overall affects to winter-run Chinook salmon are similar, with a less than 1% reduction in spawning escapement to the No Action Alternative.	Reclamation will consult with fisheries agencies consistent with the 2009 NMFS BO RPAs and coordinate with resource agencies
	Water temperatures would be generally similar at compliance locations in the upper Sacramento River under Alternative 1 compared to the No Action Alternative except in some critical water years in the Sacramento River below Clear Creek, Balls Ferry, and Jellys Ferry.	None needed
	Water temperature thresholds for spawning and incubation in the Sacramento River would be met similarly between the Alternative 1 and the No Action Alternative, with differences of less than, or equal to, 1%. The number of times the temperature thresholds are exceeded increases as the water flows downstream, but the changes in exceedence between the No Action Alternative and Alternative 1 remain generally similar (less than 1%).	
	The WUA in the Sacramento, Feather and American Rivers and Clear Creek for Chinook Salmon and steelhead spawning, fry rearing, and juvenile rearing would be generally similar (less than 1% change) for suitable habitat to the No Action Alternative.	
	The Delta hydrodynamics (outflow, X2, OMR reverse flows) would be generally similar between Alternative 1 and the No Action Alternative. This would result in similar levels of entrainment between the No Action Alternative and Alternative 1.	

Table 7-26. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1 (contd.)	Green Sturgeon Water temperatures would be generally similar at compliance locations in the upper Sacramento River under Alternative 1 compared to the No Action Alternative. Water temperature thresholds for Green Sturgeon in the Sacramento River would be met similarly between Alternative 1 and the No Action Alternative, with differences of less than or equal to 1%. The number of times the temperature thresholds are exceeded increases as the water flows downstream, but the changes in exceedence between the No Action Alternative and Alternative 1 remain generally similar (less than 1% difference). The Delta hydrodynamics would be generally similar between Alternative 1 and the No Action Alternative. This would result in similar levels of entrainment of Green Sturgeon between the No Action Alternative and Alternative 1.	None needed
	Delta Smelt and Longfin Smelt The Delta hydrodynamics would be generally similar between Alternative 1 and the No Action Alternative. This would result in similar levels of entrainment of Delta Smelt between the No Action Alternative and Alternative 1.	None needed
	Reservoir Fishes There would be similar reservoir fish habitat conditions (less than 1% change) for cold water fishes from a change in storage in Whiskeytown Lake, Shasta Lake, Oroville Lake and Folsom Lake. Black bass nesting success would be similar (less than 1% difference) between Alternative 1 and the No Action Alternative in Whiskeytown Lake, Shasta Lake, Oroville Lake and Folsom Lake.	None needed
Alternative 2	**Klamath and Trinity River Region**	
	Trinity River Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead *Pulse Flows: Coho Salmon, Spring-run Chinook Salmon, Steelhead* Late-summer preventive and emergency pulse flows may be high enough to overtop berms along the river channel, potentially increasing risk of stranding juvenile salmon upon reduction of the pulse flows back to the baseflow. Gradual ramping rates are intended to minimize this risk. *Late Summer Augmentation: Spring-run Chinook Salmon* Late-summer augmentation release operations could interrupt or dewater redds of spring-run Chinook Salmon, which may begin spawning in early- to mid-September, before releases are returned to baseflow.	None needed

Table 7-26. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	**Potential Change**	**Consideration for Mitigation Measures**
Alternative 2 (contd.)	<u>Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, and Steelhead</u> *Fall Temperature Objectives: Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead* Water temperatures meet the temperature objectives in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives at less than 2%. Spawning and adult migration would not be affected by changes in fall temperatures under Alternative 2. *Spring Temperature Objectives: Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead* Water temperatures in the spring/early-summer (May-June) meet the temperature objectives at all locations in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives at less than 5%. Juvenile rearing and outmigration would not be affected by changes in the spring water temperatures under Alternative 2. Maximum differences between Alternative 2 and the No Action Alternative during periods when exceedances occur could be up to 3°F at the North Fork Trinity confluence and about 2°F at Weitchpec. *Alluvial Bar Habitat in the Spring: Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead* Habitat availability high up on alluvial bars used by fry and juvenile salmonids for rearing would be similar to the No Action Alternative, except for about two weeks during May and June in critically dry years. Low recession rates would remain gradual enough to allow for fish to move from side-channels and off-channel areas into the main river channel as flow decline. *July to Mid-September Temperature Objectives: Spring-run Chinook Salmon* Water temperatures between July and mid-September meet the temperature objectives at all locations in a similar pattern as the No Action Alternative, with the difference in the number of days exceeding the objectives less than 1% of the time. Adult holding would not be affected by changes in the spring water temperatures under Alternative 2.	None needed

Table 7-26. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 2 (contd.)	*Late Summer Flow Release: Coho Salmon, Steelhead*	None needed
	Additional Lewiston Dam late-summer flow releases, which will extend cooler water temperatures to the confluence, are expected to provide suitable water temperatures for rearing juveniles	
	Pacific Lamprey Increased late-summer augmentation flows may cause increased water velocities and disturbance of fine sediments along the summer baseflow channel where lamprey ammocoetes are living. Because the range of augmentation flows would be within the typical range of annual fluctuations in the upper Trinity River, which lampreys experience over their freshwater juvenile life stage, it is expected that juvenile lampreys will redistribute to other areas of suitable habitat over the course of the augmentation flow cycle, if disturbed by higher water velocities.	None needed
	Reservoir Fishes Black bass nesting success is slightly higher under Alternative 2 compared to the No Action Alternative.	None needed
	Lower Klamath River	
	Coho Salmon, Spring-run and Fall-run Chinook Salmon, Steelhead, Pacific Lamprey The risk of Ich infection, epizootic events, and fish die-offs would be reduced compared to the No Action Alternative through increased habitat area, increased water velocities, improved migration cues, and a decrease in frequency of water temperatures exceeding 73.4°F.	None needed
	Eulachon Affects to flows in the lower Klamath River and Estuary would be similar between Alternative 2 and the No Action Alternative.	None needed
	Central Valley and Bay-Delta Region	
	Chinook Salmon and Steelhead SALMOD results indicate some critical years may result in decreased production of Chinook Salmon compared with the No Action Alternative, however, the overall averages show similar production levels (less than 3% reduction) for all four runs of Chinook Salmon (and through similar life stages, steelhead). IOS results indicate winter-run Chinook Salmon would experience reduced survival during several critical water years, but the overall spawning escapement in critical water years would increase by about 2%. The average overall affects to winter-run Chinook salmon are similar with a less than 1% reduction in spawning escapement to the No Action Alternative.	None needed

1 Table 7-26. Comparison of Action Alternatives to No Action Alternative (contd.)

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 2 (contd.)	Water temperatures would be generally similar at compliance locations in the upper Sacramento River under Alternative 2 compared to the No Action Alternative. Water temperature thresholds for spawning and incubation in the Sacramento River would be met similarly between the Alternative 2 and the No Action Alternative, with differences of less than or equal to 1%. The number of times the temperature thresholds are exceeded increases as the water flows downstream, but the changes in exceedence between the No Action Alternative and Alternative 2 remain generally similar (less than 1% difference). The WUA in the Sacramento, Feather and American Rivers and Clear Creek for Chinook Salmon and steelhead spawning, fry rearing, and juvenile would be generally similar (less than 1% change) for suitable habitat to the No Action Alternative. The Delta hydrodynamics would be generally similar between Alternative 2 and the No Action Alternative. This would result in similar levels of entrainment between the No Action Alternative and Alternative 2.	
	<u>Green Sturgeon</u> Water temperatures would be generally similar (less than 0.5ºF) at compliance locations in the upper Sacramento River under Alternative 2 compared to the No Action Alternative. Water temperature thresholds for Green Sturgeon in the Sacramento River would be met similarly between Alternative 2 and the No Action Alternative, with differences of less than, or equal to, 1%. The number of times the temperature thresholds are exceeded increases as the water flows downstream, but the changes in exceedence between the No Action Alternative and Alternative 2 remain generally similar (less than 1% difference). The Delta hydrodynamics (outflow, X2, OMR reverse flows) would be generally similar between Alternative 2 and the No Action Alternative. This would result in similar levels of entrainment of Green Sturgeon between the No Action Alternative and Alternative 2.	None needed
	<u>Delta Smelt and Longfin Smelt</u> The Delta hydrodynamics (outflow, X2, OMR reverse flows) would be generally similar between Alternative 2 and the No Action Alternative. This would result in similar levels of entrainment of Delta Smelt between the No Action Alternative and Alternative 2.	None needed
	<u>Reservoir Fishes</u> There would be similar reservoir fish habitat conditions (less than 1% change) for cold water fishes from a change in storage in Whiskeytown Lake, Shasta Lake, Oroville Lake and Folsom Lake between Alternative 2 and the No Action Alternative.	None needed

Key:
°F = degrees Fahrenheit
% = percent
cfs = cubic feet per second
OMR = Old and Middle River

Potential Mitigation Measures

Mitigation measures have not been identified for Central Valley Chinook Salmon. The analyses for Alternative 1 showed reduced survival of early life stages of winter-run (up to 9 percent) and fall-run Chinook Salmon smolt production (up to 6 percent). These effects would be minimized through implementation of the consultation procedures required by the 2009 NMFS BO, or through coordination with resource agencies on real-time operations.

Cumulative Effects Analysis

The cumulative effects analysis considers projects, programs, and policies that are not speculative; and are based upon known or reasonably foreseeable long-range plans, regulations, operating agreements, or other information that establishes them as reasonably foreseeable. The cumulative effects analysis under action alternatives for fisheries is summarized in Table 7-27. The methodology for this cumulative effects analysis is described in the Cumulative Effects Technical Appendix.

Table 7-27. Summary of Cumulative Effects on Fish Resources of Action Alternatives as Compared to the No Action Alternative

Scenarios	**Cumulative Effects of Actions**
No Action Alternative with Associated Cumulative Effects Actions in Year 2030	*Conditions and Actions Included in Quantitative Analyses* *(Conditions and actions incorporated into No Action Alternative modeling)* For Klamath Basin rivers, reduced snowpack due to climate change would shift flow patterns to an earlier and shorter spring runoff period, reducing flows during summer months. During summer months, lower flows and increased temperature conditions, due to increased ambient temperatures, would likely increase the potential for Ich epizootic events and related fish die-offs. For the Central Valley and Delta, climate change and sea-level rise, development under the general plans, FERC relicensing projects, and some future projects to improve water quality or habitat are anticipated to reduce carryover storage in reservoirs, stream flows and Delta outflow as compared to past conditions. These future actions could modify surface water conditions (e.g., flow and water temperature) and affect habitat for fish and aquatic resources. *Additional Identified Actions* *(Additional reasonably foreseeable projects or actions identified in Cumulative Effects Technical Appendix)* Within the Klamath River Basin, additional reasonably foreseeable actions including the Klamath River Main Stem Dam Removal and Hoopa Valley Tribe Watershed Restoration Projects are anticipated to improve or increase available fish habitat. Within the Central Valley, additional reasonably foreseeable actions (e.g., FERC relicensing projects) could improve aquatic resources in some streams, if stream habitat restoration, fish passage and improved water temperature control result from the FERC process.
Alternative 1 with Associated Cumulative Effects Actions in Year 2030	*Alternative 1 with Conditions and Actions Included in Quantitative Analyses* Implementation of Alternative 1 would result in similar fish habitat conditions during most months and water year types as compared to the No Action Alternative in the Klamath River Basin. During flow augmentation actions in August and September, particurlarly in drier years, Alternative 1 would result in improved conditions on the lower Klamath River, reducing the likelihood of an Ich epizootic event. Implementation of Alternative 1 would result in similar fish habitat conditions during most months and water year types as compared to the No Action Alternative in the Central Valley, except during some critical water years, in which warmer water temperatures may affect Chinook salmon and steelhead. *Alternative 1 with Additional Identified Actions* Alternative 1 with the additional reasonably foreseeable actions would result in beneficial effects to fish habitat conditions in the Klamath Basin, and therefore cumulative effects to fish habitat conditions are not anticipated. Additional reasonably foreseeable actions are not anticipated to result in cumulative effects to fish habitat in the Central Valley.

Table 7-27. Summary of Cumulative Effects on Fish Resources of Action Alternatives as Compared to the No Action Alternative (contd.)

Scenarios	Cumulative Effects of Actions
Alternative 2 with Associated Cumulative Effects Actions in Year 2030	*Alternative 2 with Conditions and Actions included in Quantitative Analyses* Implementation of Alternative 2 would result in similar fish habitat conditions during most months and water year types as compared to the No Action Alternative in the Klamath River Basin. During flow augmentation actions in August and September, particularly in drier years, Alternative 2 would result in improved conditions on the lower Klamath River, reducing the likelihood of an Ich epizootic event. Implementation of Alternative 2 would result in similar fish habitat conditions as compared to the No Action Alternative in the Central Valley. *Alternative 2 with Additional Identified Actions* Alternative 2 with the additional reasonably foreseeable actions would result in beneficial effects to fish habitat conditions in the Klamath Basin, and therefore cumulative effects to fish habitat conditions are not anticipated. Additional reasonably foreseeable actions are not anticipated to result in cumulative effects to fish habitat in the Central Valley.

Key:
FERC = Federal Energy Regulatory Commission

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