Chapter 9

# Fish and Aquatic Resources

## 9.1 Introduction

This chapter describes the fish and aquatic resources that occur in the portions of the project area that could be affected as a result of implementing the alternatives evaluated in this Environmental Impact Statement (EIS). Implementation of the alternatives could affect aquatic resources through changes in ecological attributes as a result of potential changes in long-term operation of the Central Valley Project (CVP) and State Water Project (SWP) and ecosystem restoration.

## 9.2 Regulatory Environment and Compliance Requirements

Potential actions implemented under the alternatives evaluated in this EIS could affect fish and aquatic resources. Actions located on public agency lands, or implemented, funded, or approved by Federal and state agencies, would need to be compliant with appropriate Federal and state agency policies and regulations, as summarized in Chapter 4, Approach to Environmental Analyses.

## 9.3 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 aquatic resources due to changes in CVP and SWP operations may occur in the Trinity River, Central Valley, San Francisco Bay Area, Central Coast, and Southern California regions.

The following description of the affected environment focuses on CVP and SWP reservoirs, rivers downstream of CVP and SWP reservoirs, the Sacramento-San Joaquin Rivers Delta Estuary (Delta), and conditions downstream of the Delta that are affected by operation of the CVP and SWP.

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

The descriptions of species and biological and hydrodynamic processes in this chapter frequently use the terms "Delta" and "San Francisco Estuary." The Delta refers to the Sacramento-San Joaquin Delta, as legally defined in the Delta Protection Act. The San Francisco Estuary refers to the portion of the Sacramento-San Joaquin Rivers watershed downstream of Chipps Island that is influenced by tidal action and where fresh water and salt water mix, which includes the following waterbodies: Suisun, San Pablo, and San Francisco bays.

### 9.3.1 Fish and Aquatic 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 changes in the operation of the CVP and SWP implemented under the alternatives considered in this EIS, as summarized in Table 9.1. While many of the species identified in Table 9.1 also occur in tributaries to the major rivers, the focus of this EIS is on the waterbodies influenced by operations of the CVP and SWP. These focal species are fish and marine mammal species listed as threatened or endangered or at risk of being listed as endangered or threatened, legally protected, or are otherwise considered sensitive by the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (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. Details on the status, life history, habitat requirements, and population trends for each of the aquatic focal species are provided in Appendix 9B9B.

**Table 9.1 Focal Fish Species by Region of Occurrence**

| Species or *Population*[a] | Federal Status | State Status[b] | Tribal, Commercial, or Recreational Importance | Occurrence within Area of Analysis |
|---|---|---|---|---|
| **Trinity River Region** | | | | |
| Coho Salmon *Southern Oregon/Northern California Coast ESU* | Threatened | Threatened | Yes | Trinity River, Klamath River |
| Eulachon *Southern DPS* | Threatened | None | Yes | Klamath River |
| Green Sturgeon *Southern DPS* | Threatened | Species of Special Concern | Yes | Trinity River, Klamath River |
| Spring-run Chinook Salmon *Upper Klamath-Trinity River ESU* | None | Species of Special Concern | Yes | Trinity River, Klamath River |
| Steelhead (winter- and summer-run) *Klamath Mountains Province DPS* | None | Species of Special Concern[c] | Yes | Trinity River, Klamath River |
| American Shad | None | None | Yes | Trinity River |
| Pacific Lamprey | None | None | Yes | Trinity River |

| Species or *Population*[a] | Federal Status | State Status[b] | Tribal, Commercial, or Recreational Importance | Occurrence within Area of Analysis |
|---|---|---|---|---|
| White Sturgeon | None | None | Yes | Trinity River, Klamath River |
| Black Bass (Largemouth, Smallmouth, Spotted) | None | None | Yes | Trinity River |
| **Central Valley Region** | | | | |
| Winter-run Chinook Salmon *Sacramento River ESU* | Endangered | Endangered | Yes | Sacramento River[d], Delta, and Suisun Marsh |
| Spring-run Chinook Salmon *Central Valley ESU* | Threatened | Threatened | Yes | Clear Creek, Sacramento River, Feather River, American River, Delta, and Suisun Marsh |
| Steelhead *Central Valley DPS* | Threatened | None | Yes | Clear Creek, Feather River, Sacramento River; American River, Stanislaus River, San Joaquin River, Delta and Suisun Marsh |
| Green Sturgeon *Southern DPS* | Threatened | Species of Special Concern | Yes | Feather River, Sacramento River, Delta and Suisun Marsh |
| Delta Smelt | Threatened | Endangered | No | Delta and Suisun Marsh |
| Longfin Smelt *Bay Delta DPS* | Candidate | Threatened | No | Delta and Suisun Marsh |
| Fall-/late Fall-run Chinook Salmon *Central Valley ESU* | None | Species of Special Concern | Yes | Clear Creek, Feather River, Sacramento River, American River, Stanislaus River, San Joaquin River, Delta and Suisun Marsh |
| Sacramento Splittail | None | Species of Special Concern | No | Feather River, American River, Sacramento River, Delta and Suisun Marsh, San Joaquin River |
| Hardhead | None | Species of Special Concern | No | Clear Creek, Feather River, Sacramento River, American River, Delta, Stanislaus River, San Joaquin River |
| Sacramento-San Joaquin Roach | None | Species of Special Concern | No | Clear Creek, Feather River, American River, Sacramento River, Delta, Stanislaus River, San Joaquin River |

| Species or *Population*[a] | Federal Status | State Status[b] | Tribal, Commercial, or Recreational Importance | Occurrence within Area of Analysis |
|---|---|---|---|---|
| River Lamprey | None | None | Yes | Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, San Joaquin River |
| Pacific Lamprey | None | None | Yes | Clear Creek, Feather River, Sacramento River, American River, Delta, Stanislaus River, San Joaquin River |
| White Sturgeon | None | None | Yes | Feather River, Sacramento River, American River, San Joaquin River, Delta and Suisun Marsh |
| American Shad | None | None | Yes | Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, San Joaquin River |
| Black Bass (Largemouth, Smallmouth, Spotted) | None | None | Yes | Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, San Joaquin River |
| Striped Bass | None | None | Yes | Feather River, American River, Sacramento River, Delta and Suisun Marsh, Stanislaus River, San Joaquin River |
| **San Francisco Bay and Pacific Ocean Waters** | | | | |
| Steelhead<br>Central California Coast DPS | Threatened | None | Yes | San Francisco Bay region |
| Killer Whale<br>*Southern Resident DPS* | Endangered | None | No | Pacific Coast |

Notes:

a. The term *population* refers to the listed Evolutionarily Significant Unit (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 summer-run of the Klamath Mountains Province DPS steelhead population

d. Also includes lower reaches of tributaries (e.g., American River) used for nonnatal rearing areas by juvenile salmon.

The life history attributes (e.g., timing of juvenile outmigration) for most of the species listed above, along with the ecological attributes important to the species and potentially influenced by the alternatives, are discussed in this chapter according to the geographic areas (regions/subregions) where the species occurs; Pacific Lamprey, Green Sturgeon, White Sturgeon, American Shad, and Striped Bass are discussed in detail only in those regions where they spend the majority of their life cycle such that geographic information is available. There are also several species (i.e., River Lamprey, Sacramento-San Joaquin Roach, and Hardhead) for which little geographic information is available; therefore, they are not discussed in detail in this chapter, but are described in the species accounts presented in Appendix 9B. Additionally, these species are only generally addressed in the analysis of impacts presented in the Environmental Consequences section of this chapter.

The level of detail presented in the Affected Environment section is tailored to correspond the level of resolution of the analysis, which relies on modeling tools that broadly characterize the changes in CVP and SWP 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. The inclusion of unnecessary detail is avoided.

### 9.3.2 Critical Habitat

Critical habitat refers to areas designated by USFWS or NMFS for the conservation of their jurisdictional species listed as threatened or endangered under the Endangered Species Act (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. Critical habitat is defined in Section 3, Provision 5 of the ESA as follows.

> *(5)(A) The term "critical habitat" for a threatened or endangered species means–*
>
> > *(i) the specific areas within the geographical area occupied by a species at the time it is listed in accordance with the Act, on which are found those physical or biological features (I) essential to the conservation of the species, and (II) which may require special management considerations or protection; and*
> >
> > *(ii) specific areas outside the geographical area occupied by a species at the time it is listed in accordance with the provisions of section 4 of this Act, upon a determination by the Secretary that such areas are essential for the conservation of the species.*

Any Federal action (permit, license, or funding) in critical habitat requires that the Federal agency consult with USFWS or NMFS where the action has potential to adversely modify the habitat for the listed species.

ESA regulations state that the physical and biological features essential to the conservation of the species include space for individual and population growth and for normal behavior; food, water, air, light, minerals, or other nutritional or physiological requirements; cover or shelter; sites for breeding, reproduction, and rearing of offspring; and habitats that are protected from disturbance or are representative of the historical geographical and ecological distribution of a species. These principal biological and physical features are known as Primary Constituent Elements (PCEs)[1]. Specific PCEs identified for salmonids, Green Sturgeon, Delta Smelt, and Eulachon are described below.

#### *9.3.2.1 Anadromous Salmonids*

In designating critical habitat for anadromous salmonids (70 Federal Register [FR] 52536), NMFS identified the following PCEs as essential to the conservation of the listed populations:

- Freshwater spawning sites with water quantity and quality conditions and substrate that support spawning, incubation, and larval development.
- Freshwater rearing sites with:
  - Water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility
  - Water quality and forage supporting juvenile development
  - Natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks
- Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.
- Estuarine areas free of obstruction and excessive predation with:
  - Water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh water and salt water
  - Natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels
  - Juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation

Critical habitat in nontidal waters includes the stream channels in the designated stream reaches, the lateral extent of which generally defined by the ordinary high-water line.

[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.”

#### 9.3.2.1.1 Central Valley Spring-run Chinook Salmon ESU

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.

The spring-run Chinook Salmon critical habitat potentially affected by operation of the CVP and SWP includes the network of channels in the northern Delta, Sacramento River up to Keswick Dam, Clear Creek up to Whiskeytown Dam, the Feather River up to the Fish Barrier Dam, and the American River up to Watt Avenue in the Sacramento Valley subregion. The section of the American River denoted as critical habitat serves only as juvenile nonnatal rearing habitat; spring-run Chinook Salmon do not spawn in the American River. Operation of the CVP and SWP would have no effect on designated critical habitat for spring-run Chinook Salmon in the Yuba River and Big Chico, Butte, Deer, Mill, Battle, and Antelope creeks or other tributaries of the Sacramento River. Operation of the CVP and SWP could affect designated critical habitat in the Delta subregion. There is no designated critical habitat for spring-run Chinook Salmon in the San Joaquin Valley subregion.

#### 9.3.2.1.2 Sacramento River Winter-run Chinook Salmon ESU

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 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 (NMFS 1993).

#### 9.3.2.1.3 Central Valley Steelhead DPS

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, Ulatis Creek, 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.

The Central Valley Steelhead critical habitat potentially affected by operation of the CVP and SWP includes the Sacramento River up to Keswick Dam, Clear Creek up to Whiskeytown Dam, the Feather River up to the Fish Barrier Dam, and the American River up to Nimbus Dam in the Sacramento Valley subregion. Operation of the CVP and SWP would have no effect on designated critical habitat for steelhead in the Yuba River and Big Chico, Butte, Deer, Mill, Battle, and Antelope creeks or other tributaries of the Sacramento River.

##### 9.3.2.1.4 Central California Coast Steelhead DPS

The Central California Coast Steelhead DPS includes all naturally spawned populations of steelhead in streams from the Russian River to Aptos Creek, Santa Cruz County (inclusive). It also includes the drainages of San Francisco and San Pablo bays. Critical habitat for Central California Coast Steelhead includes stream reaches in the Russian River, Bodega, Marin Coastal, San Mateo, Bay Bridge, Santa Clara, San Pablo, and Big Basin Hydrologic Units. Operation of the CVP and SWP would not affect designated critical habitat for this DPS of Central California Coast Steelhead, and NMFS (2009a) concluded that operation would not likely adversely affect individual fish; therefore, this species is not addressed in this EIS.

##### 9.3.2.1.5 Southern Oregon/Northern California Coastal Coho Salmon ESU

The Southern Oregon/Northern California Coast Coho Salmon ESU consists of populations from Cape Blanco, Oregon, to Punta Gorda, California, including Coho Salmon in the Trinity River. In the Trinity River Region, all Trinity River reaches downstream of Lewiston Dam, the south fork of the Trinity River, and the entire lower Klamath River are designated as critical habitat with the exception of tribal lands (NMFS 1999).

#### *9.3.2.2 North American Green Sturgeon Southern DPS*

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

- **Food Resources.** Abundant prey items for larval, juvenile, subadult, and adult life stages.
- **Substrate Type or Size (i.e., structural features of substrates).** Substrates suitable for egg deposition and development (e.g., bedrock sills and shelves, cobble and gravel, or hard clean sand, with interstices or irregular surfaces to "collect" eggs and provide protection from predators, and free of excessive silt and debris that could smother eggs during incubation), larval development (e.g., substrates with interstices or voids providing refuge from predators and from high-flow conditions), and subadults and adults (e.g., substrates for holding and spawning).
- **Water Flow.** 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.** Water quality, including temperature, salinity, oxygen content, and other chemical characteristics, necessary for normal behavior, growth, and viability of all life stages.
- **Migratory Corridor.** A migratory pathway necessary for the safe and timely passage of Southern DPS fish within riverine habitats and between riverine and estuarine habitats (e.g., an unobstructed river or dammed river that still allows for safe and timely passage).
- **Water Depth.** Deep (greater than 5 meters [m]) 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**. Sediment quality (i.e., chemical characteristics) necessary for normal behavior, growth, and viability of all life stages.

Critical habitat in freshwater riverine habitats includes the stream channels in the designated stream reaches with the lateral extent defined by the ordinary high-water line. The ordinary high-water line on nontidal rivers is defined as "the line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank; shelving; changes in the character of soil; destruction of terrestrial vegetation; the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas" [33 Code of Federal Regulations 329.11(a)(1)].

Within the study area, critical habitat includes 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 the confluence with the Sacramento River upstream to the State Route 160 bridge over the American River; the lower Feather River from the confluence with the Sacramento River upstream to the Fish Barrier Dam; and the lower Yuba River from the 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 (NMFS 2009b).

#### *9.3.2.3 Delta Smelt*

In designating critical habitat for Delta Smelt (59 FR 65256), USFWS identified the following PCEs essential to the conservation of the species: (1) suitable substrate for spawning; (2) water of suitable quality and depth to support survival and reproduction (e.g., temperature, turbidity, lack of contaminants); (3) sufficient Delta flow to facilitate spawning migrations and transport of larval Delta Smelt to appropriate rearing habitats; and (4) 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) (USFWS 1994a).

#### *9.3.2.4 Eulachon Southern DPS*

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 fall reflecting key life history phases of Eulachon: (1) freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, and with migratory access for adults and juveniles; (2) 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; and (3) nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

Within the study area, critical habitat for Eulachon includes the Klamath River from the mouth upstream to the confluence with Omogar Creek. The critical habitat designation specifically excludes all lands of the Yurok Tribe and Reshigini Rancheria, based upon a determination that the benefits of exclusion outweigh the benefits of designation (NMFS 2011b). 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 percent of the total annual production for the DPS (NMFS 2011a, 2011b).

### 9.3.3 Trinity River Region

The 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 in Humboldt and Del Norte counties from the confluence with the Trinity River to the Pacific Ocean. The CVP Trinity Lake and Lewiston Reservoir are located upstream of the confluences of several Trinity River tributaries (i.e., north fork, south fork, and New River) and flows on these tributaries are not affected by CVP facilities. The Trinity River flows approximately 112 miles from Lewiston Reservoir to its confluence with the Klamath River, traversing through Trinity and Humboldt counties and the Hoopa Indian Reservation within Trinity and Humboldt counties. The Trinity River is the largest tributary to the Klamath River (DOI and DFG 2012).

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

#### *9.3.3.1 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 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, Coast Range Sculpin, and Smallmouth Bass (USFWS et al. 2004).

#### *9.3.3.2 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, Pacific Lamprey, and Eulachon.

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 was allowed to encroach 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 et al. 1999). The berm reduced the potential for encroachment and maturation of woody vegetation along the stabilized channel.

The ongoing Trinity River Restoration Program includes specific minimum instream flows (as described in Chapter 5, Surface Water Resources and Water Supplies); mechanical channel rehabilitation; fine and coarse sediment management; watershed restoration; infrastructure improvement; and adaptive management components (NCRWQCB et al. 2009, USFWS et al. 1999). The mechanical channel rehabilitation includes removal of fossilized riparian berms that had been anchored by extensive woody vegetation root systems and had confined the river. Following removal of the berms, the areas have been re-vegetated to support native vegetation, re-establish alternate point bars, and re-establish complex fish habitat similar to conditions prior to construction of the dams. Sediment management activities include introduction of coarse sediment at locations to support spawning and other aquatic life stages; and relocation of sand outside of the floodway. 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 planted on the restored floodplains and flows will be managed to encourage natural riparian growth on the floodplain and limit encroachment on the newly formed gravel bars. Improvement projects have been completed and others are under construction or in the planning phases. These restoration actions are occurring in the 40-mile restoration reach between Lewiston Dam and the confluence with north fork of the Trinity River (TRRP 2014).

#### 9.3.3.2.1 Fish in the Trinity River

The following focal fish species that occur in the Trinity River are considered in this EIS.

- Coho Salmon
- Chinook Salmon (spring- and fall-run)
- Steelhead (winter-and summer-run)
- Green Sturgeon
- White Sturgeon
- Pacific Lamprey
- American Shad

*Coho Salmon*

Coho Salmon in the Trinity River are thought to be exclusively 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 occurs primarily in November and December. Coho Salmon eggs incubate from 35 to more than 100 days, depending on water temperature, and emerge from the gravel 2 weeks to 7 weeks after hatching. 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. Coho Salmon smolts typically migrate to the ocean between March and June, with most leaving in April and May (the term "smolt" refers to young salmon prior to entering the ocean that have undergone the physiological changes necessary for life in salt water).

Coho Salmon were not likely the dominant species of salmon in the Trinity River before dam construction. However, the species was widespread in the Trinity River Basin, ranging as far upstream as Stuarts Fork above present-day Trinity Dam. Passage for Coho Salmon and other anadromous salmonids is now blocked at Lewiston Dam, which prevents access to roughly 109 miles of upstream habitat for Coho Salmon (DOI 2000). The Trinity River Salmon and Steelhead Hatchery (Trinity River Hatchery) produces Coho Salmon with an annual production goal of 500,000 yearlings to mitigate the upstream habitat loss (CHSRG 2012).

Several interrelated factors affect Coho Salmon abundance and distribution in the Trinity River. These factors include water temperature, water flow, habitat suitability, habitat availability, hatcheries, predation, competition, disease, ocean conditions, and harvest. Current CVP operations primarily affect water temperature, water flow, and habitat suitability in the Trinity River (Reclamation 2008a). Currently accessible habitat downstream of Lewiston Dam represents about 50 percent of historically available habitat (USFWS 1999).

Habitat in the Trinity River has changed since flow regulation that began with the completion of Trinity and Lewiston dams, with the encroachment of riparian vegetation restricting channel movement and limiting fry rearing habitat (Trush et al. 2000). The Trinity River Restoration Program is implemented to provide higher peak flows to restore attributes of a fully functioning alluvial river, such as alternating bar features and additional off-channel habitat, and to provide better rearing habitat for Coho Salmon (Reclamation 2008a, TRRP 2013). Several restoration actions have been completed to reconnect the river with the floodplain, including selective removal of terraces and riparian berms and physical alteration of the adjacent floodplain to increase inundation frequency. Releases from Trinity Lake occur on a variable flow schedule with higher spring releases to promote the restored geomorphic processes and habitat.

An estimated 21,906 Coho Salmon migrated into the Trinity River Basin upstream of the Willow Creek in 2013, of which 6,631 entered Trinity River Hatchery (located near Lewiston Dam) and 15,275 were estimated to have spawned in the river (CDFW 2014). The run-size estimates have ranged from 852 fish in 1994 to 59,079 fish in 1987. The 2011 run was ranked 10th of the 37 years on record and is 27.6 percent of the 17,161 average (CDFW 2014).

*Spring-run Chinook Salmon*

Spring-run Chinook Salmon migrate upstream in the Trinity River from April through September, with most fish arriving at the reach downstream of Lewiston Dam by the end of July. These fish remain in deep pools until the onset of the spawning season, which typically begins the third week of 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. 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. In 2013, an estimated 8,961 spring-run Chinook Salmon entered the Trinity River upstream of Junction City, including the 2,578 fish that entered the Trinity River Hatchery and 6,129 natural area spawners CDFW 2014). 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).

Emergence of spring-run Chinook Salmon fry in the Trinity River begins in December and continues into mid-April. Juvenile spring-run Chinook Salmon typically outmigrate 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.

*Fall-run Chinook Salmon*

The fall-run Chinook Salmon migration in the Trinity River begins in August and continues into December, with spawning beginning in mid-October. Spawning activity peaks in November, and continues through December. Spawning of fall-run Chinook Salmon occurs throughout the mainstem Trinity River from Lewiston Dam to the Hoopa Valley (Myers et al. 1998). The first spawning activity usually occurs just downstream from Lewiston Dam and extends farther downstream as the spawning season progresses.

Like spring-run Chinook Salmon, emergence of fall-run Chinook Salmon fry begins in December and continues 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.

An estimated 36,989 fall-run Chinook Salmon migrated into the Trinity River upstream of Willow Creek in 2013, of which 3,852 entered Trinity River Hatchery and 32,257 spawned naturally (CDFW 2014). This estimate is approximately 84.5 percent of the 43,762 mean run-size for the years since 1977, which has ranged from 9,207 fish in 1991 to 147,888 fish in 1986 (CDFW 2014).

*Steelhead*

Steelhead 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 steelhead runs have been observed in the north and south forks of the Trinity River and in the tributaries of New River and Canyon Creek (BLM 1995).

Adult summer steelhead enter the Trinity River from April through September and over-summer in deep pools within the mainstem. Some enter the smaller tributary streams 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 steelhead spawner escapements for the Trinity River upstream of Lewiston prior to construction of the dam were estimated to average 8,000 adults annually. Post-dam survey (reported in 2004) ranged from 20 to 1,037 adult summer steelhead in the tributaries and Trinity River (USFWS et al. 2004).

Juvenile summer-run steelhead may rear in fresh water for up to 3 years before outmigrating. Rearing in the Trinity River is highly variable, but most summer-run steelhead either outmigrate as young-of-the-year (YOY) or at age 1+ (Scheiff et al. 2001, Pinnix and Quinn 2009, Pinnix et al. 2013). 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 1 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 from January through April. Adult winter-run steelhead begin their upstream migration 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).

An estimated run-size of 16,594 adult fall-run steelhead migrated into the Trinity River upstream of Willow Creek in 2013, including the 2,375 fish (80 natural-origin and 2,295 hatchery-origin) that entered the Trinity River Hatchery and 13,560 natural area spawners (9,039 of natural origin and 4,521 of hatchery origin) (CDFW 2014). 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*

Most information on 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 4 years on average after around age 16 (Klimley et al. 2007). 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 of Green Sturgeon 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). Juvenile Green Sturgeon may rear for 1 to 3 years in the Klamath River system before they migrate to the estuary and Pacific Ocean (NRC 2004, FERC 2007a, CALFED 2007), usually during summer and fall (Emmett et al. 1991, Hardy and Addley 2001).

In the Trinity River Basin, Green Sturgeon are known to spawn in the mainstem from the confluence with the Klamath to as far upstream as Gray's Falls near Burnt Ranch. Juveniles are captured at Willow Creek on the Trinity River (Scheiff et al. 2001, Pinnix and Quinn 2009).

*White Sturgeon*

Small numbers of White Sturgeon occur in Klamath and Trinity rivers (NRC 2004). Presumably, these individuals are on feeding migrations. Historically there may have been small spawning runs (Moyle 2002).

*Pacific Lamprey*

Pacific Lamprey are the only anadromous lamprey species in the Trinity River Basin. This species is important to local tribes and supports a subsistence fishery on the 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 that 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).

Little information is available on factors that influence populations of Pacific Lamprey in the Trinity River, but they are adversely affected by many of the same factors as salmon and steelhead, because of parallels in their life cycles. Lack of access to historical spawning habitats caused by the mainstem dams and other migration barriers, modification of spawning and rearing habitat because of downstream impacts from dams, altered hydrology, and predation by nonnative invasive species such as Brown Trout all likely adversely affect the Trinity River Pacific Lamprey population.

*American Shad*

American Shad, an introduced, anadromous fish, has become established in the Klamath and Trinity rivers. American Shad occur in the lowermost portions of the Trinity River, but are primarily found in the lower Klamath River. Adult fish enter estuaries or streams in late spring or early summer and spawn soon afterward in fresh water. Juvenile shad have been captured regularly in the rotary-screw traps at the Pear Tree and Willow Creek sites during salmonid outmigrant monitoring (Scheiff et al. 2001, Pinnix and Quinn 2009, Pinnix et al. 2013). Sport fishing for American Shad occurs seasonally throughout the lower Trinity River.

#### 9.3.3.2.2 Hatcheries on the Trinity River

The Trinity River Hatchery is located immediately downstream of Lewiston Dam, and is operated by CDFW and funded by Reclamation to mitigate the loss of salmonid production upstream of Lewiston Dam resulting from the Trinity Dam (Reclamation 2008a). The hatchery produces Coho Salmon, fall-run Chinook Salmon, spring-run Chinook Salmon, and steelhead. The hatchery's Coho Salmon program currently uses only endemic Coho Salmon broodstock and releases approximately 500,000 yearlings annually from March 15 to May 15. The fall-run Chinook Salmon program has a goal of releasing 2 million sub-yearlings in June and 900,000 yearlings in October from in-river broodstock, and the spring-run Chinook Salmon program has a goal of releasing 1 million subyearlings in June and 400,000 yearlings in October from in-river broodstock. The steelhead program currently uses only in-river broodstock with a goal to release 800,000 steelhead smolts (approximately 6 inches) from March 15 to May 1.

### *9.3.3.3 Lower Klamath River from Trinity River to Pacific Ocean*

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

##### 9.3.3.3.1 Fish in the Lower Klamath River

Focal fish species that occur in the lower Klamath River downstream of the Trinity River confluence are included for analysis in this EIS and include all those found in the Trinity River, as described above, with the exception of Eulachon.

Eulachon 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. Eulachon are sexually mature at 2 years and spawn at ages 3, 4, and/or 5 (Scott and Crossman 1973). 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 high as Brooks Riffle, about 40 kilometers (about 24 miles) upstream of the mouth, but have been observed as high as Pecwan Creek and even Weitchpec during exceptional years (YTFP 1998); 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 are passively carried from spawning grounds to the ocean via river currents (Scott and Crossman 1973).

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 great 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, 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).

### 9.3.4 Central Valley Region

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

- Shasta Lake and Keswick Reservoir
- Whiskeytown Lake
- Clear Creek
- Sacramento River from Keswick Reservoir to the Delta (near Freeport)
- Battle Creek
- Feather River
- Yuba and Bear Rivers
- American River
- Delta

- Yolo Bypass
- Millerton Lake
- San Joaquin River from the Stanislaus River confluence to the Delta (near Vernalis)
- New Melones Reservoir, Tulloch Reservoir, and Goodwin Lake
- Stanislaus River
- San Luis Reservoir

#### *9.3.4.1 Shasta Lake and Keswick Reservoir*

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. Shasta Dam has no fish passage facilities; however, the dam has a fish trapping facility that operates in conjunction with the Coleman NFH on Battle Creek.

##### 9.3.4.1.1 Shasta Lake

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 2013b). 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 degrees Fahrenheit (°F) (Reclamation 2003). 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 2013). 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 2013).

Water quality in Shasta Lake is generally considered good, largely because of the continual inflow of cool, high-quality water from the major tributaries to the lake. The primary water quality concerns in the lake is turbidity, typically associated with heavy rainfall events that move soils and runoff from abandoned mines in the area into the lake.

Warm-water fish habitat in Shasta Lake is influenced primarily by fluctuations in the lake level and the availability of shoreline cover (Reclamation 2003). Water surface elevations in Shasta Lake can fluctuate approximately 55 feet annually as a result of operation of Shasta and Sacramento River diversions (Reclamation 2003). 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 2003).

##### 9.3.4.1.2 Keswick Reservoir

Keswick Reservoir is a re-regulating reservoir for Shasta Lake. The water surface elevation is relatively constant. Residence time for water in Keswick Reservoir is about a day, compared with a residence time of about a year for water in Shasta Lake. Consequently, water temperatures tend to be controlled by releases from Shasta Dam and average less than 55°F. Despite the cool temperatures, the reservoir supports warm-water and cold-water fishes, including Largemouth Bass, crappie and catfish, and Rainbow Trout (Reclamation 2003).

#### *9.3.4.2 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 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 Oak Bottom curtain is damaged and cannot be fully deployed; it is scheduled to be repaired in 2015. 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, Brown Trout, Kokanee Salmon, Largemouth Bass, crappie, sunfish, catfish, and bullhead (USFWS et al. 2004).

#### *9.3.4.3 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. 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.

##### 9.3.4.3.1 Fish in Clear Creek

This analysis is focused on Chinook Salmon, steelhead, and Pacific Lamprey in Clear Creek.

*Spring-run Chinook Salmon*

Clear Creek currently supports a modest run of spring-run Chinook Salmon, which since 1998 has ranged from 0 in 2001 to an estimated high of 659 fish in 2013 (CDFW 2014). Adult spring-run Chinook Salmon migrate into Clear Creek from April through September. Adult fish tend to move as far upstream as possible to access cooler temperatures downstream of Whiskeytown Dam and hold over in summer until spawning in September through October. In the NMFS 2009 BO, NMFS expressed concern that spring-run Chinook Salmon unable to enter Clear Creek for spawning could hybridize with fall-run Chinook Salmon spawning in the Sacramento River (NMFS 2009a).

NMFS (2009a) reported that insufficient instream flows could fail to attract adult spring-run holding in the Sacramento River mainstem into Clear Creek. Adult spring-run Chinook Salmon tend to spread downstream of their holding areas prior to spawning (from Whiskeytown Dam downstream to the Clear Creek Road Bridge) from September through October. Egg incubation occurs from September through December, and juveniles rear from October through April (NMFS 2009a).

Spawning gravel is annually augmented in Clear Creek downstream of Whiskeytown Dam under the CVPIA Clear Creek Restoration Program and in accordance with the 2009 NMFS BO (Reclamation 2013a). Additionally, water temperature criteria to protect spring-run Chinook Salmon during spawning and incubation are generally met; however, in recent years, water temperatures in Clear Creek during the spawning and incubation period (i.e., September 15 to October 31) have exceeded the temperature targets at times (Brown et al. 2012).

Based on rotary screw trap captures, juvenile spring-run Chinook Salmon outmigrate from Clear Creek from May through February. Peak outmigration occurs over a 9-week period from early December 2008 through early February 2009 (Earley et al. 2010). Trap data indicate that the majority of juveniles identified as spring-run (based on length-at-date size criteria) leave as age-0 fish, less than 40 millimeter (mm) in fork length (USFWS 2008b, Earley et al. 2010).

*Fall-/Late Fall-run Chinook Salmon*

Since 1995, restoration activities implemented in accordance with programs implemented under the CVPIA, CALFED, and the 2009 NMFS BO have increased stocks of fall-run Chinook Salmon by more than 400 percent (Brown 2011). In 2014, fall-run Chinook Salmon estimated escapement was 15,794 compared to the average baseline (1967-1991) estimated escapement of 1,689.

Fall/late fall-run Chinook Salmon primarily use the lower reaches of Clear Creek for all life history phases. Fall-run Chinook migrate into Clear Creek between the spring- and late fall-runs and spawn in October through December (USFWS 2015). A picket weir installed about 7.4 miles upstream of the confluence with the Sacramento River from August 1 to November 1 is used to prevent fall-run Chinook Salmon from spawning in the upper reaches with spring-run.

Late-fall-run Chinook Salmon migrate into Clear Creek from November through April, with peak migration in December; peak spawning occurs in January.

Based on rotary screw trap captures and length-at-date size criteria, fall-run Chinook Salmon make up the vast majority of all Chinook Salmon outmigrating from lower Clear Creek. Late fall-run juveniles constitute a small percentage of juvenile Chinook Salmon leaving Clear Creek. Juvenile fall-/late fall-run Chinook Salmon primarily outmigrate from Clear Creek as age-0 fish less than 40 mm in fork length (USFWS 2008b, Earley et al. 2010). Peak age-0 outmigration in 2008/2009 was from January and February for fall-run Chinook Salmon and during April to May for late fall-run Chinook Salmon (Earley et al. 2010).

*Steelhead*

Operation of Whiskeytown Dam supports cold-water habitat for steelhead in Clear Creek, the amount of which depends on flow releases which range from 30 to 200 cubic feet per second (cfs) depending on water year type (Reclamation 2008a). Steelhead have recolonized the habitat that became accessible with the removal of the McCormick-Saeltzer Dam in 2000. Redd surveys conducted since 2003 indicate that a small, but increasing population of steelhead resides in Clear Creek, with the highest density in the first mile below Whiskeytown Dam (USFWS 2007).

Adult steelhead immigration into Clear Creek usually occurs from August through March, with a peak occurring from September to November (USFWS 2008b). Adult steelhead tend to hold in the upper reaches of Clear Creek from September to December.

Spawning typically begins in December and continues through early March. Peak spawning occurs from late January to early February (USFWS 2007). The embryo incubation life stage begins with the onset of spawning in late December and generally extends through April.

Spawning distribution has recently expanded from the upper 4 miles of lower Clear Creek to the entire 17 miles of lower Clear Creek, although it appears to be concentrated in areas of newly added spawning gravels. Recently, more steelhead were observed spawning in the lowest reach of the creek where resulting juveniles can be subject to warmer water temperatures during summer (Brown 2011).

Summertime water temperatures are often critical for steelhead rearing and limit rearing habitat quality in many streams. Instream flow releases are intended to maintain suitable water temperatures throughout most of Clear Creek during summer. Snorkel surveys from 1999 to 2002 indicate that rearing steelhead may be present throughout all of lower Clear Creek (Good et al. 2005). Based on rotary screw trap captures, fry make up the vast majority of all steelhead/Rainbow Trout captured in lower Clear Creek. Peak outmigration of juvenile steelhead fry occurred from mid-March through April of 2009 (Earley et al. 2010).

*Pacific Lamprey*

Pacific Lamprey is expected to inhabit all reaches in Clear Creek upstream to Whiskeytown Dam. The loss of access to historical habitat and apparent population declines throughout California and the Sacramento and San Joaquin River basins indicate the population is likely reduced compared with historical levels (Moyle et al. 2009). Little information is available on factors influencing populations of Pacific Lamprey in Clear Creek, but they are likely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles.

Ocean stage adult Pacific Lampreys likely migrate into Clear Creek in summer, where they hold for approximately 1 year before spawning (Hanni et al. 2006). No information is available on spawning in Clear Creek; however, spawning period documented by Hannon and Deason (2008) for Pacific Lampreys in the American River of early January to late May, with peak spawning typically in early April, may also apply to Clear Creek. Pacific Lamprey ammocoetes rear in Clear Creek for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping in Clear Creek suggest that some outmigration of Pacific Lampreys may occur year-round, but peak outmigration occurs from early winter through spring (Hanni et al. 2006).

#### 9.3.4.3.2 Extent and Status of Aquatic Habitat

Whiskeytown Dam limits the contribution of coarse sediment for transport downstream in Clear Creek, which NMFS (2009a) 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 temperatures conditions on Clear Creek are presented in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 6, 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. In 2012, a total of 9,974 tons of gravel was placed at four sites:

Guardian Rock site, Placer Bridge, Clear Creek Road Crossing, and at Tule Backwater. A gravel injection project did not occur in 2013 (CVPIA 2014).

Most supplemental spawning gravel is placed into Clear Creek at long-term injection sites awaiting high flows to move gravel into the creek. 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 2007, 2008b). 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. The amount of area used in 2008 was the highest measured and more than double the amount used in 2000, suggesting that the gravel augmentation program has been successful in creating new spawning habitat. 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 determine the availability of fish habitat, expressed as Weighted Useable Area (WUA), have been conducted by USFWS for Clear Creek (USFWS 2006). For spring-run Chinook Salmon, it was determined that spawning WUA peaked at the highest modeled flow (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) spawning habitat peaked at 650 cfs. The WUA for steelhead/Rainbow Trout spawning habitat peaked at 350 cfs and 600 cfs in these segments, respectively (USFWS 2007). In the lower reach downstream of the Clear Creek Road Bridge, WUA for both fall-run Chinook Salmon and steelhead/Rainbow Trout spawning habitat peaked at 300 cfs (USFWS 2011a).

At all flows, the amount of spawning habitat present in Clear Creek is less than the amount needed to achieve the abundance recovery goal of spring-run Chinook Salmon spawning (based on the original USFWS [2007] estimates). 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 is greater than the amount of spawning habitat needed to achieve the abundance recovery goal for steelhead. In contrast, the amount of spawning habitat present in Clear Creek is less than the amount of spawning habitat needed to support 7,920 adult fall-run Chinook Salmon in Clear Creek (USFWS 2015).

*Rearing Habitat*

The WUA 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), fry rearing habitat peaked at the highest modeled flow (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).

As described above for spawning habitat, USFWS (2015) compared the total amount or 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 is 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 is less than the amount needed to support 7,920 adult fall-run Chinook Salmon in Clear Creek.

##### 9.3.4.3.3 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 a barrier to upstream migration for anadromous salmonids. After its removal, anadromous salmonids recolonized an additional 12 miles of habitat upstream to Whiskeytown Dam. With the removal of McCormick-Saeltzer Dam, passage of spring-run Chinook Salmon has increased. 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 with a segregation weir that is operated from August 1 to November 1. After November 1, fall-run Chinook Salmon have access to the entire river for spawning.

#### *9.3.4.4 Sacramento River from Keswick Reservoir 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 open spaces that provide more natural types of habitat. The flow regime in the Sacramento River is managed for water supply and flood management, as described in Chapter 5, Surface Water Resources and Water Supplies. The following discussion focuses on the fish in the Sacramento River and aquatic habitat conditions.

##### 9.3.4.4.1 Fish in the Sacramento River

The analysis is focused on the following species:

- Chinook Salmon (winter-, spring-, and fall/late fall-run)
- Steelhead
- Green Sturgeon
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad

*Winter-run Chinook Salmon*

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, but winter-run Chinook 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 from other Sacramento River Chinook runs and from all other populations within the range of Chinook Salmon (DFG 1985, 1998b).

Access to approximately 58 percent of the original winter-run Chinook Salmon habitat has been blocked by dam construction (Reclamation 2008a). The remaining accessible habitat occurs in the Sacramento River downstream of Keswick Dam and in Battle Creek. The number of winter-run Chinook Salmon in Battle Creek is unknown, but if they do occur, they are scarce (Reclamation and SWRCB 2003).

Escapement data indicate that the winter-run Chinook Salmon population declined from its levels in the 1970s to relatively low levels through the 1980s and 1990s, with a small rebound in the early 2000s (Azat 2012).

Adult winter-run Chinook Salmon migrate upstream past the location of the Red Bluff Diversion Dam (RBDD) beginning in mid-December and continuing into early August. Most of the run passes RBDD between January and May, with the peak in mid-March (DFG 1985). Winter-run Chinook Salmon spawn only in the Sacramento River, almost exclusively above RBDD, with the majority spawning upstream of Balls Ferry, based on aerial redd survey data collected after passage was provided past the Anderson-Cottonwood Irrigation District (ACID) diversion.

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; a high proportion of winter run Chinook spawn on the recently placed gravel (USFWS and Reclamation 2008). Spawning occurs 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 RBDD may begin in late July, generally peaks in September, and can continue until mid-March in drier years (Vogel and Marine 1991). The majority (75 percent) of winter-run Chinook Salmon outmigrate past RBDD as fry (Martin et al. 2001), where they rear before outmigrating to the Delta primarily in December through April (Appendix 9B). Between 44 and 81 percent (mean 65 percent) of juvenile winter-run Chinook Salmon used areas downstream of RBDD for nursery habitat, and the relative usage of rearing habitat upstream and downstream of RBDD 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).

*Spring-run Chinook Salmon*

Historically, spring-run Chinook Salmon in the Sacramento River Basin were found in the upper and middle reaches (1,000 to 6,000 feet) of the American, Yuba, Feather, Sacramento, McCloud and Pit rivers, as well as smaller tributaries of the upper Sacramento River downstream of present-day Shasta Dam (NMFS 2009a). Estimates indicate that 82 percent of the approximately 2,000 miles of salmon spawning and rearing habitat available in the mid-1800s is unavailable or inaccessible today (Yoshiyama et al. 1996). Naturally spawning populations of spring-run Chinook Salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (DFG 1998b). Most of these reaches are outside the project area; however, all spring-run Chinook Salmon migratory life stages must pass through the project area.

Spring-run Chinook Salmon abundance in the Sacramento River mainstem has apparently declined sharply through time, with escapement estimates ranging from approximately 5,000 to 23,000 fish in the 1980s, 100 to 4,100 fish in the 1990s, and 0 to 621 fish between 2000 and 2014 (CDFW 2015). However, the criteria for run classification at RBDD have changed so no conclusions can be reached about changes in the number of spring-run Chinook Salmon in the Sacramento River. Chinook Salmon expressing spring-run timing do spawn in the mainstem Sacramento River between RBDD and Keswick Dam (NMFS 2009a). The Sacramento River now serves primarily as a migratory corridor for the adult and juvenile life stages of spring-run (and other runs) of Chinook Salmon.

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 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). Peak movement of juvenile (yearling) spring-run Chinook Salmon in the Sacramento River at Knights Landing occurs in December and again in March and April for YOY juveniles. Pulse flows that occur during precipitation events tend to stimulate downstream movement along the Sacramento River. Spring-run juveniles that remain in the Sacramento River over summer are confined to approximately 100 miles of the upper mainstem, where cool water temperatures are maintained by dam releases.

*Fall-/Late Fall-run Chinook Salmon*

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 fresh water. Fall-run Chinook Salmon migrate upstream past RBDD on the Sacramento River between July and December, typically spawning in upstream reaches from October through March. Late fall-run Chinook Salmon migrate upstream past RBDD from August to March and spawn from January to April (NMFS 2009a, TCCA 2008). The majority of young fall-run Chinook Salmon migrate to the ocean during the first few months following emergence, although some may remain in fresh water and migrate as yearlings. Late fall-run juveniles typically enter the ocean after 7 to 13 months of rearing in fresh water, at 150- to 170 mm in fork length, considerably larger and older than fall-run Chinook Salmon (Moyle 2002).

The primary spawning area used by fall- and late fall-run Chinook Salmon in the Sacramento River is the area from Keswick Dam downstream to RBDD. Spawning densities for each of the runs are generally highest in this reach.

Annual fall-run and late fall-run Chinook Salmon escapement to the Sacramento River and its tributaries has generally been declining in the last decade, following peaks in the late 1990s to early 2000s (Azat 2012).

*Steelhead*

Although steelhead can be divided into two life history types, summer-run steelhead and winter-run steelhead, based on their state of sexual maturity at the time of river entry, only winter-run steelhead are currently found in Central Valley rivers and streams. 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).

Adult steelhead migrate upstream past the Fremont Weir between August and March, primarily from August through October; they migrate upstream past

RBDD during all months of the year, but primarily during September and October (NMFS 2009a). The primary spawning area used by steelhead in the Sacramento River is the area from Keswick Dam downstream to RBDD. Unlike salmon, steelhead may live to spawn more than once and generally rear in freshwater streams for 2 to 4 years before outmigrating to the ocean. Both spawning areas and migratory corridors are used by juvenile steelhead for rearing prior to outmigration. 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 2009a).

Recent steelhead monitoring data are scarce for the upper portion of the Sacramento River system. In 1989, Hallock (1989) reported that steelhead had declined drastically in the Sacramento River upstream of the Feather River confluence. In the 1950s, the average estimated spawning population size upstream of the Feather River confluence was 20,540 fish (McEwan and Jackson 1996). In 1991–1992, the annual run size for the total Sacramento River system was likely fewer than 10,000 adult fish (McEwan and Jackson 1996). From 1967 to 1993, the estimated number of steelhead passing the Red Bluff Pumping Plant ranged from a low of 470 to a high of 19,615 (CHSRG 2012). Steelhead escapement surveys at the site of RBDD ended in 1993.

*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 RBDD (Reclamation 2008a). 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 and possibly up to the Cow Creek confluence (Brown 2007, Poytress et al. 2013). 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 over the last 15 years (Beamesderfer et al. 2004). 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, larvae, and post-larval Green Sturgeon are now commonly reported in sampling directed at Green Sturgeon and other species (Beamesderfer et al. 2004, Brown 2007). YOY Green Sturgeon have been observed annually since the late 1980s in fish sampling efforts at RBDD and the Glenn-Colusa Irrigation District (GCID) intake (Beamesderfer et al. 2004). Acoustically tagged Green Sturgeon were detected upstream of RBDD from 2004 to 2006 (Heublein et al. 2009). Adult Green Sturgeon that migrate upstream in April, May, and June are completely blocked by the ACID diversion dam

(NMFS 2009b), 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). Larval Green Sturgeon have been regularly captured during their dispersal stage at about 2 weeks of age (24 to 34 mm fork length) in rotary screw traps at RBDD (DFG 2002a) 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 2002a). 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). A genetic analysis of Green Sturgeon larvae captured in the Sacramento River resulted in an estimate of the number of adult spawning pairs upstream of RBDD ranging from 32 to 124 between 2002 and 2006 (Israel 2006). 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.

*White Sturgeon*

In California, White Sturgeon are most abundant within the Delta region, but the population spawns mainly in the Sacramento River; a small part of the population is also thought to spawn in the Feather River (Moyle 2002). In addition to spawning, White Sturgeon embryo development and larval rearing occur in the Sacramento River (Moyle 2002, Israel et al. 2008). White Sturgeon are found in the Sacramento River primarily downstream of RBDD (TCCA 2008), with most spawning between Knights Landing and Colusa (Schaffter 1997).

The population status of White Sturgeon in the Sacramento River is unclear. Overall, limited information on trends in adult and juvenile abundance in the Delta population suggests that numbers are declining (Reis-Santos et al. 2008). Spawning stage adults generally move into the lower reaches of the Sacramento River during winter prior to spawning, then migrate upstream in response to higher flows to spawn from February to early June (Schaffter 1997, McCabe and Tracy 1994). Most spawning in the Sacramento River occurs in April and May (Kohlhorst 1976). YOY White Sturgeon make an active downstream migration that disperses them widely to rearing habitat throughout the lower Sacramento River and Delta (McCabe and Tracy 1994, Israel et al. 2008).

*Sacramento Splittail*

Historically, splittail were widespread in the Sacramento River from Redding to the Delta (Rutter 1908 as cited in Moyle et al. 2004). This distribution has become somewhat reduced in recent years (Sommer et al. 1997, 2007b). During drier years there is evidence that spawning occurs farther upstream (Feyrer et al. 2005). Adult splittail migrate upstream in the lower Sacramento River to above near the mouth of the Feather River and into the Sutter and Yolo bypasses (Sommer et al. 1997, Feyrer et al. 2005, Sommer et al. 2007b). Each year, mainly during the spring spawning season, a small number of individuals have been documented at the Red Bluff Pumping Plant and the entrance to the GCID intake (Moyle et al. 2004).

Nonreproductive adult splittail are most abundant in moderately shallow, brackish areas, but can also be found in freshwater areas with tidal or riverine flow (Moyle et al. 2004). Adults typically migrate upstream from brackish areas in January and February and spawn in fresh water on inundated floodplains in March and April (Moyle et al. 2004, Sommer et al. 2007b). In the Sacramento drainage, the most important spawning areas appear to be the Yolo and Sutter bypasses; however, some spawning occurs almost every year along the river edges and backwaters created by small increases in flow. Splittail spawn in the Sacramento River from Colusa to Knights Landing in most years (Feyrer et al. 2005).

Most juvenile splittail move from upstream areas downstream into the Delta from April through August (Meng and Moyle 1995, Sommer et al. 2007b). The production of YOY Sacramento Splittail is largely influenced by extent and period of inundation of floodplain spawning habitats, with abundance spiking following wet years and declining after dry years (Sommer et al. 1997, Moyle et al. 2004, Feyrer et al. 2006). Other factors that may affect the Sacramento Splittail adult population include flood control operations and infrastructure, entrainment by irrigation diversion, recreational fishing, changed estuarine hydraulics, pollutants, and nonnative species (Moyle et al. 2004, Sommer et al. 2007b).

*Pacific Lamprey*

Pacific Lampreys are anadromous, rearing in fresh water before outmigrating to the ocean, where they grow to full size prior to returning to their natal streams to spawn. Data from mid-water trawls in Suisun Bay and the lower Sacramento River indicate that adults likely migrate into the Sacramento River and tributaries from late fall (November) through early-summer (June) (Hanni et al. 2006). Adult Pacific Lampreys, either immature or spawning stage, have been detected at the GCID diversion from December through July and nearly all year at RBDD (Hanni et al. 2006). Hannon and Deason (2008) documented Pacific Lampreys spawning in the American River between early January and late May, with peak spawning typically in early April. Spawning in the Sacramento River is expected to occur during a similar timeframe. Pacific Lamprey ammocoetes rear in parts of the Sacramento River for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping at sites on the mainstem Sacramento River indicate that outmigration of Pacific Lamprey peaks from early winter through early summer, but some outmigration is observed year-round at both RBDD and the GCID diversion dam (Hanni et al. 2006).

*Striped Bass*

Striped Bass are anadromous; adult Striped Bass are distributed mainly in the lower bays and ocean during summer, and in the Delta during fall and winter. Spawning takes place in spring from April to mid-June (Leet et al. 2001) at which time Striped Bass swim upstream to spawning grounds. Striped Bass are not believed to spawn or rear in the Sacramento River upstream of RBDD (TCCA 2008). Most Striped Bass spawning occurs in the lower Sacramento River between Colusa and the confluence of the Sacramento and Feather rivers (Moyle 2002). About one-half to two-thirds of the eggs are spawned in the Sacramento River and the remainder in the Delta (Leet et al. 2001). After spawning, most adult Striped Bass move downstream into brackish and salt water for summer and fall.

Eggs are free-floating and negatively buoyant, hatching as they drift downstream with larvae occurring in shallow and open waters of the lower reaches of the Sacramento and San Joaquin rivers, the Delta, Suisun Bay, Montezuma Slough, and Carquinez Strait. The Sacramento River functions primarily as a migration corridor for both adults and drifting eggs/larvae.

#### 9.3.4.4.2 Aquatic Habitat

The mainstem Sacramento River provides habitat for native and introduced (nonnative) 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 (Vogel 2011).

A few miles downstream of Keswick Dam, near Redding, the river enters the valley and the 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 middle Sacramento River between Red Bluff and Chico Landing, the mainstem channel is flanked by broad floodplains (TNC 2007a). 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 2009a). 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 flow patterns as determined 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 (TNC 2007a, DWR 1985). 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 2013b). To address the issue of spawning gravel loss downstream of Keswick Dam, Reclamation has placed approximately 5,000 tons of washed spawning gravel into the Sacramento River downstream of Keswick about every other year since 1997 (Reclamation 2010a).

*Spawning Habitat Availability*

Winter-run Chinook Salmon spawning in the upper reaches of the Sacramento River is affected by the operations of the seasonal 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. When the dam is installed in the river, the WUA upstream of the Cow Creek confluence is higher than when the dam is removed. Farther downstream, there is less variability in WUA.

The WUA for winter-run Chinook Salmon spawning peaks at around 10,000 cfs in the upstream reach upstream of the ACID intake when the dam flashboards are in. With the boards out, the peak is around 5,500 cfs. In the next reach downstream (ACID intake to Cow Creek), spawning WUA also peaked at around 10,000 cfs. In the lower reach (Cow Creek to Battle Creek), WUA spawning habitat peaks at around 5,250 cfs, but there is low variability in spawning WUA from 3,250 to 8,000 cfs

Overall, spawning habitat WUA values differ for fall-run and late fall-run Chinook Salmon, but the flow versus habitat relationship is about the same for the two runs. Upstream of the ACID intake, spawning habitat WUA for fall- and late fall-run Chinook Salmon peaks 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 peaks at around 5,000 cfs for both runs. Between Cow Creek and Battle Creek, spawning habitat WUA for both runs peaks at about 3,500 cfs. The highest density of redds for fall- and late fall-run Chinook Salmon occur in the middle ACID intake to Cow Creek reach.

The spawning habitat WUA values for steelhead peaks 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 peaks at river flows around 6,000 cfs. In the lower reach, from Cow Creek to Battle Creek, spawning habitat WUA also peaks at river flows of about 6,500 cfs, but do not vary substantially in a flow range between about 4,000 and 8,000 cfs.

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

USFWS (2005a) 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 RBDD, 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, but 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 2005a).

*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 flooding can be significant within the river corridor (TNC 2007b).

Fry rearing habitat WUA for winter-run Chinook Salmon fry rearing habitat peaks at around 5,500 cfs in the reach upstream of the ACID intake when the dam flashboards are in. With the boards out, the peak is around 6,500 cfs. In the next reach downstream (ACID intake to Cow Creek), fry rearing habitat WUA for winter-run Chinook Salmon peaks at around 31,000 cfs (the highest flow evaluated). In the lower reach (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 variation at flows.

The fry rearing habitat WUA values differ for fall-run and late fall-run Chinook Salmon, but the flow versus habitat relationship was similar for the two runs. Upstream of the ACID intake, fry rearing habitat WUA for fall- and late fall-run Chinook Salmon peaks at the lowest flow analyzed (3,250 cfs) with the dam flashboards in. With the flashboards out, fry rearing habitat WUA peaks 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 peaks at 3,250 cfs (the lowest flow evaluated), declining as flows increase.

Juvenile rearing habitat WUA for winter-run Chinook Salmon juvenile rearing habitat peaks at around 8,000 cfs in the upstream reach above the ACID intake when the dam flashboards are in. With the boards out, the peak is around 9,000 cfs. However, there is 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 peaks at around 31,000 cfs (the highest flow evaluated). In the lower reach (Cow Creek to Battle Creek), juvenile rearing habitat WUA for winter-run Chinook Salmon peaks at around 3,500 cfs but shows only moderate (<50 percent) reductions in WUA over the entire range of flows evaluated.

The juvenile rearing habitat WUA values differ for fall-run and late fall-run Chinook Salmon, but the flow versus habitat relationship is similar for the two runs. 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 (<50 percent) reductions in juvenile rearing WUA over the entire range of flows evaluated. Between the ACID intake and Cow Creek, fry rearing WUA peaked at around 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 peaked at 3,250 cfs (the lowest flow evaluated), declining 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 (2005) conducted limiting life-stage analyses for winter-, fall-, and late-fall-run Chinook Salmon in the Sacramento River above Battle Creek and found that in most cases, juvenile habitat is limiting. An important limitation of this analysis is 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 is 3,250 cfs. Flows during summer generally exceed this amount in order to meet temperature requirements for winter-run Chinook Salmon. 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.

#### 9.3.4.4.3 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). After completion of Shasta Dam in 1945, access to approximately 207 miles was blocked. 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 GCID intakes and RBDD, were of particular concern as potential passage or entrainment problems for Chinook Salmon, steelhead, and other migratory fish species (NRC 2012, NMFS 2009a, McEwan and Jackson 1996). Recently, RBDD was eliminated, 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 2009a), rendering approximately 3 miles of spawning habitat upstream of the diversion dam inaccessible. Adult Green Sturgeon that pass upstream of the intake before April are delayed for 6 months until the flashboards are pulled before returning downstream to the ocean. Newly emerged Green Sturgeon larvae that hatch upstream of the ACID intake would need to hold for 6 months upstream of the dam or pass over it and be subjected to higher velocities and turbulent flow below the intake (NMFS 2009a).

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. 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.

Reclamation is currently coordinating with USFWS to support improvements at other fish screens. In 2013, CVPIA funds were used to construct the Natomas Mutual Sankey Fish Screen on the Sacramento River that replaced two existing diversions on the Natomas Cross Canal. This project also resulted in the removal of an anadromous fish migration barrier (seasonal diversion dam) on the Natomas Cross Canal. The fish screening program also completed construction of four fish screens on the Sacramento River and one fish screen in the Delta.

Potential barriers to migration for adult Green Sturgeon into the upper reaches of the Sacramento River include structures such as the ACID intake, Sacramento River Deep Water Ship Channel locks, Fremont Weir, Sutter Bypass, and DCC gates on the Sacramento River (70 FR 17386). A set of locks at the end of the Sacramento River Deep Water Ship Channel at the connection with the Sacramento River "blocks the migration of all fish from the deep-water ship channel back to the Sacramento River" (DWR 2005).

##### 9.3.4.4.4 Hatcheries

The Livingston Stone NFH, located at the foot of Shasta Dam, is a conservation hatchery that has been producing and releasing juvenile winter-run Chinook Salmon since 1998. There is growing concern about the potential genetic effects that may result from the use of a conventional hatchery program to supplement winter-run Chinook Salmon populations. To maintain a low risk of compromised genetic fitness, Lindley et al. (2007) recommend that no more than 5 percent of the naturally spawning population should be composed of hatchery fish. Since 2001, more than 5 percent of the winter-run Chinook Salmon run has been composed of hatchery-origin fish, and in 2005 the contribution of hatchery fish was more than 18 percent (Lindley et al. 2007).

The Livingston Stone NFH minimizes hatchery affects in the population by preferentially collecting wild adult winter-run Chinook Salmon for brood stock (USFWS 2011b). Up to 15 percent of the estimated run size for winter-run Chinook Salmon run may be collected for brood stock use (up to a maximum of 120 natural-origin winter-run Chinook Salmon per brood year). Although there is no adult production goal, Livingston Stone NFH releases up to 250,000 winter-run Chinook Salmon a year in late January or early February. Winter-run Chinook Salmon are released at the pre-smolt stage and are intended to rear in the freshwater environment prior to smoltification. The pre-smolts are released into the Sacramento River at Caldwell Park in Redding, about 10 miles downstream of the hatchery. All juvenile winter-run Chinook Salmon produced at Livingston Stone NFH are adipose fin-clipped and coded wire-tagged (CHSRG 2012).

The Delta Smelt propagation program at the Livingston Stone NFH is operated as a captive broodstock program. Delta Smelt propagation at Livingston Stone NFH functions as a backup refugial population. No Delta Smelt from the Livingston Stone NFH are currently released (USFWS 2011b).

##### 9.3.4.4.5 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 2009a). 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).

#### *9.3.4.5 Battle Creek*

Battle Creek is a tributary that enters the Sacramento River about 20 miles southeast of Redding. The cold, spring-fed waters of Battle Creek historically supported large runs of Chinook Salmon and steelhead. Diversion dams constructed in the early 1900s for hydroelectric power production reduced instream flow and blocked anadromous salmonids from accessing habitat in large portions of the north and south forks of Battle Creek.

Coleman NFH, located on Battle Creek, was established in 1942 by Reclamation to partially mitigate habitat and fish losses from historical spawning areas caused by construction of two CVP features, Shasta and Keswick dams. The hatchery is funded by Reclamation and operated by USFWS. The steelhead program at the hatchery was initiated in 1947 to mitigate losses resulting from the CVP (USFWS 2012). The weir at the hatchery is a barrier to anadromous fish passage, as are various Pacific Gas & Electric Company (PG&E) dams (e.g., Wildcat) located on Battle Creek (Yoshiyama et al. 1996). Yoshiyama et al. (1996) reported that the Coleman South Fork Diversion Dam is the first impassible barrier on Battle Creek.

Beginning in 1995, planning was initiated to restore naturally spawning anadromous fish populations in Battle Creek, and construction began in 2010 on the Battle Creek Salmon and Steelhead Restoration Project (Reclamation 2014a). When complete, the Battle Creek restoration project will restore ecological processes along 42 miles of Battle Creek and 6 miles of tributaries while minimizing reductions to hydroelectric power generation, although five dams are decommissioned (Wildcat, Coleman, South, Lower Ripley, and Soap Creek feeder diversion dams). New fish screens and fish ladders that meet NMFS and CDFW criteria will be constructed at three diversion dams (North Battle Creek Feeder, Eagle Canyon, and Inskip Diversion Dams). Connectors are proposed that prevent the discharge of North Fork Battle Creek water to South Fork Battle Creek and the mixing of flow sources. Higher minimum flow requirements will increase instream flows, subsequently cooling water temperatures, increasing stream area, and providing reliable passage conditions for adult salmonids in downstream reaches. The project will result in 42 miles of newly accessible anadromous fish habitat and improved water quality for the Coleman NFH.

#### *9.3.4.6 Lake Oroville and Thermalito Complex*

Lake Oroville on the Feather River is formed by Oroville Dam, approximately 70 miles upstream from its confluence with the Sacramento River. Lake Oroville is fed by the north, middle, and south forks of the Feather River. A portion of the water released from Lake Oroville flows into the Thermalito Complex, as described in Chapter 5, Surface Water Resources and Water Supplies.

##### 9.3.4.6.1 Fish in Lake Oroville

Lake Oroville thermally stratifies in spring, destratifies in fall, and remains destratified throughout winter. FERC (2007b) reports indicate that surface water temperatures of the epilimnion begin to warm in the early spring, reach maximum temperatures (approximately mid-80°F) during late July, and gradually decline to winter minimums. The transition zone (i.e., metalimnion) between the upper warmer and lower colder waters typically ranges from about 30 to 50 feet below the lake surface during midsummer. The deeper water of the hypolimnion can reach a temperature of about 44°F near the reservoir bottom during periods of stratification (FERC 2007b). Cold-water fish species include Coho Salmon, Rainbow Trout, Brown Trout, and Lake Trout. The Lake Oroville cold-water fishery is not self-sustaining, possibly because of insufficient spawning and rearing habitat in the reservoir and accessible tributaries; cold-water spawning is not known to occur in Lake Oroville. The Coho Salmon fishery is sustained by a "put-and-grow" hatchery stocking program (FERC 2007b). The Lake Oroville warm-water fishery is a regionally important self-sustaining recreational fishery and is the site of several annual bass fishing tournaments. Spotted Bass are the most abundant bass species in Lake Oroville, followed by Largemouth Bass, Redeye Bass, and Smallmouth Bass, respectively. Other important warm-water species include catfish, crappie, and sunfish. Common carp are also abundant in Lake Oroville.

##### 9.3.4.6.2 Fish in Thermalito Forebay and Afterbay

Ambient meteorological conditions and the temperature of the water released from Lake Oroville generally affect water temperatures in the Thermalito Diversion Pool and Thermalito Forebay (FERC 2007b). Thermalito Forebay is an open, cold, shallow reservoir that remains cold throughout the year because it is supplied with water from Thermalito Diversion Pool, although pump-back operations from Thermalito Afterbay can increase water temperatures in the forebay. Thermalito Forebay provides habitat primarily for cold-water fish species, although the same warm-water fish species found in Lake Oroville are believed to exist in the forebay in low numbers (FERC 2007b). Additionally, CDFW manages a "put-and-take" trout fishery in Thermalito Forebay.

Thermalito Afterbay provides habitat for cold-water and warm-water fish species including Largemouth Bass, Smallmouth Bass, Rainbow Trout, Brown Trout, Bluegill, Redear Sunfish, Black Crappie, Channel Catfish, carp, and large schools of Wakasagi (FERC 2007b). A popular Largemouth Bass fishery currently exists, large trout are sometimes caught near the inlet, and an experimental steelhead fishery occurs in the Afterbay. Only limited salmonid stocking occurs at the afterbay, so these fish most likely passed through the Thermalito Pumping-Generating Plant from the forebay.

#### *9.3.4.7 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 the 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).

##### 9.3.4.7.1 Fish in the Feather River

The Feather River below Oroville supports a variety of anadromous and resident fish species. The distribution of anadromous fish in the Feather River is limited to approximately 67 miles of river downstream from the Fish Barrier Dam. At least 44 species of fish have been reported to historically or currently occur in the lower Feather River system, including numerous resident native and introduced species and several anadromous species (FERC 2007b).

The analysis is focused on the following species:

- Chinook Salmon (winter-, spring-, and fall/late fall-run)
- Steelhead
- Green Sturgeon
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad

*Spring-run Chinook Salmon*

Approximately two-thirds of the natural spring-run and fall-run Chinook Salmon spawning occur in the low-flow channel of the lower Feather River, downstream of the Fish Barrier Dam, and one-third of the spawning occurs in the high-flow channel downstream of the Thermalito Afterbay Outlet (FERC 2007b). NMFS (2009a) indicated that significant redd superimposition occurs in the lower Feather River because of oversaturation of the natural carrying capacity of the available spawning habitat (e.g., Sommer et al. 2001b) with an overproduction of hatchery spring-run Chinook Salmon and a lack of physical separation between spring-run and fall-run Chinook Salmon adults.

Adult spring-run Chinook Salmon typically enter fresh water in spring, hold over summer, and spawn in fall. Juveniles typically spend a year or more in fresh water before outmigrating. Adult spring-run Chinook Salmon begin their upstream migration from the ocean in late January and early February (DFG 1998b) and migrate from the Sacramento River into spawning tributaries primarily between mid-April and mid-June (Lindley et al. 2004). Adult Chinook Salmon exhibiting the typical life history of the spring-run have been found holding at the Thermalito Afterbay Outlet and the Fish Barrier Dam as early as April (FERC 2007b). Spring-run Chinook Salmon spawning occurs during September and October, depending on water temperatures (NMFS 2012a). Spring-run Chinook Salmon fry emerge from the gravel from November to March (Moyle 2002). Most juvenile spring-run Chinook Salmon outmigrate from the lower Feather River within a few days of emergence, and 95 percent of the juvenile Chinook have typically outmigrated from the Oroville facilities project area by the end of May (FERC 2007b).

An independent population of spring-run Chinook Salmon historically occurred in the lower Feather River downstream of Oroville Dam, and a naturally spawning population of spring-run Chinook Salmon may persist in this reach (Lindley et al. 2004). The number of naturally spawning spring-run Chinook Salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run Chinook Salmon and fall-run Chinook Salmon (Good et al. 2005).

Substantial numbers of spring-run Chinook Salmon, as identified by run timing, return to the Feather River Fish Hatchery. From 1986 to 2011, the median number of spring-run Chinook Salmon returning to the Feather River Fish Hatchery was 3,655, compared to a median of 7,869 spring-run Chinook Salmon returning to the entire Sacramento River Basin (NMFS 2012a). Abundance estimates of lower Feather River spring-run Chinook Salmon may be distorted by naturally occurring genetic introgression with fall-run Chinook Salmon, Feather River Fish Hatchery practices, and Federal and state escapement estimation methodology. Coded wire tags obtained from Feather River Fish Hatchery returns indicate substantial introgression has occurred between spring-run Chinook Salmon and fall-run Chinook Salmon populations within the lower Feather River (NMFS 2009a).

*Fall-run Chinook Salmon*

Fall-run Chinook Salmon generally begin upstream migration into the lower Feather River during summer months (FERC 2007b). Although timing of fall-run Chinook Salmon spawning may be influenced by water temperature conditions (FERC 2007b), spawning activity in the lower Feather River occurs from late August through December and generally peaks during mid- to late November (Myers et al. 1998). Concurrent spawning with spring-run Chinook Salmon, which generally occurs from September to October, has led to hybridization between the spring- and fall-run Chinook Salmon in the lower Feather River (NMFS 2012a).

In the lower Feather River, fall-run Chinook Salmon embryo incubation and alevin (yolk-sac fry) emergence generally occurs from mid-October through March, depending on water temperature conditions (FERC 2007b). Fall-run Chinook Salmon fry emergence generally occurs in the lower Feather River downstream of the Fish Barrier Dam from late December through March, and most juvenile fall-run Chinook Salmon outmigrate from the lower Feather River within a few days of emergence (FERC 2007b).

*Steelhead*

Steelhead immigrate into the Feather River from July to March (McEwan 2001). Currently, most of the natural steelhead spawning in the lower Feather River occurs in the low-flow channel downstream of the Fish Barrier Dam; however, limited spawning also occurs downstream of the Thermalito Afterbay Outlet (FERC 2007b). Results of a 13-week redd survey conducted between January 6 and April 3, 2003, indicated that redd construction generally occurs in the lower Feather River between late December and March, peaking in late January (FERC 2007b). The FERC (2007b) study suggests that nearly half (48 percent) of all redds were constructed in the uppermost mile of the low-flow channel downstream of the Fish Barrier Dam. Redd density in this 1-mile section of the low-flow channel was approximately 36 redds per mile, more than 10 times more than any other section of the lower Feather River (FERC 2007b).

A moderate percentage of the steelhead fry appear to outmigrate from the lower Feather River soon after emerging from the gravel. Juvenile steelhead that do not outmigrate may rear in the river for up to 1 year. Juvenile steelhead in the Feather River outmigrate from about February through September, with peak outmigration occurring from March through mid-April. In-river juvenile rearing is generally associated with secondary channels in the low-flow channel (e.g., Hatchery Ditch) (FERC 2007b).

*Pacific Lamprey*

The Pacific Lamprey inhabits accessible reaches of the lower Feather River (DWR 2003a). Information on Pacific Lamprey status in the lower Feather River is limited, but the loss of access to historical habitat and apparent population declines throughout California and the Sacramento and San Joaquin River basins indicate populations are greatly decreased compared with historical levels (Moyle et al. 2009). Little information is available on factors limiting Pacific Lamprey populations in the lower Feather River, but they are likely adversely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles.

Ocean-stage adults likely migrate into the lower Feather River in spring and early summer, where they hold for approximately 1 year before spawning (Hanni et al. 2006). Hannon and Deason (2008) have documented Pacific Lamprey spawning in the nearby American River from between early January and late May, with peak spawning typically occurring in early April. Pacific Lamprey ammocoetes rear in the lower Feather River for all or part of their 5-¬ to 7-year freshwater residence. Data from rotary screw trapping suggest that outmigration of Pacific Lamprey generally occurs from early winter through early summer (Hanni et al. 2006), although some outmigration likely occurs year-round as observed in the mainstem Sacramento River (Hanni et al. 2006) and in other river systems (Moyle 2002).

*Sacramento Splittail*

Sacramento Splittail enter the lower Feather River, primarily in wet years, with most individuals collected in the high-flow channel downstream of Thermalito Afterbay Outlet (DWR 2004a). On the lower Feather River, February through May was assumed to encompass the period of splittail spawning, egg incubation, and initial rearing (Sommer et al. 2008, DWR 2004a). Splittail use shallow flooded vegetation for spawning and are infrequently observed in the Feather River from the confluence with the Sacramento River up to Honcut Creek. The majority of spawning activity in the Feather River is thought to occur downstream of the Yuba River confluence (FERC 2007b). The primary factor that likely limits the lower Feather River splittail population is availability of spawning and rearing habitats as related to inundation of floodplains (Moyle et al. 2004, DWR 2004a).

*Green Sturgeon*

Historically, Green Sturgeon likely spawned in the Sacramento, Feather, and San Joaquin rivers (Adams et al. 2007). A substantial amount of habitat in the Feather River was lost with the construction of Oroville Dam. Although the presence of Green Sturgeon in the Sacramento River has been supported by direct angler observations and rotary screw trapping of eggs, larvae, and YOY Green Sturgeon, only intermittent observations of Green Sturgeon have been reported in the lower Feather River (Beamesderfer et al. 2007). The occasional capture of larval Green Sturgeon in outmigrant traps suggests that Green Sturgeon spawn in the lower Feather River (Moyle 2002). However, prior to 2011 only two records of adult Green Sturgeon in the lower Feather River were confirmed (NMFS 2005b). In 2011, videography monitoring conducted by the Anadromous Fish Restoration Program confirmed Green Sturgeon spawning activity in the lower Feather River and found evidence of spawning behavior in the Yuba River (AFRP 2011). Seesholtz et al. (2014) provided the first documentation of Green Sturgeon spawning in the Feather River.

*White Sturgeon*

White Sturgeon are known to use the lower Feather River primarily for spawning, embryo development, and early rearing. Limited quantitative information is available on the status of White Sturgeon in the lower Feather River, but the spawning population was most likely much larger prior to construction of Oroville Dam in 1961 (Israel et al. 2008). Seesholtz (2003) reported no evidence of sturgeon was found in the lower Feather River after an exhaustive search for their presence in 2003. However, 16 White Sturgeon were recorded from creel surveys and sightings during 2006, and more were captured by anglers in 2007 (Israel et al. 2008). Numerous factors likely limit the success of the White Sturgeon population in the lower Feather River, but loss of historical habitat, alteration of temperatures and flows caused by Oroville Dam and other impoundments in the watershed, and recreational fishing and poaching are expected to be among the most important factors.

*Striped Bass*

Striped Bass occur in the lower Feather River and have been reported to occur in the Thermalito Forebay (FERC 2007b). Striped Bass are a popular sport fish in the lower Feather River during periods when they migrate upstream to spawn.

*American Shad*

American Shad enter the Feather River annually in spring to spawn and are popular for sport fishing. American Shad are present in the lower Feather River from May through mid-December during the adult immigration, spawning, and outmigration periods of their life cycle (DWR 2003a).

#### 9.3.4.7.2 Aquatic Habitat

Historically, spawning habitat suitable for anadromous salmonid species likely existed above the current location of Oroville Dam on the Feather River (Yoshiyama et al. 2001). Extensive mining, irrigation, and development of hydroelectric dams significantly reduced the amount of suitable habitat for these species (Yoshiyama et al. 2001). Schick et al. (2005) estimated approximately 71 miles of suitable habitat was historically available for spring-run Chinook Salmon in the lower Feather River.

Most Chinook Salmon and steelhead spawning is concentrated in the uppermost 3 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 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 2004b).

The FERC (2007b) study reported that an estimated 97 percent of the sediment from the upstream watershed is trapped in Lake Oroville, such that only very fine sediment is discharged from Lake Oroville to the lower Feather River. As a result, gravel and large woody material from upstream reaches are limited along the lower Feather River. The FERC (2007b) study reported that the median gravel diameter (D50) of surface samples suggests that gravels in the low-flow channel generally are too large for successful redd construction by steelhead or salmon and that armoring is particularly evident in this reach; however, suitability of gravel sizes for spawning Chinook Salmon generally increased with distance downstream of Oroville Dam. The study suggested that size distributions of subsurface gravel samples were similar in the low- and high-flow channels. Analyses of fine sediment (less than 6 mm in diameter) suggested that fine sediment within gravels in the lower Feather River were suitable for incubating Chinook Salmon and steelhead embryos (FERC 2007b).

#### 9.3.4.7.3 Fish Passage

The Oroville facilities, including Oroville Dam, Thermalito Diversion Dam, and the Fish Barrier Dam, currently block the upstream migration of anadromous fish to historically available spawning areas in the upstream tributaries of the Feather River. In a study of Green Sturgeon passage impediments, FERC identified three potential physical barriers to upstream migration by Green Sturgeon in the lower Feather River during representative low-flow conditions (approximately 2,074 cfs during November 2002) and high-flow conditions (approximately 9,998 cfs during July 2003) (FERC 2007b). The three potential physical barriers are Shanghai Bench, the Sunset Pumps, and Steep Riffle (located 2 miles upstream of the Thermalito Afterbay Outlet). However, the study also noted that determinations of potential passage barriers in the lower Feather River are speculative.

#### 9.3.4.7.4 Hatcheries

The Feather River Fish Hatchery is part of the SWP Oroville Complex and is a mitigation hatchery for loss of habitat upstream of DWR's Oroville Dam that is no longer accessible to anadromous fish species (NMFS 2009a). Three hatchery programs are conducted here, producing fall-run Chinook Salmon, spring-run

Chinook Salmon, and steelhead. The Feather River Fish Hatchery supports the only spring-run Chinook Salmon hatchery program currently in the Central Valley (CHSRG 2012). Spring-run Chinook Salmon produced at the Feather River Fish Hatchery are included in the listed spring-run Chinook Salmon ESU (70 FR 37160). FERC is in consultation with NMFS on the effects of relicensing Oroville Dam (including the effects of Feather River Fish Hatchery).

Fall-run Chinook Salmon in the Feather River are trapped and spawned at the hatchery with a goal of producing 6 million fall-run Chinook Salmon smolts for release into Carquinez Straits between April and June. Up to 2 million additional fish may be reared as part of a separate ocean enhancement program. Feather River fall-run Chinook Salmon are currently marked at a 25 percent rate (constant fractional marking) with an adipose fin-clip and a coded wire-tag (CHSRG 2012).

Adult hatchery-produced spring-run Chinook are intended to spawn naturally or to be genetically integrated with the natural population through artificial propagation. There are no specific goals for the number of adult spring-run Chinook Salmon; however, the juvenile production goal is to release 2 million smolts during April or May. These fish are all released into the Feather River south of Yuba City at the Boyd's Pump Boat Launch (44 miles downstream of the hatchery). Juvenile hatchery-produced spring-run Chinook Salmon are currently 100 percent marked with an adipose fin-clip and a coded wire-tag (CHSRG 2012).

The steelhead program at the Feather River Hatchery traps and artificially spawns both marked hatchery-origin and unmarked natural-origin steelhead. Only a few unmarked fish are trapped annually. Currently, only fish returning to the Feather River Basin are used for broodstock. There are no specific goals for the number of adult steelhead produced by this program; however, the juvenile production goal is to release 450,000 yearling steelhead annually during late January or February. All Feather River Hatchery steelhead are marked with an adipose fin-clip prior to release. These fish are all released into the Feather River south of Yuba City at the Boyd's Pump Boat Launch or at the confluence of the Feather and Sacramento rivers (Verona Marina) (CHSRG 2012).

Prior to 2004, separation of spring-run and fall-run Chinook Salmon returning to the Feather River Fish Hatchery was solely based on run timing, which resulted in considerable mixing of fall-run and spring-run Chinook Salmon stocks (DWR 2009, NMFS 2012a). In 2005, the Feather River Fish Hatchery implemented a methodology change for distinguishing spring-run Chinook Salmon from fall-run Chinook Salmon (CHSRG 2012). To maintain genetic integrity, fish entering the Feather River Fish Hatchery prior to July 1 receive an external tag, and only these externally tagged fish are used as spring-run Chinook Salmon broodstock (DWR 2009). Since 2005, the hatchery has attempted to mark 100 percent of spring-run Chinook Salmon produced at the hatchery with an adipose fin-clip, coded wire-tag (CHSRG 2012) and race and brood year specific otolith thermal marks (DWR 2009).

The Feather River Fish Hatchery employs best management practices and protocols to avoid the spread of diseases from the hatchery. The hatchery has been successful in adaptively managing disease concerns as they arise by the installing an ultraviolet treatment system, modifying the stocking of Lake Oroville, conducting periodic testing, and using prescribed therapeutic treatments (DWR 2004c).

#### 9.3.4.7.5 Disease

Several endemic salmonid pathogens and diseases occur in the Feather River Basin, including *Ceratomyxa shasta* (salmonid ceratomyxosis), *Flavobacterium columnare* (columnaris), Infectious Hematopoietic Necrosis (IHN) virus, *Renibacterium salmoninarum* (bacterial kidney disease), and *Flavobacterium psychrophilum* (cold-water disease) (DWR 2004c). Each of these diseases has been shown to infect stocked and native salmonids in the Feather River; however, these diseases are not known to infect non-salmonids (FERC 2007b). Whirling disease has never been detected in the lower Feather River downstream of Oroville Dam, but has been found in upstream tributaries such as the north and south forks of the Feather River (DWR 2004c). Of the fish diseases in the Feather River Basin, IHN and salmonid ceratomyxosis are main contributors to fish mortality at the Feather River Fish Hatchery and are of highest concern for fisheries management in the region (DWR 2004c). The Feather River Fish Hatchery experienced severe IHN outbreaks in 2000 and 2001. A study by the University of California at Davis and USFWS indicated that although there were no clinical signs of disease, adult salmonids returning to either the Yuba or the Feather rivers demonstrated IHN infection rates of 28 percent and 18 percent, respectively (Brown et al. 2004).

Salmonid ceratomyxosis is endemic to the Feather River Basin; local salmonid stocks have co-evolved with this pathogen and exhibit some natural resistance. Salmonid ceratomyxosis causes mortality in all ages of anadromous and resident trout and salmon, although Rainbow Trout and steelhead are more susceptible to the disease than are Chinook and Coho Salmon (DWR 2004c). Mortality generally occurs when water temperatures exceed 50°F; however, fish can become infected at temperatures as low as 39°F (Bartholomew 2012).

#### 9.3.4.7.6 Predation

The FERC (2007b) study suggests that the Fish Barrier Dam, which directs most anadromous salmonid spawning to occur in the low-flow channel, concentrates juvenile salmonids within this reach. Counts of known predators on juvenile anadromous salmonids in the low-flow channel are reported to be low; however, significant numbers of predators reportedly do exist in the high-flow channel downstream of Thermalito Afterbay Outlet (Seesholtz et al. 2004). Limited information is available to estimate the current rate of predation on juvenile salmonids in the lower Feather River.

#### *9.3.4.8 Yuba River*

Portions of the Yuba River watershed along the North Yuba River between New Bullards Bar Reservoir and Englebright Lake and along the Lower Yuba River between Englebright Lake and the Feather River could be affected by operation of the Lower Yuba River Water Accord (DWR et al. 2007), as described in Chapter 5, Surface Water Resources and Water Supplies.

Fish species found in the New Bullards Bar Reservoir include Rainbow Trout, Brown Trout, Kokanee Salmon, bass, Bluegill, crappie, and bullhead (DWR et al. 2007). A similar mix of species is found in Englebright Reservoir. Fall-run and spring-run Chinook Salmon and steelhead occur in the Yuba River downstream of Englebright Dam (YCWA 2009). Sacramento Splittail have been documented only in the lower Feather River and not in the Yuba River. Low numbers of Green Sturgeon and White Sturgeon occasionally range into the Yuba River (Beamesderfer et al. 2004). Other species found in the lower Yuba River include American Shad, Smallmouth Bass, and Striped Bass (DWR et al. 2007).

#### *9.3.4.9 Bear River*

The Bear River flows into the Feather River downstream of the confluence of the Feather and Yuba rivers. The Bear River includes Nevada Irrigation District's Rollins and Combie reservoirs along the upper and middle reaches of the Bear River and South Sutter Water District's Camp Far West Reservoir along the lower reach of the Bear River (FERC 2013, NID 2005).

Fall-run and spring-run Chinook Salmon and steelhead occur in the Bear River (YCWA 2009). Sacramento Splittail have been documented only in the lower Feather River and not in the Bear River. Low numbers of Green Sturgeon and White Sturgeon occasionally range into the Bear River (Beamesderfer et al. 2004). Rollins Reservoir is currently managed as a put-and-take fishery for rainbow and Brown Trout. Kokanee reproduce naturally in the lake. Gill net surveys from 1970 to 1983 documented numerous other species including bass, catfish, sunfish, Golden Shiner, Tui Chub, Pond Smelt, crappie, and Bluegill (DFG 1974-1983 in NID 2008). Native fishes found in Combie Reservoir may include Sacramento Pikeminnow, Sacramento Sucker, Hardhead, Tui Chub, Hitch, and Inland Silverside. Nonnative fishes likely include Bluegill, Green Sunfish, Largemouth Bass, Spotted Bass, Smallmouth Bass, common carp, Golden Shiner, Threadfin Shad, Black Crappie, Brown Bullhead, White Catfish, Channel Catfish, Western Mosquitofish, and stocked Rainbow Trout (NID 2009).

#### *9.3.4.10 Folsom Lake and Lake Natoma*

The American River watershed encompasses approximately 2,100 square miles (Reclamation et al. 2006). The three forks of the American River (north, middle, and south forks) converge upstream of Folsom Dam, with the combined flow moving through Lake Natoma and the lower American River for about 23 miles before entering the Sacramento River.

Water surface elevations vary annually as a result of seasonal inflow and water release and are generally the least variable during spring and most variable during summer (USACE et al. 2012). Thermal stratification of the reservoir generally begins during April and usually persists throughout summer until November, when cooler temperatures, winter rains, and high inflows create mixing and result in "turnover" (Reclamation 2005, USACE et al. 2012). During summer, a thermocline develops that separates the epilimnion (i.e., upper layer of warm water) and the hypolimnion (i.e., lower layer of cooler water). This thermal stratification and segregation of habitats allow for both cold-water and warm-water species to coexist in Folsom Lake (USACE et al. 2012). Warm-water fish species include native Hardhead, California Roach, Sacramento Pikeminnow, and Sacramento Sucker, as well as nonnative Largemouth Bass, Smallmouth Bass, Spotted Bass, sunfish, Black Crappie, and White Crappie (Reclamation 2007). Cold-water fish species include native Rainbow Trout and planted Chinook and Kokanee Salmon, as well as nonnative Brown Trout (Reclamation 2007).

Nimbus Dam creates Lake Natoma, which serves as a regulating afterbay to the Folsom power plant, maintaining more uniform flows in the lower American River. Lake Natoma is a shallow reservoir with an average depth of about 16 feet (Reclamation 2005). Surface water elevations in Lake Natoma may fluctuate between 4 and 7 feet daily (USACE et al. 2012). Lake Natoma has relatively low productivity as a fishery due to the effects of wide water temperature variability associated with the lake fluctuating elevation. Reclamation (2007) reports that fish species found in Lake Natoma are generally the same as those in Folsom Lake. Although CDFW annually stocks Lake Natoma with hatchery Rainbow Trout, conditions in Lake Natoma are more favorable for warm-water fish species (Reclamation 2007).

#### *9.3.4.11 Lower American River between Lake Natoma and the Sacramento River*

The lower American River extends approximately 23 miles from Nimbus Dam downstream to the confluence with the Sacramento River. Access to the upper reaches of the river by anadromous fish is blocked at Nimbus Dam.

##### 9.3.4.11.1 Fish in the Lower American River

The lower American River system supports numerous resident native and introduced species as well as several anadromous species.

The analysis is focused on the following species:

- Fall-run Chinook Salmon
- Steelhead
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad

*Fall-run Chinook Salmon*

Historically, the American River supported fall-run and perhaps late fall-run Chinook Salmon (Williams 2001). Both naturally and hatchery produced Chinook Salmon spawn in the lower American River. Recent analysis by DFG and USFWS (2010) indicated that approximately 84 percent of the natural fall-run Chinook Salmon spawners in the American River are hatchery-origin fish. Kormos et al. (2012) reported that 79 percent of the fall-run Chinook Salmon entering the Nimbus Fish Hatchery in 2010 and 32 percent of the fish spawning in the American River were of hatchery origin.

Adult fall-run Chinook Salmon enter the lower American River from about mid-September through January, with peak migration from approximately mid-October through December (Williams 2001). Spawning occurs from about mid-October through early February, with peak spawning from mid-October through December. Chinook Salmon spawning occurs within an 18-mile stretch from Paradise Beach to Nimbus Dam; however, most spawning occurs in the uppermost 3 miles (DFG 2012a). Chinook Salmon egg and alevin incubation occurs in the lower American River from about mid-October through April. There is high variability from year to year; however, most incubation occurs from about mid-October through February. Chinook Salmon fry emergence occurs from January through mid-April, and juvenile rearing extends from January to about mid-July (Williams 2001). Most Chinook Salmon outmigrate from the lower American River as fry between December and July, peaking in February to March (Snider and Titus 2002, PSMFC 2014).

*Steelhead*

Natural spawning by steelhead in the American River occurs (Hannon and Deason 2008), but the population is supported primarily by the Nimbus Fish Hatchery. The total estimated steelhead return to the river (spawning naturally and in the hatchery) has ranged from 946 to 3,426 fish, averaging 2,184 fish per year from 2002 to 2010 (CHSRG 2012). Steelhead spawning surveys have shown approximately 300 steelhead spawning in the river each year (Hannon and Deason 2008). Lindley et al. (2007) classifies the listed (i.e., naturally spawning) population of American River steelhead at a high risk of extinction because it is reportedly mostly composed of steelhead originating from Nimbus Fish Hatchery. NMFS views the American River population as important to the survival and recovery of the species (NMFS 2009a).

Nielsen et al. (2005) found steelhead in the American River to be genetically different from other Central Valley stocks. Eel River steelhead were used to found the Nimbus Hatchery stock, and steelhead from the American River (collected from both the Nimbus Fish Hatchery and the American River) are genetically more similar to Eel River steelhead than other Central Valley Steelhead stocks. Based on studies by Hallock et al. (1961), Staley (1976), and Neilsen (2005), Lee and Chilton (2007) reported that American River winter-run steelhead are genetically and phenotypically different, and demonstrate a later upstream migration period than Central Valley Steelhead. Zimmerman et al. (2008) also noted that there remains a strong resident component (i.e., fish that do not migrate to the ocean) of the *O. mykiss* population that interacts with and produces anadromous individuals. Steelhead and Rainbow Trout are the same species and when juveniles of the species are found in fresh water, it is unclear if they will exhibit an anadromous (steelhead) or resident (Rainbow Trout) life history strategy. Thus, they are often collectively referred to as *O. mykiss* at this stage to indicate this uncertainty.

Adult steelhead enter the American River from November through April with a peak occurring from December through March (SWRI 2001). Steelhead have been trapped at Nimbus Fish Hatchery as early as the first week of October. Results of a spawning survey conducted from 2001 through 2007 indicate that steelhead spawning occurs in the lower American River from late December through early April, with the peak occurring in late February to early March (Hannon and Deason 2008). Spawning density is highest in the upper 7 miles of the river, but spawning occurs as far downstream as Paradise Beach. About 90 percent of spawning occurs upstream of the Watt Avenue Bridge (Hannon and Deason 2008).

Embryo incubation begins with the onset of spawning in late December and generally extends through May, although incubation can occur into June in some years (SWRI 2001). Steelhead embryo and alevin mortality associated with high flows in the American River has not been documented, but flows high enough to mobilize spawning gravels do occur during the spawning and embryo incubation periods (i.e., late December through early April) (NMFS 2009a).

Juvenile *O. mykiss* have been documented year-round throughout the lower American River, with rearing generally upstream of spawning areas. Juveniles reportedly can rear in the lower American River for a year or more before outmigrating as smolts from January through June (Snider and Titus 2000a, SWRI 2001). However, Snider and Titus (2002) reported only 1 yearling steelhead capture, and PSMFC (2014) reported capturing primarily YOY fry and parr. Peak outmigration occurs from March through May (McEwan and Jackson 1996, SWRI 2001, PSMFC 2014).

Rearing habitat for juvenile steelhead in the lower American River occurs throughout the upper reaches downstream to Paradise Beach. In summer, juveniles occur in most major riffle areas, with the highest concentrations near the higher density spawning areas (Reclamation 2008a). The number of juveniles in the American River decreases throughout summer (Reclamation 2008a). Warm water temperatures stress juvenile steelhead rearing in the American River, particularly during summer and early fall. However, laboratory studies suggest that American River steelhead may be more tolerant of high temperatures than steelhead from regions farther north (Myrick and Cech 2004).

*Pacific Lamprey*

The Pacific Lamprey inhabits accessible reaches of the American River. Information on the status of Pacific Lamprey in the American River is limited, but the loss of historical habitat and apparent population declines throughout

California indicate populations are greatly decreased compared to historical levels (Moyle et al. 2009).

Hannon and Deason (2008) documented Pacific Lamprey spawning in the American River between early January and late May, with peak spawning typically in early April. Pacific Lamprey ammocoetes rear in the American River for all or part of their 5¬- to 7-year freshwater residence. Data from rotary screw trapping in the nearby Feather River suggest that outmigration of Pacific Lamprey generally occurs from early winter through early summer (Hanni et al. 2006), although some outmigration likely occurs year-round, as observed at sites on the mainstem Sacramento River (Hanni et al. 2006) and in other river systems (Moyle 2002).

Because of the parallels in their life cycles, particularly spawning, lampreys may be adversely affected by many of the same factors as salmon and steelhead. Little information is available on factors influencing Pacific Lamprey populations in the American River, but the dams likely play an important role. Moyle et al. (2009) suggested that in addition to blocking upstream migration, dams may disrupt upstream sediment inputs required to maintain habitat for ammocoetes and subject ammocoetes to rapid decreases in stream flow. Moyle et al. (2009) also indicated that ramping rates sufficient to protect salmonids may not be adequate to prevent the stranding of ammocoetes and metamorphosing individuals, which are vulnerable to desiccation and avian predation. Additionally, commercial harvest of lampreys on the American River (presumably for bait) may reduce spawning success in some years (Hannon and Deason 2008).

*Sacramento Splittail*

Splittail likely spawn in the lower reaches of the American River (Sommer et al. 1998, 2008; Moyle et al. 2004). During wet years, upstream migration is more directed and fish tend to swim farther upstream (Moyle 2002), thus more individuals are expected to use the American River in wet years. Although juvenile splittail are known to rear in upstream areas for a year or more (Baxter 1999), most move to the Delta after only a few weeks of rearing on floodplain habitat (Reclamation 2008a). Most juveniles move downstream into the Delta from April to August (Meng and Moyle 1995). The primary factor potentially limiting the American River population of Sacramento Splittail is availability of inundated floodplains for spawning and rearing habitats (Moyle et al. 2004).

*White Sturgeon*

Limited quantitative information is available on the distribution and status of White Sturgeon in the American River; however, small numbers of adults apparently use the American River, as evidenced by sturgeon report cards submitted to CDFW by anglers in recent years (e.g., DFG 2012b).

*Striped Bass*

Striped Bass are found in the American River throughout the year, with the greatest abundance in summer (SWRI 2001). Although the occurrence of spawning in the American River is uncertain, the river is believed to serve as a nursery area for YOY and subadult Striped Bass (SWRI 2001). Striped Bass are distributed from the confluence with the Sacramento River to Nimbus Dam (Moyle 2002), and they provide a locally important sportfishing resource.

*American Shad*

Adult American Shad ascend the lower American River to spawn during the late spring. During this period, they provide an important sport fishery. The shortage of adequate attraction flows in major tributaries such as the American River may be contributing to declines in the population (Moyle 2002).

**9.3.4.11.2 Aquatic Habitat**

Since 1955, Nimbus Dam has blocked upstream passage by anadromous fish and restricted available habitat in the lower American River to the approximately 23 river miles between the dam and the confluence with the Sacramento River. Additionally, Folsom Dam has blocked the downstream transport of sediment that contributes to the formation and maintenance of habitat for aquatic species.

In 2008, Reclamation, in coordination with USFWS and the Sacramento Water Forum, began implementation of salmonid habitat improvement in the lower American River. An estimated 5,000 cubic yards of gravel and cobble were placed just upstream of Nimbus Fish Hatchery in 2008, followed by an estimated 7,000 cubic yards adjacent to the Nimbus Fish Hatchery in fall 2009. In September 2010, approximately 11,688 cubic yards (approximately 16,200 tons) of gravel and cobble were placed at Sailor Bar to enhance spawning habitat for Chinook Salmon and steelhead in the lower American River (Merz et al. 2012). Additionally, the 2010 augmentation site contained a constructed cobble island and "scallops" in the substrate designed to add habitat heterogeneity to the main channel and rearing habitat for juvenile Chinook Salmon and steelhead. Additionally, approximately 5,500 tons of cleaned cobble were placed downstream of the 2010 augmentation site. The specific purpose of this placement was to divert flow into an adjacent, perched side channel, thereby preventing the dewatering of salmonid redds in a historically important spawning and rearing area during low-flow conditions.

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 2009a). Spawning bed materials in the lower American River may begin to mobilize at flows of 30,000 cfs, with more substantial mobilization at flows of 50,000 cfs or greater (Reclamation 2008a). At 115,000 cfs (the highest flow modeled), particles up to 70 mm median diameter would be moved in the high-density spawning areas around Sailor Bar and Sunrise Avenue. Flood frequency analysis for the American River at Fair Oaks gage shows that, on average, flood control releases exceed 30,000 cfs about once every 4 years and exceed 50,000 cfs about once every 5 years (Reclamation 2008a).

In 2008, Reclamation began implementing floodplain and spawning habitat restoration projects in the American River to assist in meeting the requirements of the 1992 CVPIA, Section 3406 (b)(13). The side channel at Upper Sunrise was identified as a suitable site for steelhead spawning habitat restoration. In 2008, the CVPIA (b)(13) program cut and widened the side channel so that it inundated at a greater range of flows. The project reduced steelhead stranding, but also inadvertently reduced Chinook Salmon and steelhead spawning and rearing habitat (AFRP 2012). Consequently, the main channel was filled at the head-cut to create greater head pressure, thereby allowing flow once again through the side channel. Monitoring at the Upper Sunrise project revealed immediate response from Chinook Salmon and steelhead moving up into the side channel to spawn after completion of the project. Spawning and rearing habitat enhancement projects occurred each year from 2008 through 2014 in the reach from Nimbus Dam down to River Bend Park. These annual projects are planned to continue.

#### 9.3.4.11.3 Fish Passage

Including the mainstem, north, middle, and south forks, more than 125 miles of riverine habitat historically were available for anadromous salmonids in the American River watershed (Yoshiyama et al. 1996). Access to the upper reaches of the river has been blocked by a series of impassable dams, including Old Folsom Dam, first constructed in the American River between 1895 and 1939.

Reclamation operates a fish diversion weir approximately 0.25 mile downstream of Nimbus Dam, which functions to divert adult steelhead and Chinook Salmon into Nimbus Fish Hatchery. The weir is annually installed during September prior to the arrival of fall-run Chinook Salmon and steelhead and is removed at the conclusion of fall-run Chinook Salmon immigration in early January (Reclamation and DFG 2011). Some steelhead may be trapped prior to weir removal, but they are returned to the river. A new fish passageway is being implemented in the Nimbus Dam stilling basin, commonly referred to as Nimbus Shoals. The passageway will replace the existing fish diversion weir with a new flume and fish ladder that will connect to the existing fish ladder near Nimbus Fish Hatchery.

#### 9.3.4.11.4 Hatcheries

CDFW operates the Nimbus Salmon and Steelhead Hatchery and American River Trout Hatchery, located immediately downstream from Nimbus Dam. Facilities associated with Nimbus Fish Hatchery include a fish weir, fish ladder, gathering and handling tanks, hatchery-specific buildings, and rearing ponds. Nimbus Fish Hatchery was constructed primarily to mitigate the loss of spawning habitat for Chinook Salmon and Central Valley Steelhead that were blocked by the construction of Nimbus Dam (Reclamation and DFG 2011); it does not address lost habitat upstream from Folsom Dam (CHSRG 2012). The hatchery operations include the trapping, artificial spawning, rearing, and release of steelhead and fall-/late fall-run Chinook Salmon. Propagation programs for American River winter-run steelhead and Central Valley fall/ late fall-run Chinook Salmon are operated by CDFW under contract with Reclamation (Lee and Chilton 2007). The Nimbus Fish Hatchery Winter-run Steelhead Program is an isolated-harvest program (i.e., it does not include natural-origin steelhead in the broodstock), designed and implemented to artificially spawn the adipose fin-clipped adult steelhead that seasonally enter the trapping facilities (CHSRG 2012). These fin-clipped fish are not part of the Central Valley Steelhead DPS. The Nimbus Fish Hatchery Winter-run Steelhead Program propagates fish for recreational fishing opportunities and harvest (CHSRG 2012).

Steelhead have been trapped at Nimbus Fish Hatchery as early as the first week of October; however, since 2000, the ladder has been opened in early November. Trapping of steelhead has continued to occur as late as the second week of March. Presently, winter-run steelhead are trapped at Nimbus Fish Hatchery, and artificially spawned adults are marked with an adipose fin clip (CHSRG 2012). Unmarked steelhead adults are not retained at Nimbus Fish Hatchery for use in the annual broodstock and are released back to the river (CHSRG 2012). In addition, marked or unmarked *O. mykiss* that are less than 16 inches long may be resident hatchery-origin trout and are returned to the river (CHSRG 2012).

On average, the program has raised and released approximately 422,000 yearling steelhead since brood year 1999 (CHSRG 2012). Since 1998, all steelhead/Rainbow Trout produced in Nimbus Fish Hatchery have been marked with an adipose fin-clip to aid in subsequently identifying hatchery-origin fish.

Juvenile steelhead yearlings are not held past March 30 because of increasing hatchery water temperatures and to encourage outmigration during spring. If releases occur during periods of low flows in the Sacramento River and possibly the American River, some released fish migrate back to Nimbus Fish Hatchery and may take up residency rather than migrating downstream (Lee and Chilton 2007). Additionally, juvenile fish are released in February and early March to coincide with State Water Resources Control Board (SWRCB) D-1641 closures of the DCC gates from February 1 through May 20 to reduce straying into the Delta. Reclamation determines the exact timing and duration of the gate closures after discussion with USFWS, CDFW, and NMFS.

Reclamation is implementing a genetic screening study of Nimbus Fish Hatchery steelhead. Reclamation, in contract with NMFS, is conducting a parental-based tagging study of American River steelhead and continuing a study to determine a more genetically appropriate stock.

CDFW releases all hatchery-produced steelhead juveniles into the American River at boat ramps on the American River or at the confluence of the Sacramento and American rivers and releases all unclipped steelhead adults returning to Nimbus Fish Hatchery into the lower American River via the river return tube that is just downstream of the fish ladder. In accordance with California law, the current protocol of Nimbus Fish Hatchery is to destroy all surplus eggs to prevent inter-basin transfer of eggs or juveniles to other hatcheries or waters.

The goal of the Nimbus Fish Hatchery Integrated Fall/Late Fall-run Chinook Salmon Program is to release 4 million smolts. Each fall, Nimbus Hatchery staff collect approximately 10,000 adult fall-run Chinook Salmon, with an annual goal of harvesting 8,000,000 eggs and releasing the 4,000,000 smolts. All adult fall-run Chinook Salmon collected at the hatchery are euthanized, and no trapped salmon are returned to the American River (Reclamation 2008a).

#### 9.3.4.11.5 Disease

The occurrence of a bacterial-caused inflammation of the anal vent (commonly referred to as "rosy anus") of steelhead in the lower American River has been reported by CDFW to be associated with relatively warm water temperatures (Water Forum 2005b). Anal vent inflammation of steelhead in the lower American River was observed in 2004 during periods when water temperatures were measured between 65°F and 68°F (Water Forum 2005a, 2005b). The Water Forum (2005b) suggested that, in addition to possible diminished immune system responses and incidences of diseases associated with elevated water temperatures, disease transmission may be exacerbated by crowding under conditions when water flows are reduced.

#### 9.3.4.11.6 Predation

Reduced cold-water storage in Folsom Lake and using Folsom Lake to meet Delta water quality objectives and demands influence habitat conditions in the lower American River for warm-water predator species that feed on juvenile salmonids and potentially alter predation pressure (Water Forum 2005b). Additionally, isolation of redds in side channels resulting from fluctuations in Folsom Lake releases may increase predation of emergent fry (Water Forum 2005b).

### *9.3.4.12 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, San Joaquin, and east side tributary flows converge and tidal influences from San Francisco Bay are greater.

#### 9.3.4.12.1 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).

The analysis is focused on the following species:

- Chinook Salmon (winter-, spring-, and fall-/late fall-run)
- Steelhead
- Green Sturgeon
- White Sturgeon

- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad
- Delta Smelt
- Longfin Smelt
- Sacramento Splittail

The Interagency Ecological Program (IEP) has been monitoring fish populations in the San Francisco Estuary for decades. Survey methods have included beach seining, midwater trawls, townet Kodiak trawls, otter trawls, and other methods (Honey et al. 2004) to sample the pelagic fish assemblage throughout the estuary. Three of the most prominent resident pelagic fishes captured in the surveys (Delta Smelt, Longfin Smelt, and Striped Bass) have shown substantial long-term population declines (Kimmerer et al. 2000, Bennett 2005, Rosenfield and Baxter 2007). Reductions in pelagic fish abundance since 2002 have been recognized as a serious water and fish management issue and have become known as the Pelagic Organism Decline (POD) (Sommer et al. 2007a). In response to the POD, the IEP formed a study team in 2005 to evaluate the potential causes of the decline. An overall negative trend in habitat quality has occurred for Delta Smelt and Striped Bass (and potentially other fish species) as measured by water quality attributes and midwater trawl catch data since 1967, with Delta Smelt and Striped Bass experiencing the most apparent declines in abundance, distribution, and a related index of environmental quality (Feyrer et al. 2007). More specifically, the position of X2 and water clarity may be important factors influencing the quality of habitat for these species (McNally et al. 2010). Other factors, such as the introduction of nonnative clam species, also contribute to reducing habitat quality.

*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 2001b, 2003b). Adults are believed to primarily use the mainstem Sacramento River for passage through the Delta (NMFS 2009a). After entry into the Delta, juvenile winter-run Chinook Salmon remain and rear in the Delta until they are 5 to 10 months of age (based on scale analysis) (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 Chinook Salmon 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 2009a).

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 2009a).

*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 (Budy et al. 2002, Naughton et al. 2005, Cooke et al. 2006, NMFS 2009a). 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 2009a). 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, but historical populations that occurred in the San Joaquin River and tributaries have been extirpated. 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.

Juvenile spring-run Chinook Salmon show two distinct outmigration patterns in the Central Valley: outmigrating to the Delta and ocean during their first year of life as YOY, or holding over in their natal streams and outmigrating the following fall/winter as yearlings. Yearlings typically enter the Delta as early as November and December and continue outmigration through at least March. Yearlings are less numerous than the YOY smolts that enter the Delta from January through June (NMFS 2009a). YOY spring-run Chinook Salmon presence in the Delta peaks during April and May, as suggested by the recoveries of Chinook Salmon in the CVP and SWP salvage operations and the Chipps Island trawls of a size consistent with the predicted size of spring-run fish at that time of year. 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 2009a). 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.

*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.

Most fall-run Chinook Salmon fry rear in fresh water from December through June, with outmigration as smolts primarily from January through June. 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 fresh water and outmigrate as yearling smolts the following November through April. Late fall-run fry rear in fresh water from April through the following April and outmigrate as smolts from October through February (Snider and Titus 2000b). Juvenile Chinook Salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay (MacFarlane and Norton 2002).

Results of mark-recapture studies conducted using juvenile Chinook Salmon released into both the Sacramento and San Joaquin rivers have shown high mortality during passage downstream through the rivers and Delta (Brandes and McLain 2001, Newman and Rice 2002). Juvenile salmon migrating from the San Joaquin River generally experience greater mortality than fish outmigrating from the Sacramento River. In years when spring flows are reduced and water temperatures are increased, mortality is typically higher in both rivers. Closing the DCC gates and installation of the Head of Old River Barrier to reduce the movement of juvenile salmon into the Delta contribute to improved survival of outmigrating juvenile Chinook Salmon.

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.

*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 2009a). 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.

Adult steelhead can be present in portions of the Delta with suitable conditions during any month of the year. Upstream migrating adult steelhead enter the Sacramento and San Joaquin River basins through their respective mainstem river channels. Steelhead entering the Mokelumne River system (including Dry Creek and the Cosumnes River) and the Calaveras River system to spawn are likely to move up the mainstem San Joaquin River channel before branching off into the channels of their natal rivers, although some may detour through the South Delta waterways and enter the San Joaquin River through the Head of Old River.

Steelhead entering the San Joaquin River Basin appear to have a later spawning run, with adults entering the system starting in late October through December, indicating that migration up through the Delta may begin a few weeks earlier. During fall, warm water temperatures in the south Delta waterways and water quality impairment because of low dissolved oxygen at Stockton have been suggested as potential barriers to upstream migration (NMFS 2009a). Reduced water temperatures, as well as rainfall runoff and flood control release flows, provide the stimulus to adult steelhead holding in the Delta to move upriver toward their spawning reaches in the San Joaquin River tributaries. Adult steelhead may continue entering the San Joaquin River Basin through winter.

Juvenile steelhead can be found in all waterways of the Delta, but particularly in the main channels leading from their natal river systems (NMFS 2009a). 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). Steelhead are salvaged annually at the project export facilities (e.g., 4,631 fish were salvaged in 2010, and 1,648 in 2011) (Aasen 2011, 2012).

Outmigrating steelhead smolts enter the Delta primarily from the Sacramento or San Joaquin River. Mokelumne River steelhead smolts can either follow the north or south branches of the Mokelumne River through the central Delta before entering the San Joaquin River, although some fish may enter farther upstream if they diverge from the south branch of the Mokelumne River into Little Potato Slough. Calaveras River steelhead smolts enter the San Joaquin River downstream of the Port of Stockton. Although steelhead have been routinely documented by CDFW in trawls at Mossdale since 1988 (SJRGA 2011), it is unknown whether successful outmigration occurs outside the seasonal installation of the barrier at the Head of Old River (between April 15 and May 15 in most years). Prior to the installation of the Head of Old River barrier, steelhead smolts exiting the San Joaquin River Basin could follow one of two routes to the ocean, either staying in the mainstem San Joaquin River through the central Delta, or entering the Head of Old River and migrating through the south Delta and its associated network of channels and waterways.

*Green Sturgeon*

Green Sturgeon reach maturity around 14 to 16 years of age and can live to be 70 years old, returning to their natal rivers every 3 to 5 years for spawning (Van Eenennaam et al. 2005). Adult Green Sturgeon move through the Delta from February through April, arriving at holding and spawning locations 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 behavior exhibited by adult Green Sturgeon on the Rogue River and Klamath River systems (Erickson et al. 2002, Benson et al. 2007).

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 of 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).

Juvenile Green Sturgeon and White Sturgeon are periodically (although rarely) collected from the lower San Joaquin River at south Delta water diversion facilities and other sites (NMFS 2009a; Aasen 2011, 2012). Green Sturgeon are salvaged from the south Delta Project diversion facilities and are generally juveniles greater than 10 months but less than 3 years old (Reclamation 2008a). NMFS (2005b) suggested that the high percentage of San Joaquin River flows contributing to the Tracy Fish Collection Facility could mean that some entrained Green Sturgeon originated in the San Joaquin River Basin. Jackson (2013) reported spawning by White Sturgeon in the San Joaquin River, and anglers have reported catching a few Green Sturgeon in recent years in the San Joaquin River (DFG 2012b).

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. Project operations at the DCC have the potential to reroute Green Sturgeon as they outmigrate through the lower Sacramento River to the Delta (Israel and Klimley 2008, Vogel 2011). 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.

*White Sturgeon*

White Sturgeon are similar to Green Sturgeon in terms of their biology and life history. Like Green Sturgeon and other sturgeon species, White Sturgeon are late-maturing and infrequent spawners, which makes them vulnerable to overexploitation and other sources of adult mortality. White Sturgeon are believed to be most abundant within the San Francisco Bay-Delta region (Moyle 2002). Both nonspawning adults and juveniles can be found throughout the Delta year-round (Radtke 1966, Kohlhorst et al. 1991, Moyle 2002, DWR et al. 2013). When not undergoing spawning or ocean migrations, adults and subadults are usually most abundant in brackish portions of the Bay-Delta (Kohlhorst et al. 1991). The population status of White Sturgeon in the Delta is unclear, but it is not presently listed. Overall, information on trends in adults and juveniles suggests that numbers are declining (Moyle 2002, NMFS 2009a).

The Delta population of White Sturgeon spawns mainly in the Sacramento and Feather rivers, with occasional spawning in the San Joaquin River (Moyle 2002, Jackson 2013). Spawning-stage adults generally move into the lower reaches of rivers during winter prior to spawning and migrate upstream in response to higher flows to spawn from February to early June (McCabe and Tracy 1994, Schaffter 1997).

After absorbing yolk sacs and initiating feeding, YOY White Sturgeon make an active downstream migration that disperses them widely to rearing habitat throughout the lower rivers and the Delta (McCabe and Tracy 1994). White Sturgeon larvae have been observed to be flushed farther downstream in the Delta and Suisun Bay in high outflow years, but are restricted to more interior locations in low outflow years (Stevens and Miller 1970).

Salinity tolerance increases with increasing age and size (McEnroe and Cech 1985), allowing White Sturgeon to access a broader range of habitat in the San Francisco Estuary (Israel et al. 2008). During dry years, White Sturgeon have been observed following brackish waters farther upstream, while the opposite occurs in wet years (Kohlhorst et al. 1991). Adult White Sturgeon tend to concentrate in deeper areas and tidal channels with soft bottoms, especially during low tides, and typically move into intertidal or shallow subtidal areas to feed during high tides (Moyle 2002). These shallow water habitats provide opportunities for feeding on benthic organisms, such as opossum shrimp, amphipods, and even invasive overbite clams, and small fishes (Israel et al. 2008, Kogut 2008). White Sturgeon also have been found in tidal habitats of medium-sized tributary streams to the San Francisco Estuary, such as Coyote Creek and Guadalupe River in the south bay and Napa and Petaluma rivers and Sonoma Creek in the north bay (Leidy 2007).

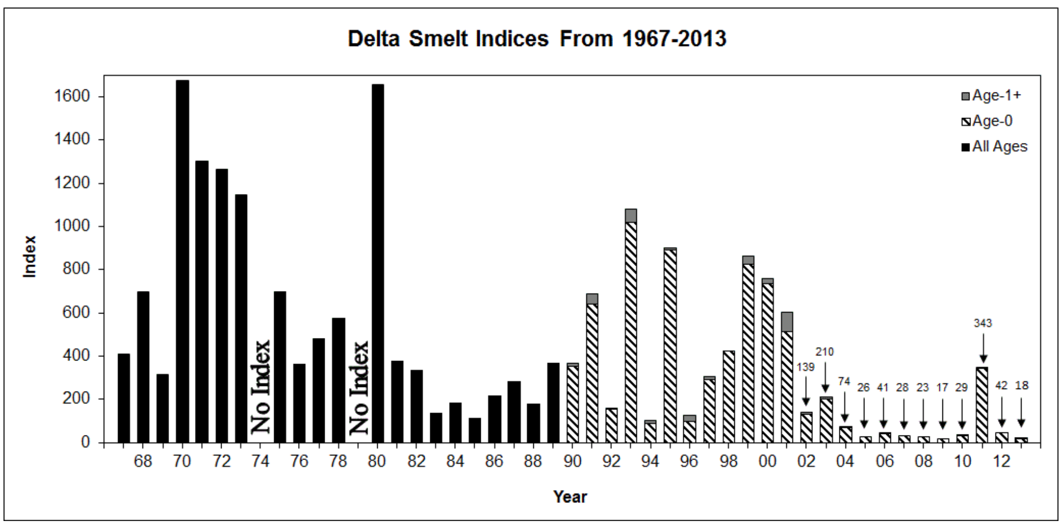
Numerous factors likely affect the White Sturgeon population in the Delta, similar to those for Green Sturgeon. Survival during early life history stages may be adversely affected by insufficient flows, lack of rearing habitat, predation, warm water temperatures, decreased dissolved oxygen, chemical toxicants in the water, and entrainment at diversions (Cech et al. 1984, Israel et al. 2008). Historical habitats, including shallow intertidal feeding habitats, have been lost in the Delta because of channelization. Over-exploitation by recreational fishing and poaching also likely has been an important factor adversely affecting numbers of adult sturgeon (Moyle 2002), although new regulations were implemented in 2007 by CDFW to reduce harvest. Like Green Sturgeon, there are substantial passage problems for White Sturgeon such as the Fremont Weir (Sommer et al. 2014).

*Delta Smelt*

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 (USFWS 2008a). 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. 2007a). 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 (Feyrer et al. 2007, Sommer et al. 2007a, Moyle and Bennett 2008, MacNally et al. 2010, 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. The Fall Midwater Trawl (FMWT) Survey is recognized by some as the best available long-term index of Delta Smelt relative abundance (USFWS 2008). Figure 9.1 presents the FMWT abundance indices for Delta Smelt from 1967 to 2013 (CDFW 2014b). Fewer than 10 Delta Smelt were collected in these surveys in 2014; the 2014 Delta Smelt index was 9, making it the lowest in FMWT history (CDFW 2014a, Austin 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).

**Figure 9.1 Fall Midwater Trawl Abundance Indices for Delta Smelt from 1967 to 2013**




Source: California Department of Fish and Wildlife, Trends in Abundance of Selected Species, January 15, 2014. http://www.dfg.ca.gov/delta/data/fmwt/Indices/

Studies conducted to synthesize available information about Delta Smelt indicate that 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 Grizzly Bay, 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 fresh water, 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, many juvenile Delta Smelt continue to grow and rear in the low salinity zone until maturing the following winter (Bennett 2005). Some Delta Smelt also rear in upstream areas such as the Cache Slough complex, depending on habitat conditions (Sommer and Mejia 2013).

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, 2011; 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).

Higher outflow causes X2 and the low salinity zone to more frequently overlap with the Suisun Bay/Marsh region, which is broader and shallower and typically has greater turbidity than the mainstem Sacramento and San Joaquin rivers. The overlap of the low salinity zone (or X2) with the Suisun Bay/Marsh leads to more favorable growth and survival conditions for Delta Smelt in fall (Baxter et al. 2010, Feyrer et al. 2011); however others have questioned the use by Feyrer et al. (2013) of outflow and X2 location as an indicator of Delta Smelt habitat (Manly et al. 2014) because other factors may be influencing survival.

In addition to salinity, turbidity is an important factor associated with habitat use; Delta Smelt show a strong preference for higher turbidity water (Feyrer et al. 2007, 2011; Sommer and Mejia 2013). Turbidity has decreased in recent decades within the Delta (Kimmerer 2004, Schoellhamer 2011), which has likely contributed to declines in environmental quality of Delta Smelt habitat (Feyrer et al. 2007, 2011). Higher turbidities are believed to allow Delta Smelt to hide from open-water predators, such as Striped Bass (Gregory and Levings 1998, Nobriga et al. 2005), and contribute to feeding success (Lindberg et al. 2000, IEP 2015).

Water temperature is another important environmental factor that affects Delta Smelt habitat and population dynamics (Sommer and Mejia 2013). A longer period of optimal water temperatures in cooler years increases the number of spawning events and cohorts produced (Bennett 2005). During rearing, summer water temperatures also have been shown to be an important predictor of Delta Smelt occurrence, based on multidecadal analyses of summer tow net survey data (Nobriga et al. 2008).

The quality and availability of food also have important effects on the abundance and distribution of Delta Smelt (Sommer and Mejia 2013, Kimmerer 2008). Delta Smelt feed primarily on zooplankton, and Nobriga (2002) showed that Delta Smelt larvae with food in their guts typically co-occurred with higher calanoid copepod densities. Food quality and availability have varied substantially, largely because of the history of nonnative species introduction into the San Francisco Estuary (Baxter et al. 2008, Winder and Jassby 2011). The decline of zooplankton in the western Delta has been hypothesized to be related to several factors, including increased ammonium concentrations from wastewater effluent and agricultural runoff (Wilkerson et al. 2006; Dugdale et al. 2007; Miller et al. 2012; Glibert 2010; Glibert et al. 2011, 2014).

In 2011 and 2012, an unanticipated change in water management operations led to relatively large phytoplankton blooms in the western Delta, including in the Sacramento River near Rio Vista. Historically, rice fields along the Colusa Basin Drain are flooded in fall to decompose the rice stubble, and the water is released through the Knights Landing Outfall gates into the Sacramento River. In 2011 and 2012, construction at the outfall gates required the water to be diverted into the Yolo Bypass, resulting in higher than normal flows. These events temporarily resulted in a fall pulse flow in the Yolo Bypass that increased the volume of flow by more than 300 to 900 percent (Frantzich 2014). Concurrently, a substantial increase in nutrients, phytoplankton, and zooplankton was observed in the Yolo Bypass and Cache Slough. In 2013, the fall pulse flow of rice drainage water did not occur in the Yolo Bypass, and nutrient concentrations did not increase. These nutrient inputs, when they occur, and corresponding increases in phytoplankton and zooplankton production, could contribute to improved foraging opportunities for Delta Smelt.

Results in prior years indicate that 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 river channels (Kimmerer 2008, Grimaldo et al. 2009, Baxter et al. 2010).

In January 2015, the IEP Management Analysis and Synthesis Team (MAST) published a report to provide an assessment and conceptual model of factors affecting Delta Smelt throughout its life cycle. One focus of the report was an evaluation of a notable increase in abundance of all Delta Smelt life stages in 2011, which indicated that the Delta Smelt population could potentially rebound when conditions are favorable for spawning, growth, and survival.

The IEP MAST updated conceptual model described the habitat conditions and ecosystem drivers affecting each Delta Smelt life stage, across seasons and how the seasonal effects contributed to the annual success of the species. The conclusions of the report highlighted some key points about Delta Smelt and their habitat, using 2011 as the example year. In summary, the report concluded that Delta Smelt likely benefitted from the following favorable habitat conditions in 2011:

1) Adults and larvae benefitted from high winter 2010 and spring 2011 outflows, which reduced entrainment risk and possibly improved other habitat conditions, prolonged cool spring water temperatures, and possibly good food availability in late spring.

2) Juvenile Delta Smelt benefitted from cool water temperatures in late spring and early summer as well as from relatively good food availability and low levels of harmful Microcystis.

3) Subadults benefitted from good food availability and from favorable habitat conditions in the large low salinity zone, located more toward Suisun Bay in 2010.

In addition to the beneficial conditions described in the IEP MAST report, available food for Delta Smelt may have been supplemented in 2011 and 2012 when water management operations resulted in the release of Colusa Basin Drain water through the Yolo Bypass. The resultant increases in nutrients and phytoplankton led to measurable increases in zooplankton (e.g., calanoid copepods) in the Yolo Bypass, Cache Slough, and the Sacramento River near Rio Vista (Frantzich 2014).

*Longfin Smelt*

Longfin Smelt populations occur along the Pacific Coast of North America, and the San Francisco Estuary represents the southernmost population. Longfin Smelt generally occur in the Delta; Suisun, San Pablo, and San Francisco bays; and the Gulf of the Farallones, just outside San Francisco Bay. Longfin Smelt are not a focus of any specific RPA actions. However, RPA actions that benefit Delta Smelt, salmonids, and sturgeon, including increasing Delta outflow, have the potential to benefit other fish, including Longfin Smelt, given their similar habitat requirements and trophic feeding levels.

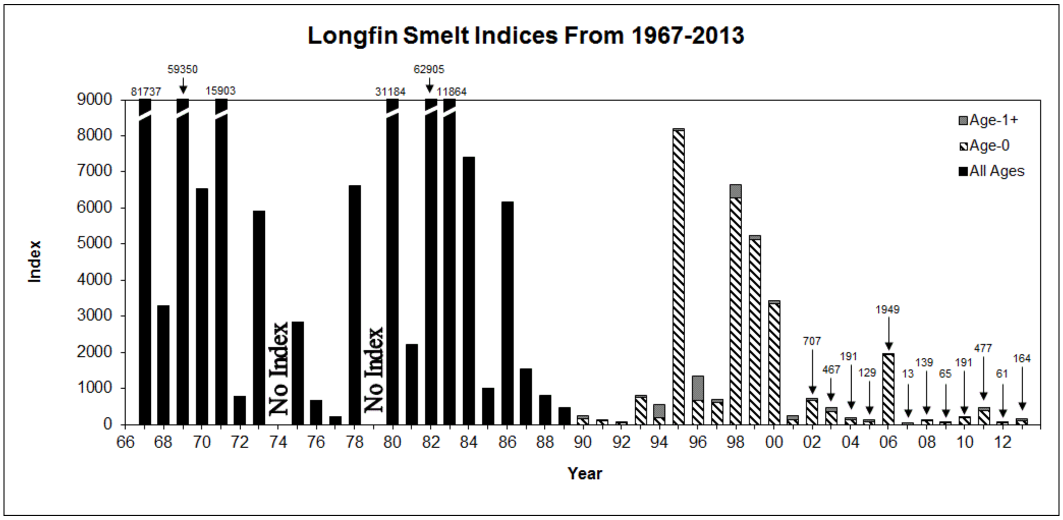
Longfin Smelt are anadromous and spawn in fresh water in the Delta, generally at 2 years of age (Moyle 2002). They migrate upstream to spawn during late fall through winter, with most spawning from November through April (DFG 2009a). Spawning in the Sacramento River is believed to occur from just downstream of the confluence of the Sacramento and San Joaquin rivers 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 2009a).

Longfin Smelt larvae are most abundant in the water column usually from January through April (Reclamation 2008a). 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).

Longfin Smelt in the San Francisco Estuary are broadly distributed in both time and space, and interannual distribution patterns are relatively consistent (Rosenfield and Baxter 2007). Seasonal patterns in abundance indicate that the population is at least partially anadromous (Rosenfield and Baxter 2007), and the detection of Longfin Smelt within the estuary throughout the year suggests that, similar to Striped Bass, anadromy is one of several life history strategies or contingents in this population.

The relative population size of Longfin Smelt in the San Francisco Estuary is measured by indices of abundance generated from different sampling programs. The abundance of age 0 and older fish is best indexed by the Fall Midwater Trawl and Bay Study, while the abundance of larvae and young juveniles is best indexed by the 20-mm survey. The relationship between these indices and actual population sizes is unknown. The abundance of Longfin Smelt in the estuary has fluctuated over time but has exhibited statistically significant step-declines around 1989 to 1991 and in 2004 (Thomson et al. 2010). A synthesis of prior studies conducted by USFWS in its 12-Month Finding on a Petition to List the San Francisco Bay-Delta Population of the Longfin Smelt as Endangered or Threatened (USFWS 2012) reported that increased Delta outflow in winter and spring is the largest factor possibly affecting Longfin Smelt abundance. The trend in Longfin Smelt abundance from 1967 through 2013 is presented on Figure 9.2.

**Figure 9.2 Fall Midwater Trawl Abundance Indices for Longfin Smelt from 1967 to 2013**




Source: California Department of Fish and Wildlife, Trends in Abundance of Selected Species, January 15, 2014. http://www.dfg.ca.gov/delta/data/fmwt/Indices/

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, Bennett and Moyle 1996, Kimmerer 2004, Kimmerer et al. 2009).

Water exports and inadvertent entrainment at the SWP and CVP export facilities are anthropogenic sources of mortality for Longfin Smelt. The export facilities are known to entrain most species of fish in the Delta (Brown et al. 1996). Longfin Smelt entrainment 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.

*Sacramento Splittail*

Sacramento Splittail are found primarily in marshes, turbid sloughs, and slow-moving river reaches throughout the Delta subregion (Sommer et al. 1997, 2008). Sacramento Splittail are most abundant in moderately shallow, brackish tidal sloughs and adjacent open-water areas, but they also can be found in freshwater areas with tidal or riverine flow (Moyle et al. 2004).

Adult Sacramento Splittail typically migrate upstream from brackish areas in January and February and spawn in fresh water, particularly on inundated floodplains when they are available, in March and April (Sommer et al. 1997, Moyle et al. 2004, Sommer et al. 2008). A substantial amount of splittail spawning occurs in the Yolo and Sutter bypasses and the Cosumnes River area of the Delta (Moyle et al. 2004). Spawning also can occur in the San Joaquin River during high-flow events (Sommer et al. 1997, 2008). However, not all adults migrate significant distances to spawn as evidenced by spawning in the Napa and Petaluma rivers (Feyrer et al. 2005).

Although juvenile Sacramento Splittail are known to rear in upstream areas for a year or more (Baxter 1999), most move to the Delta after only a few weeks or months of rearing in floodplain habitats along the rivers (Feyrer et al. 2006). Juveniles move downstream into the Delta from April to August (Meng and Moyle 1995, Feyrer et al. 2005). Sacramento Splittail recruitment is largely limited by extent and period of inundation of floodplain spawning habitats, with abundance observed to spike following wet years and dip after dry years (Moyle et al. 2004). However, the 5- to 7-year life span buffers the adult population abundance (Sommer et al. 1997, Moyle et al. 2004). Other factors that may adversely affect the splittail population in the Delta include entrainment, predation, changed estuarine hydraulics, nonnative species (Moyle et al. 2004), pollutants (Greenfield et al. 2008), and limited food.

*American Shad*

American Shad is a recreationally important anadromous species introduced into the Sacramento-San Joaquin River Basin in the 1870s (Moyle 2002). American Shad spend most of their adult life at sea and may make extensive migrations along the coast. American Shad become sexually mature while in the ocean and migrate through the Delta to spawning areas in the Sacramento, Feather, American, and Yuba rivers. Some spawning also takes place in the lower San Joaquin, Mokelumne, and Stanislaus rivers (USFWS 1995). The spawning migration may begin as early as February, but most adults migrate into the Delta in March and early April (Skinner 1962). Migrating adults generally take 2 to 3 months to pass through the Sacramento-San Joaquin estuary (Painter et al. 1979).

Fertilized eggs are slightly negative buoyant, are not adhesive, and drift in the current. Newly hatched larvae are found downstream of spawning areas and can be rapidly transported downstream by river currents because of their small size. Juvenile shad rear in the Sacramento River below Knights Landing, the Feather River below Yuba City, and the Delta; rearing also takes place in the Mokelumne River near the DCC to the San Joaquin River. No rearing occurs in the American and Yuba rivers (Painter et al. 1979). Some juvenile shad may rear in the Delta for up to a year before outmigrating to the ocean (USFWS 1995). Outmigration from the Delta begins in late June and continues through November (Painter et al. 1979).

Juvenile American Shad are frequently encountered in the Delta during the FMWT Survey and in fish salvage monitoring at the south Delta SWP and CVP fish facilities (DWR et al. 2013). American Shad use of the Delta has been observed to vary with salinity (e.g., X2 position) and outflows (Kimmerer 2002).

American Shad are entrained at the Tracy Fish Collection Facility (Bowen et al. 1998) and in the Clifton Court Forebay, mostly during May through December when young American Shad migrate downstream. The American Shad population in the Sacramento-San Joaquin River Basin has declined since the late 1970s, most likely because of increased diversion of water from rivers and the Delta, combined with changing ocean conditions, and possibly pesticides (Moyle 2002). Salvage of American Shad at project export facilities in water year 2011 represented nearly 659,000 fish (Aasen 2012), with similar but slightly lower salvage in 2010 (545,125 fish) (Aasen 2011).

*Striped Bass*

Striped Bass is a recreationally important anadromous species introduced into the Sacramento-San Joaquin River Basin between 1879 and 1882 (Moyle 2002). Despite their nonnative status and piscivorous feeding habits, Striped Bass are considered important because they are a major game fish in the Delta. Striped Bass use the Delta as a migratory route and for rearing and seasonal foraging. Striped Bass spend the majority of their lives in salt water, returning to fresh water to spawn. When not migrating for spawning, adult Striped Bass in the San Francisco Bay-Delta are found in San Pablo Bay, San Francisco Bay, and the Pacific Ocean (Moyle 2002). Adult Striped Bass spend about 6 to 9 months of the year in San Francisco and San Pablo bays (Hassler 1988). Striped Bass also use deeper areas of many of the larger channels in the Delta, in addition to large embayments such as Suisun Bay.

Spawning occurs in spring, primarily in the Sacramento River between Sacramento and Colusa and in the San Joaquin River between Antioch and Venice Island (Farley 1966). Eggs are free-floating and negatively buoyant and hatch as they drift downstream, with larvae occurring in shallow and open waters of the lower reaches of the Sacramento-San Joaquin rivers, the Delta, Suisun Bay, Montezuma Slough, and Carquinez Strait. According to Hassler (1988), the distribution of larvae in the estuary depends on river flow. In low-flow years, all Striped Bass eggs and larvae are found in the Delta, while in high-flow years, the majority of eggs and larvae are transported downstream into Suisun Bay.

YOY Striped Bass distribute themselves in accordance with the estuarine salinity gradient (Kimmerer 2002, Feyrer et al. 2007), indicating that salinity is a major factor affecting their habitat use and geographic distributions. Kimmerer (2002) found that distributions of fish species, including Striped Bass, substantially overlapped with the low salinity zone. Older Striped Bass are increasingly flexible about their distribution relative to salinity (Moyle 2002).

The entrainment of Striped Bass has been observed at the project export facilities, including Clifton Court Forebay (Stevens et al. 1985, Bowen et al. 1998, Aasen 2012). In water year 2011, salvage of Striped Bass at export facilities (approximately 550,000 fish) continued a generally low trend observed since the mid-1990s. Prior to 1995, annual Striped Bass salvage was generally above 1 million fish (Aasen 2012). DWR et al. (2013) reported that Striped Bass longer than 24 mm were effectively screened at Tracy Fish Collection Facility and bypassed the pumps. However, planktonic eggs, larvae, and juveniles smaller than 24 mm in length received no protection from entrainment.

Striped Bass, primarily YOY, are one of the pelagic fish of the upper estuary that have shown substantial variability in their populations, with evidence of long-term declines (Kimmerer et al. 2000, Sommer et al. 2007a). As discussed earlier for Delta Smelt, a substantial portion of the abundance patterns has been associated with variation of outflow in the estuary (Jassby et al. 1995, Kimmerer et al. 2001, Loboschefsky et al. 2012), although this is disputed by some stakeholders (Bourez 2011). However, surveys showed that population levels for YOY Striped Bass began to decline sharply around 1987 and 2002 (Thomson et al. 2010), despite relatively moderate hydrology, which typically supports at least modest fish production (Sommer et al. 2007a). Moyle (2002) cites causes of decline in Striped Bass to include climatic factors, entrainment at project export facilities in the south Delta, other diversions, pollutants, reduced estuarine productivity, invasions by alien species, and human exploitation. Kimmerer et al. (2000, 2001) attribute the decline in juvenile YOY Striped Bass to declining carrying capacity, likely related to food limitation. Loboschefsky et al. (2012) showed that there had been no long-term decline for age 1 and older Striped Bass as of 2004.

*Pacific Lamprey*

The Pacific Lamprey is a widely distributed species that uses the Delta for upstream migration as adults, for downstream migration as juveniles, and for rearing as ammocoetes (larval form) (Hanni et al. 2006, Moyle et al. 2009). Pacific Lampreys are present in the north, central, and south Delta, and ammocoetes are present year-round in all of the regions (DWR et al. 2013). Limited information on status of Pacific Lamprey in the Delta exists, but the number of lampreys inhabiting the Delta is likely greatly suppressed compared with historical levels, as suggested by the loss of access to historical habitat and apparent population declines throughout California and the Sacramento-San Joaquin River Basin (Moyle et al. 2009).

Limited data indicate most adult Pacific Lamprey migrate though the Delta enroute to upstream holding and spawning grounds in the early spring through early summer (Hanni et al. 2006). As documented in other large river systems, it is likely that some adult migration through the Delta occurs from late fall and winter through summer and possibly over an even broader period (Robinson and Bayer 2005, Hanni et al. 2006, Moyle et al. 2009, Clemens et al. 2012, Lampman 2011). Data from the FMWT Survey in the lower Sacramento and San Joaquin rivers and Suisun Bay suggest that peak outmigration of Pacific Lamprey through the Delta coincides with high-flow events from fall through spring (Hanni et al. 2006). Some outmigration likely occurs year-round, as observed at sites farther upstream (Hanni et al. 2006), and in other river systems (Moyle 2002). Some Pacific Lamprey ammocoetes likely spend part of their extended (5 to 7 years) freshwater residence rearing in the Delta, particularly in the upstream, freshwater portions (DWR et al. 2013).

#### 9.3.4.12.2 Aquatic Habitat

Flow management in the Delta has created stress on aquatic resources by (1) changing aspects of the historical flow regime (timing, magnitude, duration) that supported life history traits of native species; (2) limiting access to or quality of habitat; (3) contributing to conditions better suited to invasive, nonnative species (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 on 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 (Moyle 2002).

Water temperatures in the Delta follow a seasonal pattern of winter cold-water conditions and summer warm-water conditions, largely because of the region's Mediterranean climate, 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 (Kimmerer 2004, Mount et al. 2012, NRC 2012, Wagner et al. 2011). Water temperatures in summer now approach or exceed the upper thermal tolerances (e.g., 20 to 25° Centigrade [C]) for cold-water fish species such as salmonids and Delta-dependent species such as Delta Smelt. This is especially true in parts of the south Delta and San Joaquin River, potentially restricting the distribution of these species and precluding previously important rearing areas (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). The major species influenced by current Delta hydrology include Delta Smelt, Longfin Smelt, Sacramento Splittail, White Sturgeon, juvenile Chinook Salmon, and Striped Bass (Jassby et al. 1995, Kimmerer 2002, Rosenfield and Baxter 2007, Kimmerer et al. 2009, Fish 2010, Perry et al. 2012, Thomson et al. 2010, Feyrer et al. 2011, Loboschefsky et al. 2012, Mount et al. 2012).

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, this 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 fresh water 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, 2011; USFWS 2008a). It is also helps define the extent of habitat available for oligohaline pelagic organisms and their prey. An analysis of historical monitoring data by Feyrer et al. (2007) revealed that 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. Project operations and other potential factors (e.g., lower outflows) have tended to shift 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 (USFWS 2008a, 2011a; Kimmerer et al. 2009; Baxter et al. 2010).

#### 9.3.4.12.3 Nutrients and Food Web Support

Nutrients are essential components of terrestrial and aquatic environments because they 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. Nutrient concentrations in the Delta have been well studied (Jassby et al. 2002; Kimmerer 2004; Glibert 2010; Glibert et al. 2011, 2014).

Estuaries are commonly characterized as highly productive nursery areas for numerous aquatic organisms. Nixon (1988) noted that there is a broad continuum of primary productivity levels in different estuaries, which in turn affects fish production and abundance. 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). In the Delta and Suisun Marsh, this appears to result from turbidity, clam grazing (Jassby et al. 2002), and nitrogen and phosphorus dynamics (Wilkerson et al. 2006, Van Niewenhuyse 2007, Glibert 2010, Glibert et al. 2014).

There has been a significant long-term decline in phytoplankton biomass (chlorophyll a) and primary productivity to low levels in the Suisun Bay region and the Delta (Jassby et al. 2002). Shifts in nutrient concentrations such as high levels of ammonium and toxic contaminants such as microcystins 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; Lehman et al. 2005, 2008b, 2010; 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. *Potamocorbula* is most abundant in the brackish and saline water of Suisun Bay and the western Delta, and *Corbicula* is most abundant in the fresh water of the central 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, Kimmerer 2002).

Additionally, introduction of the clams led to the decline of higher-food-quality native copepods and the establishment of poorer quality nonnative copepods. More recently, the cyclopoid copepod, *Limnoithona*, has rapidly become the most abundant copepod in the Delta after its introduction in 1993 (Hennessy and Enderlein 2013). This species is hypothesized to be a low-quality food source and intraguild predator of native and nonnative calanoid copepods (CRA 2005). The clam *Potamocorbula* also has been implicated in the reduction of the native opossum shrimp, a preferred food of Delta native fishes such as Sacramento Splittail and Longfin Smelt (Feyrer et al. 2003). Reductions in food availability and food quality have led to lower fish foraging efficiency and reduced growth rates (Moyle 2002).

Studies on food quality have been relatively limited in the San Francisco Estuary, with even less information on long-term trends. Nonetheless, several studies have documented or suggested the food limitations for aquatic species in the estuary, including zooplankton (Mueller-Solger et al. 2002, Kimmerer et al. 2005), Delta Smelt (Bennett 2005, Bennett et al. 2008), Chinook Salmon (Sommer et al. 2001a), Sacramento Splittail (Greenfield et al. 2008), Striped Bass (Loboschefsky et al. 2012), and Largemouth Bass (Nobriga 2009).

#### 9.3.4.12.4 Turbidity

Turbidity is an important water quality component in the Delta that 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 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 (*Corbula 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 2008a). USFWS and the Independent Review Panel have expressed concern over the efficacy of the turbidity triggers, even though Delta Smelt do show a preference for turbid waters (IRP 2011).

#### 9.3.4.12.5 Contaminants

Contaminants can change ecosystem functions and productivity through numerous pathways. Changes to nutrient concentrations and ratios in the Delta, and their impacts on the food web and fish, have been summarized by Glibert et al. (2011). The trends in other contaminant loadings and their ecosystem effects are not well understood. Efforts are underway to evaluate direct and indirect toxic effects on the POD 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, 2008b, 2010.)

There are longstanding concerns related to mercury and selenium in the Sacramento and San Joaquin watersheds, the Delta, and San Francisco Bay (see Chapter 6, Surface Water Quality, for additional detail on these constituents). Additional study is needed to avoid increases in mercury exposure resulting from tidal wetlands restoration; methylmercury is produced at a relatively high rate in wetlands and newly flooded aquatic habitats (Davis et al. 2003). Methylmercury increases in concentration at each level in the food chain and can cause concern for people and birds that eat piscivorous fish (bass) and sturgeon, as described in Chapter 6, Surface Water Quality. It has not been shown to be a direct problem for fish in the Delta, but studies of other fish summarized by Alpers et al. (2008) indicate that mercury in fish has been linked to hormonal and reproductive effects, liver necrosis, and altered behavior in fish. With regard to selenium, benthic foragers like diving ducks, sturgeon, and splittail have the greatest risk of selenium toxicity; the invasion of the nonnative bivalves (e.g., *P. amurensis*) has resulted in increased bioavailability of selenium to benthivores in San Francisco Bay (Linville et al. 2002).

Baxter et al. (2008) prepared a 2007 synthesis of results as part of a POD 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

Weston study of sediment toxicity recommended additional study of the effects of the pyrethroid insecticides on benthic organisms. 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).

#### 9.3.4.12.6 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. (2015) used acoustic telemetry to examine survival of late fall-run Chinook Salmon smolts outmigrating from the Sacramento River through the Delta and San Francisco Estuary. 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.

*North Delta Fish Passage and Entrainment*

In the north Delta, migrating fish have multiple potential pathways as they move upstream into the Sacramento or Mokelumne river systems. The DCC, when open, can divert fish as they outmigrate along this route. The opening of the DCC when salmon are returning to spawn to the Mokelumne and Cosumnes rivers is believed to lead to increased straying of these fish into the American and Sacramento rivers because of confusion over olfactory cues. In recent years, experimental DCC closures have been scheduled during the fall-run Chinook Salmon migration season for selected days, coupled with pulsed flow releases from reservoirs on the Mokelumne River, in an attempt to reduce straying rates of returning adults. These closures have corresponded with reduced recoveries of Mokelumne River hatchery fish in the American River system and increased returns to the Mokelumne River hatchery (EBMUD 2012).

Marston et al. (2012) studied stray rates for in-migrating San Joaquin River Basin adult salmon that stray into the Sacramento River Basin. Results indicated that it was unclear whether reduced San Joaquin River pulse flows or elevated exports caused increased stray rates.

Outmigrating juvenile fish moving down the mainstem Sacramento River also can enter the DCC when the gates are open and travel through the Delta via the Mokelumne and San Joaquin river channels. In the case of juvenile salmonids, this shifted route from the north Delta to the central Delta increases their mortality rate (Kjelson and Brandes 1989, Brandes and McLain 2001, Newman and

Brandes 2010, Perry et al. 2012). Salmon migration studies show losses of approximately 65 percent for groups of outmigrating fish that are diverted from the mainstem Sacramento River into the waterways of the central and southern Delta (Brandes and McLain 2001; Vogel 2004, 2008; Perry and Skalski 2008). Perry and Skalski (2008) found that, by closing the DCC gates, total through-Delta survival of marked fish to Chipps Island increased by nearly 50 percent for fish moving downstream in the Sacramento River system. Closing the DCC gates appears to redirect the migratory path of outmigrating fish into Sutter and Steamboat sloughs and away from Georgiana Slough, resulting in higher survival rates. Species that may be affected include juvenile Green Sturgeon, steelhead, and winter and spring-run Chinook Salmon (NMFS 2009a).

Fish passage in the north Delta also can be affected by water quality. Water quality in the mainstem Sacramento River and its distributary sloughs can be poor at times during summer, creating conditions that may stress migrating fish or even impede migration. These conditions include dissolved oxygen, water temperatures, and, for some species, salinity (e.g., Delta Smelt). For adult Chinook Salmon, dissolved oxygen concentration less than 3 to 5 milligrams per liter (mg/L) can impede migration (Hallock et al. 1970) as can mean daily water temperatures of 21 to 23°C, depending on whether water temperatures are rising or falling (Strange 2010). Dissolved oxygen levels and water temperatures can exceed these thresholds in the Delta for periods during summer and fall.

The SWP Barker Slough Pumping Plant, located on a tributary to Cache Slough, may cause larval fish entrainment. The intake is equipped with a positive barrier fish screen to prevent fish at least 25 mm in size from being entrained. CDFW has monitored entrainment of larval Delta Smelt less than 20 mm at Barker Slough since 1995. When the presence of Delta Smelt larvae is indicated, pumping rates from Barker Slough are reduced to a 5-day running average rate of 65 cfs, not to exceed a 75-cfs daily average for any day, for a minimum of 5 days and until monitoring shows no Delta Smelt are present.

*Central and South Delta Fish Passage and Entrainment*

The south Delta intake facilities include the CVP and SWP export facilities; local agency intakes, including Contra Costa Water District intakes; and agricultural intakes. Contra Costa Water District intakes and the CVP Contra Costa Canal Pumping Plant include fish screens; however, most of the remaining intakes do not include fish screens. 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 (Kimmerer and Nobriga 2008). Delta diversions can create reverse flows, drawing fish toward project facilities (Arthur et al. 1996, Kimmerer 2008, Grimaldo et al. 2009). While swimming through southern Delta channels, fish can be subjected to stress from poor water quality (seasonally high temperatures, low dissolved oxygen, high water transparency, and *Microcystis* blooms) and slow water velocities in lake-like habitats. Any of these factors can cause elevated mortality rates by weakening or disorienting the fish and increasing their vulnerability to predators (Vogel 2011). Cunningham et al. (2015) found a negative influence of the export/inflow ratio on the survival of fall-run Chinook populations and a negative influence of increased total Delta exports on the survival of spring-run Chinook populations.

Water from the San Joaquin River mainly moves downstream through the Head of Old River and through the channels of Old and Middle rivers and Grant Line and Fabian-Bell canals toward the south Delta intake facilities. Conversely, when water to the north of the diversion points for the two facilities moves southward (upstream), the net flow is negative (toward) the pumps. When the temporary barriers are installed from April through November, internal reverse circulation is created within the channels isolated by the barriers from other portions of the south Delta. These conditions are most pronounced during late spring through fall when San Joaquin River inflows are low and water diversion rates are typically high. Drier hydrologic years also reduce the frequency of net downstream flows in the south Delta and mainstem San Joaquin River.

A portion of fish that enter the CVP 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 (example.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, Brown et al. 1996). Fish entrainment and salvage are particular concerns during dry years when the distributions of young Striped Bass, Delta Smelt, Longfin Smelt, and other migratory fish species shift closer to the project facilities (Stevens et al. 1985, Sommer et al. 1997).

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.

The life stage of the fish at which entrainment occurs may be important for population dynamics (IRP 2011). For example, winter entrainment of Delta Smelt, Longfin Smelt, and Threadfin Shad may correspond to migration and spawning of adult fish, and spring and summer exports may overlap with development of larvae and juveniles. The loss of prespawning adults and all their potential progeny may have greater consequences than entrainment of the same number of larvae or juvenile fish. Entrainment risk for fish tends to increase with increased reverse flows in Old and Middle rivers (Kimmerer 2008, Grimaldo et al. 2009).

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 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.

There are more than 2,200 diversions in the Delta (Herren and Kawasaki 2001). These irrigation diversion pipes are shore-based, typically small (30 to 60 centimeter pipe diameter), and operated via pumps or gravity flow, and most lack fish screens. These diversions increase total fish entrainment and losses and alter local fish movement patterns (Kimmerer and Nobriga 2008). Delta Smelt have been found in samples of Delta irrigation diversions, as well as larger wetland management diversions downstream. However, Nobriga et al. (2004) found that the low and inconsistent entrainment of Delta Smelt measured in the study reflected habitat use by Delta Smelt and relatively small hydrodynamic influence of the diversion.

#### 9.3.4.12.7 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).

Additionally, preliminary evidence suggests that contaminants and disease may impair Striped Bass. Studies by Lehman et al. (2010) suggest that the liver tissue and health of Striped Bass and Mississippi Silverside were adversely affected by tumors, particularly at sampling stations where concentrations of tumor-promoting microcystins were elevated. Exposure of Sacramento Splittail and Threadfin Shad to microcystins in experimental diets resulted in severe liver damage; shad also exhibited ovarian necrosis, indicating impairment of health and reproductive potential (Acuna et al. 2012).

In contrast, histopathological and viral evaluation of juvenile Longfin Smelt and Threadfin Shad collected in 2006 indicated no histological abnormalities and no evidence of viral infections or high parasite loads (Foott et al. 2006). Parasites were noted in Threadfin Shad gills at a high frequency, but the infections were not considered severe. Thus, both Longfin Smelt and Threadfin Shad were considered healthy in 2006 (a high-flow year). Adult Delta Smelt collected from the Delta during winter 2005 also were considered healthy, showing little histopathological evidence for starvation or disease (Reclamation 2008a). However, there was some evidence of low frequency endocrine disruption. In 2005, 9 of 144 (6 percent) of adult Delta Smelt males were intersex, having immature oocytes in their testes (Reclamation 2008a).

#### 9.3.4.12.8 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 or harmful. Some introduced species do not greatly affect the ecosystem, or have minimal ability to spread or increase in abundance. Others have commercial or recreational value (e.g., Striped Bass, American Shad, and Largemouth Bass).

Many nonnative fishes have been introduced into the Delta for sport fishing (game fish such as Striped Bass, Largemouth Bass, Smallmouth Bass, Bluegill, and other sunfish), as forage for game fish (Threadfin Shad, Golden Shiner, and Fathead Minnow), for vector control (Inland Silverside, Western Mosquitofish), for human food use (Common Carp, Brown Bullhead, and White Catfish), and from accidental releases (Yellowfin Goby, Shimofuri Goby, and Shokihaze Goby) (Moyle 2002). Introduced fish may compete with native fish for resources and, in some cases, prey on native species.

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. 2007a, 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).

#### 9.3.4.12.9 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 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.

Striped Bass, White Catfish, Largemouth Bass and other centrarchids, and silversides are among the introduced, nonnative species that are notable predators of smaller-bodied fish species and juveniles of larger species in the Delta. Along with Largemouth Bass, Striped Bass are believed to be major predators on larger-bodied fish in the Delta. In open-water habitats, Striped Bass are most likely the primary predator of juvenile and adult Delta Smelt (DWR et al. 2013) and can be an important open-water predator on juvenile salmonids (Johnston and Kumagai 2012). Native Sacramento Pikeminnow may also prey on juvenile salmonids and other fishes. Limited sampling of smaller pikeminnows did not find evidence of salmonids in the foregut of Sacramento Pikeminnow (Nobriga and Feyrer 2007), but this does not mean that Sacramento Pikeminnow do not prey on salmonids in the Delta.

Largemouth Bass abundance has increased in the Delta over the past few decades (Brown and Michniuk 2007). Although Largemouth Bass are not pelagic, their presence at the boundary between the littoral and pelagic zones makes it probable that they opportunistically consume pelagic fishes. The increase in salvage of Largemouth Bass occurred during the time period when Brazilian waterweed was expanding its range in the Delta (Brown and Michniuk 2007). The beds of Brazilian waterweed provide good habitat for Largemouth Bass and other species of centrarchids. Largemouth Bass have a much more limited distribution in the estuary than Striped Bass, but a higher per-capita impact on small fishes (Nobriga and Feyrer 2007). Increases in Largemouth Bass may have had a particularly important effect on Threadfin Shad and Striped Bass, whose earlier life stages occur in littoral habitat (Grimaldo et al. 2004, Nobriga and Feyrer 2007).

Invasive Mississippi silversides are another potentially important predator of larval and pelagic fishes in the Delta. This introduced species was not believed to be an important predator on Delta Smelt, but recent studies using DNA techniques detected the presence of Delta Smelt in the guts of 41 percent of Mississippi silversides sampled in mid-channel trawls (Baerwald et al. 2012). This finding may suggest that predation impacts could be significant, given the increasing numbers of Mississippi silversides in the Delta.

Predation of fish in the Delta is known to occur in specific areas, for example at channel junctions and areas that constrict flow or confuse migrating fish and provide cover for predatory fish (Vogel 2011). DFG (1992) identified subadult Striped Bass as the major predatory fish in Clifton Court Forebay. In 1993, for example, Striped Bass made up 96 percent of the predators removed (Vogel 2011). Cavallo et al. (2012) studied tagged salmon smolts to test the effects of predator removal on outmigrating juvenile Chinook Salmon in the south Delta. Their results suggested that predator abundance and migration rates strongly influenced survival of salmon smolts. Exposure time to predators has been found to be important for influencing survival of outmigrating salmon in other studies in the Delta (Perry et al. 2012).

#### 9.3.4.12.10 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 by 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.

#### *9.3.4.13 Yolo Bypass*

The Yolo Bypass conveys flood flows from the Sacramento Valley, including the Sacramento River, Feather River, American River, Sutter Bypass, and west side streams

The Yolo Bypass provides habitat for a wide variety of fish and aquatic species, including temporary migration corridors and juvenile rearing habitat for anadromous salmonids and other native and anadromous fishes. Species captured as adults and subsequently collected as YOY suggest that the Yolo Bypass provides spawning habitat for these species, including splittail, American Shad, Striped Bass, Threadfin Shad, Largemouth Bass and carp (Harrell and Sommer 2003, Sommer et al. 2014). The Yolo Bypass lacks suitable gravel substrate that would support salmon spawning.

##### 9.3.4.13.1 Aquatic Habitat

Aquatic habitats in the Yolo Basin include stream and slough channels for fish migration, and when flooded, seasonal spawning habitat and productive rearing habitat (Sommer et al. 2001a; CALFED 2000a, 2000b). During years when the Yolo Bypass is flooded, it serves as an important migratory route for juvenile Chinook Salmon and other native migratory and anadromous fishes moving downstream. During these times, it provides juvenile anadromous salmonids an alternative migration corridor to the lower Sacramento River (Sommer et al. 2003) and, sometimes, better rearing conditions than the adjacent Sacramento River channel (Sommer et al. 2001a, 2005). When the floodplain is activated, juvenile salmon can rear for weeks to months in the Yolo Bypass floodplain before migrating to the estuary (Sommer et al. 2001a). Research on the Yolo Bypass has found that juvenile salmon grow substantially faster in the Yolo Bypass floodplain than in the adjacent Sacramento River, primarily because of greater availability of invertebrate prey in the floodplain (Sommer et al. 2001a, 2005). When not flooded, the lower Yolo Bypass provides tidal habitat for young fish that enter from the lower Sacramento River via Cache Slough Complex (McLain and Castillo; DWR, unpublished data).

Sommer et al. (1997) demonstrated that the Yolo Bypass is one of the single most important habitats for Sacramento Splittail. Because the Yolo Bypass is dry during summer and fall, nonnative species (e.g., predatory fishes) generally are not present year-round except in perennial water sources (Sommer et al. 2003). In addition to providing important fish habitat, seasonal inundation of the Yolo Bypass supplies phytoplankton and detritus that may benefit aquatic organisms downstream in the brackish portion of the San Francisco Estuary (Sommer et al. 2004, Lehman et al. 2008a).

##### 9.3.4.13.2 Fish Passage

The Fremont Weir is a major impediment to fish passage and a source of migratory delay and loss of adult Chinook Salmon, steelhead, and sturgeon (NMFS 2009a, Sommer et al. 2014). The Fremont Weir creates a migration barrier for a variety of species, although fish with strong jumping capabilities such as salmonids may be able to pass the weir at higher flows. Although there is a fish ladder maintained by CDFW at the center of the weir, the ladder is small, outdated, and inefficient. Additionally, there are no facilities at the weir to pass upstream migrants at lower flows. Some adult winter-run, spring-run, and fall-run Chinook Salmon and White Sturgeon migrate into Yolo Bypass when there is no flow into the floodplain via the Fremont Weir. Therefore, these fish are often unable to reach upstream spawning habitat in the Sacramento River and its tributaries (Harrell and Sommer 2003, Sommer et al. 2014). Other structures in the Yolo Bypass, such as the Toe Drain, Lisbon Weir, and irrigation dams in the northern end of the Tule Canal, also may impede upstream passage of adult anadromous fish (NMFS 2009a).

Fish are also attracted into the bypass during periods when water is not flowing over the Fremont Weir. Fyke trap monitoring by DWR has shown that adult salmon and steelhead migrate up the Toe Drain in autumn and winter regardless of whether the Fremont Weir spills (Harrell and Sommer 2003, Sommer et al. 2014). The Toe Drain does not extend to the Fremont Weir because the channel is blocked by roads or other higher ground at several locations. Sturgeon and salmonids attracted by high flows into the basin become concentrated behind the Fremont Weir, where they are subject to heavy legal and illegal fishing pressure.

Stranding of juvenile salmonids and sturgeon has been reported in the Yolo Bypass in scoured areas behind the weir and in other areas as floodwaters recede (NMFS 2009a, Sommer et al. 2005). However, Sommer et al. (2005) found most juvenile salmon outmigrated off the floodplain as it drained.

#### *9.3.4.14 Suisun Marsh*

Suisun Bay and Marsh are ecologically linked with the central Delta, although with different tidal and salinity conditions than found upstream. Suisun Bay and Marsh are the largest expanse of remaining tidal marsh habitat within the greater San Francisco Bay-Delta ecosystem and include Honker, Suisun, and Grizzly bays; Montezuma and Suisun sloughs; and numerous other smaller channels and sloughs.

##### 9.3.4.14.1 Aquatic Habitat

Suisun Marsh is a brackish-water marsh bordering the northern edge of Suisun Bay. Most of its marsh area consists of diked wetlands managed for waterfowl, with the rest of the acreage consisting of tidally influenced sloughs (Suisun Ecological Workgroup 2001). The central latitudinal location of Suisun Marsh within the San Francisco Estuary makes it an important rearing area for euryhaline freshwater, estuarine, and marine fishes. Many fish species that migrate or use Delta habitats also are found in the waters of Suisun Bay. Tides reach Suisun Bay and Marsh through the Carquinez Strait, and most freshwater flows enter at the southeast border of Suisun Marsh at the confluence of the Sacramento and San Joaquin rivers. The mixing of freshwater outflows from the Central Valley with saline tidal water in Suisun Bay and Suisun Marsh results in brackish water with strong salinity gradients, complex patterns of flow interactions, and generally the highest biomass productivity in the entire estuary (Siegel et al. 2010).

Although the fish assemblages in Suisun Bay and Marsh can differ substantially from the fish assemblages in the Delta, all the species that use the Delta also use Suisun Bay and Marsh.

Flow, turbidity, and salinity are important factors influencing the location and abundance of zooplankton and small prey organisms used by Delta species (Kimmerer et al. 1998). The location where net current flowing inland along the bottom reverses direction and sinking particles are trapped in suspension is associated with higher turbidity known as the estuarine turbidity maximum. Burau et al. (2000) reports that the estuarine turbidity maximum occurs near the Benicia Bridge and in Suisun Bay near Garnet Point on Ryer Island. Zooplanktonic organisms maintain position in this region of historically high productivity in the estuary through vertical movements (Kimmerer et al. 1998).

Salinity in the Suisun Bay and Marsh system is a major water quality characteristic that strongly influences physical and ecological processes. Fish species native to Suisun Marsh require low salinities during the spawning and rearing periods (Suisun Ecological Workgroup 2001; Kimmerer 2004; Feyrer et al. 2007, 2011; Nobriga et al. 2008). The Suisun Bay and Marsh usually contain both the maximum estuarine salinity gradient and the low salinity zone. The overall estuarine salinity gradient trends from west (higher) to east (lower) in Suisun Bay and Marsh. The location of the low salinity zone gradient and X2 can be influenced by outflow. Suisun Marsh also exhibits a persistent north-south salinity gradient. Despite low and seasonal flows, the surrounding watersheds have a significant water freshening effect because of the long residence times of freshwater discharges from the upper sloughs and wastewater effluent.

The Suisun Bay and Marsh system contains a wide variety of habitats such as marsh plains, tidal creeks, sloughs, channels, cuts, mudflats, and bays. These features and the complex hydrodynamics and water quality of the system have historically fostered significant biodiversity within Suisun tidal aquatic habitats, but, like the Delta, these habitats also have been significantly altered and degraded by human activities over the decades.

Categories of tidal aquatic habitat were identified as part of the Suisun Marsh Plan development process and were defined using physical boundaries; habitats include bays, major sloughs, minor sloughs, and the intertidal mudflats in those areas (Engle et al. 2010). These tidal habitats total approximately 26,000 acres, with the various embayments totaling about 22,350 acres. Tidal slough habitat is composed of major and minor sloughs, with major sloughs of Suisun Marsh having a combined acreage of about 2,200 acres consisting of both shallow and deep channels. Minor sloughs are made up of shallow channel habitat and have a combined acreage of about 1,100 acres. Habitats in Suisun Marsh bays and sloughs support a diverse assemblage of aquatic species that typically use open-water tidal areas for breeding, foraging, rearing, or migrating.

#### 9.3.4.14.2 Fish Entrainment

Several facilities have been constructed by DWR and Reclamation to provide lower-salinity water to managed wetlands in the Suisun Marsh, including the Roaring River Distribution System, Morrow Island Distribution System, and Goodyear Slough Outfall. Other facilities constructed under the Suisun Marsh Preservation Agreement that could entrain fish include the Lower Joice Island and Cygnus Drain diversions.

The intake to the Roaring River Distribution System is screened to prevent entrainment of fish larger than approximately 25 mm (approximately 1 inch). DWR monitored fish entrainment from September 2004 to June 2006 at the Morrow Island Distribution System to evaluate entrainment losses at the facility. Monitoring took place over several months under various operational configurations and focused on Delta Smelt and salmonids. Over 20 species were identified during the sampling, but only 2 fall-run-sized Chinook Salmon (at the South Intake in 2006) and no Delta Smelt from entrained water were caught (Reclamation 2008a). The Goodyear Slough Outfall system is open for free fish movement except near the outfall when flap gates are closed during flood tides (Reclamation 2008a). Conical fish screen have been installed on the Lower Joice Island diversion on Montezuma Slough.

### *9.3.4.15 San Joaquin River from Confluence of the Stanislaus River to the Delta*

Since the construction of Friant Dam, significant changes in physical (fluvial geomorphic) processes and substantial reductions in streamflows in the San Joaquin River have occurred, resulting in large-scale alterations to the river channel and associated aquatic, riparian, and floodplain habitats. Throughout the area, there are physical barriers, reaches with poor water quality or no surface flow, and false migration pathways that have reduced habitat connectivity for anadromous and resident native fishes (Reclamation and DWR 2011). As a result, there has been a general decline in both the abundance and distribution of native fishes, with several species extirpated from the system (Moyle 2002).

Moyle (2002) reported that of the 21 native fish species historically present in the San Joaquin River, at least 8 are now uncommon, rare, or extinct. The deep-bodied fish assemblage (e.g., Sacramento Splittail, Sacramento Blackfish) has been replaced by nonnative species like carp and catfish.

The San Joaquin River from the Stanislaus River to the Delta is dominated by nonnative species such as Largemouth Bass, Inland Silverside, carp, and several species of sunfish and catfish (Moyle 2002). Anadromous species include fall-run Chinook Salmon, steelhead, Striped Bass, American Shad, White Sturgeon, and several species of lamprey (Reclamation et al. 2003). The fall-run Chinook Salmon population is supported in part by hatchery stock in the Merced River. Spawning by anadromous salmonids in the San Joaquin River Basin occurs only in the tributaries to the San Joaquin River, including the Merced, Tuolumne, and Stanislaus rivers (Brown and Moyle 1993). Spring-run Chinook Salmon no longer exist in the San Joaquin River, but are targeted for restoration in this system under Reclamation's San Joaquin River Restoration Program. In early 2015, the program experimentally released juvenile spring-run Chinook Salmon into the San Joaquin River near the Merced River. Surviving adults may return to the San Joaquin River as early as spring 2017. Because of the uncertainty of future restoration success and the current lack of natural presence in the San Joaquin River, spring-run Chinook Salmon is not included in the analysis of San Joaquin River fish.

#### 9.3.4.15.1 Fish in the San Joaquin River

The analysis is focused on the following species:

- Fall-run Chinook Salmon
- Steelhead
- White Sturgeon
- Sacramento Splittail
- Pacific Lamprey
- Striped Bass
- American Shad

*Fall-run Chinook Salmon*

Fall-run Chinook Salmon are present in the San Joaquin River and its major tributaries upstream to and including the Merced River. Spawning and rearing occur in the major tributaries (Merced, Tuolumne, and Stanislaus rivers) downstream of the mainstem dams. Weir counts in the Stanislaus River suggest that adult fall-run Chinook Salmon in the San Joaquin River Basin typically migrate into the upper rivers between late September and mid-November and spawn shortly thereafter (Pyper et al. 2006; Anderson et al. 2007; FISHBIO 2010, 2011).

The San Joaquin River downstream of the Stanislaus River primarily provides upstream passage for adult fall-run Chinook Salmon and downstream passage for juveniles and smolts as they outmigrate from the tributary spawning and rearing areas to the Delta to the Pacific Ocean. The juvenile fall-run Chinook Salmon outmigration in the San Joaquin River Basin typically occurs during winter and spring, extending primarily from January through May. The outmigration consists primarily of fry in winter and smolts in spring (FISHBIO 2007, 2013). Trawl sampling in the lower San Joaquin River from Mossdale to the Head of Old River (the Mossdale Trawl) captures Chinook Salmon from February into July, with peak catches generally during April and May (Speegle et al. 2013).

*Steelhead*

Steelhead were historically present in the San Joaquin River, though data on their population levels are lacking (McEwan 2001). The current steelhead population in the San Joaquin River is substantially reduced compared with historical levels, although resident Rainbow Trout occur throughout the major San Joaquin River tributaries. Additionally, small populations of steelhead persist in the lower San Joaquin River and tributaries (e.g., Stanislaus, Tuolumne, and possibly the Merced rivers) (Zimmerman et al. 2009, McEwan 2001). Steelhead/Rainbow

Trout of anadromous parentage occur at low numbers in all three major San Joaquin River tributaries. These tributaries have a higher percentage of resident Rainbow Trout compared to the Sacramento River and its tributaries (Zimmerman et al. 2009).

Presence of steelhead smolts from the San Joaquin River Basin is estimated annually by CDFW based on the Mossdale Trawl (SJRGA 2011). The sampling trawls capture steelhead smolts, although usually in small numbers. One steelhead smolt was captured and returned to the river during the 2009 sampling period (SJRGA 2010), and three steelhead were captured and returned in both 2010 and 2011 (Speegle et al. 2013).

*Sacramento Splittail*

Historically, Sacramento Splittail were widespread in the San Joaquin River and found upstream to Tulare and Buena Vista lakes, where they were harvested by native peoples (Moyle et al. 2004). Today, Sacramento Splittail likely ascend the San Joaquin River to Salt Slough during wet years (Baxter 1999). During dry years, Sacramento Splittail are uncommon in the San Joaquin River downstream of the Tuolumne River (Moyle et al. 2004). Most spawning takes place in the flood bypasses, along the lower reaches of the Sacramento and San Joaquin rivers and major tributaries, and lower Cosumnes River and similar areas in the western Delta.

Most juveniles apparently move downstream into the Delta from April to August (Meng and Moyle 1995). Factors influencing the Sacramento Splittail population are unclear, but the population is largely influenced by extent and period of inundation of floodplain spawning habitats, with abundance spiking following wet years and declining after dry years (Moyle et al. 2004). Other factors that may influence the San Joaquin River portion of the population include flood control, entrainment by diversion, recreational fishing, pollutants, and nonnative species (Moyle et al. 2004).

*Pacific Lamprey*

The Pacific Lamprey is a widely distributed anadromous species found in accessible reaches of the San Joaquin River and many of its tributaries.

Data from mid-water trawls in the lower San Joaquin River near Mossdale indicate that adults likely migrate into the San Joaquin River in spring and early summer (Hanni et al. 2006). In other large river systems, the initial adult migration from the ocean generally stops in summer, and Pacific Lampreys hold until the following winter or spring before undergoing a secondary migration to spawning grounds (Robinson and Bayer 2005, Clemens et al. 2012). Midwater trawl surveys in the San Joaquin River suggest that peak ammocoete outmigration occurs in January and February (Hanni et al. 2006).

Little information is available on factors influencing Pacific Lamprey in the San Joaquin River, but they are likely adversely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles. Lack of access to historical spawning habitats because of the mainstem dams and other migration barriers, modification of spawning and rearing habitats, altered hydrology, entrainment by water diversions, and predation by nonnative invasive species such as Striped Bass all likely influence Pacific Lamprey in the San Joaquin River and tributaries.

*Striped Bass*

Striped Bass are regularly found in San Joaquin River tributaries, including in lower mainstem deep pools of the Stanislaus and Tuolumne rivers (e.g., Anderson et al. 2007). Ainsley et al. (2013) reported that Striped Bass were collected at two locations between the Head of the Old River and the mouth of the Stanislaus River on the mainstem San Joaquin River in May.

*American Shad*

Little is known about American Shad populations inhabiting the San Joaquin River. American Shad may spawn in the San Joaquin River system, but their abundance is unknown. Sport fishing for American Shad occurs seasonally in the San Joaquin River.

*Sturgeon*

Little is known about White Sturgeon populations inhabiting the San Joaquin River. Spawning-stage adults generally move into the lower reaches of rivers during winter prior to spawning, then migrate upstream to spawn in response to higher flows (Schaffter 1997, McCabe and Tracy 1994). Based on tag returns from White Sturgeon tagged in the Sacramento-San Joaquin Estuary and recovered by anglers, Kohlhorst et al. (1991) estimated that over 10 times as many White Sturgeon spawn in the Sacramento River as in the San Joaquin River.

CDFW fisheries catch information for the San Joaquin River obtained from fishery report cards (DFG 2008, 2009b, 2010, 2011, 2012b; CDFW 2013, 2014) documented that anglers upstream of Highway 140 caught between 8 and 25 mature White Sturgeon annually between 2007 and 2013. Below Highway 140 downstream to Stockton, anglers caught between 2 and 35 mature White Sturgeon annually over the same time period; most of the White Sturgeon caught were released.

On July 30, 2013, USFWS issued a news release describing White Sturgeon spawning for the first time in the San Joaquin River (USFWS 2013). Viable White Sturgeon eggs were collected in 2011 at one sampling location downstream of Laird Park (Gruber et al. 2012) and in 2012 at four sampling locations generally between Laird Park and the Stanislaus River confluence (Jackson and Van Eenennaam 2013).

Green Sturgeon are also present in the San Joaquin River, but at considerably lower numbers than White Sturgeon. Between 2007 and 2012, anglers reported catching six Green Sturgeon in the San Joaquin River (Jackson and Van Eenennaam 2013). Although the reported presence of Green Sturgeon in the San Joaquin River coincides with the spawning migration period of Green Sturgeon within the Sacramento River, no evidence of spawning has been detected (Jackson and Van Eenennaam 2013).

#### 9.3.4.15.2 Aquatic Habitat

Aquatic habitat conditions vary spatially and temporally throughout the lower San Joaquin River because of differences in habitat availability and connectivity, water quantity and quality (including water temperature), and channel morphology.

Downstream of the Stanislaus River confluence, the San Joaquin River is more sinuous than upstream reaches and contains oxbows, side channels, and remnant channels. It conveys the combined flows of the major tributaries, including the Merced, Tuolumne, Stanislaus, and Calaveras rivers. Flood control levees closely border much of the river but are set back in places, creating some off-channel aquatic habitat areas when inundated (Reclamation and DWR 2011). The channel gradient in this portion of the San Joaquin River is low, and the lack of gravel or coarser substrate precludes spawning by salmonids.

#### 9.3.4.15.3 Fish Passage

In the reach of the river downstream of the confluence of the Stanislaus River, fish encounter passage challenges associated with water diversions, and adult salmon migrating upstream from the Delta also may encounter prohibitively high stream temperatures that delay migration until temperatures decline (McBain and Trush 2002). Installation of seasonal barriers in the Delta also can impair fish passage.

#### 9.3.4.15.4 Hatcheries

No hatcheries in the San Joaquin River Basin are affected by CVP or SWP operations. The Merced River Hatchery, located on the Merced River, is operated by CDFW to supplement the fall-run Chinook Salmon population. It is not included in the CVP or SWP service areas. As part of the San Joaquin River Restoration Program, CDFW has begun operation of a conservation hatchery downstream of Friant Dam to produce spring-run Chinook Salmon (Reclamation and DWR 2010).

#### 9.3.4.15.5 Predation

Recent studies of predation in the San Joaquin River are limited to the major tributaries, where largemouth and Smallmouth Bass have been identified as the most important predators of juvenile Chinook Salmon (McBain and Trush and Stillwater Sciences 2006). Striped Bass also have been identified as salmon predators, though recent evidence for the San Joaquin River is lacking.

### *9.3.4.16 New Melones Reservoir, Tulloch Reservoir, and Goodwin Lake*

The north, middle, and south forks of the Stanislaus River converge upstream of the CVP New Melones Reservoir. Water from New Melones Reservoir flows into Tulloch Reservoir (Reclamation 2010b). Downstream of Tulloch Reservoir, the Stanislaus River flows to Goodwin Lake and then approximately 40 miles to the confluence with the San Joaquin River.

New Melones Reservoir is located approximately 60 miles upstream from the confluence of the Stanislaus and San Joaquin rivers and is operated by Reclamation. New Melones Reservoir is an artificial environment and does not support a naturally evolved aquatic community. Most of the species in the reservoir were introduced, although a few native species may still be present. From a fisheries perspective, recreational fishing is the most important use of New Melones Reservoir. Fish species in New Melones Reservoir include Rainbow Trout, Brown Trout, Largemouth Bass, sunfishes such as Black Crappie and Bluegill, and three species of catfish (Reclamation 2010b). Rainbow Trout, Brown Trout, and large Channel Catfish are generally restricted to colder, deeper water during summer, when New Melones Reservoir has two distinct thermal layers of water, although large Brown Trout and Channel Catfish are found in shallow water near steep banks at night when they ascend to feed.

Tulloch Reservoir is operated as an afterbay for the New Melones Reservoir and is subject to fluctuating water levels that occur on a daily and seasonal basis. Tulloch Reservoir stratifies weakly during summer and contains a reserve of relatively cold, well-oxygenated water that is released downstream. Tulloch Reservoir supports both warm and cold freshwater habitat. Goodwin Power (2013) reported that DFG captured 15 species in Tulloch Reservoir from 1969 through 1998. Five dominant species made up almost 80 percent of the catch; White Catfish (31 percent of the total), Bluegill (20 percent), Sacramento Sucker (11 percent), Smallmouth Bass (10 percent), and Black Crappie (7 percent). Of these, only the Sacramento Sucker is native. Other native species in the catch were Sacramento Hitch, Hardhead, Sacramento Pikeminnow, and Rainbow Trout (now stocked). Other nonnative fish found in Tulloch reservoir include Largemouth Bass and Threadfin Shad (DFG 2002b).

Little information exists regarding aquatic resources in Goodwin Lake. It is assumed that fish assemblies are similar to those described for Tulloch Reservoir.

#### *9.3.4.17 Stanislaus River from Goodwin Dam to the San Joaquin River*

##### 9.3.4.17.1 Fish in the Stanislaus River

Steelhead and fall-run Chinook Salmon occur in the lower Stanislaus River. Other anadromous fish species that occur in the lower Stanislaus River include Striped Bass, American Shad, and an unidentified species of lamprey (SRFG 2003). The analysis is focused on the following species:

- Fall-run Chinook Salmon
- Steelhead
- Pacific Lamprey
- Striped Bass
- American Shad

*Fall-run Chinook Salmon*

Historically, spring-run Chinook Salmon were believed to be the primary salmon run in the Stanislaus River, but the fall-run Chinook Salmon population became dominant following construction of Goodwin Dam. Spring-run Chinook Salmon have since been extirpated from the river. Data collected by private fishery consultants, nonprofit organizations, and DFG demonstrate the majority of adults migrate upstream from late September through December with peak migration from late October through early November. Most Chinook Salmon spawning occurs between Riverbank (River Mile 33) and Goodwin Dam (River Mile 58.4) (Reclamation 2012b). For Stanislaus River salmon, spawning generally occurs between October and December based on spawning surveys; however, there is evidence that indicates that spawning activity may occur as early as September or as late as January (Reclamation 2012).

Rotary screw trap data indicate that about 99 percent of salmon juveniles migrate out of the Stanislaus River from January through May (SRFG 2004). Fry migration generally occurs from January through March, followed by smolt migration from April through May (Reclamation 2012). Watry et al. (2012) found that in both 2010 and 1011, peak passage during the pre-smolt period generally corresponded with flow pulses. Zeug et al. (2014) examined 14 years of rotary screw trap data on the lower Stanislaus River and found a strong positive response in survival, the proportion of pre-smolt migrants and the size of smolts when cumulative flow and flow variance were greater and concluded that the data suggested that periods of high discharge in combination with high discharge variance are important for successful emigration as well as migrant size and the maintenance of diverse migration strategies.

Mesick (2001) surmised that when water exports are high relative to San Joaquin River flows, little, if any, San Joaquin River water reaches San Francisco Bay where it may be needed to help attract the salmon back to the Stanislaus River. During mid-October from 1987 through 1989, when export rates exceeded 400 percent of Vernalis flows, Mesick (2001) found that straying rates ranged between 11 and 17 percent. In contrast, straying rates were estimated to be less than 3 percent when Delta export rates were less than about 300 percent of San Joaquin River flow at Vernalis during mid-October.

One of the most prominent limiting factors appears to be the high rates of mortality for juveniles migrating through dredged channels in the Stanislaus River and Delta, particularly the Stockton Deep Water Ship Channel (Pickard et al. 1982). Pickard et al. (1982) reported that the survival of juvenile fish in the deep-water ship channel is highest during flood flows or when a barrier is placed at the head of the Old River that more than doubles the flow in the ship channel. The Stanislaus River Fish Group (SRFG) (2004) noted that escapement is also directly correlated with springtime flows when each brood migrates downstream as smolts. However, the cause of the mortality in the ship channel has not been studied. It is possible that mortality results from the combined effects of warm water temperatures, low dissolved oxygen concentrations, ammonia toxicity, and predation.

As discussed earlier, dredging for gravel and gold, regulated flows, and the diking of floodplains for agriculture have substantially limited the availability of spawning and rearing habitat for fall-run Chinook Salmon. Reclamation has conducted spawning gravel augmentation to improve spawning and rearing habitats in the reach between Goodwin Dam and Knights Ferry most years since 1999. The dredged areas also contain an abundance of large predatory fish, although the SRFG concluded that there is uncertainty about whether predation is a substantial source of mortality for juvenile salmon.

The SRFG also concluded that water diversions for urban and agricultural use in all three San Joaquin River tributaries, which reduce flows and potentially result in unsuitably warm water temperatures during spring and fall, affect fall-run Chinook Salmon juvenile rearing and adult and juvenile migration in the lower San Joaquin River and Delta.

*Steelhead*

Steelhead were thought to be extirpated from the San Joaquin River system (NMFS 2009a). However, monitoring has detected small self-sustaining (i.e., non-hatchery origin) populations of steelhead in the Stanislaus River and other streams previously thought to be devoid of steelhead (SRFG 2003, McEwan 2001). There is a catch-and-release steelhead fishery in the lower Stanislaus River between January 1 and October 15.

Historically, the distribution of steelhead extended into the headwaters of the Stanislaus River (Yoshiyama et al. 1996). Steelhead currently can migrate more than 58 miles up the Stanislaus River to the base of Goodwin Dam. In the Stanislaus River, there is little data regarding the migration patterns of adult steelhead since adults generally migrate during periods when river flows and turbidity are high making fish difficult to observe with standard adult monitoring techniques. Results from the nearby Mokelumne River suggest that most adult steelhead migrate upstream from late September through March, although some fish have been observed as early as mid-August (Reclamation 2012). High Delta export rates relative to San Joaquin River flows at Vernalis, when adults are migrating through the Delta (presumably December through May), may result in adults straying to the Sacramento River Basin.

It is believed that steelhead spawn primarily between December and March in the Stanislaus River. Although steelhead spawning locations are unknown in the Stanislaus, most are thought to occur upstream of Oakdale, where gradients are slightly higher and more riffle habitat is available (Reclamation 2008a). The spawning adults require holding and feeding habitat with cover adjacent to suitable spawning habitat. These habitat features are relatively rare in the lower Stanislaus River because of in-river gravel mining and the scouring of gravel from riffles in Goodwin Canyon.

Juvenile steelhead rear in the Stanislaus River for at least 1 year, and usually 2 years, before migrating to the ocean. As a result, flow, water temperature, and dissolved oxygen concentration in the reach between Goodwin Dam and the Orange Blossom Bridge (their primary rearing habitat) are critical during summer (Reclamation 2012).

Small numbers of steelhead smolts have been captured in rotary screw traps at Caswell State Park and near Oakdale (FISHBIO 2007; Watry et al. 2007, 2012), and data indicate that steelhead outmigrate primarily from February through May. Rotary screw traps are generally not considered efficient at catching fish as large as steelhead smolts, and the number captured is too small to estimate capture efficiency, so no steelhead smolt outmigration population estimate has been calculated. The capture of these fish in downstream migrant traps and the advanced smolting characteristics exhibited by many of the fish indicate that some steelhead/rainbow juveniles might migrate to the ocean in spring. However, it is not known whether the parents of these fish were anadromous or fluvial (they migrate within fresh water). Resident populations of steelhead/rainbow in large streams are typically fluvial, and migratory juveniles look much like smolts.

*Pacific Lamprey*

The Pacific Lamprey is a widely distributed anadromous species that inhabits accessible reaches of the Stanislaus River (SRFG 2003). Limited information on Pacific Lamprey status in the Stanislaus River exists, but the species has experienced loss of access to historical habitat and apparent population declines throughout California and the Sacramento and San Joaquin River basins (Moyle et al. 2009). Little information is available on factors influencing Pacific Lamprey populations in the Stanislaus River, but they are likely adversely affected by many of the same factors as salmon and steelhead because of parallels in their life cycles.

Ocean stage adults likely migrate into the Stanislaus River in spring and early summer, where they hold for approximately 1 year before spawning (Hanni et al. 2006). Hannon and Deason (2008) have documented Pacific Lampreys spawning in the American River from between early January and late May, with peak spawning typically in early April. Spawning time is presumably similar in the Stanislaus River. Pacific Lamprey ammocoetes are expected to rear in the Stanislaus River for all or part of their 5- to 7-year freshwater residence. Data from rotary screw trapping in the nearby Mokelumne and Tuolumne rivers suggest that outmigration of Pacific Lamprey generally occurs from early winter through early summer (Hanni et al. 2006). Catches of juvenile Pacific Lampreys in trawl surveys of the mainstem San Joaquin River, near the mouth of the Stanislaus River at Mossdale, occurred during winter and spring. Some outmigration likely occurs year-round, as observed at sites on the mainstem Sacramento River (Hanni et al. 2006). Significant numbers of lampreys of unknown species and unspecified life stage have been captured during rotary screw trapping on the Stanislaus River at Oakdale (FISHBIO 2007) and Caswell (Watry et al. 2007).

*Striped Bass*

Striped Bass occur in the Stanislaus River, and they support a sport fishery when adult fish migrate upstream to spawn. Striped Bass have been observed at Lovers Leap and at Knights Ferry from May through the end of June. These adult fish were observed in all habitats (USFWS 2002, Kennedy and Cannon 2005). The distribution of Striped Bass in the Stanislaus River is thought to be limited to downstream of the historic Knights Ferry Bridge due to a set of falls about 3 feet tall in the area (USFWS 2002).

*American Shad*

American Shad migrate up the Stanislaus River to spawn in the late spring and support a sport fishery during that period. American Shad have been observed on occasion from June through July at Lovers Leap (USFWS 2002, Kennedy and Cannon 2005). American Shad were found primarily in the faster habitats and were observed in schools of 20 or more (USFWS 2002).

#### 9.3.4.17.2 Aquatic Habitat

Schneider et al. (2003) conducted hydrologic analysis of the Stanislaus River and found that New Melones Dam (built in 1979) and more than 30 smaller dams cumulatively impound 240 percent of average annual unimpaired runoff. Schneider et al. (2003) concluded that this has reduced winter floods and spring snow melt runoff, and increased summer base flows to supply irrigation demand. As a result, the frequency and extent of overbank flooding has been reduced. Based on historical data and field measurements, Schneider et al. (2003) suggested that the channel had incised approximately 1 to 3 feet since dam construction, and that the discharge needed for overbank flows has approximately doubled.

With respect to the related need for geomorphic flows, Kondolf et al. (2001) estimated bedload mobilization flows in the Stanislaus River to be around 5,000 to 8,000 cfs to mobilize the median particle size of the channel bed material. Flows necessary to mobilize the bed material increased downstream from a minimal 280 cfs where gravel had been recently added near Goodwin Dam to about 5,800 cfs at Oakdale Recreation Area (Reclamation 2008a). Before construction of New Melones Dam, a bed-mobilizing flow of 5,000 to 8,000 cfs was equivalent to a 1.5- to 1.8-year return interval flow. Following construction of the dam, 5,000 cfs represents approximately a 5-year return interval flow, and 8,000 cfs exceeds all flows within the 21-year study period, 1979 to 1999 (maximum flow = 7,350 cfs on January 3, 1997). The probability of occurrence for a daily average flow exceeding 5,330 cfs (the pre-dam bankfull discharge) is 0.01 per year.

Cold water in the Stanislaus River is affected by the cold-water pool in New Melones Reservoir and air temperatures, as described in Chapter 6, Surface Water Quality. Reclamation manages the cold-water supply and makes cold-water releases from New Melones Reservoir to provide suitable temperatures for steelhead rearing, spawning, egg incubation smoltification, and adult migration in the Stanislaus River downstream of Goodwin Dam.

During the 1960s, Hallock et al. (1970) found that adult radio-tagged Chinook Salmon delayed their upstream migration whenever dissolved oxygen concentrations were less than 5 mg/L at Stockton. SWRCB D-1422 requires water to be released from New Melones Reservoir to maintain dissolved oxygen standards in the Stanislaus River, as described in Chapter 6, Surface Water Quality.

*Spawning and Rearing Habitat*

Upstream dams have suppressed channel-forming flows that replenish spawning beds in the Stanislaus River (Kondolf et al. 1996). The physical presence of the dams impedes normal sediment transportation processes. Kondolf (et al. 2001) identified levels of sediment depletion at 20,000 cubic yards per year as a result of a variety of factors, including mining, and geomorphic processes associated with past and ongoing dam operations. In 2011, 5,000 tons of gravel were placed in Goodwin Canyon downstream of Goodwin Dam, of which around 70 percent was transported into nearby downstream areas during high flows (SOG 2012).

Extensive instream gravel mining removed large quantities of spawning habitat (Kondolf et al. 2001). Gravel mining also has resulted in instream mine pits that occur in the primary salmonid spawning areas, including a large, approximately 1-mile-long pit called the Oakdale Recreation Pond. Instream mine pits trap bedload sediment, store large volumes of sand and silt, and pass sediment-starved water downstream, where it typically erodes the channel bed and banks to regain its sediment load (Kondolf et al. 2001). Reclamation restores and replenishes spawning gravel and rearing habitat lost from the construction and operation of dams in the Stanislaus River to restore adversely affected spawning habitat and remediate sediment related loss of geomorphic function, such as channel incision.

*Floodplain Habitat*

Kondolf et al. (2001) identified that floodplain terraces and point bars inundated before operation of New Melones Reservoir have become fossilized with fine material and thick riparian vegetation that is never rejuvenated by scouring flows. Channel forming flows in the 8,000-cfs range have occurred only twice since New Melones Reservoir began operation 28 years ago.

Based on historical data and field measurements, Schneider et al. (2003) suggested that the channel incised approximately 1 to 3 feet since dam construction, and that the discharge needed for overbank flows has approximately doubled. Without inundation, the floodplains cannot provide terrestrial food for juvenile salmon or organic matter that helps produce more food within the river. Increased flows required for inundation also have had the effect of further isolating floodplains from the channel, leading to the loss of floodplain habitats.

In 2011, a habitat restoration project to increase spawning habitat also restored 640 feet of remnant side channel habitat, allowing water to flow at the current 1.5-year return interval (575 cfs), in addition to three cross channels designed to inundate at higher flows (SOG 2011).

#### 9.3.4.17.3 Fish Passage and Entrainment

Constructed in 1913, Goodwin Dam was probably the first permanent barrier to significantly affect anadromous fish access to upstream habitat in the Stanislaus River. Goodwin Dam had a fishway, but Chinook Salmon could seldom pass it, and other salmonids may have been similarly affected. Yoshiyama et al. (1996) estimated that historically Chinook Salmon and other salmonids had access to 113 miles of habitat, compared with 58 miles under current conditions.

There are numerous small, unscreened diversions on the lower Stanislaus River (Herren and Kawasaki 2001). The effects of these diversions on fish is not clear; however, in tracking the fate of 49 radio tagged fish, S.P. Cramer and Associates (1998) did not detect any entrainment at several moderately sized unscreened pumps in the lower Stanislaus River.

#### 9.3.4.17.4 Predation

Areas of the Stanislaus River, including spawning riffles in the active channel, were mined for gravel and gold primarily between 1940 and 1970. The mined areas consist of long, deep ditches and large ponds that provide habitat for predators, such as Striped Bass, Sacramento Pikeminnow, Largemouth Bass, and Smallmouth Bass (Mesick 2002). Studies by S.P. Cramer and Associates (1998) documented predation on juvenile salmonids by bass in the Tuolumne and Stanislaus rivers. However, in its review of information, the SRFG (2004) concluded that the available studies and observations suggest that fish predators in the Stanislaus River may be limited to adult pikeminnow and Riffle Sculpin feeding on newly emerged fry, whereas Smallmouth Bass, Largemouth Bass, and possibly American Shad probably feed on relatively few parr that remain in the river during late spring and summer when water temperatures are high.

It is possible that predation is high for juveniles rearing in the deep-water ship channel in the Delta as observed by Pickard et al. (1982). Predation rates on hatchery-reared juveniles and tagged juveniles may be higher than those for naturally produced fish. NMFS (2009a) made reference (without citation) to predation studies on the Tuolumne River that have shown losses of up to 60 percent of outmigrating salmon smolts in run-of-river gravel mining ponds and dredged areas. NMFS (2009a) also noted that losses on the Stanislaus River have not been similarly quantified, but predation on fall-run Chinook Salmon smolts and steelhead by Striped Bass and Largemouth Bass has been documented. NFMS concluded that these run-of-river ponds also reduce flow velocities as compared to incoming river channels, requiring outmigrating salmonids to expend more energy to traverse these sections. Operational releases provide flows lower than typical unimpaired flows, which NMFS indicated these conditions exacerbates the effect of this stressor on outmigrating juveniles and degrades the habitat value of necessary freshwater migratory corridors.

### *9.3.4.18 San Luis Reservoir*

San Luis Reservoir is located at the base of the foothills on the west side of the San Joaquin Valley in Merced County, as described in Chapter 5, Surface Water Resources and Water Supplies. Water from the Delta is delivered to San Luis Reservoir via the California Aqueduct and Delta-Mendota Canal for storage.

San Luis Reservoir and O'Neill Forebay support several species of fish that have become established within the system, either by direct introduction or from the Delta system via pumping from the California Aqueduct and Delta-Mendota Canal. Striped Bass are the predominant species in San Luis Reservoir (DWR 1987) and support a recreational fishery. Other species include

Sacramento Blackfish, American Shad, Threadfin Shad, Largemouth Bass, Kokanee Salmon, Green Sunfish, Bluegill, White Sturgeon, and White Crappie.

There are no sensitive fish species in the San Luis Reservoir except, possibly, individuals entrained by the CVP and SWP projects in the Delta. These individuals have already been lost to their populations, as they cannot return to the Delta once entrained. Potentially occurring fish species with special status that may have been imported from the Delta include Chinook Salmon, Delta Smelt, Hardhead, and Sacramento Splittail (Reclamation and CSP 2013).

### 9.3.5 San Francisco Bay Area Region

Fish and aquatic habitat resources in the San Francisco Bay Area Region include habitat through San Francisco Bay and along the Pacific Ocean coast. The anadromous fish species discussed above use the Pacific Ocean as part of their life cycles. In addition, the Pacific Ocean supports the killer whale which relies upon Chinook Salmon (e.g., fall-run Chinook Salmon) for food.

The San Francisco Bay Area Region also includes fish habitat within reservoirs that store CVP and SWP water. CVP and SWP water supplies are stored in Contra Loma and San Justo reservoirs; the SWP Bethany Reservoir and Lake Del Valle; the Contra Costa Water District Los Vaqueros Reservoir; and the East Bay Municipal Utility District (EBMUD) Upper San Leandro, San Pablo, Briones, and Lafayette reservoirs and Lake Chabot. Many of these reservoirs also store water from local and regional water supplies. CVP and SWP water is generally not stored in reservoirs within Santa Clara County (SCVWD 2010).

#### *9.3.5.1 Pacific Ocean Habitat of the Killer Whale*

The Pacific Ocean along the coast of California is included in this description of the affected environment because of it provides habitat for the Southern Resident killer whale population. The effect of the action, however, is limited to changes in the number of Chinook Salmon produced in the Central Valley entering the Pacific Ocean, which contribute an important component of the killer whale diet.

Southern Resident killer whales are found primarily in the coastal waters offshore of British Columbia and Washington and Oregon in summer and fall (NMFS 2008). During winter, killer whales are sometimes found off the coast of central California and more frequently off the Washington coast (Independent Hilborn et al. 2012).

The 2005 NMFS endangerment listing (70 FR 69903) for the Southern Resident killer whale distinct population segment lists several factors that may be limiting the recovery of killer whales, including the quantity and quality of prey, accumulation of toxic contaminants, and sound and vessel disturbance. In the Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*), NMFS (2008) posits that reduced prey availability forces whales to spend more time foraging, which may lead to reduced reproductive rates and higher mortality rates. Reduced food availability may lead to mobilization of fat stores, which can release stored contaminants and adversely affect reproduction or immune function (NMFS 2008).

The Independent Science Panel reported that Southern Resident killer whales depend on Chinook Salmon as a critical food resource (Independent Science Panel and ESSA Technologies 2012). Hanson et al. (2010) analyzed tissues from predation events and feces to confirm that Chinook Salmon were the most frequent prey item for killer whales in two regions of the whale's summer range off the coast of British Columbia and Washington state, representing over 90 percent of the diet in July and August. Samples indicated that when Southern Residents are in inland waters from May to September, they consume Chinook Salmon stocks that originate from regions including the Fraser River, Puget Sound, the Central British Columbia Coast, West and East Vancouver Island, and Central Valley California (Hanson et al. 2010).

Significant changes in food availability for killer whales have occurred over the past 150 years, largely due to human impacts on prey species. Salmon abundance has been reduced over the entire range of the Southern Resident killer whales, from British Columbia to California. The Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*) (NMFS 2008) indicates that wild salmon have declined primarily due to degraded aquatic ecosystems, overharvesting, and production of fish in hatcheries. The recovery plan supports restoration efforts to rebuild depleted salmon populations and other prey to ensure an adequate food base for Southern Resident killer whales.

Central Valley streams produce Chinook Salmon that contribute to the diet of Southern Resident killer whales. The number of Central Valley salmon that annually enter the ocean and survive to a size susceptible to predation by killer whales is not known. However, estimates of total Chinook Salmon production produced by the Comprehensive Assessment and Monitoring Program, administered by USFWS and Reclamation, provide an approximation of the size of the ocean population of Central Valley Chinook Salmon potentially available to killer whales. Since 1992, total production of fall-run Chinook Salmon ranged from 53,129 in 2009 to 1,436,928 in 2002 (Table 9.2). The term "total production" here represents the number of fish that returned from the ocean plus those that were taken as part of the commercial and sport fishery. It does not include natural mortality in the ocean, including salmon taken by killer whales.

**Table 9.2 Total Production (Number of Individuals) of Central Valley Fall-run Chinook Salmon in the Pacific Ocean and Ocean Harvest 1992-2011**

| Year | Total Production | Ocean Harvest |
|---|---|---|
| 1992 | 333,087 | 203,318 |
| 1993 | 553,617 | 352,913 |
| 1994 | 711,654 | 449,060 |
| 1995 | 1,391,357 | 994,194 |
| 1996 | 891,739 | 471,865 |
| 1997 | 1,146,471 | 679,151 |
| 1998 | 557,433 | 263,935 |
| 1999 | 795,768 | 316,873 |
| 2000 | 1,156,596 | 571,829 |
| 2001 | 976,034 | 218,424 |
| 2002 | 1,436,928 | 418,785 |
| 2003 | 1,019,686 | 297,140 |
| 2004 | 977,463 | 500,929 |
| 2005 | 874,670 | 356,514 |
| 2006 | 453,274 | 110,540 |
| 2007 | 202,311 | 87,528 |
| 2008 | 71,870 | 0 |
| 2009 | 53,129 | 0 |
| 2010 | 208,050 | 13,851 |
| 2011 | 329,092 | 57,224 |

Source: DOI 2012

#### *9.3.5.2 Contra Loma Reservoir*

The Contra Loma Reservoir is a CVP facility in Contra Costa County that provides offstream storage along the Contra Costa Canal. The 80-acre reservoir is part of 661-acre Contra Loma Regional Park and Antioch Community Park (Reclamation 2014b). There are currently 20 known fish species, including 8 species of game fish, in Contra Loma Reservoir. The East Bay Parks and Recreation District (EBRPD) and CDFW stock Rainbow Trout and Channel Catfish in the reservoir. The reservoir also supports self-sustaining populations of Largemouth Bass, crappie, Redear Sunfish, and Bluegill, which are also popular with anglers (Reclamation 2014b). Other species found include White Catfish, Threadfin Shad, Bigscale Logperch, Common Carp, Sacramento Blackfish, Warmouth, Green Sunfish, Goldfish, Prickly Sculpin, and Inland Silversides (Reclamation 2014b).

Many of the fish species present have been unintentionally introduced from the Delta via the Contra Costa Canal. Recently, the Rock Slough Fish Screen at the head of Contra Costa Canal was constructed to prevent the entrainment of federally protected species such as Delta Smelt at the Rock Slough Intake of the Contra Costa Canal. The new screen also minimizes fish entrainment and significantly reduces the potential for fish introductions into Contra Loma Reservoir from the Contra Costa Canal (Reclamation 2014b).

#### *9.3.5.3 San Justo Reservoir*

The San Justo Reservoir is a CVP facility in San Benito County that provides offstream storage as part of the San Felipe Division, as described in Chapter 5, Surface Water Resources and Water Supplies. Other than stocked Rainbow Trout, all of the fish and other aquatic organisms that have been observed in San Justo Reservoir are nonnative species (SBCWD 2012).

#### *9.3.5.4 South Bay Aqueduct Reservoirs*

Bethany Reservoir, Patterson Reservoir, and Lake Del Valle are SWP facilities associated with the South Bay Aqueduct in Alameda County, as described in Chapter 5, Surface Water Resources and Water Supplies. At Bethany Reservoir, anglers catch five types of bass (Spotted, White, Largemouth, Smallmouth, and Striped), crappie, catfish, and trout (CSP 2013). Presumably, many of the same species would be found in Patterson Reservoir. Lake Del Valle is stocked regularly with trout and catfish. Largemouth and Smallmouth Bass, Striped Bass, and panfish are also caught (EBPRD 2014).

#### *9.3.5.5 Los Vaqueros Reservoir*

Los Vaqueros Reservoir is a Contra Costa Water District offstream storage facility in Contra Costa County, as described in Chapter 5, Surface Water Resources and Water Supplies. Aquatic habitat quality for fish is low to moderate due to poorly developed cover vegetation along the shoreline. The reservoir has been stocked with more than 300,000 game fish, primarily Rainbow Trout and Kokanee Salmon. Other fish introduced to the reservoir include Striped Bass, Largemouth Bass, sunfish, Brown Bullhead, and Channel Catfish (Reclamation and CCWD 2011).

#### *9.3.5.6 East Bay Municipal Utility District Reservoirs*

The EBMUD reservoirs in Alameda and Contra Costa County used to store water within and near the EBMUD service area include Briones Reservoir, San Pablo Reservoir, Lafayette Reservoir, Upper San Leandro Reservoir, and Lake Chabot. Water stored in these reservoirs includes water from local watersheds, the Mokelumne River watershed, and CVP water supplies, as described in Chapter 5, Surface Water Resources and Water Supplies. San Pablo Reservoir is regularly stocked with trout and catfish (EBMUD 2014). Other species caught in the reservoir include crappie, Largemouth Bass, Smallmouth Bass, Spotted Bass, and carp (OEHHA 2009).

CDFW annually stocks trout in Lafayette Reservoir. Other species found in the reservoir include Bluegill, black bass, Black Crappie, and several species of catfish (Lafayette Chamber of Commerce 2014).

Lake Chabot is stocked with hatchery-raised Rainbow Trout and Channel Catfish by EBRPD and CDFW for recreational fishing. The lake also supports a popular nonnative, warm-water recreational fishery for Largemouth Bass, Bluegill, and Black Crappie. Some native trout escape from the Upper San Leandro Reservoir during spill events and likely end up in Lake Chabot (EBMUD 2013).

### 9.3.6 Central Coast Region

The Central Coast Region includes portions of San Luis Obispo and Santa Barbara counties served by the SWP. SWP water is delivered to southern Santa Barbara County communities through Cachuma Lake.

#### *9.3.6.1 Cachuma Lake*

Cachuma Lake is a facility owned and operated by Reclamation in Santa Barbara County. Cachuma Lake provides a variety of habitats for fish species, including deep-water areas, rocky drop-offs, shallow areas, and weed beds (wetland areas). Cachuma Lake and the upper Santa Ynez River are popular fishing areas that have been stocked with game fish by CDFW and the County of Santa Barbara. Native fish species in Cachuma Lake include steelhead/Rainbow Trout, Armored Three-Spine Stickleback, and Prickly Sculpin. Key game fish include Largemouth Bass, Smallmouth Bass, Bluegill, Green Sunfish, Redear Sunfish, Black Crappie, and White Crappie. Other species that have been identified in the lake include Channel Catfish, Black Bullhead, Threadfin Shad, goldfish, carp, and Mosquitofish (Reclamation 2010c).

### 9.3.7 Southern California Region

The Southern California Region includes portions of Ventura, Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties served by the SWP. There are six SWP reservoirs along the main canal, West Branch, and East Branch of the California Aqueduct and many other reservoirs owned and operated by regional and local agencies. The Metropolitan Water District of Southern California's Diamond Valley Lake and Lake Skinner primarily store water from the SWP. Other reservoirs store SWP water, including United Water Conservation District's Lake Piru; City of Escondido's Dixon Lake; City of San Diego's San Vicente Reservoir and Lower Otay Reservoir; Helix Water District's Lake Jennings; and Sweetwater Authority's Sweetwater Reservoir.

#### *9.3.7.1 State Water Project Reservoirs*

The SWP reservoirs include Quail Lake, Pyramid Lake, and Castaic Lake in Los Angeles County; Silverwood Lake and Crafton Hills Reservoir in San Bernardino County; and Lake Perris in Riverside County.

Although small compared to nearby Pyramid and Castaic lakes, Quail Lake's 290 acres and 3 miles of shoreline offer shoreline fishing. Striped Bass, Channel

Catfish, Blackfish, Tule Perch, Threadfin Shad, and Hitch have been found at Quail Lake (DWR 1997).

Pyramid Lake is located in the Angeles and Los Padres National Forests, about 60 miles northwest of downtown Los Angeles. Largemouth Bass, Smallmouth Bass, and Striped Bass as well as Bluegill, crappie, Brown Bullhead, Channel Catfish, and trout are caught by anglers in Pyramid Lake (OEHHA 2013a). Rainbow Trout, Bluegill, Green Sunfish, Largemouth Bass, catfish, and Prickly Sculpin are found in Piru Creek below the dam (DWR 2004d).

Castaic Lake supports a warm-water fishery for Striped Bass and Largemouth Bass. Bluegill and assorted minnows provide a forage base for the bass as well as being caught by anglers. CDFW maintains a Rainbow Trout fishery in Castaic Lake through stocking (DWR 2007).

Silverwood Lake is located in the San Bernardino National Forest and surrounded by the Silverwood Lake State Recreation Area at the edge of the Mojave Desert and at the base of the San Bernardino Mountains. Common sport fish caught in Silverwood Lake include stocked Rainbow Trout, Largemouth Bass, Bluegill, carp, crappie, catfish, and Striped Bass (CSP 2010, OEHHA 2013b). Other species found in the lake include blackfish, Brown Bullhead, Tui Chub, and Tule Perch (OEHHA 2013b).

The Crafton Hills Reservoir area includes 4.5 acres of open water and 1.9 acres of open space. One fish species, Mosquitofish, was observed in the reservoir (DWR 2009b).

Lake Perris is located within the Lake Perris State Recreation Area, which provides extensive recreational opportunities, as described in Chapter 15, Recreation Resources. Lake Perris is stocked with Rainbow Trout and managed as a recreational fishery. Common fish species in the lake include Largemouth Bass, Channel Catfish, Bluegill, Spotted Bass, Flathead Catfish, Green Sunfish, Redear Sunfish, and Black Crappie (DWR 2010). Other species found in the lake include Inland Silversides and Threadfin Shad (DWR 2007).

#### *9.3.7.2 Non-SWP Reservoirs in Riverside County*

Diamond Valley Lake and Lake Skinner in Riverside County are offstream storage facilities owned and operated by Metropolitan Water District of Southern California. These lakes are major reservoirs used to store SWP water. Diamond Valley Lake supports Largemouth Bass, Striped Bass, catfish, Redear Sunfish, Bluegill, and stocked Rainbow Trout (DVM 2014). Fish species found in Lake Skinner include Striped Bass, Largemouth Bass, carp, and Bluegill. The Metropolitan Water District also stocks catfish in summer and trout in winter (Riverside County 2014).

#### *9.3.7.3 Non-SWP Reservoir in Ventura County*

Lake Piru, located in Ventura County, is used to store SWP water by United Water Conservation District. Like Pyramid Lake upstream on Piru Creek, sport fish species in Lake Piru include trout, Largemouth Bass, catfish, crappie, Bluegill, and Redear Sunfish (CA Lakes 2014). Other species found there include

Bigscale Logperch, Black Bullhead, carp, goldfish, Golden Shiner, Green Sunfish, and Inland Silversides (CalFish 2014).

#### *9.3.7.4 Non-SWP Reservoirs in San Diego County*

Reservoirs in San Diego County that are used to store SWP water include the City of Escondido's Dixon Lake; City of San Diego's San Vicente, El Capitan, and Lower Otay reservoirs; Helix Water District's Lake Jennings; and Sweetwater Authority's Sweetwater Reservoir.

Dixon Lake is located in the hills above the City of Escondido within the Escondido Multiple Habitat Conservation Plan area (City of Escondido 2012). Fish species found in Dixon Lake include Rainbow Trout, Channel Catfish, Bluegill, Largemouth Bass, Striped Bass, and Black Crappie (SDFish 2014).

San Vicente Reservoir has been stocked with various sport fish including sunfish, Largemouth Bass, Black Crappie, catfish, and Rainbow Trout. Other species found in the reservoir include Threadfin Shad and Prickly Sculpin (SDCWA and USACE 2008). El Capitan reservoir is stocked with Largemouth Bass, crappie, Bluegill, Channel Catfish, Blue Catfish, Green Sunfish, and Common Carp (City of San Diego 2014a). Fish species in Lower Otay Reservoir include Largemouth Bass, Bluegill, Black Crappie, White Crappie, Channel Catfish, Blue Catfish, White Catfish, and bullheads (City of San Diego 2014b).

Lake Jennings is regularly stocked with trout and Channel Catfish. Other species found in the lake are Bluegill, Largemouth Bass and Blue Catfish (SDFish 2015).

Eleven fish species were observed in Sweetwater Reservoir during biological surveys for the wetlands habitat recovery project, all of which were nonnative and typical of southern California warm-water lakes. Species observed include Channel Catfish, Threadfin Shad, Bluegill, and Largemouth Bass (Sweetwater Authority 2013).

#### *9.3.7.5 Non-SWP Reservoir in San Bernardino County*

Lake Arrowhead, in San Bernardino County, is used to store SWP water by the Lake Arrowhead Community Services District (County of San Bernardino 2011; LACSD 2014a, 2014b). Lake Arrowhead is a private lake, and its use is restricted to homeowners in a tract of land roughly 1 mile around the perimeter of the lake, known as Arrowhead Woods. Fish species found in the lake include trout, Kokanee Salmon, bass, catfish, crappie, sunfish, and carp.

## 9.4 Impact Analysis

This section describes the potential mechanisms and analytical methods; results of the impact analyses; potential mitigation measures; and cumulative effects.

### 9.4.1 Potential Mechanisms and Analytical Methods

The impact analysis considers changes in the ecological attributes that affect fish and aquatic resources related to changes in CVP and SWP operations under the alternatives as compared to the No Action Alternative and the Second Basis of Comparison.

#### *9.4.1.1 CVP and SWP Reservoirs*

Changes in CVP and SWP 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, Folsom Lake, New Melones Lake, and San Luis Reservoir). 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.

The downstream reservoirs (i.e., Lewiston Lake, Keswick Reservoir, Thermalito Forebay and Afterbay, Lake Natoma, Tulloch Reservoir, and Goodwin Lake) are operated to maintain relatively stable water elevations. These types of operations would result in similar conditions in the No Action Alternative, Alternatives 1 through 5, and the Second Basis of Comparison. Therefore, changes at these reservoirs are not evaluated in this EIS.

##### 9.4.1.1.1 Changes in CVP and SWP Reservoir Storage Volume

To evaluate changes in operation, changes in reservoir storage and elevation were estimated based upon modeled monthly average storage and reservoir elevation output from CalSim II for the entire 82-year period under the operations defined for each alternative, as described in Appendix 5A, CalSim II and DSM2 Modeling. 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 and SWP reservoirs.

The effects analysis in Chapter 5, Surface Water Resources and Water Supplies, 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 presented as average monthly storage by water year type. Although aquatic habitat within the CVP and SWP 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.

##### 9.4.1.1.2 Changes in CVP and SWP 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 bass and catfish. Deeper layers are cooler and are suitable for cold water species. Drawdown of reservoir storage from June through October can diminish the volume of cold water, thereby reducing the amount of habitat for cold water fish species within these reservoirs during these months.

Reservoir storage and surface water elevations in the reservoirs from the CalSim II model were used to analyze potential effects on reservoir fishes. 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 bass nests, based upon a relationship between black bass 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 fluctuation 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 <0.065 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) (Scott and Crossman 1973). Many self-sustaining black bass populations in North America experience a nest success (i.e., the nest produces swim-up fry) rate of 21 to 96 percent, with many reporting survival rates in the 40 to 60 percent range (Forbes 1981; Hunt and Annett 2002; Steinhart 2004). This would suggest that much less than 100 percent survival is required to have a self-sustaining population. 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.

#### *9.4.1.2 Rivers*

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

##### 9.4.1.2.1 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 also can influence the frequency and duration of inundated floodplains (e.g., Yolo Bypass) that support salmonid rearing and conditions for other native fish species. With implementation of the physical actions under NMFS RPA Action I.6.1, the inundation regime in the Yolo Bypass will be modified and managed to better coincide with the presence of juvenile salmonids and with a greater frequency. While this action is included in every alternative, changes in flows in the Sacramento River at the Freemont Weir associated with the various alternatives could result in slight differences in the flows entering the bypass and changes in the amount of habitat available to rearing salmonids.

The effects analysis in Chapter 5, Surface Water Resources and Water Supplies, 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 presented as both average monthly flows by month and water year type and monthly frequency of exceedance plots to allow examination of the entire range of simulation results for each of the alternatives as a means of evaluating differences among alternatives. Differences in monthly average flows of greater than 5 percent between alternatives are considered biologically meaningful and may affect fish and aquatic resources.

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 for each life stage of these species in the rivers in which flows may be altered by CVP and SWP 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 Weighted Useable Area (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 changes in flow, 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 Draft 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. Because the WUA-flow relationships developed by the most recent IFIM studies present WUA values within particular flow ranges at particular variable steps, it was often the case that the monthly flow for a particular reach fell between two flows for which there were WUA values. In these cases, the value was determined by linear interpolation between the available WUA values for the flows immediately below and above the target flow. When the target flow was lower than the lowermost flow for which a WUA value exists, the corresponding WUA value was determined by linear interpolation between a flow of zero and the lowermost flow for which a WUA value exists. When the target flow was higher than the highest flow for which a WUA value exists, the corresponding WUA value was determined by assuming the WUA value for the highest flow.

WUA values are calculated and presented only on a monthly time-step, and not as seasonal or annual values. WUA values based on the monthly CalSim II flows were prepared for detailed evaluation of the alternatives. Monthly WUA values are presented as the average total WUA in each river segment, for the entire 82-year simulation period and the average total WUA in each of five water year types for each alternative. Differences between the alternatives and the two bases of comparison (No Action Alternative and Second Basis of Comparison) are used to identify the effects of each alternative on habitat availability (WUA) for each species and life stage in each river. These comparisons were made only for the months in which the species and life stage are anticipated to be present in each river/reach based on the life history timing presented in Appendix 9B.

The ability to estimate WUA values is limited due to the monthly time-step of the CalSim II results. The monthly time-step is most limiting during the fall through spring seasons, when flows vary significantly on a daily basis due to hydrologic conditions. Hydrologic variability in the runoff and tributary flows cause significant variability of flows in the areas of interest for the WUA computations. During the periods of low flows, regulated flows from reservoir releases dampen the impact of daily variability of flows on WUA estimates. Monthly time-step simulation results do not capture the daily variability or change in variability between alternative operations. Therefore, differences in monthly average WUA of greater than 5 percent between alternatives are considered biologically meaningful and may have an effect on the specific life stage being analyzed.

#### 9.4.1.2.2 Changes in Water Temperatures

Water temperatures in the rivers and streams downstream of the CVP and SWP reservoirs are influenced by factors such as reservoir cold water pool, 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 waters released from the reservoir. During this time of year, ambient air temperatures contribute substantially to warming instream flows downstream of reservoirs. The 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 two approaches: 1) a comparison of average monthly water temperatures between the alternatives and the two bases of comparison (No Action Alternative and Second Basis), and 2) a comparison of average monthly water temperatures to established temperature objectives intended to be protective of fish. In addition, Reclamation's salmon mortality model was applied in certain water bodies to examine the effects of temperature on salmon spawning and incubation. These approaches are described below.

*Comparison of Average Monthly Water Temperatures between Alternatives*

The effects analysis in Chapter 6, Surface Water Quality, includes a summary of the average monthly water temperature in each major stream downstream of CVP and SWP reservoirs in combination with a frequency of temperature exceedance analysis (see below) for each month. 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 two bases of comparison (No Action Alternative and Second Basis). Differences in monthly average temperatures of greater than 0.5°F between alternatives are considered biologically meaningful and may affect fish and aquatic resources.

*Comparison to Established Water Temperature Thresholds*

The average monthly temperature output from CalSim II does not allow a direct comparison to the temperature objectives identified in Table 9.3, and the effects of daily (or hourly) temperature swings are likely masked by the averaging process. Nonetheless, the average monthly water temperatures provide the basis for a coarse evaluation of the likelihood that temperature objectives (Table 9.3) would be exceeded. Differences between alternatives in the frequency that the average monthly temperature exceeds the temperature objective may be indicative of biologically meaningful changes.

**Table 9.3 Water Temperature Objectives**

| Compliance Location | Year Types | Dates | Temp. Objective (°F) | Purpose |
|---|---|---|---|---|
| **Trinity River** | | | | |
| Lewiston Dam Release | All Year Types | July–Sep | < 60 | Spring-run Chinook Salmon holding |
| | | Sep | < 56 | Spring-run Chinook Salmon spawning |
| Lewiston Dam Release | All Year Types | Oct–Dec | < 56 | Chinook Salmon, Coho Salmon, and steelhead spawning |
| **Clear Creek** | | | | |
| Whiskeytown Dam Release | All Year Types | June–Sep | 56 | Spring-run Chinook Salmon holding |
| | | Sep-Oct | 63 | Spring-run and fall-run Chinook Salmon spawning and egg incubation |
| **Sacramento River** | | | | |
| Keswick Release | All Year Types | May–Sep | 56 | Winter- and spring-run Chinook Salmon spawning and egg incubation |
| | | | 63 | Green Sturgeon spawning and egg incubation |
| Balls Ferry | All Year Types | May–Sep | 56 | Winter- and spring-run Chinook Salmon spawning and egg incubation |
| | | | 63 | Green Sturgeon spawning and egg incubation |

| Compliance Location | Year Types | Dates | Temp. Objective (°F) | Purpose |
|---|---|---|---|---|
| Bend Bridge | All Year Types | May–Sep | 56 | Winter- and spring-run Chinook Salmon spawning and egg incubation |
| | | | 63 | Green Sturgeon spawning and egg incubation |
| Red Bluff | All Year Types | Oct–Apr | 56 | Spring-, fall-, and late fall–run Chinook Salmon spawning and egg incubation |
| Hamilton City | All Year Types | Mar–Jun | 61 (optimal), 68 (lethal) | White Sturgeon spawning and egg incubation |
| **Feather River** | | | | |
| Robinson Riffle | All Year Types | Sep–Apr | 56 | Spring-run Chinook Salmon and steelhead spawning and incubation |
| | | May–Aug | 63 | Spring-run Chinook Salmon and steelhead rearing |
| Gridley Bridge | All Year Types | Oct–Apr | 56 | Fall- and late fall–run Chinook Salmon spawning and steelhead rearing |
| | | May–Sep | 64 | Green sturgeon spawning, incubation, and rearing |
| **American River** | | | | |
| Watt Avenue Bridge | All Year Types | May–Oct | 65 | Juvenile steelhead rearing |
| **Stanislaus River** | | | | |
| Orange Blossom Bridge | All Year Types | Oct–Dec | 56 | Adult steelhead migration |
| | | Jan– May | 57 | Steelhead smoltification |
| | | Jan-May | 55 | Steelhead spawning and incubation |
| | | Jun-Sep | 65 | Juvenile steelhead rearing |
| Knights Ferry | All Year Types | Jan-May | 52 | Steelhead smoltification |

*Changes in Egg Mortality*

Water temperatures also affect the survival of various life stages of the focal species. Reclamation's salmon mortality model (Appendix 9C, Reclamation Salmon Mortality Model Analysis Documentation) was used to estimate water temperature induced mortality in the early life stages (pre-spawned eggs, fertilized eggs, and pre-emergent fry) of salmonids in five rivers: Trinity, Sacramento, Feather, American, and Stanislaus, based on output from the temperature models. The salmon mortality model is limited to temperature effects on early life stages of Chinook Salmon. It does not evaluate potential direct or indirect temperature impacts on later life stages, such as emergent fry, smolts, juvenile out-migrants, or adults. Also, it does not consider other factors that may affect salmon mortality, such as in-stream flows, gravel sedimentation, diversion structures, predation, and ocean harvest. Differences between alternatives are assessed based on changes in the percent egg mortality by river over the entire 82-year CalSim II simulation period and by water year type (based on 40-30-30 indexing). Differences in the percentage of egg mortality of greater than 1 percent between alternatives are considered biologically meaningful and may have an effect on fish populations.

#### *9.4.1.3 Delta*

Changes in CVP and SWP operations under the alternatives would affect 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 ecological attributes under the alternatives that would affect fisheries and aquatic resources in the Delta would primarily be related to:

##### 9.4.1.3.1 Changes in Volume and Timing of Flows through the Delta

Operations of the CVP DCC 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 some Delta channels that can alter fish movement patterns. Seasonal flows play an especially important role in determining the reproductive success and survival of many estuarine species including salmon, Striped Bass, American Shad, Delta Smelt, Longfin Smelt, and Sacramento Splittail. 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 as a result of changes in CVP and SWP operations 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.

#### 9.4.1.3.2 Changes in Water Quality

Changes in water quality due to CVP and SWP operations under the alternatives would affect aquatic resources in the Delta primarily through changes in water temperatures, salinity, nutrient levels, pollutant concentrations and turbidity. Changes in CVP and SWP operations can increase Delta water temperatures by warmer reservoir releases and to a lesser extent, by reducing quantities of freshwater inflow and by modifying tidal and ground water hydraulics. Changes in CVP and SWP operations also can affect the location of the low salinity zone (position of X2), especially during periods of low inflows and high water exports (i.e., low outflow conditions) in drier water years. Nutrients, essential components of terrestrial and aquatic environments because they provide a resource base for primary producers, and pollutants such as selenium and mercury could be affected by changes in CVP and SWP operations. 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 and altering predation success.

The DSM2, a one-dimensional hydrodynamic and water quality simulation model, is used to evaluate changes in salinity (as represented by EC) in the Delta and at the CVP/SWP export locations. CalSim II outputs are used to evaluate changes in location of X2 in the Delta. A more detailed overview of the DSM2 model and input assumptions is presented in Appendix 5A, CalSim II and DSM2 Modeling.

The Delta boundary flows and exports from CalSim II are used as input to the DSM2 Delta hydrodynamic and water quality models to estimate tidally-based flows, stage, velocity, and salt transport within the estuary. Because CalSim II operations are simulated on a monthly basis, the DSM2 model would not be able to capture daily operations and therefore the DSM2 outputs are presented on a monthly basis, as described in Appendix 5A, CalSim II and DSM2 Modeling.

DSM2 HYDRO outputs are used to predict changes in flow rates and depths. The QUAL module of DSM2 simulates fate and transport of conservative and non-conservative water quality constituents, including salts, given a flow field simulated by HYDRO. Chloride and bromide concentrations are estimated using relationships based on DSM2 EC results, as described in Appendix 6E, Analysis of Delta Salinity Indicators.

#### 9.4.1.3.3 Changes in Fish Entrainment

Changes in CVP and SWP operations can affect through-Delta survival of migratory (e.g., salmonids) and resident (e.g., Delta and Longfin smelt) fish species through changes in the level of entrainment at CVP and SWP export pumping facilities. The south Delta CVP and SWP facilities are the largest water diversions in the Delta and in the past, have entrained large numbers of Delta fish species. Tides, 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. Entrainment risk for fish also tends to increase with increased reverse flows in Old and Middle rivers.

The potential for entrainment for migrating salmonids through the Delta was analyzed using predicted monthly salvage of salmonids from January through June using statistical relationships reported in Zeug and Cavallo (2014). In that analysis, salvage at the State Water Project and Central Valley Project was modeled as a function of physical, biological and hydrologic variables.

In evaluating the potential for entrainment of Delta Smelt, as influenced by OMR flows under the alternatives, the USFWS (2008) regression model based on Kimmerer (2008) was used to estimate potential entrainment of Delta Smelt. The equation developed by Kimmerer (2008) is based on the average December through March OMR flow (in units of cfs) as predicted by the CALSIM II model, and yields the percentage of adult Delta Smelt that may become entrained in the pumps. Further review by Kimmerer (2011) determined that the above equation has an upward bias, such that the results were reduced by 24 percent to correct this bias. In the event that a negative entrainment percentage was calculated, the result was changed to zero.

Changes in CVP and SWP operations under the alternatives could also change entrainment of larvae and early juvenile Delta Smelt. Larvae and early juvenile Delta Smelt are most prevalent in the Delta in the spring months of March through June. The USFWS (2008) regression model based on Kimmerer (2008) was used to calculate the percentage entrainment of larval and early juvenile Delta Smelt in Banks and Jones Pumping Plants. This regression is dependent on two variables: March through June average OMR flow (in cfs) and March through June average X2 position (in km). OMR and X2 values predicted by the CalSim II model for each alternative were used in estimating the entrainment loss. In the event that a negative entrainment percentage was calculated, the result was changed to zero.

In this study, the percent entrainment values estimated for Delta Smelt are used as a tool to compare the alternatives, as one of the factors that would indicate conditions that might benefit or adversely affect Delta Smelt. In the estimation of potential entrainment loss and comparison of the results for each of the alternatives, differences in entrainment estimates of greater than 5 percent between alternatives are considered biologically meaningful, with potential effects on Delta Smelt. Differences in entrainment estimates less than 5 percent between alternatives are considered to be “similar” in effects. One limitation of this approach is that it does not reflect the benefit that some of the alternatives might realize through adaptive management of OMR flows to further reduce potential entrainment, based on input from the Smelt Working Group.

#### 9.4.1.3.4 Changes in Fish Passage and Routing

Changes in CVP and SWP operations can affect through-Delta survival of migratory (e.g., salmonids) and resident (e.g., Delta and Longfin smelt) fish species through changes in passage conditions and routing. For example, changes in operation of the DCC affects the volume of water diverted into the Mokelumne

River distributary channels toward the central and south Delta. Operation of the south Delta intake facilities, including facilities owned by the CVP and SWP and Contra Costa Water District, contribute to reverse flow conditions in Old and Middle rivers.

Changes in salmonid passage and routing were evaluated using the Delta Passage Model (DPM) and an analysis of junction entrainment, as described below. The DPM is based on a detailed accounting of migratory pathways and reach-specific mortality as Chinook salmon smolts travel through a simplified network of reaches and junctions (see Appendix 9J for additional detail). Model output is expressed as through Delta survival of salmon smolts. The analysis of junction entrainment used a regression based on predicted entrainment into a distributary and the proportion of flow into the distributary to predict the probability of fish entrainment (see Appendix 9L for additional detail).

#### 9.4.1.3.5 Changes in Delta Smelt Habitat (X2 Location)

Changes in CVP and SWP operations under the alternatives could change the location of Fall X2 position (in September through December) as an indicator of available habitat for Delta Smelt. Feyrer et al. used X2 location as an indicator of the extent of habitat available with suitable salinity and water transparency for the rearing of older juvenile Delta Smelt. Feyrer et al. 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 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 is believed to lead to more favorable growth and survival conditions for Delta Smelt in fall. (Baxter et al 2010; Feyrer et al 2011). To evaluate fall abiotic habitat availability for Delta Smelt under the alternatives, X2 values (in km) 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, e.g., 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. Other scientists have developed and described life cycle models to evaluate Delta Smelt population responses to changes in flow-related variables (e.g., Maunder and Deriso 2011; Rose et al. 2013 a, b; Reed et al 2014), but these life cycle modeling approaches were not selected for use in the current study. 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.

#### 9.4.1.3.6 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. Three different models were used to assess changes in salmonid production potential: 1) SALMOD; 2) the Interactive Object-Oriented Simulation (IOS) model for winter-run Chinook Salmon; and 3) the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook Salmon.

*Comparison of Annual Production Using SALMOD*

The SALMOD model (Appendix 9D, SALMOD Analysis Documentation) was used to assess changes in the annual production potential of four races of Chinook Salmon in the Sacramento River. 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 life stage-specific mortalities and annual production potential for each species by river by water year type. Differences in mortality and annual production potential of greater than 1 percent between alternatives are considered biologically meaningful and may affect fish populations.

*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. 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 median annual escapement and the range of escapement values encompassed in the first and second quartiles (25 to 75 percent of years) over the 82-year CalSim II simulation period. Differences in escapement of greater than 1 percent between alternatives are considered biologically meaningful and may affect fish populations.

*Comparison of Annual Winter-run Chinook Salmon Escapement Using OBAN*

The Oncorhynchus Bayesian Analysis (OBAN) is a model that uses statistical relationships between historical patterns in winter-run Chinook salmon abundance and a number of other parameters that covary with abundance to predict future population abundance. The model determines the effects of water temperature, harvest, exports, striped bass abundance, and offshore upwelling using historical abundance data. The set of parameters, called covariates, that provided the best model fit was retained for the full model. The model then uses predicted future values of these parameters, primarily from CalSim II and temperature model outputs, to predict future patterns in Chinook salmon population abundance (escapement). Differences in escapement of greater than 1 percent between alternatives are considered biologically meaningful and may affect fish populations.

#### 9.4.1.4 Constructed Water Supply Facilities that Convey and Store CVP and SWP Water

The distribution system for water exported by CVP and SWP includes hundreds of miles of canals and numerous reservoirs designed to help regulate the flow of water to the areas where the water is used. Many of these canals and reservoirs support fish that were entrained into the system or intentionally stocked for recreational purposes, and changes in export deliveries could influence the quality of the aquatic habitat in these constructed water bodies. These constructed water bodies do not support important populations of native fish species and the management of flows is under the control of the entities that receive the water. Because many of the reservoirs also store water from non-CVP and SWP water supplies; it is difficult to predict changes in the aquatic habitat related to changes in CVP and SWP water supplies. Therefore, the potential effects of operation of these facilities on fish and aquatic resources are not addressed further in this EIS.

#### 9.4.1.5 Analysis of Provision of Fish Passage

As described previously in the Affected Environment section, Shasta, Folsom, and New Melones dams and their associated downstream re-regulating reservoirs permanently blocked salmonid access to upper watersheds and effectively removed many miles of suitable habitat. These barriers particularly influenced populations of winter-run and spring-run Chinook Salmon and steelhead because their life history strategies are adapted to accessing higher elevation river reaches and tributaries to successfully spawn and rear, as well as for oversummering. Improving passage would increase the amount of available habitat, including access to colder headwaters, which would be particularly important considering anticipated climate change scenarios. Improved fish passage is not included under the Second Basin of Comparison or Alternative 2. Improved fish passage through trap and haul activities is included in Alternatives 3 and 4.

#### 9.4.1.6 Analysis of Predator Control Programs

As described in Chapter 3, Description of Alternatives, Alternatives 3 and 4 include predator control actions designed to reduce predation on salmonids and Delta Smelt, primarily within the Delta. Predator control measures are included in Alternatives 3 and 4, including an increased bag limit and minimum size limit for Striped Bass and black bass. The proposed bag and size limits are intended and expected to encourage more fishing effort for and greater harvest of Striped Bass and black bass, resulting in a reduction in the Striped Bass and black bass populations throughout the Delta. In addition, a sport reward program for Sacramento Pikeminnow would be implemented to encourage fishing for and removal of predatory species. These two actions would not be implemented under the No Action Alternative, Second Basis of Comparison, or other action alternatives, with the exception of Alternatives 3 and 4.

#### *9.4.1.7 Analysis of Ocean Salmon Harvest Restrictions*

As described in Chapter 3, Description of Alternatives, Alternatives 3 and 4 include restrictions on the annual ocean Chinook Salmon harvest, which is intended to minimize harvest mortality of natural origin Central Valley Chinook Salmon, including fall-run Chinook Salmon, by evaluating and modifying ocean harvest for consistency with Viable Salmonid Population[2] standards. This would include working with the Pacific Fisheries Management Council (PFMC), CDFW, and NMFS to impose salmon harvest restrictions to reduce by-catch of winter-run and spring-run Chinook Salmon to less than 10 percent of age-3 cohort in all years.

The salmon ocean fishery off the coast of California is regulated by the PFMC, which establishes the annual catch limit to optimize overall benefits, particularly with regard to food production, recreation, and ecosystem protection. An annual catch limit generally is based on achieving the maximum sustained yield from the fishery, but also takes into account the effects of uncertainty; management imprecision; the need to rebuild stocks; and other relevant economic, social, and ecological factors. Compliance with the ESA, other laws, and treaties also may affect the annual catch limit. Each year, the maximum allowable harvest (i.e., maximum number of fish caught) is determined based on the abundance of fish spawning in the previous year. Depending on the number of spawning fish, different formulas for calculating the maximum allowable harvest (i.e., control rules) are used. These rules calculate the maximum allowable harvest as a percentage of the number of spawning fish, and are designed to maximize the yield of fish from a stock while preventing overfishing. The annual catch limit may be set at or below the maximum allowable harvest.

Reduction of the annual catch limit could directly influence the number of adult salmon reaching their natal streams to spawn, which could affect the number of salmon annually produced in Central Valley streams and the Trinity River. Harvest restrictions would be implemented under Alternatives 3 and 4, but would not be implemented under the No Action Alternative, Second Basis of Comparison, or other action alternatives.

#### *9.4.1.8 Approach to Analyzing the Effects of Alternatives on Fish*

The analysis of the effects of changes in operation of the CVP and SWP on fish and aquatic resources in this EIS is influenced by numerous factors related to the complexity of the ecosystem, changes within the system (e.g., climate change and species population trends), and the imprecision of operational controls and resolution in modeling tools. These factors are further complicated by the scientific uncertainty about some fundamental aspects of aquatic species life

[2] "A viable salmonid population (VSP)2 is an independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time frame" (McElhany et al. 2000, pg. 2).

history and how these species respond to changes in the system, as well as sometimes competing points of view on the interpretation of biological and physical data within the scientific community. In light of these factors, the analysis takes an approach that presents available information and model outputs, synthesizes the results, and draws logical conclusions on likely effects of the various alternatives. Where relevant and appropriate, the analysis attempts to identify the level of uncertainty and qualify effect conclusions where competing hypotheses may exist.

Many modeling tools have been developed to evaluate changes in CVP and SWP water management, and as a result, multiple sources of information are available to characterize conditions (e.g., water temperature, flows, reservoir storage). Most of these modeling tools explain or provide insight on one or two of the factors affecting the species, while some tools are more integrative (e.g., SALMOD) and capture multiple relationships among physical conditions and biological responses. Where integrative models were available, these were relied upon more than evaluation of the individual components. For species where these tools were not available, the analysis used a preponderance of evidence approach that drew conclusions based on trends indicated by the majority of the information. This approach assembled the full range of available information and model outputs and determined the direction (neutral, positive, or negative) of effect supported by the information.

For each focal species where sufficient information was available, the analysis includes an effects summary that presents the EIS authors' conclusions for that species and describes the rationale for the conclusion. It also presents a general indication of the level of uncertainty regarding the conclusion and presents qualifying information where disagreement in the scientific community may exist for more complete disclosure.

Because of the multiple model outputs, the body of the impact analysis contains a considerable amount of information, which is intended to summarize for the benefit of the reader, while leaving most of the detail in the appendices. The narrative contained in the body of the document and the model results in the appendices are intended to be used in concert in reviewing this EIS.

### 9.4.2 Conditions in Year 2030 without Implementation of Alternatives 1 through 5

This EIS includes two bases of comparison, as described in Chapter 3, Description of Alternatives: the No Action Alternative and the Second Basis of Comparison. Both of these bases are evaluated at 2030 conditions. Changes that would occur over the next 15 years without implementation of the alternatives are not analyzed in this EIS. However, the changes to aquatic resources that are assumed to occur by 2030 under the No Action Alternative and the Second Basis of Comparison are summarized in this section. Many of the changed conditions would occur in the same manner under both the No Action Alternative and the Second Basis of Comparison.

#### 9.4.2.1 Common Changes in Conditions under the No Action Alternative and Second Basis of Comparison

Conditions in 2030 would be different than existing conditions due to:

- Climate change and sea level rise
- General plan development throughout California, including increased water demands in portions of Sacramento Valley
- Implementation of reasonable and foreseeable water resources 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. The reservoirs would be full more frequently by the end of April or May by 2030 than 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 available water supplies to downstream uses in the summer. The reduced end of September storage also would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs.

These changes would result in a decline of the long-term average CVP and SWP water supply deliveries by 2030 as compared to recent historical long-term average deliveries under the No Action Alternative and the Second Basis of Comparison. However, the CVP and SWP water deliveries would be less under the No Action Alternative as compared to the Second Basis of Comparison, as described in Chapter 5, Surface Water Resources and Water Supplies, which could result in more crop idling.

Under the No Action Alternative and the Second Basis of Comparison, land uses in 2030 would occur in accordance with adopted general plans. Development under the general plans would change aquatic resources, especially near municipal areas.

The No Action Alternative and the Second Basis of Comparison assumes completion of water resources management and environmental restoration projects that would have occurred without implementation of Alternatives 1 through 5, including regional and local recycling projects, surface water and groundwater storage projects, conveyance improvement projects, and desalination projects, as described in Chapter 3, Description of Alternatives. The No Action Alternative and the Second Basis of Comparison also assumes implementation of actions included in the 2008 USFWS BO and 2009 NMFS BO that would have been implemented without the BOs by 2030, as described in Chapter 3, Description of Alternatives. These projects would include several projects that would affect aquatic resources, including:

- Habitat Restoration includes restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough;

and at least 17,000 to 20,000 acres of seasonal floodplain restoration in Yolo Bypass.

  - 2008 USFWS BO RPA Component 4 (Action 6). Habitat Restoration.
  - 2009 NMFS BO RPA Action I.6.1. Restoration of Floodplain Habitat.
  - 2009 NMFS BO RPA Action I.6.2. Near-Term Actions at Liberty Island/Lower Cache Slough and Lower Yolo Bypass.
  - 2009 NMFS BO RPA Action I.6.3. Lower Putah Creek Enhancements.
  - 2009 NMFS BO RPA Action I.6.4. Improvements to Lisbon Weir.
  - 2009 NMFS BO RPA Action I.7. Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass.

- 2009 NMFS BO RPA Action I.1.3. Clear Creek Spawning Gravel Augmentation.
- 2009 NMFS BO RPA Action I.1.4. Spring Creek Temperature Control Curtain Replacement.
- 2009 NMFS BO RPA Action I.2.6. Restore Battle Creek for Winter-Run, Spring-Run, and Central Valley Steelhead.
- 2009 NMFS BO RPA Action I.3.1. Operate Red Bluff Diversion Dam with Gates Out.
- 2009 NMFS BO RPA Action I.5. Funding for CVPIA Anadromous Fish Screen Program.
- 2009 NMFS BO RPA Action II.1. Lower American River Flow Management.

Implementation of these common actions are described in more detail in this section under the No Action Alternative and referred under the discussion of the Second Basis of Comparison.

#### *9.4.2.2 No Action Alternative*

As described in Chapter 3, Description of Alternatives, the No Action Alternative includes implementation of the 2008 USFWS BO and the 2009 NMFS BO Reasonable and Prudent Alternative (RPA) actions. It also includes changes not related to the coordinated long-term operation of the CVP and SWP, specifically changes in CVP and SWP operations caused by climate change and sea level rise, increased CVP and water rights water demand in portions of the Sacramento Valley, and implementation of reasonable and foreseeable non-CVP or SWP water resources management projects to provide water supplies. The resulting changes in ecological attributes and subsequent effects on fish and aquatic resources would vary geographically, as described below.

As described in Chapter 5, Surface Water Resources and 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. By 2030, the reservoirs would be full more frequently by the end of April or May than 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 available water supplies to downstream uses in the summer. The reduced storage in fall (end of September storage) would reduce the ability to release stored water to downstream regional reservoirs. These conditions would occur for all reservoirs in the California foothills and mountains, including non-CVP and SWP reservoirs. Sea level rise also would result in reduced CVP and SWP reservoir storage because the CVP and SWP must continue to meet the salinity criteria to protect Delta water users and Delta aquatic resources, including the SWRCB D-1641 and other salinity criteria to protect Delta water users. To meet these criteria, the amount of water released from CVP and SWP reservoirs must be increased as compared to recent historical conditions.

#### 9.4.2.2.1 Trinity River Region

*Aquatic Habitat Conditions in CVP and SWP Reservoirs*

As described in Chapter 5, Surface Water Resources and Water Supplies, end of September reservoir storage in Trinity Lake would be lower by 2030 as compared to recent historical conditions due to climate change and related lower snowfall. Lewiston Reservoir, a regulating reservoir, would be operated with daily changes similar to historical conditions. These changes are not anticipated to substantially affect aquatic resources in Trinity Lake or Lewiston Reservoir relative to recent historical conditions.

*Aquatic Habitat Conditions in Trinity and Lower Klamath Rivers*

Under the No Action Alternative, flow, water temperature, and aquatic habitat conditions in the Trinity River would continue to be influenced by CVP and SWP operations as described in the Affected Environment. Due to the increased potential for reduced Trinity Lake surface water storage (see above), there could be an increased potential for reduced Trinity River flows during the summer and fall months under the No Action Alternative as compared to recent historical conditions. The influence of climate change could result in higher water temperatures in Trinity Lake that could translate to higher release temperatures in the flow releases from Lewiston Dam and a reduction in habitat quality within the Trinity River for salmonids and other native species.

By 2030, implementation of 2009 NMFS BO RPA Action II.6, Preparation of Hatchery Genetic Management Plans for spring- and fall-run Chinook Salmon at the Trinity River Fish Hatchery, which is not currently being implemented, could reduce the adverse influence of recent hatchery operations on naturally produced fall-run and spring-run Chinook Salmon, and increase genetic diversity and diversity of run timing for these stocks.

*Effects Related to*

It is not anticipated that water would be transferred to or from the Trinity River Region. It also not anticipated that water transfers would result in changes to

Trinity Lake operations. Therefore, there would be no change in aquatic habitat conditions as a result of water transfers.

#### 9.4.2.2.2 Central Valley Region

*Aquatic Habitat Conditions in CVP and SWP Reservoirs*

Seasonal changes in reservoir surface elevations, storage volumes, and the volume of cold water held within the reservoirs would continue under the No Action Alternative. Conditions for reservoir fishes would continue to change seasonally in response to inflow and downstream flow releases to meet demand. Recent historical averages for reservoir storage and surface elevations in Shasta Lake, Lake Oroville, and Folsom Lake generally show increases in March and April, with a reduction in storage occurring in many years during May and June in response to releases to meet downstream demands. Water surface elevations in New Melones Reservoir generally decline throughout the spring period in many years, with reductions typically occurring from April through June.

As described in Chapter 5, Surface Water Resources and Water Supplies, end of September reservoir storage would be lower by 2030 as compared to recent historical conditions in Shasta Lake, Lake Oroville, Folsom Lake, New Melones Lake, and San Luis Reservoir due to climate change and related lower snowfall. Whiskeytown Lake, Keswick Reservoir, Thermalito Forebay and Afterbay, and Lake Natoma are regulating reservoirs and would be operated with daily changes similar to historical conditions.

Under the No Action Alternative, the magnitude of changes in seasonal surface elevation and reservoir storage could be slightly more pronounced because of changes in the timing and intensity of storm events due to climate change and an overall reduction in snow pack. A smaller snowpack could result in less water entering the reservoirs during the spring months and an increased frequency of reservoir elevation declines during the spring months. By 2030, fish in these reservoirs that spawn in shallow water (e.g., various species of black bass) could be subject to a hydrologic regime that increases the frequency of reductions in surface elevation during the spring spawning period, reducing spawning success. In addition, reduced storage volumes and reduction of the cold water pools could reduce the amount and suitability of habitat for cold water fishes (e.g., trout) within the reservoirs relative to recent historical conditions.

*Aquatic Habitat Conditions in Rivers Downstream of CVP and SWP Facilities*

As described in Chapter 5, Surface Water Resources and Water Supplies, surface water flows are anticipated to increase during the winter months as a result of an increase in rainfall and decrease in snowfall, and to decrease in other months because of the diminished snowmelt flows in the spring and early summer months. In wetter years, fall flows may be increased relative to recent conditions to meet downstream targets for Fall X2, which would lead to reduced reservoir storage in the following months and less carryover storage in May of the following year.

As described in Chapter 6, Surface Water Quality, climate change is anticipated to result in higher water temperatures during portions of the year, with a corresponding reduction in habitat quality for salmonids and other cold water fishes. Increased downstream water demands and climate change are anticipated to contribute to an inability to maintain an adequate cold water pool in critical dry years and extended dry periods in the future.

Implementation of the 2008 USFWS BO and the 2009 NMFS BO Reasonable and Prudent Alternative (RPA) actions under the No Action Alternative are anticipated to benefit aquatic species. The resulting changes in ecological attributes and subsequent effects on fish and aquatic resources would vary from river to river, as described below.

*Aquatic Habitat Conditions in the Clear Creek from Whiskeytown Dam to Sacramento River*

Under the No Action Alternative, flow, water temperature, and aquatic habitat conditions in Clear Creek would continue to be influenced by CVP and SWP operations as described in the Affected Environment. Whiskeytown Reservoir would continue to be operated to convey water from the Trinity River to the Sacramento River via the Spring Creek tunnel and to release flows to Clear Creek to support anadromous fish.

The No Action Alternative includes a suite of six 2009 NMFS BO RPA actions, intended to improve conditions for salmonids. These actions individually or in combination could influence conditions in Clear Creek by 2030. These include:

- 2009 NMFS BO RPA Action I.1. Spring Attraction Flows
- 2009 NMFS BO RPA Action I.2. Channel Maintenance Flows
- 2009 NMFS BO RPA Action I.3. Spawning Gravel Augmentation
- 2009 NMFS BO RPA Action I.4. Spring Creek Temperature Control Curtain
- 2009 NMFS BO RPA Action I.5. Thermal Stress Reduction
- 2009 NMFS BO RPA Action I.6. Adaptively Manage to Habitat Suitability/IFIM Study Results

Two of the actions involve additional flow releases to Clear Creek. 2009 NMFS BO RPA Action I.1, requires at least two pulse flows in May and June to attract adult spring-run Chinook Salmon holding in the Sacramento River. The pulse flows would be continued annually, and are expected to improve conditions for spring-run Chinook Salmon into the future. In addition, 2009 NMFS BO RPA Action I.1.2, requires the release of channel maintenance flows of a minimum of 3,250 cfs into Clear Creek seven times in a ten-year period. These channel maintenance flows are intended to provide the higher flows necessary to move spawning gravels downstream from injection sites (locations where gravel augmentation is implemented) for the purpose of increasing the amount of spawning habitat available to spring-run Chinook Salmon and steelhead. However, as described in Chapter 5, Surface Water Resources and Water Supplies, the feasibility of releasing these flows is influenced by dam safety considerations and operational constraints, and the delivery of flows of this frequency may not be possible, thus the movement of gravel through mechanical means may be required to achieve this objective.

2009 NMFS BO RPA Action I.1.3 addresses the limited availability of spawning habitat in Clear Creek through the placement of gravel in selected sites in the creek. This program is expected to continue under the No Action Alternative, with ongoing improvements to spawning habitat for steelhead, and spring-run and fall-run Chinook Salmon.

Water temperatures in Clear Creek are influenced by the temperature of water in the Whiskeytown Reservoir and, to some extent, the magnitude of the release flows. As described in the Affected Environment, Reclamation has managed releases since 2002 to meet a daily average water temperature target of 56°F at the Igo Gauge (4 miles downstream of Whiskeytown Dam) from September 15 through October 30 to support spring-run Chinook Salmon spawning. Beginning in 2004, an additional daily average temperature target of 60°F was implemented from June 1 to September 15 to protect over-summering juvenile steelhead and holding adult spring-run Chinook Salmon. 2009 NMFS BO RPA Action I.1.5 continues these temperature targets; however, recent real time operations have experienced difficulty in meeting the temperature objectives, and by 2030, it may not be possible to meet the temperature targets as often. The Spring Creek Temperature Control Curtain in Whiskeytown Lake repaired in 2011 (and also included in the 2009 NMFS BO RPA) improves this condition by retaining cold water that is released to reduce water temperatures during the summer for over-summering juvenile steelhead and holding adult spring-run Chinook Salmon and during the fall for spring- and winter-run Chinook Salmon spawning and incubation.

2009 NMFS BO RPA Action I.1.6 requires adaptive management of flows in Clear Creek based on results of habitat suitability/IFIM studies. If warranted by the studies and if sufficient water is available, this action could result in modified minimum flows in Clear Creek during the fall and winter to improve conditions for spawning and incubating salmonids. Whether flow requirements would be modified by 2030 and the extent of any changes are currently unknown.

*Aquatic Habitat Conditions in the Sacramento River from Keswick to Freeport*

Under the No Action Alternative, flow, water temperature, and aquatic habitat conditions in the Sacramento River downstream of Keswick Dam would continue to be influenced by CVP and SWP operations as described in the Affected Environment. Shasta Lake would continue to be operated to convey water from the Sacramento River to the Delta and release flows to the Sacramento River to support anadromous fish.

The No Action Alternative includes a variety of 2009 NMFS BO RPA actions or action suites intended to improve conditions for salmonids. These actions individually or in combination could influence conditions in the Sacramento River (and Battle Creek) by 2030. These include:

- 2009 NMFS BO RPA Action Suite I.2.1. Shasta Operations
  - 2009 NMFS BO RPA Action Suite I.2.1. Performance Measures
  - 2009 NMFS BO RPA Action I.2.2 (including I.2.2.A–I.2.2.C). November through February Keswick Release Schedule (Fall Actions)
  - 2009 NMFS BO RPA Action I.2.3 (including I.2.3.A–I.2.3.C). February Forecast; March – May 14 Keswick Release Schedule (Spring Actions)
  - 2009 NMFS BO RPA Action I.2.4. May 15 Through October Keswick Release Schedule (Summer Action)
  - 2009 NMFS BO RPA Action I.2.5. Winter-Run Chinook Salmon Passage and Reintroduction Program at Shasta Dam – See “Conditions for Fish Passage”
  - 2009 NMFS BO RPA Action I.2.6. Restore Battle Creek for Winter-Run, Spring-Run, and CV Steelhead
- 2009 NMFS BO RPA Action Suite I.3. Red Bluff Diversion Dam (RBDD) Operations
- 2009 NMFS BO RPA Action I.4. Wilkins Slough Operations
- 2009 NMFS BO RPA Action I.5. Funding for CVPIA Anadromous Fish Screen Program

Action Suite I.2 (Shasta Operations) was aimed at maintaining suitable temperatures for egg incubation, fry emergence, and juvenile rearing in the Sacramento River for the survival and recovery of the winter-run Chinook Salmon ESU. Spring-run Chinook Salmon and steelhead are also affected by temperature management actions from Shasta Lake. This suite of actions is designed to ensure that Reclamation uses maximum discretion to reduce adverse impacts of the projects to Chinook Salmon and steelhead in the Sacramento River by maintaining sufficient carryover storage and optimizing use of the cold water pool. Because Reclamation already operates Shasta Lake to optimize use of the cold water pool and maintain carryover storage for temperature control in the Sacramento River downstream of Shasta and Keswick dams, implementation of this suite of actions would have little effect on habitat conditions for winter-run Chinook Salmon and other fish species in the Sacramento River under the No Action Alternative.

A temperature control device has been in operation at Shasta Dam since 1998, with operations capable of maintaining a water temperature of 56°F downstream to Balls Ferry Bridge in most years through the summer spawning period for winter-run. Under the No Action Alternative, the ability to control water temperatures depends on a number of factors and management flexibility usually ends in October when the cold water pool in Shasta Lake is depleted. With climate change, cold water storage at the end of May in Shasta Lake is expected to be reduced under the No Action Alternative for all water year types. This would further reduce the already limited cold water pool in late summer. With the anticipated increase in demands for water by 2030 and less water being diverted from the Trinity River, it is expected that it would become increasingly difficult to meet water temperature targets at the various temperature compliance points.

It is likely that severe temperature-related effects will be unavoidable in some years under the No Action Alternative. Due to these unavoidable adverse effects, RPA Action Suite I.2 also specifies other actions that Reclamation must take, within its existing authority and discretion, to compensate for these periods of unavoidably high temperatures. These actions include restoration of habitat at Battle Creek (see below) which may support a second population of winter-run Chinook Salmon, and a fish passage program at Keswick and Shasta dams to partially restore winter-run Chinook Salmon to their historical cold water habitat.

2009 NMFS BO RPA Action Suite I.3 addresses mortality and delay of adult and juvenile migration of winter-run, spring-run, steelhead, and green sturgeon caused by the presence of the RBDD and the configuration of the operable gates. As described in the Affected Environment, the Red Bluff Pumping Plant and fish screen, which diverts water to the Tehama Colusa Canal and Corning Canal, was constructed to allow year-round opening of the gates at the RBDD, and is included in the 2009 NMFS BO as Action Suite I.3. Allowing the dam gates at RBDD to remain open allows salmonids, sturgeon, and other fish species to pass unimpeded all year. These passage improvements are completed and are anticipated to benefit fish species that migrate upstream of the RBDD location through improved access to spawning and rearing areas and a reduction in predation due to dispersal of predator species like Striped Bass and Sacramento Pikeminnow.

Implementation of 2009 NMFS BO RPA Action I.4 is anticipated to enhance the ability to manage temperatures for anadromous fish downstream of Shasta Dam through adjusting Wilkins Slough flow criteria in a manner that best conserves the cold water pool for summer releases. In years other than critical dry years, the need for a variance from the 5,000 cfs navigation criterion will be considered during the process of developing the Keswick release schedules (Action I.2.2-4). Reclamation has stated that it is no longer necessary to maintain 5,000 cfs at Wilkins Slough for navigation (CVP/SWP operations BA, page 2-39), however, the 5,000 cfs flow criterion is now used to support long-time water diversions that have set their intake pumps just below this level. Under the No Action Alternative, operating to a minimal flow level at Wilkins Slough based on fish needs, rather than on outdated navigational requirements, could enhance the ability to use cold water releases to maintain cooler summer temperatures in the Sacramento River.

The No Action Alternative includes implementation of the CVPIA AFSP to reduce entrainment of juvenile anadromous fish from unscreened diversions. This program is also addressed in the 2009 NMFS BO RPA Action I.5. By providing funding to screen priority diversions as identified in the CVPIA AFSP, the loss of listed fish in water diversion channels by 2030 could be reduced. In addition, if new fish screens can be constructed so that diversions can occur at low water surface elevations to allow diversions below a flow of 5,000 cfs at Wilkins Slough, then cold water at Shasta Lake could be conserved during critical dry years for release to support winter-run and spring-run Chinook Salmon needs downstream.

As described in the Affected Environment, implementation of the Battle Creek Restoration Program is underway in accordance with implementation of the CVPIA. This action, also included in the 2009 NMFS BO RPA Action I.2.6, is being implemented to partially compensate for unavoidable adverse effects of project operations by restoring winter-run and spring-run Chinook Salmon to the Battle Creek watershed. Full implementation of the Battle Creek Restoration Program under the No Action Alternative would substantially improve passage conditions for adult Chinook Salmon and steelhead by 2030 and would result in newly accessible anadromous fish habitat and improved water quality for the Coleman National Fish Hatchery (Reclamation and SWRCB 2003). Implementation of the RPA helps ensures that the Battle Creek experimental winter-run Chinook Salmon re-introduction program will proceed in a timely fashion. The Battle Creek Restoration Program is critical in creating a second population of winter-run Chinook Salmon. A second population of winter-run Chinook Salmon would reduce the risk that lost resiliency and increased vulnerability to catastrophic events might result in extinction of the species.

*Aquatic Habitat Conditions in the Feather River from Oroville Dam to Sacramento River*

As described in Chapter 5, Surface Water Resources and Water Supplies, and Chapter 6, Surface Water Quality, the NMFS and 2008 USFWS BO RPAs did not specifically recommend actions for Feather River operations. However, Reclamation and DWR operate the Shasta-Oroville-Folsom coordinated releases pursuant to 2009 NMFS BO RPA Actions 1.2.2C and 1.2.3B. The following two RPA actions for operations in the Sacramento River influence Feather River operations required to meet Delta outflow, X2, or other legal requirements:

- Action I.2.2. (including I.2.2.A–I.2.2.C) November through February Keswick Release Schedule (Fall Actions)
- Action I.2.3. (including I.2.3.A–I.2.3.C) February Forecast; March – May 14 Keswick Release Schedule (Spring Actions).

Under the No Action Alternative, Feather River flows in the high flow channel downstream of Thermalito Dam would be influenced by releases for Fall X2 Delta outflow requirements, regulation to meet water temperature criteria, and to time Lake Oroville releases and Delta export operations as described for the Affected Environment. Flows in the low flow channel downstream of Lake Oroville would remain similar to recent conditions. As part of the ongoing FERC relicensing process for the Oroville facilities, DWR has entered into a Settlement Agreement (DWR 2006) that includes actions to be implemented and included as terms of the anticipated FERC license. Depending on the progress of the relicensing process, these actions could be implemented by 2030 and would change fish habitat conditions in the Feather River relative to recent conditions.

Under the terms of the Settlement Agreement, DWR will develop a comprehensive Lower Feather River Habitat Improvement Plan. The Plan will provide an overall strategy for managing the various environmental measures developed for implementation in the plan area. The following programs and plans will be included in the comprehensive Lower Feather River Habitat Improvement Plan:

1) Gravel Supplementation and Improvement Program
2) Channel Improvement Program
3) Structural Habitat Supplementation and Improvement Program
4) Fish Weir Program
5) Riparian and Floodplain Improvement Program including the evaluation of pulse/flood flows
6) Feather River Fish Hatchery Improvement Program
7) Comprehensive Water Quality Monitoring Program
8) Oroville Wildlife Area Management Plan
9) Instream Flow and Temperature Improvement for Anadromous Fish.

Implementation of these programs and plans under the terms of the Settlement Agreement as incorporated into the new license are anticipated to improve habitat conditions and water quality for salmonids and other fishes using the channels of the Feather River above the confluence with the Sacramento River.

*Aquatic Habitat Conditions in the American River from Nimbus Dam to Sacramento River*

As described in the Affected Environment section, Reclamation releases water to the lower American River consistent with flood control requirements; existing water rights; CVP operations; the Lower American River Flow Management Standard flow recommendations developed by Reclamation, the Sacramento Area Water Forum, USFWS, NMFS, DFW, and other interested parties; SWRCB Decision 893 (D-893); and requirements of the 2009 NMFS BO RPA. The following two RPA actions for operations in the Sacramento River influence American River operations required to meet Delta outflow, X2, or other legal requirements:

- Action I.2.2. (including I.2.2.A–I.2.2.C) November through February Keswick Release Schedule (Fall Actions)
- Action I.2.3. (including I.2.3.A–I.2.3.C) February Forecast; March – May 14 Keswick Release Schedule (Spring Actions).

The No Action Alternative includes a variety of 2009 NMFS BO RPA actions or action suites intended to improve conditions for salmonids in the lower American River. These actions individually or in combination could influence conditions in the American River by 2030. These include:

- 2009 NMFS BO RPA Action II.2.1. Lower American River Flow Management
- 2009 NMFS BO RPA Action II.2. Lower American River Temperature Management
- 2009 NMFS BO RPA Action II.3. Structural Improvements
- 2009 NMFS BO RPA Action II.4. Minimize Flow Fluctuation Effects
- 2009 NMFS BO RPA Action II.5. Fish Passage at Nimbus and Folsom dams
- 2009 NMFS BO RPA Action II.6.1. Preparation of Hatchery Genetic Management Plan (HGMP) for Steelhead
- 2009 NMFS BO RPA Action II.6.2. Interim Actions Prior to Submittal of Draft HGMP for Steelhead

Under the No Action Alternative, American River flows would be influenced by releases for Fall X2 Delta outflow requirements, regulation to meet water temperature criteria, and to time Folsom Dam releases and Delta exports. However, by 2030, increasing water demands and the influence of climate change could worsen conditions for fish in the lower American River, particularly for salmonids.

Reclamation releases water from Folsom Lake to implement the flow schedule specified in the American River Flow Management Standard. The flow schedule was developed and implemented prior to issuance of the 2009 NMFS BO (Action II.1) to establish required minimum flows for anadromous salmonids in the lower American River. The flow schedule specifies minimum flows and does not preclude Reclamation from making higher releases at Nimbus Dam. The flow schedule was developed to require more protective minimum flows in the lower American River in consideration of the river's aquatic resources, particularly steelhead and fall-run.

Reclamation manages the Folsom/Nimbus Dam complex and the water temperature control shutters at Folsom Dam to maintain a daily average water temperature of 65°F or lower at Watt Avenue Bridge from May 15 through October 31, to provide suitable conditions for juvenile steelhead rearing in the lower American River. Water temperature is the physical factor with the greatest influence on salmonids in the American River. The inability to maintain suitable water temperatures for all life history stages of steelhead in the American River is a chronic issue because of operational (e.g., Folsom Lake operations to meet Delta water quality objectives and demands and deliveries to M&I users in Placer, El Dorado, and Sacramento County) and structural (e.g., limited reservoir water storage and cold water pool) factors. Under the No Action Alternative, increased water demand and climate change are expected to lead to further reductions in suitable habitat conditions and increased water temperatures.

2009 NMFS BO RPA Action II.3 requires Reclamation to evaluate physical and structural modifications that may improve temperature management capability in the lower American River. Structural improvements to be further evaluated and potentially implemented include: improvements to the Folsom Dam TCD, cold water transport through Lake Natoma, installation of a TCD at El Dorado Irrigation District's intake or its functional equivalent, and improved temperature management decision-support tools. If one or more of these actions are implemented by 2030, they could increase the likelihood that water temperatures would be suitable for steelhead more frequently.

2009 NMFS BO RPA Action II.4 addresses stranding and isolation of juvenile steelhead through implementation of flow ramping protocols. Implementation of this action, including the continued monitoring for stranding and isolation of salmonids in conjunction with flow fluctuations under the No Action Alternative, could help to better predict the potential for steelhead redd dewatering and isolation, fry stranding, and fry and juvenile isolation and to potentially avoid adverse effects to salmonids.

As described above, temperature-related effects are likely during some years under the No Action Alternative. Because of these unavoidable effects, RPA Action II.5 requires Reclamation to evaluate options for providing steelhead access their historic cold water habitat above Nimbus and Folsom dams and to provide access if feasible.

Under the No Action Alternative, 2009 NMFS BO RPA Action Suite II.6, which addresses project effects related to the Nimbus Fish Hatchery related to introgression of out-of-basin hatchery stock with wild steelhead populations in the Central Valley, would be implemented. Implementation of an HGMP prior to 2030 should minimize the effects of the ongoing steelhead hatchery program on the Central Valley steelhead DPS.

Implementation of the HGMP also would reduce operational effects on Killer Whale prey over the long term by improving the genetic diversity and diversity of run timing of Central Valley fall-run Chinook Salmon, decreasing the potential for localized prey depletions and increasing the likelihood that fall-run Chinook Salmon could withstand stochastic events, such as poor ocean conditions. By 2030, implementation of this action could begin to contribute to a more consistent food source for Killer Whales, even in years with overall poor Chinook Salmon productivity.

*Aquatic Habitat Conditions in the San Joaquin River from Friant Dam to the Stanislaus River*

Under the No Action Alternative, operations at Friant Dam would remain similar to those described under the Affected Environment. Therefore, fish and aquatic habitat conditions in the San Joaquin River downstream of Friant Dam would remain similar to those described under the Affected Environment, although water temperatures could increase as a result climate change.

*Aquatic Habitat Conditions in the Stanislaus River from Goodwin Dam to San Joaquin River*

Under the No Action Alternative, flow, water temperature, and aquatic habitat conditions in the Stanislaus River downstream of Goodwin Dam would continue to be influenced by CVP operations as described in Chapter 5, Surface Water

Resources and Water Supplies. Flows in the lower Stanislaus River are primarily controlled by releases from New Melones Lake. Water released from New Melones Dam and Powerplant is re-regulated at Tulloch Reservoir and is either diverted at Goodwin Dam or released from Goodwin Dam to the lower Stanislaus River.

The No Action Alternative includes a variety of 2009 NMFS BO RPA actions or action suites intended to improve conditions for salmonids in the Stanislaus River. These actions individually or in combination could influence conditions in the Stanislaus River by 2030. These include:

- 2009 NMFS BO RPA Action III.1.1. Establish Stanislaus Operations Group (SOG) for real-time operational decision-making
- 2009 NMFS BO RPA Action III.1.2. Provide cold water releases to maintain suitable steelhead temperatures
- 2009 NMFS BO RPA Action III.1.3. Operate the East Side Division dams to meet minimum flows
- 2009 NMFS BO RPA Action Suite III.2. Stanislaus River CV Steelhead Habitat Restoration
  - 2009 NMFS BO RPA Action III.2.1. Increase and improve quality of spawning habitat with addition of gravel
  - 2009 NMFS BO RPA Action III.2.2. Conduct floodplain restoration and inundation flows in winter or spring to inundate steelhead juvenile rearing habitat
  - 2009 NMFS BO RPA Action III.2.3. Restore freshwater migratory habitat for juvenile steelhead
  - 2009 NMFS BO RPA Action III.2.4. Evaluate Fish Passage at New Melones, Tulloch, and Goodwin dams

Under the No Action Alternative, Stanislaus River flows would be influenced by regulations to meet water quality and flow criteria. However, by 2030, conditions for fish, particularly salmonids, in the Stanislaus River fish are expected to worsen because of increased temperatures due to the influence of climate change.

In accordance with 2009 NMFS BO RPA Action III.1.1, Reclamation has convened a Stanislaus Operations Group (SOG) to provide a forum for real-time operational flexibility implementation of the actions defined in the 2009 NMFS BO RPA. This group includes representatives from Reclamation, NMFS, USFWS, DWR, CDFW, SWRCB, and outside expertise at the discretion of NMFS and Reclamation. The SOG provides direction and oversight to ensure that the East Side Division actions are implemented, monitored for effectiveness and evaluated.

Under the No Action Alternative, Reclamation will continue, where feasible, to manage the cold water supply within New Melones Reservoir as described in 2009 NMFS BO RPA Action III.1.2. The objective of these temperature criteria is to provide suitable temperatures for Central Valley steelhead rearing, spawning, egg incubation, smoltification, and adult migration in the Stanislaus River downstream of Goodwin Dam. There are no temperature control devices at New Melones, Goodwin, or Tulloch dams; thus, temperature management flexibility is limited to storage and flow management under certain conditions. Access to resources to offset operational temperature effects on steelhead in the Stanislaus River will continue to be limited, particularly in Conference Years and in drier Mid-Allocation Years. Under the No Action Alternative, steelhead would continue to be vulnerable to elevated temperatures in dry and critical dry years, even if actions are taken to improve temperature management. The frequency of these occurrences is expected to increase with climate change-related temperature increases.

Under the No Action Alternative, Reclamation would continue to meet the minimum flow schedule, to the best of their ability, as described in 2009 NMFS BO RPA Action III.1.3. The objective of the minimum flow schedule is to maintain minimum base flows to provide habitat for all life history stages of steelhead and to incorporate habitat maintaining geomorphic flows in a flow pattern that would provide migratory cues to smolts and facilitate out-migrant smolt movement. The flow schedule specifies minimum flows and does not preclude higher releases for other operational criteria. However, due to limited availability of water under the CVP water rights, it would be difficult to fully implement this action. Therefore, habitat conditions for steelhead and other fish species in the Stanislaus River would be similar or reduced relative to recent conditions in the near term. The value of this habitat also may be adversely influenced by higher temperatures associated with climate change.

Ongoing implementation of 2009 NMFS BO RPA Action Suite III.2 through 2030 is anticipated to improve the physical habitat conditions for steelhead, although climate change may affect the types and cover rates of vegetation upslope of the river, and potentially increase the rate of fine sediment transport to the river and to spawning areas.

RPA Action III.2.4 requires Reclamation to evaluate options for providing steelhead access to their historic cold water habitat upstream of New Melones, Tulloch, and Goodwin dams and to provide access if feasible. As described above, temperature-related effects will be unavoidable in some years under the No Action Alternative. Lindley et al. (2007) identified the need for upstream habitat for salmonids, given predicted climate change in the next century. This may be particularly relevant for steelhead and salmon in the Stanislaus River where Goodwin Dam blocks all access to historical spawning and rearing habitat and where the remaining population survives as a result of dam operations in downstream reaches that were historically unsuitable habitat because of high summertime temperatures. To the extent that preliminary fish passage efforts are underway by 2030, this could improve conditions for Stanislaus River salmonids.

*Aquatic Habitat Conditions in the Yolo Bypass (including Cache Slough, Lower Putah Creek, and Fremont Weir)*

As described in Chapter 5, Surface Water Resources and Water Supplies, climate change would increase the frequency of high flow events that would result in flows into the Yolo Bypass by 2030 as compared to recent historical conditions. Implementation of the operable gates at the Fremont Weir also would increase the frequency of flows into the Yolo Bypass.

Under the No Action Alternative, it is assumed that aquatic habitat conditions in the Yolo Bypass would improve by 2030 as a result of the following 2009 NMFS BO RPA actions:

- 2009 NMFS BO RPA Action I.6.1. Restoration of Floodplain Rearing Habitat.
- 2009 NMFS BO RPA Action I.6.2. Near-Term Actions at Liberty Island/Lower Cache Slough and Lower Yolo Bypass.
- 2009 NMFS BO RPA Action I.6.3. Lower Putah Creek Enhancements.
- 2009 NMFS BO RPA Action I.6.4. Improvements to Lisbon Weir.
- 2009 NMFS BO RPA Action I.7. Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass

Under the No Action Alternative, it is assumed that the elements of 2009 NMFS BO RPA Action Suite I.6.1 would be implemented in the Yolo Bypass, including up to 20,000 acres of shallow, low-velocity inundated floodplain. Actions in the Yolo Bypass also would include improvements in fish passage at Fremont Weir for anadromous salmonids, sturgeon, and other native fish species.

Passage at Fremont Weir would be facilitated by correcting a variety of passage issues within the bypass, including modification of agricultural structures in the northern Tule Canal that impede flow and cause fish passage delays. Modification of these structures under the No Action Alternative could substantially reduce fish passage delays through the Tule Canal. Similarly, replacement or modification of Lisbon Weir could allow unimpeded fish passage, reduced maintenance of the weir, and at the same time be managed to impound water for agriculture. In addition, the Knights Landing Ridge Cut could be modified to provide an exit path for upstream-migrating fish. These actions, along with the grading of downstream channels to improve connectivity to the Tule Canal when water levels fall as inundations recede and provide exit points for fish that would otherwise be stranded when inundations recede, are expected to improve conditions for salmonid rearing and fish passage by 2030.

Implementation of these ecosystem restoration actions and improvements under the No Action Alternative could increase growth and survival of juvenile Chinook Salmon, steelhead, and other native fish by providing increased seasonal access to productive foraging and high quality rearing habitat, depending on the extent and duration of restoration and inundation. These actions may also reduce migratory delays or losses by reducing predation, straying, and delays for salmonids and other migratory native fish species.

*Aquatic Habitat Conditions in the Delta*

Under the No Action Alternative, flows, water quality, and aquatic habitat conditions in the Delta would continue to be influenced by CVP and SWP operations as described in Chapter 5, Surface Water Resources and Water Supplies and Chapter 6, Surface Water Quality. Overall, long-term average CVP and SWP water supply deliveries in 2030 through the Delta would decline as compared to historical long-term average deliveries. Because entrainment of fish in the Delta export facilities is related to the amount of water exported, entrainment would decline relative to recent conditions as a result of reduced water supply delivery.

Under the No Action Alternative, climate change is anticipated to have more of an effect on Delta flows during wetter years than during drier years because CVP and SWP operations occur with more flexibility during wet years, within the constraints of flood control requirements, compared to drier years when the CVP and SWP operations may be more frequently constrained to maintain instream flows and other environmental objectives. Overall, it is anticipated that due to climate change, sea level rise, and increased water demands in the Sacramento Valley, there would be less CVP and SWP water available for export in the Delta and CVP and SWP exports would decline. The reduction in Delta exports would result in more positive OMR flows by 2030 as compared to recent historical conditions. In other words, it is expected that fish in the channels surrounding the CVP and SWP projects will be exposed to lower entrainment risks than under recent historical conditions as a result of changes in operation due to factors described above (i.e., climate change, sea level rise, and increased water demands in the Sacramento Valley) climate change by 2030.

The No Action Alternative includes a variety of RPA actions or action suites from both the USFWS and NMFS biological opinions intended to improve conditions in the Delta for Delta Smelt, Longfin Smelt, salmonids and sturgeon. These actions individually or in combination could influence aquatic habitat conditions in the Delta by 2030. These include:

- 2008 USFWS BO RPA Component 1 (Actions 1 and 2). Protection of the Adult Delta Smelt Life Stage.
- 2008 USFWS BO RPA Component 2 (Actions 3 and 5). Protection of Larval and Juvenile Delta Smelt.
- 2008 USFWS BO RPA Component 3 (Action 4). Improve Habitat for Delta Smelt Growth and Rearing (Fall X2).
- 2008 USFWS BO RPA Component 4 (Action 6). Habitat Restoration.
- 2009 NMFS BO RPA Action Suite IV.1. Modify DCC gate operations and evaluate methods to control access to Georgiana Slough and the Interior Delta

to reduce diversion of listed fish from the Sacramento River into the southern or central Delta.

- 2009 NMFS BO RPA Action Suite IV.2. Control the net negative flows toward the export pumps in Old and Middle rivers to reduce the likelihood that fish will be diverted from the San Joaquin or Sacramento River into the southern or central Delta.
- 2009 NMFS BO RPA Action IV.3. Curtail exports when protected fish are observed near the export facilities to reduce mortality from entrainment and salvage.
- 2009 NMFS BO RPA Action Suite IV.4. Improve fish screening and salvage operations to reduce mortality from entrainment and salvage.

Component 1 of the 2008 USFWS BO RPA is designed to reduce entrainment of pre-spawning adult Delta Smelt during December to March by controlling OMR flows during vulnerable periods, including adaptive management of OMR flows based on input and guidance from the Smelt Working Group to further reduce entrainment. Action 1 is designed to protect upmigrating Delta Smelt and Action 2 is designed to protect adult Delta Smelt that have migrated upstream and are residing in the Delta prior to spawning. Overall, RPA Component 1 is expected to increase the suitability of spawning habitat for Delta Smelt by decreasing the amount of Delta habitat affected by export pumping prior to, and during, the critical spawning period.

Component 2 is intended to improve flow conditions in the Central and South Delta such that larval and juvenile Delta Smelt could successfully rear in the Central Delta and move downstream when appropriate. The spring HORB would be installed only if the USFWS determines Delta Smelt entrainment is not a concern.

Implementation of Component 3 of the 2008 USFWS BO RPA requires the provision of sufficient Delta outflow to maintain a monthly average X2 no greater than 74 km in Wet water year types and 81 km in Above Normal water years. The objective of this component is to improve fall habitat for Delta Smelt through increasing Delta outflow during fall. Increases in fall habitat quality and quantity are anticipated to improve conditions for Delta Smelt under the No Action Alternative. However, implementation of this action would result in reduced storage in upstream reservoirs which could adversely affect temperature management in the Sacramento, Feather, and American rivers.

Component 4 of the 2008 USFWS BO RPA is intended to improve conditions for Delta Smelt habitat to supplement the improvements resulting from the flow actions described above. DWR is required to implement a program to create or restore a minimum of 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh. It is assumed under the No Action Alternative that this requirement would be met by the Suisun Marsh Restoration Program and would result in the restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough.

Implementation of the 2008 USFWS BO RPA would increase the likelihood that Delta Smelt habitat conditions and attributes for migration, spawning, recruitment, growth, and survival would be provided under the No Action Alternative. Implementation of actions under the 2008 USFWS BO RPA to restore tidally influenced habitat also is expected to increase salmonid and sturgeon rearing habitat and potentially food production for salmonids and Delta Smelt. Depending on the amount and type of restoration that would occur in brackish estuarine areas, restoration could increase rearing habitat for Sacramento Splittail, and alter conditions for predators and non-native fish species. Spawning habitat for roach, Hardhead, Sacramento Splittail, and Delta Smelt could be increased depending on whether restoration occurs in freshwater areas or in brackish estuarine areas. In addition, habitat restoration has the potential to alter habitat conditions for some invasive aquatic macrophyte species during some seasons, and in some locations, which could have indirect effects on predation.

Action Suite IV.1 of the 2009 NMFS BO RPA requires continued funding of monitoring programs at the RBDD, in spring-run Chinook Salmon tributaries to the Sacramento River, on the Sacramento River at Knights Landing and Sacramento, and sites within the Delta. In addition, salvage and loss of juvenile Chinook Salmon would be monitored at the Delta fish collection facilities operated by the CVP and SWP. The DCC gate operations would be modified to reduce loss of emigrating salmonids and green sturgeon. The operating criteria provide for longer periods of gate closures during the outmigration season to reduce direct and indirect mortality of yearling spring-run and winter-run Chinook Salmon, and juvenile steelhead. The closure of the DCC gates would increase the survival of salmonid emigrants through the Delta, and the early closures would reduce loss of fish with unique and valuable life history strategies in the spring-run Chinook Salmon and Central Valley steelhead populations. In addition, a working group, composed of representatives from Reclamation, DWR, NMFS, USFWS, and CDFW, would develop and evaluate engineering solutions to reduce adverse impacts on listed fish and their critical habitat.

Conditions under the No Action Alternative would be influenced by implementation of Action Suite IV.2 of the 2009 NMFS BO RPA. This action suite requires the maintenance of adequate flows in both the Sacramento River and San Joaquin River basins to increase survival of steelhead emigrating to the estuary from the San Joaquin River, and of Chinook Salmon, steelhead, and Green Sturgeon emigrating from the Sacramento River through the Delta to Chipps Island. This action suite includes actions to reduce the vulnerability of emigrating steelhead within the lower San Joaquin River to entrainment into the channels of the South Delta and at the export facilities by increasing the inflow to export ratio. In addition, there are actions to enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the main stem of the San Joaquin River for emigrating fish, including greater net downstream flows. Historical data suggest that high San Joaquin River flows in the spring result in higher survival of outmigrating Chinook Salmon smolts and greater returns of adults. The data also suggest that when the ratio between spring flows and exports increase, Chinook Salmon production increases. Increased flows within the San Joaquin River portion of the Delta could also enhance the survival of Sacramento River salmonids. Those fish from the Sacramento River that have been diverted through the interior Delta to the San Joaquin River could benefit by the increased net flow towards the ocean caused by the higher flows in the San Joaquin River from upstream and the reduced influence of the export pumps.

2009 NMFS BO RPA Action Suite IV.2 also includes flow management for the Old and Middle rivers that would be implemented in conjunction with the restrictions on exports under the 2008 USFWS BO RPA. Old and Middle river flow management is designed to ensure that emigrating steelhead from the San Joaquin Basin and the east-side tributaries remain in the mainstem of the San Joaquin River to the greatest extent possible and reduce their exposure to the adverse effects that are present in the channels leading south toward the export facilities. This is anticipated to increase the likelihood of survival of steelhead emigrating from the San Joaquin River. Reducing the risk of diversion into the central and southern Delta waterways also could increase survival of listed salmonids and Green Sturgeon entering the San Joaquin River via Georgiana Slough and the lower Mokelumne River.

2009 NMFS BO RPA Action IV.3 requires operations of the Tracy and Skinner Fish Collection Facilities to be modified according to monitoring data from upstream of the Delta. In conjunction with the two alerts for closure of the DCC (Action IV.1.1), a third alert would be used to signal that export operations may need to be altered due to large numbers of juvenile Chinook Salmon migrating into the upper Delta region, increasing their risk of entrainment into the central and south Delta and then to the export pumps. When more fish are present, more fish are at risk of diversion and losses would be higher. The third alert is important for real-time operation of the export facilities because the collection and dissemination of field data to the resource agencies and coordination of response actions could take several days. This action is designed to work in concert with the Old and Middle River flow management in action suite IV.2. Under the No Action Alternative, implementation of this action is anticipated to reduce losses of winter-run and spring-run Chinook Salmon, steelhead, and Green Sturgeon by reducing exports when large numbers of juvenile Chinook Salmon are migrating into the upper Delta region.

Action Suite IV.4 of the 2009 NMFS BO RPA is designed to increase the efficiency of the Tracy and Skinner Fish Collection Facilities to improve the overall salvage survival of winter-run and spring-run Chinook Salmon, steelhead, and Green Sturgeon to achieve a 75 percent performance goal for whole facility salvage at both state and Federal facilities. Reclamation and DWR will (1) conduct studies to evaluate current operations and salvage criteria to reduce take associated with salvage, (2) develop new procedures and modifications to improve the current operations, and (3) implement changes to the physical infrastructure of the facilities where information indicates such changes need to be made. In addition, Reclamation would continue to fund and implement the CVPIA Tracy Fish Facility Program. Reclamation and DWR would fund quality control and quality assurance programs, genetic analysis, louver cleaning loss studies, release site studies and predation studies. Funding would also be provided for new studies to estimate Green Sturgeon screening efficiency at both facilities and survival through the trucking and handling process. Under the No Action Alternative, implementation of measures to fund fish screens, reduce pre-screen loss, improve screening efficiency, and improve reporting could reduce entrainment and salvage, and result in improved survival for juvenile Salmonids migrating downstream through the Delta, as well as for Sacramento Splittail, Delta Smelt, and other native fish species.

Abundance and habitat conditions for Delta Smelt and other fish species in the Delta under the No Action Alternative in 2030 are difficult to predict. Abundance levels for Delta Smelt, Longfin Smelt, Striped Bass, Threadfin Shad, and American Shad under recent conditions are very low compared to pre-POD levels, as evidenced by the number of fish collected in sampling programs such as the FMWT surveys conducted by the IEP. Numbers of fish collected have continued to decline in recent years, even with implementation of the RPAs. Annual reviews conducted by the Delta Science Program Independent Review Panel (IRP) for the Long-Term Operations Biological Opinions have called for better metrics to measure the effects of the BO RPAs on the protected species (IRP 2011, 2013, 2014) to allow more informed decision-making, while acknowledging challenges, constraints, and the complexity of the issues.

Currently low levels of relative abundance do not bode well for the Delta Smelt or other fish species in the Delta in 2030. Challenges to fish species in the Delta are many, and would continue in the future under the No Action Alternative, including high water temperatures, reduced flows, habitat degradation, barriers, predation, low DO, contamination, entrainment, salvage, poaching, disease, competition, non-native species, and lack of available food. Use of observations on current conditions to predict future long-term changes for Delta fish is especially challenging when combined with other potentially adverse future changes foreseen for the Delta, e.g., altered hydrology due to drought, rising temperatures, and potential sea level rise (Sommer and Meija, 2013).

#### 9.4.2.2.3 Special Status Species and Critical Habitat

*Clear Creek*

Clear Creek is designated critical habitat for spring-run Chinook Salmon and Central Valley steelhead. The Primary Constituent Element (PCEs) of critical habitat for both species include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Spawning and rearing habitat for spring-run Chinook Salmon in Clear Creek has been negatively affected by flow and water temperature conditions associated with current operations. As described above, it is anticipated minimum flows in Clear Creek would be increased during the fall and winter to improve conditions for spawning salmonids as a result of recently completed IFIM studies. Continuation of spring pulse flows (RPA Action I.1.1) and implementation of channel maintenance flows (RPA Action I.1.2), in conjunction with ongoing gravel augmentation in Clear

Creek, is expected to result in improvements in the PCEs of critical habitat for spring-run Chinook Salmon and steelhead relative to recent conditions.

*Sacramento River*

The Sacramento River provides three of the six PCEs essential to support one or more life stages, including freshwater spawning sites, rearing sites, and migration corridors for winter-run and spring-run Chinook Salmon and steelhead. The Sacramento River is also designated critical habitat for the Southern DPS of Green Sturgeon. Flow and temperature changes under the No Action Alternative and the effects on spawning and rearing habitat quality were described previously.

Climate change is likely to reduce the conservation value of the spawning habitat PCE of critical habitat by increasing water temperatures, which would reduce the availability of suitable spawning habitat. Cold water in Shasta Lake is expected to be depleted sooner in the summer, impacting winter-run and spring-run Chinook Salmon spawning habitat. This reduction in an essential feature of the spawning habitat PCE could reduce the spatial structure, abundance, and productivity of salmonids. Similarly, as described above, climate change is likely to reduce availability of rearing habitat, and in turn, the value of the rearing habitat PCE of critical habitat, by increasing water temperatures.

The year-round opening of the gates at the RBDD in accordance with Action Suite I.3 of the 2009 NMFS BO RPA allows salmonids to pass unimpeded, enhancing the conservation value of the PCE for migration. Critical habitat for Green Sturgeon would also improve from unimpeded access to suitable spawning habitat upstream of the RBDD. The improved passage at the RBDD location is expected to increase the number of deep holding pools that adult Green Sturgeon can access, thereby increasing the conservation value of the water depth PCE. In addition, predation on salmon, steelhead, and sturgeon would be reduced relative to conditions when the RBDD was operational.

*American River*

The lower American River downstream of Nimbus Dam is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat in the lower American River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Flow and temperature changes under the No Action Alternative and the effects on spawning and rearing habitat quality were described previously. In addition, the influence of climate change is expected to alter hydrologic and temperature conditions in the region and could adversely affect the PCEs for Central Valley steelhead critical habitat in the American River, primarily through increased water temperatures.

*Stanislaus River*

The lower Stanislaus River downstream of Goodwin Dam is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat in the Stanislaus River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Flow and temperature changes under the No Action Alternative and the effects on spawning and rearing habitat quality were described previously. The PCEs for spawning and rearing habitat have been adversely affected by elimination of geomorphic processes that replenish and rejuvenate spawning riffles and inundate floodplain terraces to provide nutrients and rearing habitat for juvenile salmonids. In addition, moderation of flood events also eliminates or reduces the intensity and duration of freshets and storm flows, which adversely affects the PCE for migration corridors. The influence of climate change could begin to alter hydrologic and temperature conditions in the region and adversely affect the PCEs for Central Valley steelhead critical habitat in the Stanislaus River, primarily through increased water temperatures.

*Delta*

Critical habitat for both winter-run and spring-run Chinook Salmon is designated in the Sacramento River adjacent to the location of the DCC gates. The DCC is specifically not included in designated critical habitat for winter-run Chinook Salmon because the biological opinions issued by NMFS in 1992 and 1993 included measures on the operations of the gates that were designed to exclude winter-run Chinook Salmon from the channel and the waters of the Central Delta. However, for spring-run Chinook Salmon, designated critical habitat does include the DCC from its point of origin on the Sacramento River to its terminus at Snodgrass Slough, including the location of the gates. Designated critical habitat for Central Valley steelhead includes most of the Delta and its waterways, but not the DCC waterway.

Operation of the DCC gates affects the PCEs for critical habitat designated for these species. Primarily, DCC gate operations interfere with the use of the Sacramento River as a migratory corridor for Chinook Salmon and steelhead juveniles during their downstream migration from spawning grounds upstream of the Delta to San Francisco Bay and the Pacific Ocean. The operation of the gates permits fish to enter habitat and waterways they would not normally access, with substantially higher predation risks than the migratory corridor available in the Sacramento River channel. Under the No Action Alternative, operation of the gates could have a direct effect on the entrainment rate and hence the functioning of the Sacramento River as a migratory corridor.

#### 9.4.2.2.4 Effects Related to Cross Delta Water Transfers

Because all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts associated with changes in reservoir storage and river flow patterns. Potential effects to aquatic resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects were identified as changes to fish in the reservoirs and in the rivers downstream of the reservoirs and the Delta. The analysis indicated that the reservoirs did not support primary populations of fish species of management concern, and that the reservoirs would continue to be operated within the historical range of operations. The analysis also indicated that mean monthly flows in the major rivers or creeks in the Sacramento and San Joaquin rivers watersheds would be similar (less than 10 percent change) with water transfers as compared to without water transfers; and therefore, changes to aquatic resources would be less than substantial. Delta conditions also would be similar with water transfers as compared to without water transfers, including less than 5 percent changes in Delta exports and less than 1.3 percent changes in Delta outflow and X2 position. Therefore, changes to aquatic resources would be less than substantial. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under the No Action Alternative and the Second Basis of Comparison.

Under the No Action Alternative, the timing of cross Delta water transfers would be limited to July through September in accordance with the 2008 USFWS BO and 2009 NMFS BO. The maximum amount of water to be transferred would be 600,000 acre-feet/year in critical dry years or in dry years following a dry or critical dry year. In all other water year types, the maximum amount of water would be 360,000 acre-feet/year.

#### 9.4.2.2.5 Conditions for Fish Passage

As described in Chapter 3, Description of Alternatives, the No Action Alternative includes a suite of RPA actions intended to examine the reintroduction of salmonids into historical habitats upstream of currently impassable artificial barriers. The actions include consideration for passage of winter-run and spring-run Chinook Salmon, and steelhead above Shasta Dam on the Sacramento River, steelhead above Nimbus and Folsom dams on the American River, and steelhead above Goodwin, Tulloch, and New Melones dams on the Stanislaus River. The action suite outlines multiple planning and implementation steps to evaluate the efficacy of passage before long-term fish passage is provided. However, for the purposes of the describing the No Action Alternative, fish passage at each of these facilities (likely through interim means) is assumed to be functional by 2030.

As described in the Affected Environment, Reclamation is currently developing near-term and long-term fish passage solutions to provide access by anadromous salmonids to habitat upstream of Shasta Lake (2009 NMFS BO RPA Action I.2.5). The evaluation includes assessments of amount, suitability, and location of potential habitat, potential risks (e.g., predation by resident fish, disease transmission), as well as feasibility of providing upstream and downstream passage. There are approximately 60 mainstem miles and the McCloud River upstream of Shasta Lake. Reclamation (2014c) estimated approximately 9 river-miles of suitable winter-run Chinook Salmon spawning habitat in the upper Sacramento River below Box Canyon Dam, and approximately 12 river-miles of suitable spawning habitat for winter-run Chinook Salmon in the McCloud River below McCloud Dam. By 2030, access to this habitat could not only expand the amount of habitat available for winter-run Chinook Salmon relative to recent conditions, but provide access to areas of temperature refuge at a time when water temperatures in the river downstream of Keswick Dam are anticipated to increase. This could be particularly beneficial as winter-run Chinook Salmon are currently at high risk of extinction. Extinction factors include: winter-run Chinook Salmon is composed of only one population, which has been blocked from all of its historic spawning habitat; the potential for catastrophic risks associated with proximity to Mt. Lassen and the population's dependency on the cold water management of Shasta Lake; and the population has a "high" hatchery influence (Lindley et al. 2007). Combined with improvements on Battle Creek that are expected to support a second population component of winter-run Chinook Salmon, the provision for fish passage upstream of Shasta Dam may support a third population, which is consistent with the NMFS Recovery Plan for this species (NMFS 2014).

Similarly, conditions for steelhead in the American River could be influenced by fish passage at Nimbus and Folsom dams afforded by implementation of 2009 NMFS BO RPA Action II.5. As described in the Affected Environment, water temperature conditions in the lower American River downstream of Nimbus Dam currently present challenges for steelhead, especially rearing juveniles. Under the No Action Alternative, anticipated increases in temperature related to climate change could increase the vulnerability of steelhead to serious effects of elevated temperatures in most years, particularly in dry and critical dry years, even if actions are taken to improve temperature management. The provision of passage to upstream reaches of the American River, including tributaries, would give steelhead access to former spawning and rearing habitat higher in the system where water temperatures are cooler and remain cooler during the summer months. Assuming this action results in fish passage by 2030, conditions for steelhead are expected to improve because of the increased amount of available habitat and the ability to access cooler water temperatures.

Relative to recent conditions, substantial improvements also would be expected for steelhead on the Stanislaus River under the No Action Alternative, if 2009 NMFS BO RPA Action II.2.4 is determined feasible and is implemented by 2030. As described in the Affected Environment, steelhead in the Stanislaus River are exposed to multiple stressors, including high water temperatures during adult immigration, embryo incubation, juvenile rearing, and smolt outmigration. In addition, flow-dependent habitat availability is limited, particularly for the spawning, juvenile rearing, and smolt outmigration life stages. Access to former habitat in upstream areas under the No Action Alternative are anticipated to reduce many of the stressors associated with recent conditions and could provide improved resilience to climate change.

#### 9.4.2.2.6 Ocean Conditions

Operation of the CVP and SWP 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 Sacramento-San Joaquin River and associated tributaries) that enter the Pacific Ocean and become available as a food supply for the whales. The No Action Alternative would not directly affect critical habitat for Killer Whales. However, under the No Action Alternative, production of wild Chinook Salmon could increase with increased area and quality of habitat for Chinook Salmon, as discussed previously. Chinook Salmon from the Central Valley rivers and streams likely represent only a very small proportion of the diet of this Killer Whale population because most of their feeding is on Fraser River and Puget

Sound stocks (Hanson et al. 2010). Therefore, any increase in the population of Chinook Salmon originating from the Central Valley under the No Action Alternative is not expected to substantially influence the Southern Resident Killer Whale population.

#### *9.4.2.3 Second Basis of Comparison*

As described in Chapter 3, Description of Alternatives, the Second Basis of Comparison is based upon:

- Coordinated long-term operation of the CVP and SWP in 2030 without implementation of the 2008 USFWS BO and the 2009 NMFS BO RPAs
- Changes in CVP and SWP operations due to climate change and sea level rise, and increased CVP and water rights water demand in portions of the Sacramento Valley
- Implementation of reasonable and foreseeable non-CVP and -SWP water resources projects to provide additional water supplies, as described in Section 7.4.3.1, No Action Alternative
- Implementation of RPA actions that address programs and projects that were ongoing prior to issuance of the 2008 USFWS BO and 2009 NMFS BO, including restoration of Battle Creek for salmonids; replacement of the Red Bluff Diversion Dam; restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass.

Overall, under the Second Basis of Comparison, long-term average CVP and SWP water supply deliveries by 2030 through the Delta would increase, and late summer and fall reservoir storage probably would decrease as compared to recent historical conditions without consideration for climate change. However, the Second Basis of Comparison also includes changes not related to the coordinated long-term operation of the CVP and SWP, including changes in CVP and SWP operations due to climate change and sea level rise, increased CVP and water rights water demand in portions of the Sacramento Valley, and implementation of reasonable and foreseeable non-CVP or SWP water resources management projects to provide water supplies, as described under the No Action Alternative. Therefore, primarily due to climate change, both CVP and SWP reservoir storage and long-term average CVP and SWP water supply deliveries would decrease by 2030 as compared to historical long-term average deliveries.

Under the Second Basis of Comparison it is assumed that fish and aquatic resources in 2030 would continue to be influenced by CVP and SWP operations. The resulting changes in ecological attributes and subsequent effects on aquatic resources would vary geographically, as described below.

#### 9.4.2.3.1 Trinity River Region

*Aquatic Habitat Conditions in CVP and SWP Reservoirs*

End of September reservoir storage in Trinity Lake would be lower by 2030 as compared to recent historical conditions due to climate change and related lower snowfall. Lewiston Reservoir, a regulating reservoir, would be operated with daily changes similar to historical conditions. These changes are not anticipated to substantially affect aquatic resources in Trinity Lake or Lewiston Reservoir relative to recent historical conditions.

*Fish Habitat Conditions in Trinity and Lower Klamath Rivers*

Under the Second Basis of Comparison, flow, water temperature, and aquatic habitat conditions in the Trinity River would continue to be influenced by CVP and SWP operations as described in the Affected Environment. Due to the increased potential for lower Trinity Lake surface water storage (see above), there could be an increased potential for reduced Trinity River flows during the summer and fall months under the Second Basis of Comparison as compared to recent historical conditions. The influence of climate change could result in higher water temperatures in Trinity Lake that could translate to higher release temperatures in the flow releases from Lewiston Dam and a reduction in habitat quality within the Trinity River for salmonids and other native species.

*Effects Related to Water Transfers*

It is not anticipated that water would be transferred to or from the Trinity River Region. It also not anticipated that water transfers would result in changes to Trinity Lake operations. Therefore, there would be no change in aquatic habitat conditions as a result of water transfers.

#### 9.4.2.3.2 Central Valley Region

*Aquatic Habitat Conditions in CVP and SWP Reservoirs*

Seasonal changes in reservoir surface elevations, storage volumes, and the volume of cold water held within the reservoirs would continue under the Second Basis of Comparison. Conditions for reservoir fishes would continue to change seasonally in response to inflow and downstream flow releases to meet demand. End of September reservoir storage would be lower by 2030 as compared to recent historical conditions in Shasta Lake, Lake Oroville, Folsom Lake, New Melones Reservoir, and San Luis Reservoir due to climate change and related lower snowfall. Whiskeytown Lake, Keswick Reservoir, Thermalito Forebay and Afterbay, and Lake Natoma are regulating reservoirs and would be operated with daily changes similar to historical conditions.

Under the Second Basis of Comparison, the magnitude of changes in seasonal surface elevation and reservoir storage could be slightly more pronounced because of changes in the timing and intensity of storm events due to climate change and an overall reduction in snow pack. By 2030, fish in these reservoirs that spawn in shallow water (e.g., various species of black bass) could be subject to a hydrologic regime that increases the frequency of reductions in surface elevation during the spring spawning period, reducing spawning success. In addition, reduced storage volumes and reduction of the cold water pools could reduce the amount and suitability of habitat for cold water fishes (e.g., trout) within the reservoirs relative to recent historical conditions.

*Aquatic Habitat Conditions in Rivers Downstream of CVP and SWP Facilities*

Surface water flows are anticipated to increase during the winter months as a result of an increase in rainfall and decrease in snowfall, and to decrease in other months because of the diminished snowmelt flows in the spring and early summer months. Climate change is anticipated to result in higher water temperatures during portions of the year, with a corresponding reduction in habitat quality for salmonids and other cold water fishes. Increased downstream water demands and climate change are anticipated to contribute to an inability to maintain an adequate cold water pool in critical dry years and extended dry periods in the future.

*Aquatic Habitat Conditions in Clear Creek from Whiskeytown Dam to Sacramento River*

Under the Second Basis of Comparison, flow, water temperature, and aquatic habitat conditions in Clear Creek would continue to be influenced by CVP and SWP operations. Whiskeytown Reservoir would continue to be operated to convey water from the Trinity River to the Sacramento River via the Spring Creek tunnel and to release flows to Clear Creek to support anadromous fish.

The Second Basis of Comparison assumes that one of the 2009 NMFS BO RPA actions intended to improve conditions for salmonids would be implemented, 2009 NMFS BO RPA Action I.3 Spawning Gravel Augmentation, which is currently being implemented as part of the CVPIA. This action addresses the limited availability of spawning habitat in Clear Creek through the placement of gravel in selected sites in the creek. The gravel augmentation program is expected to continue under the Second Basis of Comparison, resulting in continued improvements to physical spawning habitat for steelhead, and spring-run and fall-run Chinook Salmon by 2030.

Water temperatures in Clear Creek are influenced by the temperature of water in the Whiskeytown Reservoir, ambient air temperatures, and solar radiation, and to some extent the magnitude of Whiskeytown Dam release flows. As described above for the No Action Alternative, Whiskeytown Dam has limited temperature control capabilities; however, the Spring Creek Temperature Control Curtain continues to be operated under the Second Basis of Comparison. With increasing ambient air temperature and changes in precipitation patterns as result of global warming, it may not be possible to meet the temperature targets as often in 2030 under the Second Basis of Comparison relative to recent conditions.

*Aquatic Habitat Conditions in the Sacramento River from Keswick to Freeport*

Under the Second Basis of Comparison, flow, water temperature, and aquatic habitat conditions in the Sacramento River downstream of Keswick Dam would continue to be influenced by CVP and SWP operations. Shasta Lake would continue to be operated to convey water from the Sacramento River to the Delta and release flows to the Sacramento River to support anadromous fish. Reclamation would continue to operate Shasta Lake to optimize use of the cold water pool and maintain carryover storage for temperature control in the Sacramento River downstream of Shasta and Keswick dams. As described above for the No Action Alternative, it is likely that temperature-related effects in the Sacramento River under the Second Basis of Comparison also would be unavoidable in some years; however, restoration of habitat in Battle Creek (see below) may compensate for these periods of unavoidably high temperatures by providing passage and habitat conditions to support a second population of winter-run Chinook Salmon.

The Red Bluff Pumping Plant and fish screen, which diverts water to the Tehama Colusa Canal and Corning Canal, was constructed to allow year-round opening of the gates at the RBDD. Allowing the dam gates at RBDD to remain open allows salmonids, sturgeon, and other fish species to pass unimpeded all year. These passage improvements are anticipated to improve conditions for fish species that spawn upstream of RBDD through improved access to spawning and rearing areas and a reduction in predation due to dispersal of predator species like Striped Bass and Sacramento Pikeminnow.

As described above for the No Action Alternative, it is anticipated that worsening temperature conditions under the Second Basis of Comparison would occur in some years as a result of increased demands for water by 2030, climate change, and less water being diverted from the Trinity River. Continued implementation of the Battle Creek Restoration Program would partially compensate for unavoidable adverse effects by restoring winter-run and spring-run Chinook Salmon habitat to the Battle Creek watershed. Full implementation of the Battle Creek Restoration Program is expected to substantially improve passage conditions for adult Chinook Salmon and steelhead relative to recent conditions. The Battle Creek Restoration Program has a goal of improving habitat for a second population component of winter-run Chinook Salmon, which could reduce the risk of extinction of the species from lost resiliency and increased vulnerability to catastrophic events.

*Aquatic Habitat Conditions in the Feather River from Oroville Dam to Sacramento River*

Feather River flows in the high flow channel downstream of Thermalito Dam under the Second Basis of Comparison would be influenced by regulation to meet water temperature criteria and to coordinate Lake Oroville releases and Delta export operations. Flows in the low flow channel downstream of Lake Oroville would remain similar to recent conditions. As part of the ongoing FERC relicensing process for the Oroville facilities, DWR has entered into a Settlement Agreement (DWR 2006) that includes actions to be implemented and included as terms of the anticipated FERC license. Depending on the progress of the relicensing process, these actions could be implemented by 2030 under the Second Basis of Comparison and could improve fish habitat conditions in the Feather River relative to recent conditions.

Under the terms of the Settlement Agreement, DWR will develop a comprehensive Lower Feather River Habitat Improvement Plan. Implementation of the habitat improvement plan and other actions under the terms of the Settlement Agreement is anticipated to improve habitat conditions and water quality for salmonids and other fishes using the channels of the Feather River above the confluence with the Sacramento River under the Second Basis of Comparison.

*Aquatic Habitat Conditions in the American River from Nimbus Dam to Sacramento River*

Reclamation releases water to the lower American River consistent with flood control requirements; existing water rights; CVP operations; the Lower American River Flow Management Standard; and SWRCB Decision 893 (D-893). Under the Second Basis of Comparison, American River flows would be influenced by releases for regulation to meet water temperature criteria, and to coordinate timed Folsom Lake releases and Delta exports. It is anticipated that conditions for fish in the lower American River under the Second Basis of Comparison would worsen relative to recent past operations of the American River Division of the CVP because of continued operation of the American River Division through 2030 to meet increasing water demands. In addition, the influence of climate change could alter hydrologic conditions in the region and affect habitat conditions for fish in the American River.

Through 2030, Reclamation would implement the flow schedule specified in the American River Flow Management Standard. The flow schedule specifies minimum flows and does not preclude Reclamation from making higher releases at Nimbus Dam. The flow schedule was developed to require more protective minimum flows in the lower American River in consideration of the river's aquatic resources, particularly steelhead and fall-run Chinook Salmon.

*Aquatic Habitat Conditions in the San Joaquin River from Friant Dam to the Stanislaus River*

Under the Second Basis of Comparison, fish and aquatic habitat conditions in the San Joaquin River downstream of Friant Dam would remain similar to those described under the Affected Environment, although water temperatures could increase as a result climate change.

*Aquatic Habitat Conditions in the Stanislaus River from Goodwin Dam to San Joaquin River*

Under the Second Basis of Comparison, flow, water temperature, and aquatic habitat conditions in the Stanislaus River downstream of Goodwin Dam would continue to be influenced by CVP and SWP operations as described in Chapter 5, Surface Water Resources and Water Supplies. However, by 2030, conditions for fish in the Stanislaus River fish are expected to worsen relative to recent conditions because of continued operation to meet increasing water demands. In addition, the influence of climate change is expected to begin to alter hydrologic conditions in the region and affect habitat conditions for fish in the Stanislaus River.

Under the Second Basis of Comparison, management of the cold water supply within New Melones Reservoir would continue, as would cold water releases from the reservoir to provide suitable temperatures for steelhead rearing, spawning, egg incubation smoltification, and adult migration in the Stanislaus River downstream of Goodwin Dam. There are no temperature control devices at New Melones, Goodwin, or Tulloch dams, so the only mechanism for temperature management is direct flow management. This has been achieved in the recent past through a combination of augmenting baseline water operations for meeting senior water right deliveries and D-1641 water quality standards with additional flows from: 1) the CDFW fish agreement, and 2) from b(2) or b(3) water acquisitions. Access to these resources to offset operational temperature effects on steelhead in the Stanislaus River would continue to be limited, particularly in Conference Years and in drier Mid-Allocation Years. Under the Second Basis of Comparison, steelhead would likely continue to be vulnerable to the effects of elevated temperatures in dry and critical dry years. The frequency of these occurrences is expected to increase with climate change and increased water demands.

Reclamation would continue to operate releases from the East Side Division reservoirs to achieve the minimum flow schedule specified in the 1997 New Melones Interim Plan of Operations as described in Chapter 5, Surface Water Resources and Water Supplies. Because this flow schedule has been in place for a number of years, habitat conditions for steelhead and other fish species in the Stanislaus River are not anticipated to improve under the Second Basis of Comparison relative to recent conditions.

Dam operations would continue to suppress channel-forming flows that replenish spawning beds. The physical presence of the dams impedes normal sediment transportation processes. Climate change may affect the types and cover rates of vegetation upslope of the river, potentially increasing the rate of fine sediment transport to the river and to spawning areas Ongoing gravel augmentation through 2030 is anticipated to maintain or improve physical spawning habitat conditions for steelhead.

*Aquatic Habitat Conditions in the Yolo Bypass (including Cache Slough, Lower Putah Creek, and Fremont Weir)*

Similar to the No Action Alternative, it is assumed under the Second Basis of Comparison that restoration of up to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass would occur by 2030. Actions in the Yolo Bypass also would include improvements in fish passage at Fremont Weir for anadromous salmonids, sturgeon, and other native fish species. Implementation of these ecosystem restoration actions and improvements could increase winter and spring growth and survival (relative to recent conditions) of juvenile Chinook Salmon, steelhead, and other native fish by providing increased seasonal access to productive foraging and high quality rearing habitat, depending on the extent and duration of restoration and inundation. These actions are also expected to reduce migratory delays or losses by reducing predation, straying, and delays for salmonids and other migratory native fish species.

*Aquatic Habitat Conditions in the Delta*

As described in Chapter 3, Description of Alternatives, the Second Basis of Comparison is based on coordinated long-term operation of the CVP and SWP in 2030 without implementation of the 2008 USFWS BO and the 2009 NMFS BO RPAs. Similar to the No Action Alternative, reasonable and foreseeable non-CVP and -SWP water resources projects to provide additional water supplies would be implemented, in addition to restoration of more than 10,000 acres of intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough; and up to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass.

Under the Second Basis of Comparison, flows, water quality, and aquatic habitat conditions in the Delta would continue to be influenced by CVP and SWP operations. Climate change would result in increased stream flows in the winter and spring months during storm events due to precipitation primarily occurring as rain instead of snowfall. The increased stream flows also would increase Delta outflow. Delta outflow also would be increased in the spring and summer months as more water is released from the CVP and SWP reservoirs to maintain salinity criteria in the western Delta in response to sea level rise.

Under the Second Basis of Comparison in 2030, many years will have passed without seasonal limitations on OMR reverse (negative) flow rates, with the anticipated result that fish entrainment would occur at levels comparable to recent historical conditions. Future pumping operations would continue to expose fish to the salvage facilities and entrainment losses into the future. Furthermore, operation of the permanent gates would lead to losses associated with predation at the physical structures and the local and far-field hydraulic conditions created by the barriers. Under the Second Basis of Comparison, significant reductions in the abundance of steelhead and fall-run Chinook Salmon originating in the San Joaquin River basin, (as well as the Calaveras River and Mokelumne River basins) are likely to continue.

As described above for the No Action Alternative, abundance levels for Delta Smelt, Longfin Smelt, Striped Bass, Threadfin Shad, and American Shad are currently very low, and abundance and habitat conditions for fish in the Delta in future years are difficult to predict. It is not likely that operations of the CVP and SWP under the Second Basis of Comparison would result in improvement of habitat conditions in the Delta or increases in populations for these fish by 2030, and the recent trajectory of loss would likely continue.

#### 9.4.2.3.3 Special Status Species and Critical Habitat

*Clear Creek*

Clear Creek is designated critical habitat for spring-run Chinook Salmon and Central Valley steelhead. The PCEs of critical habitat for both species include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Spawning and rearing habitat for spring-run Chinook Salmon in Clear Creek has been negatively affected by flow and water temperature conditions associated with current operations. Under the Second Basis of Comparison, there would be little change in the PCEs of critical habitat for spring-run Chinook

Salmon and Central Valley steelhead relative to recent conditions. Ongoing gravel augmentation in Clear Creek will likely result in improvements to Chinook Salmon and steelhead physical spawning habitat in Clear Creek. However, due to climate change, the conservation value of critical habitat for these species will likely be reduced under the Second Basis of Comparison by 2030, particularly in drier years when cold water releases cannot be maintained from Whiskeytown Dam.

*Sacramento River*

The Sacramento River provides three of the six PCEs essential to support one or more life stages, including freshwater spawning sites, rearing sites, and migration corridors for winter-run Chinook Salmon, spring-run Chinook Salmon, and Central Valley steelhead. The Sacramento River is also designated critical habitat for the Southern DPS of green sturgeon. Flow and temperature changes under the Second Basis of Comparison and the effects on spawning and rearing habitat quality were described previously.

As described above for the No Action Alternative, climate change is likely to reduce the conservation value of the spawning and rearing habitat PCEs of critical habitat by increasing water temperatures. The reduction in essential features of the spawning and rearing habitat PCEs could reduce the spatial structure, abundance, and productivity of salmonids.

The year-round opening of the gates at the RBDD allows salmonids to pass unimpeded, enhancing the conservation value of the PCE for migration. Critical habitat for green Sturgeon would also improve from unimpeded access to suitable spawning habitat upstream of the RBDD. The improved passage at the RBDD will increase the number of deep holding pools that adult Green Sturgeon can access, thereby increasing the conservation value of the water depth PCE. In addition, as described above, predation on salmon, steelhead, and sturgeon would be reduced relative to recent conditions when the RBDD was operational.

The No Action Alternative includes implementation of the CVPIA AFSP to reduce entrainment of juvenile anadromous fish from unscreened diversions. By providing funding to screen priority diversions as identified in the CVPIA AFSP, the loss of listed fish in water diversion channels by 2030 could be reduced. In addition, if new fish screens can be constructed so that diversions can occur at low water surface elevations to allow diversions below a flow of 5,000 cfs at Wilkins Slough, then cold water at Shasta Lake could be conserved during critical dry years for release to support winter-run and spring-run Chinook Salmon needs downstream.

*American River*

The lower American River downstream of Nimbus Dam is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat in the lower American River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Flow and temperature changes under the Second Basis of Comparison and the effects on spawning and rearing habitat quality were described previously. In addition, the influence of climate change is expected to alter hydrologic and temperature conditions in the region and adversely affect the PCEs for Central Valley steelhead critical habitat in the American River, primarily through increased water temperatures.

*Stanislaus River*

The lower Stanislaus River downstream of Goodwin Dam is designated critical habitat for Central Valley steelhead. The PCEs of critical habitat in the Stanislaus River include freshwater spawning sites, freshwater rearing areas, and freshwater migration corridors. Flow and temperature changes under the Second Basis of Comparison and the effects on spawning and rearing habitat quality were described previously. The PCEs for spawning and rearing habitat have been adversely affected by elimination of geomorphic processes that replenish and rejuvenate spawning riffles and inundate floodplain terraces to provide nutrients and rearing habitat for juvenile salmonids. In addition, moderation of flood events also eliminates or reduces the intensity and duration of freshets and storm flows, which adversely affects the PCE for migration corridors. The influence of climate change could begin to alter hydrologic and temperature conditions in the region and adversely affect the PCEs for Central Valley steelhead critical habitat in the Stanislaus River, primarily through increased water temperatures.

*Delta*

As described above for the No Action Alternative, designated critical habitat for both winter-run and spring-run Chinook Salmon lies adjacent to the location of the DCC gates and designated critical habitat for spring-run Chinook Salmon includes the DCC from its point of origin on the Sacramento River to its terminus at Snodgrass Slough. Designated critical habitat for Central Valley steelhead includes most of the Delta and its waterways; however, the DCC waterway was not included in designated critical habitat for this species.

Operation of the DCC gates under the Second Basis of Comparison will continue to affect the PCEs for critical habitat designated for spring-run Chinook Salmon and steelhead, primarily, the use of the Sacramento River as a migratory corridor. The operation of the gates permits fish to enter habitat and waterways they would not normally have access to with substantially higher predation risks than the migratory corridor available in the Sacramento River channel. Operation of the gates can have a direct effect on the entrainment rate and hence the functioning of the Sacramento River as a migratory corridor. Without the modifications to DCC gate operations to reduce loss of emigrating salmonids and green sturgeon described for the No Action Alternative, entrainment in the DCC will continue to be similar to recent historical conditions.

#### 9.4.2.3.4 Effects Related to Cross Delta Water Transfers

As described under the No Action Alternative, all water transfers would be required to avoid adverse impacts to other water users and biological resources (see Section 3.A.6.3, Transfers), including impacts associated with changes in reservoir storage and river flow patterns. Potential effects to aquatic resources could be similar to those identified in a recent environmental analysis conducted by Reclamation for long-term water transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d). Potential effects were identified as changes to fish in the reservoirs and in the rivers downstream of the reservoirs and the Delta. The analysis indicated that the reservoirs did not support primary populations of fish species of management concern, and that the reservoirs would continue to be operated within the historical range of operations. The analysis also indicated that mean monthly flows in the major rivers or creeks in the Sacramento and San Joaquin rivers watersheds would be similar (less than 10 percent change) with water transfers as compared to without water transfers; and therefore, changes to aquatic resources would be less than substantial. Delta conditions also would be similar with water transfers as compared to without water transfers, including less than 5 percent changes in Delta exports and less than 1.3 percent changes in Delta outflow and X2 position. Therefore, changes to aquatic resources would be less than substantial. For the purposes of this EIS, it is anticipated that similar conditions would occur due to cross Delta water transfers under the No Action Alternative and the Second Basis of Comparison.

Under the Second Basis of Comparison, water transfers could occur throughout the year depending upon limitations of available conveyance capacity and regulatory requirements.

#### 9.4.2.3.5 Conditions for Fish Passage

Conditions for fish passage at Shasta, Folsom, and New Melones dams under the Second Basis of Comparison would be the same as described in the Affected Environment because passage of fish to river reaches above these dams would not be provided. Populations of anadromous fish under the Second Basis of Comparison would continue to be restricted to the river reaches downstream of these dams and subjected to increasing water temperatures associated primarily with climate change.

#### 9.4.2.3.6 Ocean Conditions

Conditions for the Southern Resident Killer Whale under the Second Basis of Comparison would differ from those for the No Action Alternative, but the effects on Killer Whales would be the same.

## 9.4.3 Evaluation of Alternatives

Alternatives 1 through 5 have been compared to the No Action Alternative; and the No Action Alternative and Alternatives 1 through 5 have been compared to the Second Basis of Comparison.

### *9.4.3.1 No Action Alternative Compared to the Second Basis of Comparison*

The No Action Alternative is compared to the Second Basis of Comparison.

#### 9.4.3.1.1 Trinity River Region

*Coho Salmon*

The analysis of effects associated with changes in operation on Coho Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam for Coho Salmon.

Long term average monthly water temperatures in the Trinity River at Lewiston Dam under No Action Alternative generally would be similar to, although slightly higher (up to 0.4°F) than the temperatures that would occur under the Second Basis of Comparison (Appendix 6B, Table B-1-4). Average monthly temperatures generally would be slightly higher during November through February under the No Action Alternative, with the exception of critical years when temperatures under the No Action Alternative could be as much as 2.4°F cooler (November) and in December when water temperatures could be as much as 1.5°F warmer in below normal years (Appendix 6B, Table B-1-4). Average monthly water temperatures generally would be slightly (less than 0.5°F) higher under the No Action Alternative during July through September, except in wet years and critical years in September when temperatures would be slightly lower (0.6°F and 0.3°F, respectively).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor and likely would have little effect on Coho Salmon in the Trinity River. The substantially lower water temperatures in November of critical dry years (and higher temperatures in December) under the No Action Alternative would likely have little effect on Coho Salmon as water temperatures in the Trinity River are typically low during this time period.

The USFWS established a water temperature threshold of 56°F for Coho Salmon spawning in the reach of the Trinity River from Lewiston Dam to the confluence with the North Fork Trinity River from October through December. Although not entirely reflective of water temperatures throughout the reach, the temperature model provides average monthly water temperature outputs for releases from Lewiston Dam, which may provide perspective on temperature conditions in the reach. In October and November, average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison would exceed 56°F at Lewiston Dam in some years (Appendix 9N). Under the No Action Alternative, the threshold would be exceeded about 8 percent of the time in October, about 1 percent more frequently than under the Second Basis of Comparison. In November, both conditions would result in an exceedance frequency of about 2 percent. There would be no exceedance of the threshold in December under both the No Action Alternative and the Second Basis of Comparison.

Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be slightly more frequent (1 percent) under the No Action Alternative. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the Coho Salmon population in the Trinity River.

*Spring-run Chinook Salmon*

As described above for Coho Salmon, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Trinity River (Appendix 6B). The substantially lower water temperatures in November of critical dry years (and higher temperatures in December) under the No Action Alternative would likely have little effect on spring-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

Under both the No Action Alternative and the Second Basis of Comparison, average monthly water temperatures in the Trinity River at Lewiston Dam would infrequently (1 percent to 2 percent of the time) exceed 60°F (Appendix 9N), the threshold for spring-run Chinook Salmon holding. There would be no difference in the frequency of exceedance of the 60°F threshold under the No Action Alternative as compared to the Second Basis of Comparison. In September, however, the threshold for spawning (56°F) would be exceeded under the No Action Alternative 9 percent of the time, which is 2 percent less frequently than under the Second Basis of Comparison (11 percent).

The differences in the frequency of threshold exceedance between the No Action Alternative and Second Basis of Comparison would be relatively minor, although temperature conditions under the No Action Alternative could be slightly less likely to affect spring-run Chinook Salmon spawning than under the Second Basis of Comparison because of the slightly reduced frequency of exceedance of the 56°F threshold at Lewiston Dam in September. The biological significance of this difference, however, is uncertain.

Overall, water temperature could have adverse effects on spring-run Chinook Salmon in the Trinity River; however, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures under the No Action Alternative as compared to the Second Basis of Comparison. Thus, given these relatively minor changes in temperature and temperature threshold exceedance, and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the No Action Alternative is likely to have similar effects on the spring-run Chinook Salmon population in the Trinity River as compared to the Second Basis of Comparison.

*Fall-Run Chinook Salmon*

The potential effects of operations on fall-run Chinook Salmon were evaluated based on water temperature differences and threshold comparisons as described above for Coho and spring-run Chinook Salmon. In addition, the Reclamation Salmon Mortality Model (Appendix 9C) was applied to examine the anticipated effects of temperature on egg mortality.

The temperature differences at in the Trinity River at Lewiston Dam between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) (Appendix 6B) and likely would have little effect on fall-run Chinook Salmon. The substantially lower water temperatures in November of critical years (and higher temperatures in December) under the No Action Alternative would likely have little effect on fall-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold and months during which it applies for fall-run Chinook Salmon are the same as those for Coho Salmon. Under the No Action Alternative, the threshold would be exceeded about 8 percent of the time in October, about 1 percent more frequently than under the Second Basis of Comparison. In November, both conditions would result in an exceedance frequency of about 2 percent. There would be no exceedance of the threshold in December under either the No Action Alternative or the Second Basis of Comparison.

The water temperatures in the Trinity River downstream of Lewiston Dam are reflected in the analysis the Reclamation Salmon Mortality Model. For fall-run Chinook Salmon in the Trinity River, the long-term average egg mortality rate is predicted to be relatively low (around 4 percent), with higher mortality rates (nearly 15 percent) occurring in critical years under the No Action Alternative. The predicted long-term average egg mortality would be about 0.2 percent higher under the No Action Alternative than under the Second Basis of Comparison; in critical years the average egg mortality rate would be 1.8 percent greater under the No Action Alternative than under the Second Basis of Comparison and in wet years it would be 0.6 percent lower under the No Action Alternative (Appendix 9C, Table B-1-1). Overall, egg mortality under the No Action Alternative and the Second Basis of Comparison would be similar.

In summary, the temperature threshold exceedance suggests that temperature conditions under the No Action Alternative could be slightly more likely to affect fall-run Chinook Salmon spawning than under the Second Basis of Comparison because of the slightly increased frequency of exceedance of the 56°F threshold at Lewiston Dam in October and the slightly greater egg mortality. However, this would occur prior to the peak spawning period for fall-run Chinook Salmon.

Although the combined analysis based on water temperature suggests that operations under the No Action Alternative could be slightly more adverse than under the Second Basis of Comparison, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures (as well as egg mortality) between the No Action Alternative as compared to the Second Basis of Comparison. Overall, given these small differences and the inherent uncertainty in the temperature model, the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River.

*Steelhead*

The temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) (Appendix 6B) and likely would have little effect on steelhead in the Trinity River. The substantially lower water temperatures in November of critical years (and higher temperatures in December) under the No Action Alternative would likely have little effect on steelhead as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold for spawning in months during which it applies for steelhead are the same as those for Coho Salmon. Thus, the frequency of average monthly water temperatures in the Trinity River at Lewiston Dam exceeding the spawning threshold of 56°F for steelhead would be the same as those described above for Coho Salmon. Overall, the differences in the frequency of threshold exceedance between the No Action Alternative and Second Basis of Comparison would be relatively minor and are unlikely to affect steelhead spawning in the Trinity River.

Although the water temperature and flow changes could have adverse effects on steelhead in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures under the No Action Alternative as compared to the Second Basis of Comparison.

Overall, the No Action Alternative is likely to have similar effects on the steelhead population in the Trinity River as compared to the Second Basis of Comparison.

*Green Sturgeon*

As described in the Affected Environment and species accounts (Appendix 9B) Green Sturgeon spawn in the lower reaches of the Trinity River during April through June, and water temperatures above about 63°F are believed stressful to embryos (Van Eenennaam et al. 2005). Average monthly water temperature conditions during April through June in the Trinity River at Lewiston Dam under the No Action Alternative would be similar to temperatures under the Second Basis of Comparison and would not exceed 58°F during this period (Appendix 6B). In addition, water temperatures in the reach of the river where Green Sturgeon spawn are likely controlled by other factors (e.g., ambient air temperatures and tributary inflows) more than water operations at Trinity and Lewiston dams.

Overall, given the similarities between average monthly water temperatures at Lewiston Dam under the No Action Alternative and the Second Basis of Comparison, it is likely that temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar under both scenarios.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes in Trinity Lake 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 the No Action Alternative as compared to the Second Basis of Comparison would result in lower reservoir storage in Trinity Lake. Storage in Trinity Lake could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. Using storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs, the amount of habitat for reservoir fishes could be reduced under the No Action Alternative as compared to the Second Basis of Comparison.

As shown in Appendix 9F, bass nest survival in Trinity Lake is near 100 percent in March and April in response to increasing reservoir elevations. For May, the likelihood of survival for Largemouth Bass in Trinity Lake being in the 40 to 100 percent range is slightly (about 1-2 percent) lower under the No Action Alternative as compared to the Second Basis of Comparison. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass is lower than in May and is slightly (about 3 percent) higher under the No Action Alternative than the Second Basis of Comparison. For Spotted Bass, the likelihood of survival being greater than 40 percent is 100 percent in May and June under both the No Action Alternative and the Second Basis of Comparison.

Overall, the comparison of storage and the analysis of nesting suggest that effects of the No Action Alternative on reservoir fishes would be similar to those under the Second Basis of Comparison.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Trinity River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles. On average, the temperature of water released at Lewiston Dam under the No Action Alternative would be similar to (within 0.5°F) water temperatures under the Second Basis of Comparison. Changes in CVP water supplies and operations under the No Action Alternative would result in lower reservoir storage in Trinity Lake and somewhat reduced Trinity River flows in December through February in wetter years as compared to the Second Basis of Comparison. The highest reductions in flow would be less than 10 percent in the Trinity River (Appendix 5A), with a smaller relative reduction in the lower Klamath River and Klamath River estuary.

Given the somewhat reduced flows and similar temperatures, it is likely that the No Action Alternative would have a similar potential to affect Pacific Lamprey in the Trinity River as the Second Basis of Comparison. This conclusion likely applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).

*Eulachon*

As described in the Affected Environment, the last noticeable runs of Eulachon were observed in 1988 and 1989 by Yurok tribal fishers. It is unclear whether this species has been extirpated from the Klamath River. Given that the highest reductions in flow would be less than 10 percent in the Trinity River, which would represent even a smaller proportion in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River are unlikely to be affected by changes upstream at Lewiston Dam, it is likely that the No Action Alternative would have a similar potential to influence Eulachon in the Klamath River as would the Second Basis of Comparison.

### 9.4.3.1.2 Sacramento River System

*Winter-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years (Appendix 6B, Table B-5-4). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures progressively decreasing (up to a 2.8°F difference at Bend Bridge) in September during the wetter years under the No Action Alternative (Appendix 6B, Table B-8-4).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on winter-run Chinook Salmon in the Sacramento River. Spawning for winter-run Chinook Salmon in the Sacramento River takes place from mid-April to mid-August with incubation occurring over the same time period and extending into October. The somewhat higher water temperatures in September and October or critical dry years under the No Action Alternative could increase the likelihood of adverse effects on winter-run Chinook Salmon egg incubation during this water year type. However, the reduced water temperatures during this time period under the No Action Alternative in wetter years could reduce the likelihood of adverse effects on egg incubation relative to the Second Basis of Comparison.

*Changes in Exceedances of Water Temperature Thresholds*

With the exception of April, average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Ball's Ferry from April to September for winter-run Chinook Salmon spawning and egg incubation, with exceedances under both as high as about 42 percent and 52 percent, respectively, in some months (Appendix 9N). Under the No Action Alternative, the temperature threshold generally would be exceeded more frequently than under the Second Basis of Comparison (by about 1 percent to 3 percent) in the April through August period, with the temperature threshold in September exceeded about 10 percent less frequently under the No Action Alternative than the Second Basis of Comparison.

Farther downstream at Bend Bridge, the frequency of exceedances would increase, with exceedances under both the No Action Alternative and Second Basis of Comparison as high as about 90 percent in some months. Under the No Action Alternative, temperature exceedances generally would be more frequent (by up to 8 percent) than under the Second Basis of Comparison, with the exception of September, when threshold exceedances under the No Action Alternative would be about 29 percent less frequent.

Overall, there would be substantial differences in the frequency of threshold exceedance between the No Action Alternative and Second Basis of Comparison, particularly in September. Temperature conditions under the No Action Alternative could be more likely to affect winter-run Chinook Salmon spawning than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold from April through August. However, the substantial reduction in the frequency of exceedance in September under the No Action Alternative may reduce the likelihood of adverse effects on winter-run Chinook Salmon egg incubation during this limited portion of the spawning and egg incubation period.

*Changes in Egg Mortality*

The temperatures described above for the Sacramento River downstream of Keswick Dam are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For winter-run Chinook Salmon in the Sacramento River, the long-term average temperature induced egg mortality rate is predicted to be relatively low (around 5 percent), with higher mortality rates (exceeding 20 percent) occurring in critical dry years under the No Action Alternative. Overall, temperature induced egg mortality would be 0.7 percent higher under the No Action Alternative compared to the Second Basis of Comparison, but in critical dry years the average egg mortality rate would be 5.4 percent greater under the No Action Alternative compared to the Second Basis of Comparison (Appendix 9C, Table B-4). Overall, egg mortality in the Sacramento River under the No Action Alternative and the Second Basis of Comparison would be similar, except in critical dry water years.

*Changes in Weighted Usable Area*

As described above for the assessment methodology, Weighted Usable Area (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 spawning habitat for winter-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be greater amounts of spawning habitat available from May through September under the No Action Alternative as compared to the Second Basis of Comparison (Appendix 9E). The increase in long-term average spawning WUA during these months would be relatively small (less than 5 percent), with smaller (less than 1 percent) increases in May and July. There would a reduction in the long-term average spawning WUA in April, but this reduction is small (less than 1 percent) and would occur prior to the peak spawning period in May and June. Overall, spawning habitat availability generally would be similar under the No Action Alternative and the Second Basis of Comparison.

Modeling results indicate that, in general, there would be reduced amounts of suitable fry rearing habitat available from June through October under the No Action Alternative (Appendix 9E). The decrease in long-term average fry rearing WUA during these months would be relatively small (less than 5 percent), with smaller (less than 1 percent) increases in July and October. There would be an increase in the long-term average fry rearing WUA in September, but this reduction would be small (less than 5 percent) and would occur at a time when most fry have grown into juveniles and moved into habitats with different depth and velocity characteristics as reflected in the analysis of juvenile rearing WUA below. Overall, fry rearing habitat availability would be similar under the No Action Alternative and the Second Basis of Comparison.

Similar to the results for fry rearing WUA, modeling results indicate that there would be slightly reduced amounts of suitable juvenile rearing habitat available during the early juvenile rearing period from September through December under the No Action Alternative. There would be an increase in the long-term average juvenile rearing WUA from January through August (Appendix 9E). The decreases in long-term average juvenile rearing WUA would be relatively small (less than 5 percent), while the increases would be smaller (less than 1 percent). Overall, juvenile rearing habitat availability would be similar under the No Action Alternative and the Second Basis of Comparison.

*Changes in SALMOD Output*

SALMOD results indicate that flow-related winter-run Chinook Salmon egg mortality would be reduced by 38 percent under the No Action Alternative compared to the Second Basis of Comparison. Conversely, temperature-related egg mortality would be 20 percent higher under the No Action Alternative (Appendix 9D). Both temperature- and flow (habitat)-related fry mortality would be approximately 19 to 21 percent higher under the No Action Alternative as compared to the Second Basis of Comparison. Temperature-related juvenile mortality would be approximately 17 percent higher under the No Action Alternative, while flow (habitat)-related mortality would be approximately

17 percent lower under the No Action Alternative as compared to the Second Basis of Comparison. Overall, potential juvenile production would the same under the No Action Alternative as compared to the Second Basis of Comparison (Appendix 9D).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for winter-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison Alternative (Appendix 9J). Median Delta survival was 0.349 for the No Action Alternative and 0.352 for the Second Basis of Comparison Alternative (Appendix 9J).

*Changes in Oncorhynchus Bayesian Analysis Output*

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Escapement was generally higher under the No Action Alternative as compared to the Second Basis alternative (Appendix 9I). The median abundance under the No Action Alternative was higher in 19 of the 22 years of simulation (1971 to 2002), and there was typically greater than a 25 percent chance that the No Action Alternative values would be greater than under the Second Basis of Comparison. Median delta survival was approximately 12 percent higher under the No Action Alternative as compared to the Second Basis of Comparison (Appendix 9I). The differences in survival, although not consistent across the uncertainty in the parameter values, suggest a high probability of no difference between these two bases of comparison.

*Changes in Interactive Object-Oriented Simulation Output*

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison across the 81 years (Appendix 9H). No Action Alternative median adult escapement was 3,935 and Second Basis of Comparison median escapement was 4,042.

Similar to adult escapement, the IOS model predicted similar egg survival time histories for winter-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison Alternative across the 81 water years. No Action Alternative median egg survival was 0.990 and Second Basis of Comparison median egg survival was 0.987.

*Changes in Delta Hydrodynamics*

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February, and March. On the Sacramento River near the confluence of Georgiana Slough, the percentage of positive velocities under the No Action Alternative was indistinguishable from the Second Basis of Comparison (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the percent of positive velocities was slightly higher in January and February but almost indistinguishable in March). In Old River downstream of the facilities, the percent of positive velocities was considerably higher under the No Action

Alternative during January, moderately higher in February and slightly higher in March). On Old River upstream of the facilities, percent positive velocities were moderately lower under No Action Alternative relative to Second Basis of Comparison in January but similar in February and March). On the San Joaquin River downstream of Head of Old River, the percent of positive velocities was similar for both scenarios in January, February and March).

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough was similar under both scenarios during January, February, and March when winter-run Chinook Salmon smolts are most abundant in the Delta (Appendix 9L). At the Head of Old River, entrainment probabilities were moderately lower under the No Action Alternative during the three months of greatest winter-run Chinook Salmon abundance. At the Turner Cut junction, entrainment probabilities under the No Action Alternative were slightly lower than the Second Basis of Comparison in January and February, and almost indistinguishable in March. Overall, entrainment patterns at the Columbia Cut junction were similar to those observed at Turner Cut. Patterns at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook salmon is predicted to be greater under Second Basis of Comparison relative to No Action Alternative in every month (Appendix 9M). Winter-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of January, February, and March. Predicted values in January and February indicated a substantially reduced fraction of fish salvaged for the No Action Alternative relative to the Second Basis of Comparison.

*Changes in Fish Passage on the Sacramento and American Rivers*

The No Action Alternative includes provision for passage of winter-run Chinook Salmon at Shasta Dam. Similar actions are underway at some locations in the Pacific Northwest, but none have been attempted for large storage and flood control reservoirs such as Shasta Lake. There is considerable uncertainty about whether such a program could be effective. For example, the size of the reservoir would require that adults be transported not just into the lake, but possibly to the river inlet many miles upstream. Also because of the size of the reservoir, successful volitional passage of juveniles through the reservoir is unlikely. Thus, in order for juvenile salmonid emigrants to contribute to the population, they must be captured in the river (or at the entrance to the lake) and provided with safe transport downstream. A high level of capture efficiency for emigrating juveniles is essential for the program to be successful at generating a self-sustaining population.

If a fish passage program could establish self-sustaining populations of winter-run Chinook Salmon, spring-run Chinook Salmon, and steelhead, it would contribute substantially to satisfaction of the spatial diversity viability standard. The passage program could also contribute to abundance and productivity, if average returns consistently exceeded approximately 500 individuals. However, the passage program could also function as a population sink if fish transported above the reservoir achieved a cohort replacement rate of less than 1.

Insufficient information is available currently the on the quantity, suitability and accessibility of habitat upstream of these impoundments. Given the lack of detailed habitat data, and considerable technical uncertainties discussed previously, it is not possible to determine if (or how much) fish passage at Shasta Dam would be likely to affect the status of Central Valley winter-run Chinook Salmon populations.

*Summary of Effects on Winter-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for winter-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. For the purpose of analyzing effects on winter-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the two life cycle models, IOS and OBAN because they each integrate the available information to produce single estimates of winter-run Chinook Salmon escapement. The output from IOS indicated that winter-run Chinook Salmon escapement would be similar under both scenarios, whereas the OBAN results indicated that production escapement under the No Action Alternative would be higher than under the Second Basis of Comparison, although there would be some chance (less than a 25 percent) that escapement under the Second Basis of Comparison could be greater than the No Action Alternative.

These model results suggest that effects on winter-run Chinook Salmon would be similar under both scenarios, with a small likelihood that winter-run Chinook Salmon escapement would be higher under the No Action Alternative. This potential distinction between the two scenarios, however, may be offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program.

*Spring-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, and Feather River downstream of Oroville Dam could affect spring-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature that could affect spring-run Chinook Salmon could occur in the Sacramento River, Clear Creek, and Feather River. The following describes temperature conditions in those water bodies.

*Sacramento River*

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative. Water temperatures from October to December would be slightly higher under the No Action Alternative than under the Second Basis of Comparison in most water year types, but by less than 0.5°F on average (Appendix 6B, Table B-5-4). A similar pattern of changes in temperature generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences progressively decreasing (up to a 3.2°F difference at Red Bluff) in September during the wetter years (Appendix 6B, Table B-9-4).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Sacramento River. The slightly higher water temperatures from October to December under the No Action Alternative would likely have little effect on spring-run Chinook Salmon as water temperatures in the Sacramento River below Keswick Dam are typically low during this time period. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning, although the increased temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on spring-run Chinook Salmon spawning in this water year type. There would be little difference in potential effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under the No Action Alternative and the Second Basis of Comparison.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under the No Action Alternative relative to the Second Basis of Comparison are generally predicted to be similar (less than 0.5°F differences) from September through April and June through August (Appendix 6B, Table B-3-4). Average monthly water temperatures during May under the No Action Alternative would be lower by 0.4°F to 0.8°F than under the Second Basis of Comparison in all water year types. The lower water temperatures in May associated with the No Action Alternative reflect the effects of additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into the creek. While the reduction in May water temperatures indicated by the modeling could improve thermal conditions for spring-run Chinook Salmon, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide biologically meaningful temperature benefits.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel under the No Action Alternative relative to the Second Basis of Comparison generally were predicted to be similar (less than 0.5°F differences), but slightly higher from October through December when average monthly water temperatures would be up to 1.4°F higher in some water year types (Appendix 6B, Table B-20-4). Modeled water temperatures during May and June under the No Action Alternative were also slightly higher, up to a maximum of 0.7°F higher in June of below normal water years. Average monthly water temperatures in July through September under the No Action Alternative generally were predicted to be higher (up to 0.6°F) in drier water year types and lower (up to 1.3°F) in the wetter years. Although temperatures in the river generally become progressively higher in the downstream direction, the differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under the No Action Alternative generally increasing in most water year types relative to the Second Basis of Comparison. Water temperatures under the No Action Alternative would be somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River from July to September in wetter years (Appendix 6B, Table B-23-4).

Overall, the temperature differences in the Feather River between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Feather River. The slightly higher water temperatures in November and December under the No Action Alternative would likely have little effect on spring-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning, although the increased temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on spring-run Chinook Salmon spawning in this water year type. There would be little difference in potential effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under the No Action Alternative as compared and the Second Basis of Comparison.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for spring-run Chinook Salmon in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of water temperature threshold exceedances for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for spring-run Chinook Salmon (egg incubation) in October, November, and again in April. The exceedances were predicted to occur at the greatest frequency in October (82 percent of the time under the No action Alternative); the water temperature threshold would be exceeded less frequently in November (8 percent under the No Action Alternative) and not exceeded at all from December through March (Appendix 9N). As water temperatures warm in the spring, the thresholds were predicted to be exceeded in April by 15 percent under the No Action Alternative. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate more frequent exceedances (by up to 4 percent in October) under the No Action Alternative than under the Second Basis of Comparison. Temperature conditions in the Sacramento River under the No Action Alternative could be more likely to affect spring-run Chinook Salmon egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in October, November, and April.

*Clear Creek*

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison would not exceed the water temperature threshold of 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in June through August. However, water temperatures under the No Action Alternative and Second Basis of Comparison would exceed the water temperature threshold of 56°F established for spawning in September and October about 10 percent to 15 percent of the time. The differences between the No Action Alternative and Second Basis of Comparison could be biologically meaningful, with water temperatures under the No Action Alternative exceeding thresholds about 3 percent more frequently than under the Second Basis of Comparison in September and about 2 percent more frequently in October, respectively (Appendix 9N). Temperature conditions in Clear Creek under the No Action Alternative could be more likely to affect spring-run Chinook Salmon spawning than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in September and October.

*Feather River*

Average monthly water temperatures under both the No Action Alternative and the Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg incubation and rearing during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). The frequency of exceedance was highest in October, a month in which average monthly water could get as high as about 68°F. However, the differences in the frequency of exceedance between the No Action Alternative and Second Basis of Comparison would be relatively small. Water temperatures under the No Action Alternative would exceed the spawning temperature threshold about 1 percent more frequently than under the Second

Basis of Comparison in October, November, and December, and about 2 percent less frequently in March.

The established water temperature threshold of 63°F for rearing from May through August would be exceeded often under both the No Action Alternative and Second Basis of Comparison in May and June, but not at all in July and August. Water temperatures under the No Action Alternative would exceed the rearing temperature threshold about 1 percent more frequently than under the Second Basis of Comparison in October, November, and December, and about 2 percent less frequently in March. Temperature conditions in the Feather River under the No Action Alternative could be more likely to affect spring-run Chinook Salmon spawning and rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold from October through December.

*Changes in Egg Mortality*

These temperature differences described above are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For spring-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively high (exceeding 20 percent), with high mortality rates (exceeding 70 percent) occurring in critical dry years. Overall, spring-run Chinook Salmon egg mortality in the Sacramento River is predicted to be 0.7 percent higher under the No Action Alternative; in critical dry years the average egg mortality rate is predicted to be 10.4 percent greater than under the Second Basis of Comparison (Appendix 9C, Table B-3). Overall, egg mortality under the No Action Alternative and the Second Basis of Comparison would be similar, except in critical dry water years.

*Changes in Weighted Usable Area*

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison.

*Changes in SALMOD Output*

SALMOD results indicate that pre-spawning mortality of spring-run Chinook Salmon eggs would be approximately 22 percent greater under the No Action Alternative, primarily due to increased summer temperatures. Flow-related spring-run Chinook Salmon egg mortality would be reduced by 9 percent under the No Action Alternative compared to the Second Basis of Comparison. Conversely, temperature-related egg mortality would be 11 percent higher under the No Action Alternative (Appendix 9D, Table B-3-19). Flow (habitat)-related fry mortality would be approximately 7 percent lower under the No Action Alternative as compared to the Second Basis of Comparison. There would be no temperature- or flow (habitat)-related juvenile mortality under either alternative, as most spring-run Chinook Salmon juveniles have migrated downstream as fry and are not found in the mainstem Sacramento River. Overall, potential juvenile spring-run production would be slightly (approximately 2 percent) lower under the No Action Alternative as compared to the Second Basis of Comparison (Appendix 9D, Table B-3-16).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for spring-run between the No Action Alternative and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.296 for the No Action Alternative and 0.286 for the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Spring-run Chinook Salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough (channel 421), the percent of time that velocity was positive was similar in March for both scenarios (Appendix 9K). In April and May, percent positive velocity was slightly lower under the No Action Alternative relative to the Second Basis of Comparison. Near the confluence of the San Joaquin River and the Mokelumne River (channel 45), percent positive velocity was almost identical in March and slightly greater under the No Action Alternative relative to the Second Basis of Comparison in April and May. A similar pattern was observed in the San Joaquin River downstream of the Head of Old River (channel 21). Percent positive velocity was similar in March, whereas values for the No Action Alternative were lower relative to the Second Basis of Comparison in April and May. In Old River upstream of the facilities (channel 212) percent positive velocity was slightly lower in March and moderately higher in April and May under No Action Alternative relative to the Second Basis of Comparison. In Old River downstream of the facilities (channel 94) percent positive velocity was slightly greater in March and increasingly greater in April and May under No Action Alternative relative to the Second Basis of Comparison.

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough was similar under both scenarios during March, April, and May when spring-run are most abundant in the Delta (Appendix 9L). At the Head of Old River, entrainment probabilities were much greater under the No Action Alternative during April and May, whereas probabilities were similar in March. At the Turner Cut junction, entrainment probabilities under the No Action Alternative were slightly lower than the Second Basis of Comparison in March. During April and May, entrainment probabilities were more divergent with lower values for the No Action Alternative relative to the Second Basis of Comparison. Overall, entrainment was lower at the Columbia Cut junction relative to Turner Cut, but patterns of entrainment between these two alternatives were similar. Patterns at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month (Appendix 9M). Spring-run smolts migrating through the Delta would be most susceptible in the months of March, April, and May. Predicted values in April and May indicated a substantially reduced fraction of fish salvaged under the No Action Alternative. Predicted salvage was more similar in March, but still lower under the No Action Alternative.

*Summary of Effects on Spring-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be slightly lower under the No Action Alternative than under the Second Basis of Comparison, although production under the No Action Alternative could be over 10 percent less than under the Second Basis of Comparison in critical dry years. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month.

In Clear Creek and the Feather River, the analysis of the effects of the No Action Alternative and Second Basis of Comparison for spring-run Chinook Salmon relied on output from the WUA analysis and water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The WUA analysis suggests that there would be little difference in the availability of spawning and rearing habitat in Clear Creek. The temperature model outputs suggest that thermal conditions and effects on each of the spring-run Chinook Salmon life stages generally would be similar under both scenarios in Clear Creek and the Feather River, although water temperatures could be somewhat less suitable for spring-run Chinook Salmon holding and spawning/egg incubation in the Feather River under the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that water temperature thresholds for spawning and egg incubation would be exceeded slightly more frequently under the No Action Alternative in Clear Creek and the Feather River. The water temperature threshold for rearing spring-run Chinook Salmon would also be exceeded slightly more frequently in the Feather River. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the slightly greater likelihood of exceeding water temperature thresholds under the No Action Alternative could increase the potential for adverse effects on the spring-run Chinook Salmon populations in the Feather River. Given the similarity of the results, the No Action Alternative and Second Basis of Comparison are likely to have similar effects on the spring-run Chinook Salmon population in Clear Creek.

These model results suggest that, overall, effects on spring-run Chinook Salmon could be slightly more adverse under the No Action Alternative than under the Second Basis of Comparison, with a small likelihood that spring-run Chinook Salmon production would be lower under the No Action Alternative. This potential distinction between the two scenarios, however, may be offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This beneficial effect and its magnitude would depend on the success of the fish passage program.

*Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River below Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect fall-run Chinook Salmon in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative. Water temperatures below Keswick Dam are slightly higher from October to December under the No Action Alternative than under the Second Basis of Comparison in most water year types, but by less than 0.5°F on average (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures in June at Knights Landing progressively increasing (up to 0.9°F) under the No Action Alternative relative to the Second Basis of Comparison and progressively decreasing (up to 4.6°F) in September during the wetter years.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Sacramento River. Spawning by fall-run Chinook Salmon in the Sacramento River takes place from mid-September to December with incubation occurring over the same time period and extending into the following March. The slightly higher water temperatures from October to December under the No Action Alternative would likely have little effect on fall-run Chinook Salmon as water temperatures in the Sacramento River below Keswick Dam are typically low during this time period. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on early spawning fall-run Chinook Salmon, although the increased water temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on fall-run Chinook Salmon spawning in this water year type.

*Clear Creek*

Long-term average monthly water temperatures in Clear Creek at Igo under the No Action Alternative and the Second Basis of Comparison generally would be similar (less than 0.5°F differences) in most months (Appendix 6B, Table B-3-4). Modeled average monthly water temperatures during May under the No Action Alternative would be 0.4°F to 0.8°F lower than under the Second Basis of Comparison depending on water year type. Fall-run Chinook Salmon spawn and rear in the lower portion of Clear Creek, generally downstream of Igo. Average monthly temperatures at the confluence with the Sacramento River would be slightly higher in general but would be similar under the No Action Alternative and the Second Basis of Comparison. Modeled average monthly water temperatures at the confluence during May would be 0.8°F to 1.3°F lower under the No Action Alternative than under the Second Basis of Comparison.

The lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into Clear Creek. While the reduction in water temperature indicated by the modeling could improve thermal conditions for fall-run Chinook Salmon, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide biologically meaningful temperature benefits. Overall, thermal conditions for fall-run Chinook Salmon in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

*Feather River*

Long-term average monthly water temperatures in the Feather River in the low flow channel under the No Action Alternative relative to the Second Basis of Comparison generally are predicted to be similar (less than 0.5°F differences), but slightly higher from October through December when average monthly water temperatures would be up to 1.4°F higher in some water year types. Modeled water temperatures during May and June under the No Action Alternative were also slightly higher, up to a maximum of 0.7°F higher in June of below normal water years. Average monthly water temperatures in July through September under the No Action Alternative generally were predicted to be higher (up to 0.6°F) in drier water year types and lower (up to 1.3°F) in the wetter years. Although temperatures in the river generally become progressively higher in the downstream direction, the differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under the No Action Alternative generally decreasing in most water year types relative to the Second Basis of Comparison. Water temperatures under the No Action Alternative are somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River from July to September in wetter years.

Overall, the temperature differences in the Feather River between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Feather River. The slightly higher water temperatures in November and December under the No Action Alternative would likely have little effect on fall-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on early spawning fall-run Chinook Salmon, although the increased temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on fall-run Chinook Salmon spawning in this water year type.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under the No Action Alternative generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of June and August, when temperatures under the No Action Alternative could be as much as 0.9°F higher in below normal years (Appendix 6B, Table B-12-4). This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth generally would be lower under the No Action Alternative than the Second Basis of Comparison in September, especially in wetter water year types when water temperatures under the No Action Alternative could be up to 1.7°F cooler (Appendix 6B, Table B-14-4).

Overall, the temperature differences in the American River between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the American River. The slightly higher water temperatures in June and August in some water year types under the No Action Alternative may increase the likelihood of adverse effects on fall-run Chinook Salmon rearing in the American

River if they are present. The slightly lower water temperatures during September under the No Action Alternative would have little effect on fall-run Chinook Salmon spawning in the American River because most spawning occurs later, in November.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of water temperatures that are protective of fall-run Chinook Salmon in the Sacramento River, Clear Creek, Feather River, and American River. The following describes the extent of those exceedances for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon spawning and egg incubation in October, November, and again in April. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate more frequent exceedances (by up to 4 percent in October) under the No Action Alternative than under the Second Basis of Comparison. Temperature conditions in the Sacramento River under the No Action Alternative could be more likely to affect fall-run Chinook Salmon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in October, November, and April.

*Clear Creek*

Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during October through December (USFWS 2015). Average monthly water temperatures at Igo during this period generally fall below 56°F, except in October. Under the No Action Alternative, 56°F would be exceeded in October about 12 percent of the time as compared to 10 percent under the Second Basis of Comparison (Appendix 9N). At the confluence with the Sacramento River, average monthly water temperatures in October would be warmer, with 56°F exceeded nearly 20 percent of the time under the No Action Alternative and slightly (about 8 percent) more frequently under the Second Basis of Comparison (Appendix 6B, Figure B-4-1). During November and December, average monthly water temperatures generally would remain below 56°F at both locations. Average monthly temperatures also would remain below 56°F at both locations during the fall-run Chinook Salmon rearing period (January through April). (Appendix 6B, Figure B-4-2 and B-4-3). Temperature conditions in Clear Creek under the No Action Alternative could be more likely to affect fall-run Chinook Salmon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in October.

For fall-run Chinook Salmon rearing (January through August), the exceedances described previously for spring-run Chinook Salmon would apply, with the average monthly temperatures at Igo remaining below the 60°F threshold in all months. Downstream at the mouth of Clear Creek, average monthly water temperatures would exceed the 60°F threshold often during the summer, but the frequency of exceedance would be similar under the No Action Alternative and the Second Basis of Comparison (Appendix 6B). Temperature conditions for fall-run Chinook Salmon rearing in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

*Feather River*

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and egg incubation during some months, particularly in October, November, March, and April, when water temperature thresholds would be exceeded frequently (Appendix 9N). The frequency of exceedance would be greatest in October, when average monthly temperatures under both the No Action Alternative and Second Basis of Comparison would be above the threshold in nearly every year. The magnitude of the exceedances would be high as well, with average monthly temperatures in October reaching about 68°F. Similarly, the threshold would be exceeded under both the No Action Alternative and Second Basis of Comparison about 85 percent of the time in April. The differences between the No Action Alternative and Second Basis of Comparison, however, would be relatively small, with the No Action Alternative generally exceeding temperature thresholds about 1-2 percent more frequently than the Second Basis of Comparison during the October through April period. Temperature conditions in the Feather River under the No Action Alternative could be more likely to affect fall-run Chinook Salmon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold from October through April.

*Changes in Egg Mortality*

Water temperatures influence the viability of incubating fall-run Chinook Salmon eggs. The following describes the differences in egg mortality for the Sacramento, Feather, and American rivers.

*Sacramento River*

For fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be around 17 percent, with higher mortality rates (in excess of 35 percent) occurring in critical dry years under the No Action Alternative. Predicted egg mortality would be 0.1 percent lower under the No Action Alternative than the Second Basis of Comparison; in critical dry years the average egg mortality rate would be 2.4 percent greater than under the Second Basis of Comparison (Appendix 9C, Table B-1). Overall, egg mortality under the No Action Alternative and the Second Basis of Comparison would be relatively similar, except in critical dry water years.

*Feather River*

For fall-run Chinook Salmon in the Feather River, the long-term average egg mortality rate is predicted to be relatively low (around 7 percent), with higher mortality rates (around 14.5 percent) occurring in critical dry years under the No Action Alternative. Predicted egg mortality would be 0.2 percent higher under the No Action Alternative than the Second Basis of Comparison; in critical dry years the average egg mortality rate would be 3 percent lower than under the Second Basis of Comparison (Appendix 9C, Table B-7). Overall, egg mortality under the No Action Alternative and the Second Basis of Comparison would be similar, except in critical dry water years.

*American River*

For fall-run Chinook Salmon in the American River, the long-term average egg mortality rate is predicted to range from approximately 23 to 25 percent in all water year types under the No Action Alternative. Overall, egg mortality would be 0.2 percent higher under the No Action Alternative; in Below Normal water years the average egg mortality rate would be 2 percent greater than under the Second Basis of Comparison. In other water year types, egg mortality is predicted to be from 0.6 percent lower to 0.6 percent higher under the No Action Alternative as compared to the Second Basis of Comparison (Appendix 9C, Table B-6). Overall, egg mortality in the American River would be similar under the No Action Alternative and the Second Basis of Comparison.

*Changes in Weighted Usable Area*

Weighted usable area, which is influenced by flow, is a measure of habitat suitability. The following describes changes in WUA for fall-run Chinook Salmon in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

As an indicator of the amount of suitable spawning habitat for fall-run Chinook Salmon between Keswick Dam and Battle Creek, WUA modeling results indicate that, in general, there would be lesser amounts of spawning habitat available from September through November under the No Action Alternative as compared to the Second Basis of Comparison. Although fall-run spawning WUA would be slightly (less than 5 percent) increased in December under the No Action Alternative, this increase would occur after the peak spawning period for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-11-4). Lesser amounts in long-term average spawning WUA during September (prior to the peak spawning period) under the No Action Alternative compared to the Second Basis of Comparison would be relatively large (more than 20 percent), with smaller decreases predicted for October (around 2 percent) and November (around 6 percent). The latter month comprises the peak spawning period for fall-run Chinook Salmon in the Sacramento River. Results for the reach from Battle Creek to Deer Creek show the same pattern in changes in WUA for spawning fall-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison (Appendix 9E, Table C-10-4). Overall, spawning habitat availability would be somewhat lower under the No Action Alternative relative to the Second Basis of Comparison.

Modeling results indicate that, in general, the amount of suitable fry rearing habitat available from December to March under the No Action Alternative would be similar (less than 1 percent difference) to the amount of fry rearing habitat available under the Second Basis of Comparison (Appendix 9E, Table C-12-4).

Similar to the results for fry rearing WUA, modeling results indicate that there would be similar amounts of suitable juvenile rearing habitat available during the early juvenile rearing period from February to April under the No Action Alternative and the Second Basis of Comparison. There would a slight increase (around 3 percent) in the long-term average juvenile rearing WUA during May and June under the No Action Alternative (Appendix 9E, Table C-13-4). Overall, the amount of juvenile rearing habitat (WUA) would be similar under the No Action Alternative and the Second Basis of Comparison.

*Clear Creek*

As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison.

*Feather River*

As described above, flows in the low flow channel of the Feather River are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison. The majority of spawning activity by fall-run Chinook Salmon in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be lesser amounts of spawning habitat available in the Feather River downstream of the Thermalito Complex during September, November, and December under the No Action Alternative as compared to the Second Basis of Comparison. Fall-run spawning WUA would be slightly (less than 5 percent) increased in October (the peak spawning month) for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-24-4). The decrease in long-term average spawning WUA during September (prior to the peak spawning period) under the No Action Alternative would be relatively large (more than 15 percent), with smaller decreases of less than 1 percent in November (peak spawning period) and December (after peak spawning period). Overall, spawning habitat availability would be similar under the No Action Alternative and the Second Basis of Comparison.

*American River*

Modeling results indicate that, in general, there would be greater amounts of spawning habitat available for fall-run Chinook Salmon in the American River from October through December under the No Action Alternative as compared to the Second Basis of Comparison; fall-run spawning WUA would be slightly (less than 5 percent) increased in December with less than 1 percent increases in September and October (prior to the peak spawning period in November) (Appendix 9E, Table C-25-4). Overall, spawning habitat availability would be similar under the No Action Alternative and the Second Basis of Comparison.

*Changes in SALMOD Output – Sacramento River*

SALMOD results indicate that pre-spawning mortality of fall-run Chinook Salmon eggs in the Sacramento River would be approximately 20 percent greater under the No Action Alternative, primarily due to increased summer temperatures. Flow-related fall-run Chinook Salmon egg mortality would be reduced by 7 percent under the No Action Alternative compared to the Second Basis of Comparison. Conversely, temperature-related egg mortality would be 13 percent higher under the No Action Alternative (Appendix 9D, Table B-1-19). Flow (habitat)-related fry mortality would be approximately 1 percent lower under the No Action Alternative as compared to the Second Basis of Comparison. Temperature-related juvenile mortality would be approximately 27 percent higher under the No Action Alternative, while flow (habitat)-related mortality would be the same under the No Action Alternative as compared to the Second Basis of Comparison. Overall, potential juvenile production would be slightly (approximately 1 percent) lower under the No Action Alternative as compared to the Second Basis of Comparison (Appendix 9D, Table B-1-16).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for fall-run Chinook Salmon between the No Action Alternative and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.248 for the No Action Alternative and 0.245 for the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May, and June. At the junction of Georgiana Slough and the Sacramento River, percent positive velocity was similar under both scenarios in the month of April, and was moderately lower for the No Action Alternative relative to the Second Basis of Comparison during May and June (Appendix 9K). Near the Confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities was moderately greater under the No Action Alternative relative to the Second Basis of Comparison in April and May and almost indistinguishable in June. On Old River downstream of the facilities, the proportion of positive velocities was substantially greater in April and May, but became more similar in June. In Old River upstream of the facilities, the percent of positive velocities was moderately greater for the No Action Alternative relative to the Second Basis of Comparison in April and May and moderately lower in June. On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities was moderately lower under the No Action Alternative relative to the Second Basis of Comparison in April and May, whereas the values were similar in June.

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough was similar under both scenarios in most months, but was slightly lower under the No Action Alternative relative to the Second Basis of Comparison in the month of June (Appendix 9L). Entrainment probabilities at the Head of Old River were much greater under the No Action Alternative relative to the Second Basis of Comparison during April and May. Entrainment probabilities were similar under both alternatives in the month of June. At the Turner Cut junction, entrainment probabilities under the No Action Alternative were slightly lower than the Second Basis of Comparison in June. During April and May, entrainment probabilities were more divergent with lower values for the No Action Alternative relative to the Second Basis of Comparison. Overall, entrainment was lower at the Columbia Cut junction relative to Turner Cut, but patterns of entrainment between these two alternatives were similar. Entrainment was slightly lower for the No Action Alternative relative to the Second Basis of Comparison during June. In April and May, entrainment was lower for the No Action Alternative relative to the Second Basis of Comparison. Patterns at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month (Appendix 9M). Fall-run smolts migrating through the Delta would be most susceptible in the months of April, May, and June. Predicted values in April and May indicated a substantially reduced fraction of fish salvaged for the No Action Alternative relative to the Second Basis of Comparison. Predicted salvage was more similar in March but still lower under the No Action Alternative.

*Summary of Effects on Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be slightly lower in most water year types under the No Action Alternative than under the Second Basis of Comparison, and up to 7 percent less than under the Second Basis of Comparison in critical dry years. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month.

In Clear Creek and the Feather and American rivers, the analysis of the effects of the No Action Alternative and Second Basis of Comparison for fall-run Chinook Salmon relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of spawning and rearing habitat in Clear Creek and spawning habitat in the Feather and American rivers would be similar under the No Action Alternative and the Second Basis of Comparison. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in all of these streams generally would be similar under both scenarios. The water temperature threshold exceedance analysis that indicated that the water temperature thresholds for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly more frequently in the Feather River and Clear Creek under the No Action Alternative. Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the increased frequency of exceedance of temperature thresholds under the No Action Alternative could increase the potential for adverse effects on the fall-run Chinook Salmon populations in Clear Creek and the Feather River. Results of the analysis using Reclamation's salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under the No Action Alternative and the Second Basis of Comparison.

These model results suggest that overall, effects on fall-run Chinook Salmon could be slightly more adverse under the No Action Alternative than under the Second Basis of Comparison, with a small likelihood that fall-run Chinook Salmon production would be lower under the No Action Alternative.

The implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run and spring-run Chinook Salmon in the Sacramento River reaches downstream of Shasta Dam is unlikely to benefit fall-run Chinook Salmon unless volitional access is provided to adult fish. Similar fish passage at Folsom Dam would also be uncertain for the same reason.

*Late Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect late fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

As described above, long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the

Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative. Water temperatures below Keswick Dam are slightly higher from October to December under the No Action Alternative than under the Second Basis of Comparison in most water year types, but by less than 0.5°F on average (Appendix 6B, Table 5-5-4). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures in June at Knights Landing progressively increasing (up to 0.9°F) under the No Action Alternative relative to the Second Basis of Comparison and progressively decreasing (up to 4.6°F) in September during the wetter years.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on late fall-run Chinook Salmon in the Sacramento River. Spawning of late fall-run Chinook Salmon in the Sacramento River takes place from December to mid-April with incubation occurring over the same time period and extending into June. The slightly higher water temperatures from October to December under the No Action Alternative would likely have little effect on late fall-run Chinook Salmon migration and holding as water temperatures in the Sacramento River below Keswick Dam are typically low during this time period. The likelihood of adverse effects on late fall-run Chinook Salmon spawning and egg incubation would be similar under the No Action Alternative and the Second Basis of Comparison due to similar water temperatures during the January to May time period.

Because late fall-run Chinook Salmon have an extended rearing period, the similar water temperatures during the summer under the No Action Alternative and Second Basis of Comparison would have similar effects on rearing fry and juvenile late fall-run Chinook Salmon in the Sacramento River. The lower water temperatures under the No Action Alternative in September of wetter years may reduce the likelihood of adverse effects on fry and juvenile late fall-run Chinook Salmon in the Sacramento River during this limited time period.

*Changes in Exceedances of Water Temperature Thresholds*

Average monthly water temperatures under both the No Action Alternative and Second Basis of Comparison indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon spawning and egg incubation in October, November, and again in April. There would be no exceedances of the threshold from December to March under both the No Action Alternative and the Second Basis of Comparison. In April, model results indicate that water temperatures under the No Action Alternative would exceed the threshold about 2 percent more frequently than under the Second Basis of Comparison. Temperature conditions in the Sacramento River under the No Action Alternative could be slightly more likely to affect late fall-run Chinook Salmon spawning and egg incubation than under the Second Basis of Comparison because of the increased frequency of exceedance of the 56°F threshold in April.

*Changes in Egg Mortality*

For late fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to range from approximately 2.5 to nearly 5 percent in all water year types under the No Action Alternative. Overall, egg mortality would be 0.4 percent higher under the No Action Alternative; in Below Normal water years the average egg mortality rate would be 0.1 percent lower than under the Second Basis of Comparison. In other water year types, egg mortality is predicted to be from 0.1 to 0.8 percent higher under the No Action Alternative as compared to the Second Basis of Comparison (Appendix 9C, Table B-2). Overall, late fall Chinook Salmon egg mortality in the Sacramento River under the No Action Alternative and the Second Basis of Comparison would be similar.

*Percent Changes in Weighted Usable Area*

Modeling results indicate that there would be slightly (less than 5 percent ) greater amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under the No Action Alternative as compared to the Second Basis of Comparison late (Appendix 9E, Table C-14-4). Overall, spawning habitat availability would be similar under the No Action Alternative and the Second Basis of Comparison.

Modeling results indicate that, in general, there would be increased amounts of suitable late fall-run Chinook Salmon fry rearing habitat available in the Sacramento River during April and May under the No Action Alternative (Appendix 9E, Table C-15-4). The increase in long-term average fry rearing WUA during these months would be relatively small (less than 5 percent). Late fall-run Chinook Salmon fry rearing WUA would be decreased by about 2 percent in June under the No Action alternative as compared to the Second Basis of Comparison. Overall, late fall-run fry rearing habitat availability would be similar under the No Action Alternative and the Second Basis of Comparison.

A substantial fraction of late fall run Chinook Salmon juveniles oversummer in the Sacramento River before emigrating, which allows them to avoid predation through both their larger size and greater swimming ability. One implication of this life history strategy is that rearing habitat is most likely the limiting factor for late-fall-run Chinook Salmon, especially if availability of cool water determines the downstream extent of spawning habitat for late-fall-run Chinook Salmon. Modeling results indicate that, there would be increased amounts of suitable juvenile rearing habitat available from December through August, but this increase would be small (generally less than 2 percent) under the No Action Alternative as compared to the Second Basis of Comparison. There would be decreases in the amount of late fall-run Chinook Salmon juvenile rearing WUA in the other months (September through November) of up to 10 percent (Appendix 9E, Table C-16-4). Overall, late fall-run juvenile rearing habitat availability would be similar under the No Action Alternative relative to the Second Basis of Comparison.

*Changes in SALMOD Output – Sacramento River*

SALMOD results indicate that flow-related late fall-run Chinook Salmon egg mortality would be reduced by 4 percent under the No Action Alternative compared to the Second Basis of Comparison. Conversely, temperature-related egg mortality would be 4 percent higher under the No Action Alternative (Appendix 9D, Table B-2-4). Flow (habitat)-related fry mortality would be approximately 3 percent lower while temperature-related fry mortality would be about 2 percent higher under the No Action Alternative as compared to the Second Basis of Comparison. Temperature-related juvenile mortality would be approximately 19 percent higher under the No Action Alternative, while flow (habitat)-related mortality would approximately 51 percent higher under the No Action Alternative as compared to the Second Basis of Comparison. Overall, potential juvenile production would be the similar under the No Action Alternative and the Second Basis of Comparison (Appendix 9D, Table B-2-16).

*Changes in Delta Passage Model Output*

For late fall-run Chinook Salmon, through-Delta survival was predicted to be slightly higher under the No Action Alternative relative to the Second Basis of Comparison for all 81 years simulated by the Delta Passage Model (Appendix 9J). Median Delta survival across all years was 0.244 for the No Action Alternative and 0.199 for the Second Basis of Comparison.

*Changes in Hydrodynamics*

The late fall-run Chinook Salmon migration period overlaps with winter-run Chinook Salmon. See the section on hydrodynamic analysis for winter-run Chinook Salmon for potential effects on late fall-run Chinook Salmon.

*Changes in Junction Entrainment*

Entrainment probabilities for late fall-run are assumed to mimic that of winter-run Chinook Salmon due to overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Changes in Salvage*

Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run Chinook Salmon due to overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Summary of Effects on Late Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. For the purpose of analyzing effects on late fall-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that late fall-run Chinook Salmon production would be slightly lower under the No Action Alternative than under the Second Basis of Comparison, although production under the No Action Alternative could be slightly higher in some water year types and about 4 percent less in critical dry years than under the Second Basis of Comparison. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be lower under the No Action Alternative relative to the Second Basis of Comparison in every month.

These model results suggest that overall, effects on late fall-run Chinook Salmon could be slightly more adverse under the No Action Alternative than under the Second Basis of Comparison, with a small likelihood that late fall-run Chinook Salmon production would be lower under the No Action Alternative.

*Steelhead*

Changes in operations that influence temperature and flow conditions could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect steelhead in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

As described above, long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative. Water temperatures below Keswick Dam are slightly higher from October to December under the No Action Alternative than under the Second Basis of Comparison in most water year types, but by less than 0.5°F on average (Appendix 6B, Table 5-5-4). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences progressively decreasing (up to a 3.2°F difference at Red Bluff) in September during the wetter years (Appendix 6B, Table B-9-4).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Sacramento River. Based on the life history timing for steelhead, the slightly higher water temperatures in September of drier years under the No Action Alternative may increase the likelihood of adverse effects on steelhead adults migrating upstream in the

Sacramento River. The lower water temperatures in September of wetter years under the No Action Alternative may decrease the likelihood of adverse effects on steelhead migration compared to the Second Basis of Comparison.

*Clear Creek*

Long-term average monthly water temperatures in Clear Creek at Igo under the No Action Alternative and the Second Basis of Comparison generally would be similar (less than 0.5°F differences). Water temperatures would be slightly higher (up to about 0.5°F in dry years) during October (Appendix 6B, Table B-3-4). Modeled average monthly water temperatures during May under the No Action Alternative would be 0.4°F to 0.8°F lower than under the Second Basis of Comparison depending on water year type.

The lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into Clear Creek. While the reduction in water temperature indicated by the modeling could improve thermal conditions for steelhead, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide biologically meaningful temperature benefits. Overall, thermal conditions for steelhead in Clear Creek would be similar under the No Action Alternative and the Second Basis of Comparison.

*Feather River*

Long-term average monthly water temperature in the Feather River in the low flow channel under the No Action Alternative relative to the Second Basis of Comparison generally are predicted to be similar (less than 0.5°F differences), but slightly higher from October through December when average monthly water temperatures would be up to 1.4°F higher in some water year types. Modeled water temperatures during May and June under the No Action Alternative were also slightly higher, up to a maximum of 0.7°F higher in June of below normal water years. Average monthly water temperatures in July through September under the No Action Alternative generally were predicted to be higher (up to 0.6°F) in drier water year types and lower (up to 1.3°F) in the wetter years. Although temperatures in the river generally become progressively higher in the downstream direction, the differences between the No Action Alternative and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under the No Action Alternative generally decreasing in most water year types relative to the Second Basis of Comparison. Water temperatures under the No Action Alternative are somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River from July to September in wetter years.

Overall, the temperature differences in the Feather River between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Feather River. The slightly higher water temperatures in November and December under the No

Action Alternative would likely have little effect on adult steelhead migration as water temperatures in the Feather River are typically low during this time period. The somewhat lower water temperatures in September of wetter years may reduce the likelihood of adverse effects on adult steelhead migrating upstream and juveniles rearing in the Feather River, although the increased temperatures in September of critical dry years under the No Action Alternative may increase the likelihood of adverse effects on migrating and rearing steelhead in this water year type.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under the No Action Alternative generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of June and August, when differences under the No Action Alternative could be as much as 0.9°F higher in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth generally would be lower under the No Action Alternative than the Second Basis of Comparison in September, especially in wetter water year types when the No Action Alternative could be up to 1.7°F cooler.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the American River. The slightly warmer water temperatures in June and August under the No Action Alternative may increase the likelihood of adverse effects on steelhead rearing in the American River compared to the Second Basis of Comparison.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for steelhead in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of exceedance for each of those streams.

*Sacramento River*

As described in the life history accounts (Appendix), steelhead spawning in the mainstem Sacramento River generally occurs in the upper reaches from Keswick Dam downstream to near Balls Ferry, with most spawning concentrated near Redding. Most steelhead, however, spawn in tributaries to the Sacramento River. Spawning generally takes place in the January through March period when water temperatures in the river generally do not exceed 52°F under either the No Action Alternative or Second Basis of Comparison. While there are no established temperature thresholds for steelhead rearing in the mainstem Sacramento River, average monthly temperatures in during March through June when fry and juvenile steelhead are in the river would be below 56°F during March and April at Balls Ferry. In May and June, average monthly water temperatures would be slightly higher under the No Action Alternative than they would be under the Second Basis of Comparison in the drier years, although neither condition would exceed about 57°F. Thus, as it relates to temperature conditions for steelhead in the mainstem Sacramento River, it is unlikely that No Action Alternative and Second Basis of Comparison would differ in a biologically meaningful way.

*Clear Creek*

While there are no established temperature thresholds for steelhead spawning in Clear Creek, average monthly water temperatures in the river generally would not exceed 48°F during the spawning period (December to April) under either the No Action Alternative or Second Basis of Comparison. Similarly, while there are no established temperature thresholds for steelhead rearing in Clear Creek, average monthly temperatures in throughout the year would not exceed 56°F at Igo. Thus, as it relates to temperature for steelhead in Clear Creek, it is unlikely that the No Action Alternative and Second Basis of Comparison would differ in a biologically meaningful way.

*Feather River*

Average monthly water temperatures under both the No Action Alternative and the Second Basis of Comparison would on occasion exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for steelhead spawning and incubation during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). There would be a 1 percent exceedance of the 56°F threshold in December and no exceedances of the 56°F threshold in January and February under both the No Action Alternative and the Second Basis of Comparison. However, the differences in the frequency of exceedance between the No Action Alternative and Second Basis of Comparison during March and April would be relatively small with water temperatures under the No Action Alternative exceeding the threshold about 2 percent more frequently in March and the same exceedance frequency (75 percent) as the Second Basis of Comparison in April. Average monthly water temperatures under the

The established water temperature threshold of 63°F for rearing from May through August would be exceeded often under both the No Action Alternative and Second Basis of Comparison in May and June, but not at all in July and August. Water temperatures under the No Action Alternative would exceed the rearing temperature threshold about 9 percent more frequently than under the Second Basis of Comparison in May, but no more frequently in June. Temperature conditions in the Feather River under the No Action Alternative could be more likely to affect steelhead spawning and rearing than under the Second Basis of Comparison because of the slightly increased frequency of exceedance of the 56°F spawning threshold in March and the somewhat increased frequency of exceedance of the 63°F rearing threshold in May.

*American River*

In the American River, the water temperature threshold for steelhead rearing (May through October) is 65°F at the Watt Avenue Bridge. Average monthly water temperatures would exceed this threshold often under both the No Action Alternative and Second Basis of Comparison, especially in the July through September period when the threshold is exceeded nearly all of the time. In addition, the magnitude of the exceedance would be high, with average monthly water temperatures sometimes higher than 76°F. The differences between the No Action Alternative and Second Basis of Comparison, however, would be relatively small and occur only in June (1 percent less frequent under the No Action Alternative), and in September, when average monthly water temperatures under the No Action Alternative would exceed 65°F about 7 percent less frequently than under the Second Basis of Comparison. Temperature conditions in the American River under the No Action Alternative could be less likely to affect steelhead rearing than under the Second Basis of Comparison because of the reduced frequency of exceedance of the 65°F rearing threshold.

*Changes in Weighted Usable Area*

The following describes changes in WUA for steelhead in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

Modeling results indicate that, in general, there would be greater amounts of suitable steelhead spawning habitat available from December through March under the No Action Alternative as compared to the Second Basis of Comparison (Appendix 9E, Table C-20-4). The increases in long-term average steelhead spawning WUA would be relatively small (less than 3 percent). Overall, spawning habitat availability would be similar under the No Action Alternative and the Second Basis of Comparison.

*Clear Creek*

As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for steelhead (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison.

*Feather River*

As described above, flows in the low flow channel of the Feather River are not anticipated to differ under the No Action Alternative relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning habitat for steelhead (as indexed by WUA) available under the No Action Alternative as compared to the Second Basis of Comparison. The majority of spawning activity by steelhead in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be greater amounts of spawning habitat for steelhead in the Feather River downstream of Thermalito available from December through April under the No Action Alternative as compared to the Second Basis of Comparison. The increases in long-term average steelhead spawning WUA during this time period would generally be less than 4 percent (Appendix 9E, Table C-22-4). Overall, steelhead spawning habitat availability in the Feather River would be similar under the No Action Alternative and the Second Basis of Comparison.

*American River*

Modeling results indicate that, in general, there would be variable changes in the amount of spawning habitat for steelhead in the American River downstream of Nimbus Dam available from December through April under the No Action Alternative as compared to the Second Basis of Comparison. The increases in long-term average steelhead spawning WUA during December, February and March would generally be less than 3 percent, while the decrease in April would also be less than 3 percent (Appendix 9E, Table C-26-4). Overall, steelhead spawning habitat availability in the American River would be similar under the No Action Alternative and the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Sacramento River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing than there is for Chinook Salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for winter-run and fall-run Chinook Salmon above.

*Changes in Entrainment at Junctions*

Entrainment at Georgiana Slough was similar under both scenarios in most months, but was slightly lower under the No Action Alternative in the month of June (Appendix 9L). At the Head of Old River, entrainment under the No Action Alternative was slightly lower during January and February. Entrainment probabilities were much greater under the No Action Alternative during April and May. Entrainment probabilities were similar under both alternatives in the month of June. At the Turner Cut junction, entrainment probabilities under the No Action Alternative were slightly lower than the Second Basis of Comparison in January, February, March, and June. During April and May, entrainment probabilities were more divergent with lower values for the No Action Alternative relative to the Second Basis of Comparison. Overall, entrainment was lower at the Columbia Cut junction relative to Turner Cut, but patterns of entrainment between these two alternatives were similar. Entrainment was slightly lower for the No Action Alternative relative to the Second Basis of Comparison during January, February, March, and June. In April and May, entrainment was lower for the No Action Alternative relative to the Second Basis of Comparison.

Patterns at the Middle River and Old River junctions were similar to those observed at the Columbia and Turner Cut junctions.

*Summary of Effects on Steelhead*

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. The analysis of the effects of the No Action Alternative and Second Basis of Comparison for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under the No Action Alternative and the Second Basis of Comparison. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead in all of these streams generally would be similar under both scenarios. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for steelhead spawning and egg incubation would be exceeded more frequently in the Feather River. The water temperature threshold for steelhead rearing would also be exceeded more frequently in the Feather River. Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the increased frequency of exceedance of temperature thresholds under the No Action Alternative could increase the potential for adverse effects on the steelhead population in the Feather River.

These model results suggest that overall, effects on steelhead could be slightly more adverse under the No Action Alternative than under the Second Basis of Comparison, particularly in the Feather River. Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Keswick Dam and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers.

*Green Sturgeon*

Potential effects on Green Sturgeon were evaluated based on anticipated water temperature conditions and exceedances of established temperature thresholds in the Sacramento and Feather rivers as described below.

*Changes in Water Temperature*

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative. Water temperatures below Keswick Dam are slightly higher from

October to December under the No Action Alternative than under the Second Basis of Comparison in most water year types, but by less than 0.5°F on average (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures in June at Knights Landing progressively increasing (up to 0.9°F) under the No Action Alternative relative to the Second Basis of Comparison and progressively decreasing (up to 4.6°F) in September during the wetter years.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on Green Sturgeon in the Sacramento River. The lower water temperatures from January through May under the No Action Alternative may decrease the likelihood of adverse effects on migrating adult Green Sturgeon and spawning and egg incubation compared to the Second Basis of Comparison.

*Feather River*

Long-term average monthly water temperatures in the Feather River in the low flow channel under the No Action Alternative relative to the Second Basis of Comparison generally are predicted to be similar (less than 0.5°F differences), but slightly higher from October through December when average monthly water temperatures would be up to 1.4°F higher in some water year types. Modeled water temperatures during May and June under the No Action Alternative were also slightly higher, up to a maximum of 0.7°F higher in June of below normal water years. Average monthly water temperatures in July through September under the No Action Alternative generally were predicted to be higher (up to 0.6°F) in drier water year types and lower (up to 1.3°F) in the wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the differences between the No Action Alternative and Second Basis of Comparison would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under the No Action Alternative generally decreasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento River (Appendix 6B, Table B-23-1).

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on Green Sturgeon in the Feather River. The slightly higher water temperatures from January through April under the No Action Alternative may decrease the likelihood of adverse effects on migrating adult Green Sturgeon compared to the Second Basis of Comparison. Higher water temperatures in May and June under the No Action Alternative could increase the likelihood of adverse effects on egg incubation and rearing of Green Sturgeon in the Feather River as compared to the Second Basis of Comparison.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers. The following describes the exceedances for each of those rivers.

*Sacramento River*

Average monthly water temperatures in the Sacramento River at Bend Bridge under both the No Action Alternative and Second Basis of Comparison would exceed the water temperature threshold of 63°F established for Green Sturgeon egg incubation in August and September, with exceedances under the No Action Alternative occurring about 7 percent of the time in August and about 12 percent of the time in September. This is 1 to 2 percent more frequently than under the Second Basis of Comparison. Average monthly water temperatures at Bend Bridge could exceed the threshold by up to 10 degrees (reaching 73°F) during this period. Temperature conditions in the Sacramento River under the No Action Alternative could be more likely to affect Green Sturgeon rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 63°F threshold in August and September.

*Feather River*

Average monthly water temperatures in the Feather River at Gridley Bridge under both the No Action Alternative and Second Basis of Comparison would exceed the water temperature threshold of 64°F established for Green Sturgeon spawning, incubation, and rearing in May, June, and September; no exceedances under either condition would occur in July and August. The frequency of exceedances would be high, with both the No Action Alternative and Second Basis of Comparison exceeding the threshold in June nearly 100 percent of the time. The magnitude of the exceedance also would be substantial, with average monthly temperatures higher than 72°F in June, and higher than 75°F in July and August. Average monthly water temperatures under the No Action Alternative would exceed the threshold during May about 9 percent more frequently than the Second Basis of Comparison and about 35 percent less frequently in September. Temperature conditions in the Feather River under the No Action Alternative could be more likely to affect Green Sturgeon rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 64°F threshold in May. The reduction in exceedance frequency in September may have little effect on rearing Green Sturgeon as many juvenile sturgeon may have migrated downstream to the lower Sacramento River and Delta by this time.

*Summary of Effects on Green Sturgeon*

The analysis of the effects of the No Action Alternative and Second Basis of Comparison for Green Sturgeon relied on water temperature model output for the Sacramento and Feather rivers at various locations downstream of Shasta Dam and the Thermalito complex. The temperature model outputs for each of these rivers suggest that thermal conditions and effects on Green Sturgeon in the Sacramento and Feather rivers generally would be slightly more adverse under the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for Green Sturgeon spawning, incubation, and rearing would be exceeded more frequently under the No Action Alternative in the Sacramento River. The water temperature threshold for Green Sturgeon spawning, incubation, and rearing would also be exceeded more frequently during some months in the Feather River but would be exceeded substantially less frequently in September under the No Action Alternative.

Overall, the increased frequency of exceedance of temperature thresholds under the No Action Alternative could increase the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers relative to the Second Basis of Comparison.

*White Sturgeon*

Changes in water temperature conditions in the Sacramento River would be the same as those described above for Green Sturgeon in the Sacramento River. Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on White Sturgeon in the Sacramento River.

The water temperature threshold established for White Sturgeon spawning and egg incubation in the Sacramento River at Hamilton City is 61°F from March through June. Although there would be no exceedances of the threshold in March and April, water temperatures under both the No Action Alternative and Second Basis of Comparison would exceed this threshold in May and June. The average monthly water temperatures in May under the No Action Alternative would exceed this threshold about 55 percent of the time (about 6 percent more frequently than the Second Basis of Comparison). In June, average monthly water temperatures under the No Action Alternative would exceed the threshold about 86 percent of the time (about 13 percent more frequently than the Second Basis of Comparison). Average monthly water temperatures during May and June under the No Action Alternative would as high as about 65°F which is below the 68°F threshold considered lethal for White Sturgeon eggs. Temperature conditions in the Sacramento River under the No Action Alternative could be more likely to affect White Sturgeon rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 61°F threshold in May and June.

The analysis of the effects of the No Action Alternative and Second Basis of Comparison for White Sturgeon relied on water temperature model output for the Sacramento River at various locations downstream of Shasta Dam. The temperature model outputs suggest that thermal conditions and effects on White Sturgeon in the Sacramento River generally would be slightly more adverse under the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for White Sturgeon spawning, incubation, and rearing would be exceeded more frequently under the No Action Alternative in the Sacramento River.

Overall, the increased frequency of exceedance of temperature thresholds under the No Action Alternative could increase the potential for adverse effects on White Sturgeon in the Sacramento River relative to the Second Basis of Comparison.

*Delta Smelt*

The potential effects of the No Action Alternative as compared to the Second Basis of Comparison were analyzed based on differences in proportional entrainment and the fall abiotic index as described below.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under the No Action Alternative would be 7 to 8.3 percent, depending on the water year type, with a long-term average percent entrainment of 7.6 percent. Percent entrainment of adult Delta Smelt under the No Action Alternative would be similar to results under the Second Basis of Comparison (but slightly lower, by 1 to 2 percent). Under the Second Basis of Comparison, the long-term average percent entrainment would be 9 percent.

A proportional entrainment regression model (based on Kimmerer 2008) was also used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June (Appendix 9G). Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under the No Action Alternative would be 1.3 to 19.3 percent, depending on the water year type, with a long term average percent entrainment of 8.6 percent, and highest entrainment under critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under the No Action Alternative would be lower than projected entrainment under the Second Basis of Comparison by 4.3 to 9.4 percent. Under the Second Basis of Comparison, the long-term average percent entrainment would be 15.5 percent, and highest entrainment would occur under critical water year conditions, at 23.6 percent.

The predicted position of Fall X2 (in September through December) is used as an indicator of fall abiotic habitat index for Delta Smelt. Feyrer et al. (2011) 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. (2011) 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 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 is believed to lead to more favorable growth and survival conditions for Delta Smelt in fall. 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.

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. Results indicate that under the No Action Alternative, the X2 position would range from 75.9 km to 92.4 km, depending on the water year type, with a long term average X2 position of 84 km. The most eastward location of X2 is predicted under Critical water year conditions. The X2 positions predicted under the No Action Alternative would be similar to results under the Second Basis of Comparison in drier water year types. In wetter years, the X2 location would be further west under the No Action Alternative than under the Second Basis of Comparison, by 6.1 to 9.8 km. This difference is largely due to implementation of 2008 USFWS BO RPA Component 3 (Action 4), under the No Action Alternative, which requires Reclamation and DWR to provide sufficient Delta outflow to maintain a monthly average X2 no more eastward than 74 km in above normal and wet year types. Under the Second Basis of Comparison, the long-term average X2 position would be 88.1 km, a location that does not provide for the advantageous overlap of the low salinity zone with Suisun Bay/Marsh.

Overall, the No Action Alternative likely would result in better conditions for Delta Smelt than would the Second Basis of Comparison, primarily due to lower percentage entrainment for larval and juvenile life stages, and more favorable location of Fall X2 in wetter years, and on average.

*Longfin Smelt*

The effects of the No Action Alternative as compared to the Second Basis of Comparison were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

As described in Appendix 5A, OMR flows would generally be negative in all months under the Second Basis of Comparison, with the long-term average ranging from -3,700 to -7,400 cfs from December through June; whereas the OMR flows would generally be less negative during this time period under the No Action Alternative. The greatest differences between alternatives would be in April and May, where long-term average OMR flows would be positive under the No Action Alternative (Appendix 5A, Table C-17-4). The decrease in the magnitude of negative flows, with positive flows in April and May, under the No Action Alternative as compared to the Second Basis of Comparison suggests that it could reduce the potential for entrainment of Delta Smelt at the export facilities.

Under the No Action Alternative, Longfin Smelt abundance index values range from 1,147, under critical water year conditions, to a high of 16,635 under wet water year conditions, with a long-term average value of 7,951. Under the Second Basis of Comparison, Longfin Smelt abundance index values range from 947 during critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257. These results suggest that the Longfin Smelt abundance index values would be higher in every water year type under the No Action Alternative as compared to the Second Basis of Comparison, with a long-term average index for the No Action Alternative that is almost 10 percent higher than the long-term average index for the Second Basis of Comparison. For below normal, dry, and critical water years, the Longfin Smelt abundance index values would be over 20 percent higher under the No Action Alternative than under the Second Basis of Comparison, with the greatest difference (26.2 percent) predicted under dry conditions.

Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in dry and critical years, potential adverse effects on the Longfin Smelt population under the No Action Alternative likely would be less than under the Second Basis of Comparison.

*Sacramento Splittail*

Sacramento Splittail could benefit from the increase in inundated floodplain resulting from implementation of 2009 NMFS BO RPA Action I.6.1, Restoration of Floodplain Rearing Habitat, which would restore 17,000 to 20,000 acres for the primary purpose of enhancing rearing habitat for juvenile salmonids. The efforts currently underway in the Yolo Bypass to comply with this action apply to all alternatives under consideration and it is assumed that a notch in the Fremont Weir (6,000 cfs capacity) will be constructed and that the inundation objectives will be met by 2030. It is not currently known if and how the notch would be operated and how flows entering the bypass would be managed to accommodate floodplain rearing.

While this action is common to all alternatives, changes in operations that influence the hydrology in the Sacramento River could affect the frequency and duration of flows available to provide inundation on the bypass. To generally evaluate the potential influence of these changes in hydrology, the flows entering the Yolo Bypass during December through April were examined to determine the differences among alternatives. It was assumed that changes in flow, particularly those in the range of the 6,000 cfs capacity of the notch and during drier years, would be more likely to influence the acreage of inundated floodplain or the frequency and duration of inundation. It also was assumed that the magnitude of flow (and flow change) roughly corresponds to the amount of inundated floodplain created.

Under the No Action Alternative, flows entering the Yolo Bypass generally would be lower than under the Second Basis of Comparison, especially during below normal years when flows entering the bypass under the No Action Alternative would be lower in December through March (Appendix 5A, Table C-26-4). These decreases would occur during periods of relatively low flow in the bypass, and could slightly decrease the frequency of potential inundation.

Overall, the slight decreases under the No Action Alternative could result in less spawning habitat for Sacramento Splittail than under the Second Basis of Comparison because of the decreased area of potential habitat (inundation) and the potential for a slight decrease in the frequency of inundation.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

*Changes in Available Habitat (Storage)*

As described in Chapter 5, Surface Water Resources and Water Supplies, changes in CVP and SWP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison generally would result in lower reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be lower under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Tables 5.12 through 5.14, in the fall and winter months due to the inclusion of Fall X2 criteria under the No Action Alternative.

The highest reductions in Shasta Lake and Lake Oroville storage could be in excess of 20 percent. Storage in Folsom Lake could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within the CVP and SWP water supply reservoirs is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be reduced under the No Action Alternative as compared to the Second Basis of Comparison.

*Changes in Black Bass Nesting Success*

Black bass nest survival in CVP and SWP reservoirs is anticipated to be near 100 percent in March and April due to increasing reservoir elevations (Appendix 9F). For May, the likelihood of nest survival for Largemouth Bass in Shasta Lake being in the 40 to 100 percent range is about 2 percent higher under the No Action Alternative as compared to the Second Basis of Comparison. For June, the likelihood of nest survival being greater than 40 percent for Largemouth Bass is similar (within 1 percent) under the No Action Alternative and Second Basis of Comparison; however, nest survival of greater than 40 percent is likely only in about 20 percent of the years evaluated. The likelihood of nest survival for Smallmouth Bass in Shasta Lake exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (100 percent) in May under both the No Action Alternative and the Second Basis of Comparison with the likelihood of greater than 40 percent nest survival being slightly less under the No Action Alternative as compared to the Second Basis of Comparison. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Shasta Lake is drawn down. The likelihood of survival being greater than 40 percent is somewhat higher (about 10 percent) under the No Action Alternative as compared to the Second Basis of Comparison.

For May and June, the likelihood of nest survival for Largemouth Bass in Lake Oroville being in the 40 to 100 percent range is higher under the No Action Alternative as compared to the Second Basis of Comparison, about 10 percent higher in May and 3 percent higher in June. However, June nest survival of greater than 40 percent is likely only in about 40 percent of the years evaluated. The likelihood of nest survival for Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (>90 percent) in May under both the No Action Alternative and the Second Basis of Comparison with the likelihood of greater than 40 percent survival being slightly (about 4 percent) higher under the No Action Alternative as compared to the Second Basis of Comparison. For June, Spotted Bass survival would be less than for May due to greater daily reductions in water surface elevation as Lake Oroville is drawn down. The likelihood of survival being greater than 40 percent is substantially (about 20 percent) higher under the No Action Alternative as compared to the Second Basis of Comparison.

Black bass nest survival in Folsom Lake is near 100 percent in March, April, and May due to increasing reservoir elevations. For June, the likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the 40 to 100 percent range is somewhat (around 5 percent) higher under the No Action Alternative as compared to the Second Basis of Comparison. For Spotted Bass, nest survival for June would be less than for May due to greater daily reductions in water surface elevation. However, the likelihood of survival being greater than 40 percent is somewhat (about 5 percent) higher under the No Action Alternative as compared to the Second Basis of Comparison.

*Summary of Effects on Reservoir Fishes*

Reservoir storage is anticipated to be reduced under the No Action Alternative relative to the Second Basis of Comparison and this reduction could affect the amount of warm and cold water habitat available within the reservoirs. However, it is unlikely that aquatic habitat within the CVP and SWP water supply reservoirs is limiting and therefore, it is unlikely that habitat for reservoir fish in the CVP and SWP storage reservoirs under the No Action Alternative and the Second Basis of Comparison would differ in a biologically meaningful manner.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs under the No Action Alternative would be similar to or slightly higher than under the Second Basis of Comparison.

Overall, the results of the nest survival analysis suggest that conditions in the reservoirs would be more likely to support self-sustaining populations of black bass under the No Action Alternative than under the Second Basis of Comparison.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Sacramento River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles.

*Changes in Water Temperature*

The following describes anticipated changes in average monthly water temperature in the Sacramento, Feather, and American rivers and the potential for those changes to affect Pacific Lamprey.

*Sacramento River*

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative. Water temperatures below Keswick Dam are slightly higher from October to December under the No Action Alternative than under the Second Basis of Comparison in most water year types, but by less than 0.5°F on average (Appendix 6B, Table 5-5-4). A similar temperature pattern generally would be exhibited downstream at Ball’s Ferry, Jelly’s Ferry, and Bend Bridge, with average monthly temperatures in June progressively increasing by a small margin under the No Action Alternative relative to the Second Basis of Comparison. Due to the similarity of water temperatures under the No Action Alternative and Second Basis of Comparison from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

*Feather River*

Long-term average monthly water temperature in the Feather River in the low flow channel (downstream of the Thermalito Complex) under the No Action Alternative relative to the Second Basis of Comparison generally are predicted to be similar (less than 0.5°F differences), but slightly higher from October through December when average monthly water temperatures would be up to 1.4°F higher in some water year types. Modeled water temperatures during May and June under the No Action Alternative were also slightly higher, up to a maximum of 0.7°F higher in June of below normal water years. Average monthly water temperatures in July through September under the No Action Alternative generally were predicted to be higher (up to 0.6°F) in drier water year types and lower (up to 1.3°F) in the wetter years (Appendix 6B, Table B-20-4). Although temperatures in the river would become progressively higher in the downstream directions, the differences in water temperatures between the No Action Alternative and Second Basis of Comparison would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under the No Action Alternative generally decreasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento River (Appendix 6B, Table B-23-4).

Due to the similarity of water temperatures under the No Action Alternative and Second Basis of Comparison from January through April, there would be little difference in potential effects on Pacific Lamprey adults during their upstream migration. The slightly higher water temperatures from May through the summer may increase the likelihood of adverse effects on Pacific Lamprey during their holding, and spawning periods.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under the No Action Alternative generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August, when differences under the No Action Alternative could be as much as 0.9°F higher in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth generally would be lower under the No Action Alternative than the Second Basis of Comparison in September, especially in wetter water year types when the No Action Alternative could be up to 1.7°F cooler. Due to the similarity of water temperatures under the No Action Alternative and Second Basis of Comparison from January through May, there would be little difference in potential effects on Pacific Lamprey adults during their upstream migration. The higher water temperatures during June and August may increase the likelihood of adverse effects on Pacific Lamprey during their holding, and spawning periods.

*Summary of Effects on Pacific Lamprey*

In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Based on the somewhat reduced flows and increased temperatures during their spawning and incubation period under the No Action Alternative, it is unlikely that conditions for and effects on Pacific Lamprey in the Sacramento, Feather, and American rivers under the No Action Alternative and the Second Basis of Comparison would differ in a biologically meaningful manner. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

*Striped Bass, American Shad, and Hardhead*

Changes in operations influence temperature and flow conditions that could affect Striped Bass, American Shad, and Hardhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

The following describes temperature conditions in the Sacramento, Feather, and American rivers.

*Sacramento River*

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under the No Action Alternative would generally be similar (less than 0.5°F difference) to water temperatures under the Second Basis of Comparison. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher, respectively, under the No Action Alternative as compared to the Second Basis of Comparison and up to 1°F cooler in September of wetter years under the No Action Alternative. Water temperatures from October to December would be slightly higher under the No Action Alternative than under the Second Basis of Comparison in most water year types, but by less than 0.5°F on average (Appendix 6B, Table 5-5-4). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures in June progressively increasing by a small margin under the No Action Alternative relative to the Second Basis of Comparison. In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly increased temperatures during some months under the No Action Alternative would have substantial adverse effects on these species.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel (below the Thermalito Complex) under the No Action Alternative relative to the Second Basis of Comparison generally were predicted to be similar (less than 0.5°F differences), but slightly higher from October through December when average monthly water temperatures would be up to 1.4°F higher in some water year types (Appendix 6B, Table B-20-4). Although temperatures in the river would become progressively higher in the downstream directions, the differences between the No Action Alternative and Second Basis of Comparison would exhibit a similar pattern at the downstream locations (Appendix 6B, Table B-23-4). As described above for the Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly increased temperatures during some months under the No Action Alternative would have substantial adverse effects on these species in the Feather River.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under the No Action Alternative generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August, when differences under the No Action Alternative could be as much as 0.9°F higher in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than under the Second Basis of Comparison in June. As described above for the Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly increased temperatures during some months under the No Action Alternative would have substantial adverse effects on these species in the American River.

*Summary of Effects on Striped Bass, American Shad, and Hardhead*

In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the slightly decreased flows and increased temperatures during their spawning and incubation period under the No Action Alternative, it is unlikely that conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers under the No Action Alternative and the Second Basis of Comparison would differ in a biologically meaningful manner.

**9.4.3.1.3 Stanislaus River/Lower San Joaquin River**

*Fall-Run Chinook Salmon*

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River downstream of the Stanislaus River confluence, as measured at Vernalis. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under the No Action Alternative and Second Basis of Comparison generally would be similar (differences less than 0.5°F), with small differences in critical dry years when the No Action Alternative would 0.8°F and 1.3°F warmer on average than under the Second Basis of Comparison during June and September, respectively, and 0.7°F cooler in November (Appendix 6B, Table B-17-4).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under the No Action Alternative would be lower in all water year types than the Second Basis of Comparison by as much as 1.9°F. In most other months, water temperatures under the No Action Alternative generally would be similar, although somewhat higher, compared to the Second Basis of Comparison. An exception to this pattern occurs in April and December when average monthly water temperatures in all water year types would be lower under the No Action Alternative by as much as about 1.2°F (April) and 0.4°F (December)in the drier years (Appendix 6B, Table B-18-4).

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between the No Action Alternative and Second Basis of Comparison. Decreases in average monthly water temperatures in October and April would be more pronounced under the No Action Alternative, with average differences as much as 2.7°F in October and 2.0°F in April (Appendix 6B, Table B-19-4) relative to the Second Basis of Comparison. The magnitude of differences in average monthly water temperatures between the No Action

Alternative and the Second Basis of Comparison in May and June also would increase relative to the upstream locations.

Based on the life history timing for fall-run Chinook Salmon, the lower temperatures in October and December under the No Action Alternative may reduce the likelihood of adverse to fall-run Chinook Salmon spawning and egg incubation as compared to the Second Basis of Comparison.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally considered suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and November approximately 30 percent of the time in the Stanislaus River at Goodwin Dam under the No Action Alternative (Appendix 6B, Figures B-17-1 and B-17-2). Similar exceedances would occur under the Second Basis of Comparison, although slightly less frequently in November. Water temperatures for rearing from January to May generally would be below 56°F, except in May when average monthly water temperatures would reach about 60°F under both the No Action Alternative and the Second Basis of Comparison (Appendix 6B, Figure B-17-8).

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded frequently under both the No Action Alternative and Second Basis of Comparison during October and November. Under the No Action Alternative, average monthly water temperatures would exceed 56°F about 57 percent of the time in October (Appendix 6B, Figure B-18-1). This, however, would be about 28 percent less frequently than under the Second Basis of Comparison. In November, average monthly water temperatures would exceed 56°F about 33 percent of the time under the No Action Alternative, which would be about 5 percent more frequent than under the Second Basis of Comparison (Appendix 6B, Figure B-18-2).

From January through May, rearing fall-run Chinook Salmon would be subjected to average monthly water temperatures that exceed 56°F in March (less than 10 percent of the time) and May (about 30 percent of the time) under the No Action Alternative which is about 10 percent more frequently in May than under the Second Basis of Comparison (Appendix 6B, Figure B-18-8).

*Changes in Egg Mortality (Stanislaus River)*

For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg mortality rate is predicted to be around 7 percent, with higher mortality rates (in excess of 14 percent) occurring in critical dry years under the No Action Alternative. Overall, egg mortality would be 0.4 percent lower under the No Action Alternative; in most water year types the average egg mortality rate would be lower than under the Second Basis of Comparison by up to 1.5 percent in critical dry years (Appendix 9C, Table B-8). In water year types where there is increased egg mortality under the No Action Alternative (wet and below-normal years), the increases would be 0.1 and 0.3 percent, respectively. Overall, fall-run

Chinook Salmon egg mortality in the Stanislaus River under the No Action Alternative and the Second Basis of Comparison would be similar.

*Changes in Delta Hydrodynamics*

San Joaquin River-origin fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. Near the Confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities was moderately greater under the No Action Alternative relative to the Second Basis of Comparison in April and May and almost indistinguishable in June (Appendix 9K). On Old River downstream of the facilities, the proportion of positive velocities was substantially greater in April and May, but became more similar in June. In Old River upstream of the facilities, the percent of positive velocities was moderately greater for the No Action Alternative relative to the Second Basis of Comparison in April and May, and moderately lower in June. On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities was moderately lower under the No Action Alternative relative to the Second Basis of Comparison in April and May, whereas the values were similar in June.

*Changes in Entrainment at Junctions*

Entrainment probabilities at the Head of Old River were much greater under the No Action Alternative relative to the Second Basis of Comparison during April and May. Entrainment probabilities were similar under both alternatives in the month of June (Appendix 9L). At the Turner Cut junction, entrainment probabilities under the No Action Alternative were slightly lower than the Second Basis of Comparison in June. During April and May, entrainment probabilities were more divergent with lower values for the No Action Alternative relative to the Second Basis of Comparison. Overall, entrainment was lower at the Columbia Cut junction relative to Turner Cut, but patterns of entrainment between these two scenarios were similar. Entrainment was slightly lower for the No Action Alternative relative to the Second Basis of Comparison during June. In April and May, entrainment was lower for the No Action Alternative relative to the Second Basis of Comparison. Patterns at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

*Changes in Fish Passage on the Stanislaus River*

The No Action Alternative includes the provision of passage at New Melones Dam for spring-run Chinook Salmon and steelhead. The challenges and difficulties associated with providing fish passage upstream of Shasta and Folsom dams were briefly summarized previously, and the same considerations apply to passage upstream of New Melones Dam.

If a fish passage program could establish self-sustaining populations of spring-run Chinook Salmon and steelhead upstream of New Melones, it would contribute substantially to satisfaction of the spatial diversity viability standard. The passage program could also contribute to abundance and productivity, if average returns consistently exceeded 500 individuals. However, the passage program could also function as a population sink if fish transported above the reservoir achieved a cohort replacement rate of less than 1.

Insufficient information is available currently on the quantity, suitability, and accessibility of habitat upstream of New Melones. Given poor habitat data and the considerable technical uncertainties discussed previously, it is not possible to determine if (or how much) fish passage at New Melones Dam are likely to affect the status of Central Valley spring-run Chinook Salmon and steelhead populations.

While the purpose of the fish passage action is not intended to benefit fall-run Chinook Salmon, it could provide benefit if volitional passage by adult fish is successful.

*Summary of Effects on Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under the No Action Alternative as compared to the Second Basis of Comparison. In the Stanislaus River, the analysis of the effects of the No Action Alternative and Second Basis of Comparison for fall-run Chinook Salmon relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in the Stanislaus River generally would be similar under both scenarios, although water temperatures could be somewhat more suitable for fall-run Chinook Salmon spawning/egg incubation under the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that suitable water temperatures for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly more frequently in November, but substantially less frequently in October under the No Action Alternative. Suitable water temperatures for fall-run Chinook Salmon rearing would be exceeded somewhat more frequently under the No Action Alternative. Results of the analysis using Reclamation’s salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under the No Action Alternative and the Second Basis of Comparison.

Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the differences in the frequency of exceedance of suitable temperatures for spawning and rearing under the No Action Alternative could affect the potential for adverse effects on the fall-run Chinook Salmon populations in the Stanislaus River. However, the direction and magnitude of this effect is uncertain and it likely that the effects on fall-run Chinook Salmon in the Stanislaus River would be similar under both the No Action Alternative and Second Basis of Comparison. Implementation of a fish passage project, although intended to address the limited availability of suitable habitat for Spring-run Chinook Salmon and steelhead in the Stanislaus River reaches downstream of Goodwin Dam, likely would provide some benefit to fall-run Chinook Salmon if volitional passage were provided and additional habitat could be accessed. Any potential benefit to fall-run Chinook Salmon is uncertain.

*Steelhead*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River downstream of the Stanislaus River confluence, as measured at Vernalis could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under the No Action Alternative and Second Basis of Comparison generally would be similar (differences less than 0.5°F), with small differences in critical dry years when the No Action Alternative would 0.8°F and 1.3°F warmer on average than under the Second Basis of Comparison during June and September, respectively, and 0.7°F cooler in November (Appendix 6B, Table B-17-4).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under the No Action Alternative would be lower than the Second Basis of Comparison in all water year types by as much as 1.9°F. In most other months, water temperatures under the No Action Alternative generally would be similar, although somewhat higher, to the Second Basis of Comparison, except in April when average monthly water temperatures in all water year types would be lower under the No Action Alternative by as much as about 1.2°F in the drier years (Appendix 6B, Table B-18-4).

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between the No Action Alternative and Second Basis of Comparison. Decreases in average monthly water temperatures in October and April would be more pronounced under the No Action Alternative, with average differences as much as 2.7°F (Appendix 6B, Table B-19-4) relative to the Second Basis of Comparison. The magnitude of differences in average monthly water temperatures between the No Action Alternative and the Second Basis of Comparison in May and June also would increase relative to the upstream locations.

Overall, the temperature differences between the No Action Alternative and Second Basis of Comparison would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Stanislaus River. Based on the life history timing for steelhead, the slightly higher temperatures under the No Action Alternative may increase the likelihood of adverse effects to steelhead rearing in the Stanislaus River; the lower temperatures in October and December under the No Action Alternative may reduce the likelihood of adverse effects on adult steelhead during their upstream migration.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both the No Action Alternative and Second Basis of Comparison during October and November. Under the No Action Alternative, average monthly water temperatures would exceed 56°F about 57 percent of the time in October which is about 28 percent less frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-1). In November, average monthly water temperatures would exceed 56°F about 33 percent of the time under the No Action Alternative, which would be about 5 percent more frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-2).

In January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. This threshold would not be exceeded under either the No Action Alternative or Second Basis of Comparison during January or February. In March through May, however, exceedances would occur under both the No action Alternative and Second Basis of Comparison in each month, with the threshold most frequently exceeded (nearly half the time) under the No Action Alternative in May (Appendix 9N). Average monthly water temperatures under the No Action Alternative would exceed the threshold more frequently in March (5 percent) and May (5 percent), and less frequently (17 percent) in April than under the Second Basis of Comparison.

From June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded under both the No Action Alternative and Second Basis of Comparison in all months but November, and would exceed the threshold about 16 percent of the time in July under both the No Action Alternative and Second Basis of Comparison. The differences between the No Action Alternative and Second Basis of Comparison, however, could be biologically meaningful, with average monthly water temperatures under the No Action Alternative generally exceeding the threshold up to about 3 percent more frequently than under the Second Basis of Comparison.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles upstream of Knights Ferry, average monthly water temperatures under the No Action Alternative would exceed 52°F in March, April, and May about 8 percent, 33 percent, and 63 percent of the time, respectively. Water temperatures under the No Action Alternative would result in exceedances occurring about 1 to 2 percent less frequently during the January through May period. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and would be exceeded less frequently. The magnitude of the exceedance also would be less. Average monthly water temperatures under the No Action Alternative and the Second Basis of Comparison would not exceed the threshold during January through March. In April and May, exceedances of 2 percent and 18 percent would occur under the No Action Alternative, which would represent a frequency of about 6 percent less than the Second Basis of Comparison in April and about an 8 percent higher frequency in May.

Overall, the differences between the No Action Alternative and Second Basis of Comparison would be relatively small, with the exception of substantial differences in the frequency of exceedances in October when the average monthly water temperatures under the No Action Alternative would exceed the threshold for adult steelhead migration about 28 percent less frequently and in April during the spawning period when the exceedance frequency would be about 17 percent less. Given the frequency of exceedance under both the No Action Alternative and Second Basis of Comparison and the generally stressful temperature conditions in the river, the substantial differences (improvements) in October and April under the No Action Alternative suggest that there would be less potential to adversely affect steelhead under the No Action Alternative than under the Second Basis of Comparison. Even during months when the differences would be relatively small, the lower frequency of exceedances under the No Action Alternative could represent a biologically meaningful and positive difference.

*Changes in Delta Hydrodynamics*

San Joaquin River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing than there is for Chinook salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for fall-run Chinook Salmon in the San Joaquin River basin above.

*Changes in Entrainment at Junctions*

At the Head of Old River, entrainment under the Second Basis of Comparison was slightly higher during January and February relative to the No Action Alternative. Entrainment probabilities were much lower under the Second Basis of Comparison during April and May. Entrainment probabilities were similar under both scenarios in the month of June (Appendix 9L). At the Turner Cut junction, entrainment probabilities under the No Action Alternative were slightly lower than the Second Basis of Comparison in January, February March and June. During April and May, Entrainment probabilities were more divergent with lower values for the No Action Alternative relative to the Second Basis of Comparison. Overall, entrainment was lower at the Columbia Cut junction relative to Turner Cut but patterns of entrainment between these two alternatives were similar. Entrainment was slightly lower for the No Action Alternative relative to the Second Basis of Comparison during January, February, March and June. In April and May, Entrainment was lower for the No Action Alternative relative to the Second Basis of Comparison. Patterns at the Middle River and Old River junctions were similar to those observed at the Columbia and Turner Cut junctions.

*Summary of Effects on Steelhead*

The analysis of the effects of the No Action Alternative and Second Basis of Comparison for steelhead relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead in all of these streams generally would be similar under both scenarios, although water temperatures could be somewhat more suitable for steelhead rearing under the No Action Alternative. Water temperatures could be somewhat less suitable during the adult upstream migration period under the No Action relative to the Second Basis of Comparison. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature threshold for steelhead migration would be exceeded less frequently in October, but more frequently in November under the No Action Alternative. The water temperature threshold for steelhead spawning would also be exceeded less frequently in May, but less frequently in other months under the No Action Alternative. The water temperature threshold for steelhead rearing generally would be exceeded more frequently under the No action Alternative while the temperature thresholds for smoltification would be exceeded less frequently in most months.

Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the differences in the magnitude and frequency of exceedance of suitable temperatures for the various life stages under the No Action Alternative could affect the potential for adverse effects on the steelhead populations in the Stanislaus River. However, the direction and magnitude of this effect is uncertain. Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could provide a benefit to steelhead, however, the extent of benefit is uncertain.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

As described in Chapter 5, Surface Water Resources and Water Supplies, changes in CVP and SWP water supplies and operations under the No Action Alternative as compared to the Second Basis of Comparison would result in lower Storage levels in New Melones Reservoir under the No Action Alternative as compared to the Second Basis of Comparison, as summarized in Table 5.16, due to increased instream releases to support fish flows under the 2009 NMFS BO.

Storage in New Melones could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within New Melones is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be reduced under the No Action Alternative as compared to the Second Basis of Comparison.

As shown in Appendix 9F, predicted survival in New Melones is higher than in the other reservoirs during May and June. For March, Largemouth Bass and Smallmouth Bass nest survival is predicted to be above 40 percent in all of the years simulated. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is reasonably high, but is lower (about 13 percent) under the No Action Alternative as compared to the Second Basis of Comparison. For May, this pattern is reversed with the likelihood of high nest survival being slightly (about 3 percent) greater under the No Action Alternative. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is also higher (about 8 percent) under the No Action Alternative as compared to the Second Basis of Comparison. For Spotted Bass, nest survival in March is anticipated to be near 100 percent in every year under both the No Action Alternative and Second Basis of Comparison. The likelihood of survival being greater than 40 percent is high in April under both the No Action Alternative and the Second Basis of Comparison with the likelihood of greater than 40 percent survival being slightly (about 1 percent) lower under the No Action Alternative as compared to the Second Basis of Comparison. For May, this pattern is reversed with the likelihood of high Spotted Bass nest survival being slightly (about 2 percent) higher under the No Action Alternative. For June, Spotted Bass nest survival would be greater than 40 percent in approximately 98 percent of the years under the No Action Alternative, compared to every year under the Second Basis of Comparison.

Overall, the potential for adverse effects could slightly higher under Alternative 1 as compared to the Second Basis of Comparison because of the overall relative reductions in reservoir storage and the slightly improved nest survival in some months.

*Other species*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

As described above, average monthly water temperatures in the Stanislaus River at Goodwin Dam under the No Action Alternative and Second Basis of Comparison generally would be similar. Downstream at Orange Blossom Bridge, average monthly water temperatures in the November to March period under the No Action Alternative generally would be similar to, although somewhat higher than, under the Second Basis of Comparison, except in April when average monthly water temperatures in all water year types would be lower under the No Action Alternative. This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between the No Action Alternative and Second Basis of Comparison (Appendix 6B, Table B-19-1).

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could adversely affect these larval lamprey. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar under the No Action Alternative and the Second Basis of Comparison.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar under the No Action Alternative and the Second Basis of Comparison.

#### *9.4.3.2 Alternative 1*

As described in Chapter 3, Description of Alternatives, Alternative 1 is identical to the Second Basis of Comparison. As described in Chapter 4, Approach to Environmental Analysis, Alternative 1 is compared to the No Action Alternative and the Second Basis of Comparison. However, because aquatic resource conditions under Alternative 1 are identical to aquatic resource conditions under the Second Basis of Comparison; Alternative 1 is only compared to the No Action Alternative.

##### 9.4.3.2.1 Alternative 1 Compared to the No Action Alternative

*Trinity River Region*

*Coho Salmon*

The analysis of effects associated with changes in operation on Coho Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam for Coho Salmon.

Long-term average monthly water temperatures in the Trinity River at Lewiston Dam under Alternative 1 generally would be similar to, although slightly cooler, (up to 0.4°F), than under the No Action Alternative (Appendix 6B, Table B-1-1). Average monthly temperatures generally would be slightly lower (up to 0.4°F) during November through February under Alternative 1, with the exception of critical years when temperatures under Alternative 1 could be as much as 2.4°F warmer (November) and in December when water temperatures could be as much as 1.5°F cooler in below normal years (Appendix 6B, Table B-1-1). Average monthly water temperatures generally would be similar (less than 0.5°F differences) under Alternative 1 and the No Action Alternative during July through September, except in wet years and critical years in September when temperatures would be slightly higher (0.6°F and 0.3°F, respectively) under Alternative 1.

The USFWS established a water temperature threshold of 56°F for Coho Salmon spawning in the reach of the Trinity River from Lewiston to the confluence with the North Fork Trinity River from October through December. Although not entirely reflective of water temperatures throughout the reach, the temperature model provides average monthly water temperature outputs for releases from the Lewiston Dam, which may provide perspective on temperature conditions in the reach. In October and November, average monthly water temperatures under both Alternative 1 and the No Action Alternative would exceed 56°F at Lewiston Dam in some years (Appendix 9N). Under Alternative 1, the threshold would be exceeded about 6 percent of the time in October, about 1 percent less frequently than under the No Action Alternative. In November, both conditions would result in an exceedance frequency of about 2 percent. There would be no exceedance of the threshold in December under both the Alternative 1 and the No Action Alternative.

Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be slightly less frequent (1 percent) under Alternative 1. The higher water temperatures in November of critical years (and lower temperatures in December) under Alternative 1 would likely have little effect on Coho Salmon as water temperatures in the Trinity River are typically low during this time period. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), Alternative 1 and the No Action Alternative are likely to have similar effects on the Coho Salmon population in the Trinity River.

*Spring-run Chinook Salmon*

The analysis of effects associated with changes in operation on spring-run Chinook Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

As described above for Coho Salmon, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Trinity River. The higher average monthly water temperatures (up to 2.4°F) in November of critical years (and lower temperatures in December) under Alternative 1 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

Under both Alternative 1 and the No Action Alternative, average monthly water temperatures in the Trinity River at Lewiston Dam would infrequently (1 percent to 2 percent of the time) exceed 60°F, the threshold for spring-run Chinook Salmon holding. There would be no difference in the frequency of exceedance of the 60°F threshold under Alternative 1 as compared to the No Action Alternative. In September, however, the threshold for spawning (56°F) would be exceeded 11 percent of the time under Alternative 1 which is about 2 percent more frequently than under the No Action Alternative.

Overall, the differences in the frequency of threshold exceedance between Alternative 1 and the No Action Alternative would be relatively minor, although, temperature conditions under Alternative 1 could be slightly more likely to adversely affect spring-run Chinook Salmon spawning than under the No Action Alternative because of the slightly increased frequency of exceedance of the 56°F threshold at Lewiston Dam in September.

The majority of spring-run Chinook Salmon in the Trinity River are produced in the South Fork Trinity watershed. Although the water temperatures under Alternative 1 could adversely affect spring-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences water temperatures under Alternative 1 as compared to the No Action Alternative.

Overall, Alternative 1 is likely to have similar effects on the spring-run Chinook Salmon population in the Trinity River as compared to the No Action Alternative.

*Fall-Run Chinook Salmon*

The analysis of effects associated with changes in operation on fall-run Chinook Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam. In addition, the Reclamation Salmon Mortality Model was used to assess egg mortality.

As described above for Coho Salmon, the temperature differences between Alternative 1 and No Action Alternative would be relatively minor (less than 0.5°F) and egg incubation likely would have little effect on fall-run Chinook Salmon in the Trinity River. The higher water temperatures (as much as 2.4°F) in November of critical years (and lower temperatures in December) under Alternative 1 would likely have little effect on fall-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold and months during which it applies for fall-run Chinook Salmon are the same as those for Coho Salmon. Under Alternative 1, the threshold would be exceeded about 6 percent of the time in October, about 1 percent less frequently than under the No Action Alternative. In November, both conditions would result in an exceedance frequency of about 2 percent. There would be no exceedance of the threshold in December under both Alternative 1 and the No Action Alternative. Overall, the differences in the frequency of threshold exceedance between Alternative 1 and the No Action Alternative would be relatively minor. Temperature conditions under the Alternative 1 could be slightly less likely to adversely affect fall-run Chinook Salmon spawning than under the No Action Alternative because of the slightly reduced frequency of exceedance of the 56°F threshold at Lewiston Dam in October. However, this would occur prior to the peak spawning period for fall-run Chinook Salmon.

The temperatures described above for the Trinity River downstream of Lewiston Dam are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For fall-run Chinook Salmon in the Trinity River, the long-term average egg mortality rate is predicted to be relatively low (around 4 percent), with higher mortality rates (nearly 15 percent) occurring in critical dry years under the No Action Alternative. The predicted long-term average egg mortality would be about 0.2 percent lower under Alternative 1 than under the No Action Alternative; in critical dry years the average egg mortality rate would be 1.8 percent lower under Alternative 1 than under the No Action

Alternative and in wet years it would be 0.6 percent higher under Alternative 1 (Appendix 9C, Table B-1-5). Overall, egg mortality under Alternative 1 and the No Action Alternative would be similar.

Based on the water temperature changes described above Alternative 1 would not likely have adverse effects on fall-run Chinook Salmon in the Trinity River compared to the No Action Alternative. Further, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures (as well as egg mortality) under Alternative 1 as compared to the No Action Alternative.

Overall, Alternative 1 is likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River as compared to the No Action Alternative.

*Steelhead*

The analysis of effects associated with changes in operation on steelhead relied on temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

Temperature differences between Alternative 1 and No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Trinity River. The higher water temperatures (up to 2.4°F) in November of critical years (and lower temperatures in December) under Alternative 1 would likely have little effect on steelhead as water temperatures in the Trinity River are typically low during this time period.

The temperature threshold and months during which it applies for steelhead are the same as those described for Coho Salmon. Thus, the frequency of average monthly water temperatures in the Trinity River at Lewiston Dam exceeding the threshold of 56°F for steelhead would be the same as those described above for Coho Salmon. Overall, the differences in the frequency of threshold exceedance between Alternative 1 and the No Action Alternative would be relatively minor and are unlikely to affect steelhead spawning in the Trinity River.

Based on the water temperature changes described above, Alternative 1 would not likely have adverse effects on steelhead in the Trinity River compared to the No Action Alternative. Further, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures under Alternative 1 as compared to the No Action Alternative. Overall, Alternative 1 is likely to have similar effects on the steelhead population in the Trinity River as compared to the No Action Alternative.

*Green Sturgeon*

The analysis of effects associated with changes in operation on Green Sturgeon relied on temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

Green Sturgeon spawn in the lower reaches of the Trinity River during April through June, and water temperatures above about 63°F are believed stressful to embryos (Van Eenennaam et al. 2005). Average monthly water temperature conditions during April through June in the Trinity River at Lewiston Dam under Alternative 1 would be similar to the temperatures under the No Action Alternative and would not exceed 58°F during this period. In addition, water temperatures in the reach of the river where Green Sturgeon spawn are likely controlled by other factors (e.g., ambient air temperatures and tributary inflows) more than water operations at Trinity and Lewiston dams.

Overall, given the similarities between average monthly water temperatures at Lewiston Dam under Alternative 1 and the No Action Alternative, it is likely that temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar under both scenarios.

*Reservoir Fishes*

The analysis of effects associated with changes in operation 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 result in higher reservoir storage in Trinity Lake. Storage in Trinity Lake could increase by up to about 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

Using Trinity Lake storage as an indicator of habitat available to fish species inhabiting the reservoir, the amount of habitat for reservoir fishes would not be reduced under Alternative 1 as compared to the No Action Alternative.

As shown in Appendix 9F, nest survival in Trinity Lake is near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of survival for Largemouth Bass in Trinity Lake being in the 40 to 100 percent range is slightly (about 2 percent) higher under Alternative 1 as compared to the No Action Alternative. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass is somewhat lower than in May and is slightly lower (about 2 percent) under Alternative 1 as compared to the No Action Alternative. For Spotted Bass, the likelihood of survival being greater than 40 percent would be 100 percent in May under both Alternative 1 and the No Action Alternative. For June, Spotted Bass survival in Trinity Lake would be less than for May due to greater daily reductions in water surface elevation. The likelihood of survival being greater than 40 percent would be similar (near 100 percent) under 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 would be similar to those under the No Action Alternative.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Trinity River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles. On average, the temperature of water released at Lewiston Dam under Alternative 1 generally would be similar to (less than 0.5°F differences) to those under the No Action Alternative. Given the similarities in temperature, it is likely that the effects on Pacific Lamprey would be similar under Alternative 1 and the No Action Alternative. This conclusion likely applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).

*Eulachon*

It is unclear whether this species has been extirpated from the Klamath River. Given that the highest increases in flow under Alternative 1 would be less than 10 percent in the Trinity River (Appendix 5A), with a smaller relative change in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River are unlikely to be affected by changes upstream at Lewiston Dam, it is likely that Alternative 1 would have a similar potential to influence Eulachon in the Klamath River as the No Action Alternative.

*Sacramento River System*

*Winter-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar to (less than 0.5°F difference) to water temperatures under the No Action Alternative. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years in some water year types(up to 0.3°F) (Appendix 6B, Table B-5-1). A similar pattern of changes in temperature generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures under Alternative 1 progressively increasing (up to a 2.8°F difference at Bend Bridge) in September during the wetter years under Alternative 1(Appendix 6B, Table B-8-1).

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor(less than 0.5°F) and likely would have little effect on winter-run Chinook Salmon in the Sacramento River. Spawning for winter-run Chinook Salmon in the Sacramento River takes place from mid-April to mid-August with incubation occurring over the same time period and extending into October. The somewhat lower water temperatures in September and October or critical dry years under the No Action Alternative could reduce the likelihood of adverse effects on winter-run Chinook Salmon egg incubation and fry rearing during this water year type. However, the increased water temperatures during this time period under Alternative 1 in wetter years could increase the likelihood of adverse effects on egg incubation relative to the No Action Alternative.

#### *Changes in Exceedances of Water Temperature Thresholds*

With the exception of April, average monthly water temperatures under both Alternative 1 and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Ball's Ferry from April to September for winter-run Chinook Salmon spawning and egg incubation, with exceedances under both as high as about 52 percent and 42 percent, respectively, in some months (Appendix 9N). Under Alternative 1, the temperature threshold generally would be exceeded less frequently than under the No Action Alternative (by about 1 percent to 3 percent) in the April through August period, with the temperature threshold in September exceeded about 10 percent more frequently under Alternative 1 than the No Action Alternative. Farther downstream at Bend Bridge, the frequency of exceedances would increase, with exceedances under both Alternative 1 and the No Action as Alternative as high as about 90 percent in some months. Under Alternative 1, temperature exceedances generally would be less frequent (by up to 8 percent) than under the No Action Alternative, with the exception of September, when threshold exceedances under Alternative 1 would be about 29 percent more frequent.

Overall, there would be substantial differences in the frequency of threshold exceedance between Alternative 1 and the No Action Alternative, particularly in September. Temperature conditions under Alternative 1 would reduce the likelihood of adverse effects on winter-run Chinook Salmon egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold from April through August. However, the substantial increase in the frequency of exceedance in September under Alternative 1 may increase the likelihood of adverse effects on winter-run Chinook Salmon egg incubation during this limited portion of the spawning and egg incubation period.

#### *Changes in Egg Mortality*

The temperatures described above for the Sacramento River downstream of Keswick Dam are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For winter-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively low (around 4 percent), with higher mortality rates (exceeding 20 percent) occurring in critical dry years under Alternative 1. Overall, egg mortality would be 0.7 percent lower under Alternative 1 compared to the No Action Alternative; in critical dry years the average egg mortality rate would be 5.4 percent lower under Alternative 1 than under the No Action Alternative (Appendix 9C, Table B-4). Overall, winter-run Chinook Salmon egg mortality in the Sacramento River under Alternative 1 and the No Action Alternative would be similar, except in critical dry water years.

#### *Changes in Weighted Usable Area*

As described above for the assessment methodology, Weighted Usable Area (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 spawning habitat for winter-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be lower amounts of spawning habitat available from May through September under Alternative 1 as compared to the No Action Alternative (Appendix 9E). The decrease in long-term average spawning WUA during these months would be relatively small (less than 5 percent), with smaller (less than 1 percent) decreases in May and July. There would be increase in the long-term average spawning WUA in April, but this increase is small (less than 1 percent) and would occur prior to the peak spawning period in May and June. Overall, spawning habitat availability would be similar under Alternative 1 and the No Action Alternative.

Modeling results indicate that, in general, there would be higher amounts of suitable fry rearing habitat available from June through October under Alternative 1 (Appendix 9E) compared to the No Action Alternative. The increase in long-term average fry rearing WUA during these months would be relatively small (less than 5 percent), with smaller (less than 1 percent) reductions in July and October. There would be a decrease in the long-term average fry rearing WUA in September, but this reduction would be small (less than 5 percent) and would occur at a time when most fry have grown into juveniles and moved into habitats with different depth and velocity characteristics as reflected in the analysis of juvenile rearing WUA below. Overall, fry rearing habitat availability would be similar under Alternative 1 and the No Action Alternative.

Similar to the results for fry rearing WUA, modeling results indicate that there would be slightly increased amounts of suitable juvenile rearing habitat available during the early juvenile rearing period from September through December under Alternative 1. There would be a decrease in the long-term average juvenile rearing WUA from January through August (Appendix 9E). The increases in long-term average juvenile rearing WUA would be relatively small (less than 5 percent), while the decreases would be smaller (less than 1 percent). Overall, juvenile rearing habitat availability would be similar under Alternative 1 and the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that flow-related winter-run Chinook Salmon egg mortality would be increased by 61 percent under Alternative 1 compared to the No Action Alternative. Conversely, temperature-related egg mortality would be 16 percent lower under Alternative 1 (Appendix 9D, Table B-4-4). Both temperature- and flow (habitat)-related fry mortality would be approximately 16 to 17 percent lower under Alternative 1 as compared to the No Action Alternative. Temperature-related juvenile mortality would be approximately 15 percent lower under Alternative 1, while flow (habitat)-related mortality would be approximately 21 percent higher under Alternative 1 as compared to the No

Action Alternative. Overall, potential juvenile production under Alternative 1 would be the similar to the No Action Alternative (Appendix 9D, Table B-4-1).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for winter-run Chinook Salmon between Alternative 1 and the No Action Alternative (Appendix 9J). Median Delta survival would be 0.352 for Alternative 1 and 0.349 for the No Action Alternative.

*Changes in Oncorhynchus Bayesian Analysis Output*

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Escapement was generally lower under Alternative 1 as compared to the No Action Alternative (Appendix 9I). The median abundance under Alternative 1 was lower in 19 of the 22 years of simulation (1971 to 2002), and there was typically greater than a 25 percent chance that Alternative 1 values would be lower than under the No Action Alternative. Median delta survival was approximately 12 percent lower under Alternative 1 as compared to the No Action Alternative. The differences in survival, although not consistent across the uncertainty in the parameter values, suggest a high probability of no difference between these two scenarios.

*Changes in Interactive Object-Oriented Simulation Output*

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between Alternative 1 and the No Action Alternative across the 81 water years (Appendix 9H). Under Alternative 1 median adult escapement was 4,042 and under the No Action Alternative, median escapement was 3,935.

Similar to adult escapement, the IOS model predicted similar egg survival time histories for winter-run Chinook Salmon between Alternative 1 and the No Action Alternative across the 81 water years (Appendix 9H). Under Alternative 1 median egg survival was 0.987 and under the No Action Alternative median egg survival was 0.990 (.

*Changes in Delta Hydrodynamics*

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February and March. On the Sacramento River near the confluence of Georgiana Slough, the percentage of positive velocities under Alternative 1 was indistinguishable from the No Action Alternative (Appendix 9K).

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough was similar under both Alternative 1 and No Action Alternative during January, February and March when winter-run Chinook Salmon smolts are most abundant in the Delta (Appendix 9L).

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 1 relative to No Action Alternative in every month

(Appendix 9M). Winter-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of January, February and March. Predicted values in January and February indicated an increase in the fraction of fish salvaged for Alternative 1 relative to the No Action Alternative.

*Summary of Effects on Winter-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for winter-run Chinook Salmon and their response to change under Alternative 1 as compared to the No Action Alternative. For the purpose of analyzing effects on winter-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the two life cycle models, IOS and OBAN because they each integrate the available information to produce single estimates of winter-run Chinook Salmon escapement. The output from IOS indicated that winter-run Chinook Salmon escapement would be similar under both scenarios, whereas the OBAN results indicated that escapement under Alternative 1 would be lower than under the No Action Alternative, although there would be some chance (less than a 25 percent) that escapement under the Alternative 1 could be greater than the No Action Alternative.

These model results suggest that effects on winter-run Chinook Salmon would be similar under both scenarios, with a small likelihood that winter-run Chinook Salmon escapement would be lower under Alternative 1 than under the No Action Alternative. This potential distinction between the two scenarios, however, may be offset or reversed by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program.

*Spring-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, and Feather River downstream of Oroville Dam could affect spring-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature that could affect spring-run Chinook Salmon could occur in the Sacramento River, Clear Creek, and Feather River. The following describes temperature conditions in those water bodies.

*Sacramento River*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table B-5-1). A similar pattern of changes in temperature generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences progressively increasing (up to a 3.2°F difference at Red Bluff) in September during the wetter years (Appendix 6B, Table B-9-1).

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Sacramento River. The slightly lower water temperatures from October to December under Alternative 1 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Sacramento River below Keswick Dam are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on spring-run Chinook Salmon spawning, although the decreased temperatures in September of critical dry years under Alternative 1 may reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning in this water year type. There would be little difference in potential effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under Alternative 1 and the No Action Alternative.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative 1 relative to the No Action Alternative are generally predicted to be similar to or lower (up to about 0.5°F differences) from September through April and June through August from September through April and June through August (Appendix 6B, Table B-3-1). Average monthly water temperatures during May under Alternative 1 would be higher by 0.4°F to 0.8°F than under the No Action Alternative in all water year types. Overall, effects on spring-run Chinook Salmon due to temperature differences between Alternative 1 and the No Action Alternative would be relatively minor.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel under Alternative 1 relative to the No Action Alternative generally were predicted to be similar (less than 0.5°F differences), but slightly lower from October through December when average monthly water temperatures would be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Modeled water temperatures during May and June under Alternative 1 were also slightly lower, up to a maximum of 0.7°F lower in June of below normal water years. Average monthly water temperatures in July through September under Alternative 1 generally were predicted to be lower (up to 0.6°F) in drier water year types and higher (up to 1.3°F) in the wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the differences between Alternative 1 and No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperatures under Alternative 1 generally increasing in most water year types relative to the No Action Alternative. Water temperatures under the No Action

Alternative were predicted to be somewhat (0.7°F to 1.6°F) warmer on average and up to 4.0°F warmer at the confluence with the Sacramento River from July to September in wetter years (Appendix 6B, Table B-23-1).

Overall, the temperature differences in the Feather River between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Feather River. The slightly lower water temperatures in November and December under Alternative 1 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on spring-run Chinook Salmon spawning, although the decreased temperatures in September of critical dry years under Alternative 1 may reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning in this water year type. There would be little difference in potential effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under Alternative 1 and the No Action Alternative.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for spring-run Chinook Salmon in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of water temperature threshold exceedances for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both Alternative 1 and No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for spring-run Chinook Salmon (egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October (79 percent of the time under Alternative 1); under Alternative 1 the water temperature threshold would be exceeded less frequently in November (7 percent of the time under Alternative 1) and not exceeded at all from December through March (Appendix 9N). As water temperatures warm in the spring, the thresholds would be exceeded in April by 15 percent under Alternative 1. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate less frequent exceedances (by up to 4 percent in October) under Alternative 1 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 1 could be less likely to affect spring-run Chinook Salmon egg incubation than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in October, November, and April.

*Clear Creek*

Average monthly water temperatures under both Alternative 1 and No Action Alternative would not exceed the water temperature threshold of 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in

June through August. However, water temperatures under Alternative 1 and No Action Alternative would exceed the water temperature threshold of 56°F established for spawning in September and October about 10 percent to 15 percent of the time (Appendix 9N). The differences between Alternative 1 and the No Action Alternative could be biologically meaningful, with water temperatures under Alternative 1 exceeding thresholds about 3 percent less frequently than under the No Action Alternative in September and about 2 percent less frequently in October, respectively (Appendix 9N). Temperature conditions in Clear Creek under Alternative 1 could be less likely to affect spring-run Chinook Salmon spawning than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in September and October.

*Feather River*

Average monthly water temperatures under both Alternative 1 and the No Action Alternative would exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg incubation and rearing during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). The frequency of exceedance was highest in October, a month in which average monthly water could get as high as about 68°F. However, the differences in the frequency of exceedances between Alternative 1 and No Action Alternative would be relatively small. Water temperatures under Alternative 1 would exceed the temperature threshold about 1 percent less frequently than under the No Action Alternative in October, November, and December, and about 2 percent more frequently in March.

The established water temperature threshold of 63°F for rearing during May through August would be exceeded often under both Alternative 1 and the No Action Alternative in May and June, but not at all in July and August. Water temperatures under Alternative 1 would exceed the rearing temperature threshold about 9 percent less frequently than under the No Action Alternative in May. Temperature conditions in the Feather River under Alternative 1 could be less likely to affect spring-run Chinook Salmon spawning and rearing than under the No Action Alternative because of the decreased frequency of exceedance of the water temperature thresholds.

*Changes in Egg Mortality*

These temperature differences described above are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For spring-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively high (exceeding 20 percent), with high mortality rates (exceeding 70 percent) occurring in critical dry years. Overall, spring-run Chinook Salmon egg mortality in the Sacramento River is predicted to be 0.7 percent lower under Alternative 1; in critical dry years the average egg mortality rate is predicted to be 10.4 percent lower than under the No Action Alternative (Appendix 9C, Table B-3). Overall, spring-run Chinook Salmon egg mortality in the Sacramento River under Alternative 1 and the No Action Alternative would be similar, except in critical dry water years.

*Changes in Weighted Usable Area*

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 1 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that pre-spawning mortality of spring-run Chinook Salmon eggs would be approximately 18 percent lower under Alternative 1, primarily due to decreased summer temperatures. Flow-related spring-run Chinook Salmon egg mortality would be increased by 10 percent under Alternative 1 compared to the No Action Alternative. Conversely, temperature-related egg mortality would be 10 percent lower under Alternative 1 (Appendix 9D, Table B-3-4). Flow (habitat)-related fry mortality would be approximately 8 percent higher under Alternative 1 as compared to the No Action Alternative. There would be no temperature- or flow (habitat)-related juvenile mortality under either alternative, as most spring-run Chinook Salmon juveniles have migrated downstream as fry and are not found in the mainstem Sacramento River. Overall, potential spring-run juvenile production would be slightly (approximately 2 percent) higher under Alternative 1 as compared to the No Action Alternative (Appendix 9D, Table B-3-1).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for spring-run Chinook Salmon between Alternative 1 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.286 for Alternative 1 and 0.296 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

Spring-run Chinook Salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough (DSM2 channel 421), the percent of time that velocity was positive was similar in the March for both scenarios. In April and May, percent positive velocity near the junction of Georgiana Slough was slightly higher under Alternative 1 relative to the No Action Alternative. In Old River upstream of the facilities (DSM2 channel 212) percent positive velocity was slightly higher in March and moderately lower in April and May under Alternative 1 relative to the No Action Alternative (Appendix 9K). In Old River downstream of the facilities (channel 94) percent positive velocity was slightly lower in March and increasingly lower in April and May under Alternative 1 relative to No Action Alternative.

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough was similar under both Alternative 1 and No Action Alternative during March, April and May when spring run are most abundant in the Delta (Appendix 9L).

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 relative to No Action Alternative in every month (Appendix 9M). Spring-run smolts migrating through the Delta would be most susceptible in the months of March April and May. Predicted values in April and May indicated a larger fraction of fish salvaged for Alternative 1. Predicted salvage was more similar in March but still higher under Alternative 1.

*Summary of Effects on Spring-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under Alternative 1 and the No Action Alternative. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be slightly higher under Alternative 1 than under the No Action Alternative, although production under Alternative 1 could be over 10 percent greater than under the No Action Alterative in critical dry years. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 relative to No Action Alternative in every month.

In Clear Creek and the Feather River, the analysis of the effects of Alternative 1 and the No Action Alternative for spring-run Chinook Salmon relied on output from the WUA analysis and water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The WUA analysis suggests that there would be little difference in the availability of spawning and rearing habitat in Clear Creek. The temperature model outputs suggest that thermal conditions and effects on each of the spring-run Chinook Salmon life stages generally would be similar under both scenarios in Clear Creek and the Feather River, although water temperatures could be somewhat more suitable for spring-run Chinook Salmon holding and spawning/egg incubation in the Feather River under Alternative 1. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that water temperature thresholds for spawning and egg incubation would be exceeded slightly less frequently under Alternative 1 than under the No Action Alternative in Clear Creek and the Feather River. The water temperature threshold for rearing spring-run Chinook Salmon would also be exceeded slightly less frequently in the Feather River under Alternative 1. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the slightly greater likelihood of exceeding water temperature thresholds under Alternative 1 could increase the potential for adverse effects on the spring-run Chinook Salmon populations in the Feather River. Given the similarity of the results, Alternative 1 and the No Action Alternative are likely to have similar effects on the spring-run Chinook Salmon population in Clear Creek.

These model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse under Alternative 1 than the No Action Alternative, with a small likelihood that spring-run Chinook Salmon production would be lower under the No Action Alternative. This potential distinction between the two scenarios, however, may be partially offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program.

*Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River downstream of Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect fall-run Chinook Salmon in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball’s Ferry Jelly’s Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures in June at Knights Landing progressively decreasing (up to 0.9°F) under Alternative 1 relative to the No Action Alternative and progressively increasing (up to 4.6°F) in September during the wetter years.

Overall, the temperature differences between Alternative 1 and the o Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Sacramento River. The slightly lower water temperatures from October to December under Alternative 1 would likely have little effect on fall-run Chinook Salmon as water temperatures in the Sacramento River below Keswick Dam are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on early spawning fall-run Chinook Salmon under Alternative 1, although the reduced water temperatures in September of critical dry years under Alternative 1 may decrease the likelihood of adverse effects on fall-run Chinook Salmon spawning in this water year type.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative 1 relative to the No Action Alternative are generally predicted to be similar to or lower (up to about 0.5°F) from September through April and June through August (Appendix 6B, Table B-3-1). Average monthly water temperatures during May under Alternative 1 would be higher by 0.4°F to 0.8°F than under the No Action Alternative in all water year types. Average monthly temperatures at the confluence with the Sacramento River would exhibit a similar pattern, although temperatures in the creek would be slightly higher in general.

Under Alternative 1, temperature conditions at Igo would be slightly cooler than under the No Action Alternative. However, these temperature outputs represent conditions at Igo, a location upstream of most fall-run Chinook Salmon spawning and rearing. Temperatures where fall-run Chinook Salmon inhabit the creek would be somewhat higher as indicated by average monthly temperatures at the confluence with the Sacramento River, although these temperatures would be similar under Alternative 1 and the No Action Alternative. Overall, water temperature effects on fall-run Chinook Salmon in Clear Creek due to temperature differences between Alternative 1 and the No Action Alternative would be relatively minor.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel under Alternative 1 relative to the No Action Alternative generally were predicted to be similar (less than 0.5°F differences), but slightly lower from October through December when average monthly water temperatures would be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Modeled water temperatures during May and June under Alternative 1 were also slightly lower, up to a maximum of 0.7°F lower in June of below normal water years. Average monthly water temperatures in July through September under Alternative 1 generally were predicted to be lower (up to 0.6°F) in drier water year types and higher (up to 1.3°F) in the wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the differences between Alternative 1 and No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperatures under Alternative 1 generally increasing in most water year types relative to the No Action Alternative. Water temperatures under Alternative 1 were predicted to be somewhat (0.7°F to 1.6°F) warmer on average and up to

4.0°F warmer at the confluence with the Sacramento River from July to September in wetter years (Appendix 6B, Table B-23-1).

Overall, the temperature differences in the Feather River between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Feather River. The slightly lower water temperatures in November and December under Alternative 1 would likely have little effect on fall-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on early spawning fall-run Chinook Salmon, although the decreased temperatures in September of critical dry years under Alternative 1 may reduce the likelihood of adverse effects on fall-run Chinook Salmon spawning in this water year type.

*American River*

Long-term average monthly water temperatures in the American River at Nimbus Dam under Alternative 1 generally would be similar (differences less than 0.5°F) to the No Action Alternative, with the exception of during June and August, when temperatures under Alternative 1 could be as much as 0.9°F lower in below normal years (Appendix 6B, Table B-12-1). This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the No Action Alternative in June. In addition, average monthly water temperatures at the mouth generally would be higher under Alternative 1 than the No Action Alternative in September, especially in wetter water year types when Alternative 1 could be up to 1.7°F warmer (Appendix 6B, Table B-14-1).

Overall, the temperature differences in the American River between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the American River. The slightly lower water temperatures in June and August in some water year types under Alternative 1 may decrease the likelihood of adverse effects on fall-run Chinook Salmon rearing in the American River if they are present. The slightly higher water temperatures during September under Alternative 1 would have little effect on fall-run Chinook Salmon spawning in the American River because most spawning occurs later in November.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of water temperatures that are protective of fall-run Chinook Salmon in the Sacramento River, Clear Creek, Feather River, and American River. The following describes the extent of those exceedances for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both Alternative 1 and the No Action Alternative indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon spawning and egg incubation in October, November, and again in April. There would be no exceedances of the threshold from December to March under both Alternative 1 and the No Action Alternative. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate less frequent exceedances (by up to 4 percent in October) under Alternative 1 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 1 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold in October, November, and April.

*Clear Creek*

Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during October through December (USFWS 2015). Average monthly water temperatures at Igo during this period generally fall below 56°F, except in October. Under Alternative 1, the 56°F threshold would be exceeded in October about 10 percent of the time as compared to 12 percent under the No Action Alternative (Appendix 9N). At the confluence with the Sacramento River, average monthly water temperatures in October would be warmer, with the 56°F threshold exceeded slightly less frequently under Alternative 1 compared to the No Action Alternative (Appendix 6B, Figure B-4-1). During November and December, average monthly water temperatures generally would remain below 56°F at both locations (Appendix 6B, Figure B-4-2 and B-4-3). Temperature conditions in Clear Creek under Alternative 1 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold in October.

For fall-run Chinook Salmon rearing (January through August), the exceedances described previously for spring-run Chinook Salmon would apply, with the average monthly temperatures at Igo remaining below the 60°F rearing threshold in all months. Downstream at the mouth of Clear Creek, average monthly water temperatures would exceed the 60°F threshold often during the summer, but the frequency of exceedance would be similar under Alternative 1 and the No Action Alternative (Appendix 6B). Temperature conditions for fall-run Chinook Salmon rearing in Clear Creek would be similar under Alternative 1 and the No Action Alternative.

*Feather River*

Average monthly water temperatures under both Alternative 1 and No Action Alternative would exceed the water temperature threshold of 56°F established in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and egg incubation during some months, particularly in October, November, March, and April, when temperature thresholds would be exceeded frequently (Appendix 6B, Table B-22-4). The frequency of exceedance would be greatest in October, when average monthly temperatures under both Alternative 1 and the No Action Alternative would be above the threshold in nearly every year. The magnitude of the exceedances would be high as well, with average monthly temperatures in October reaching about 68°F. Similarly, the threshold would be exceeded under both Alternative 1 and the No Action Alternative about 85 percent of the time in April. The differences between Alternative 1 and the No Action Alternative, however, would be relatively small, with Alternative 1 generally exceeding temperature thresholds about 1-2 percent less frequently than the No Action Alternative during the October through April period. Temperature conditions in the Feather River under Alternative 1 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold from October through April.

*Changes in Egg Mortality*

Water temperatures influence the viability of incubating fall-run Chinook Salmon eggs. The following describes the differences in egg mortality for the Sacramento, Feather, and American rivers.

*Sacramento River*

For fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be around 17 percent, with higher mortality rates (in excess of 35 percent) occurring in critical dry years under Alternative 1. Predicted egg mortality would be 0.1 percent higher under Alternative 1 than under the No Action Alternative; in critical dry years the average egg mortality rate would be 2.4 percent lower than under the No Action Alternative (Appendix 9C, Table B-1). Overall, fall-run Chinook Salmon egg mortality in the Sacramento River under Alternative 1 and the No Action Alternative would be similar, except in critical dry water years.

*Feather River*

For fall-run Chinook Salmon in the Feather River, the long-term average egg mortality rate is predicted to be relatively low (around 7 percent), with higher mortality rates (around 17 percent) occurring in critical dry years under Alternative 1. Predicted egg mortality would be 0.2 percent lower under Alternative 1 than under the No Action Alternative; in critical dry years the average egg mortality rate would be 3 percent greater than under the No Action Alternative (Appendix 9C, Table B-7). Overall, fall-run Chinook Salmon egg mortality in the Feather River under Alternative 1 and the No Action Alternative would be similar, except in critical dry water years.

*American River*

For fall-run Chinook Salmon in the American River, the predicted long-term average egg mortality rate is predicted to range from approximately 22 to 25 percent in all water year types under Alternative 1. The predicted egg mortality rate would be 0.2 percent lower under Alternative 1 than under the No Action Alternative; in Below Normal water years the average egg mortality rate would be 2 percent lower than under the No Action Alternative. In other water year types, egg mortality is predicted to be from 0.6 percent lower to 0.6 percent higher under Alternative 1 as compared to the No Action Alternative (Appendix 9C, Table B-6). Overall, fall-run Chinook Salmon egg mortality in the

American River under Alternative 1 and the No Action Alternative would be similar.

*Changes in Weighted Usable Area*

Weighted usable area, which is influenced by flow, is a measure of habitat suitability. The following describes changes in WUA for fall-run Chinook Salmon in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

As an indicator of the amount of suitable spawning habitat for fall-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be greater amounts of spawning habitat available from September through November under Alternative 1 as compared to the No Action Alternative; fall-run spawning WUA would be slightly (less than 5 percent) reduced in December, but this is after the peak spawning period for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-11-4). The increase in long-term average spawning WUA during September (prior to the peak spawning period) under Alternative 1 would be relatively large (more than 20 percent), with smaller increases in October (around 2 percent) and November (around 6 percent) which comprise the peak spawning period for fall-run Chinook Salmon. Results for the reach from Battle Creek to Deer Creek show the same pattern in changes in WUA for spawning fall-run Chinook Salmon between Alternative 1 and the No Action Alternative (Appendix 9E, Table C-10-4). Overall, spawning habitat availability would be somewhat higher under Alternative 1 relative to the No Action Alternative.

Modeling results indicate that, in general, the amount of suitable fry rearing habitat available from December to March under Alternative 1 would be similar (less than 1 percent difference) to the amount of fry rearing habitat available under the No Action Alternative (Appendix 9E, Table C-12-4).

Similar to the results for fry rearing WUA, modeling results indicate that, there would be similar amounts of suitable juvenile rearing habitat available during the early juvenile rearing period from February to April under Alternative 1 and the No Action Alternative. There would be a slight decrease (around 3 percent) in the long-term average juvenile rearing WUA during May and June under Alternative as compared to the No Action Alternative (Appendix 9E, Table C-13-4). Overall, the amount of juvenile rearing habitat (WUA) would be similar under Alternative 1 and the No Action Alternative.

*Clear Creek*

As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 1 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative.

*Feather River*

As described above, Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 1 relative to the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative. The majority of spawning activity by fall-run Chinook Salmon in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be greater amounts of spawning habitat available in September, November, and December under Alternative 1 as compared to the No Action Alternative; fall-run spawning WUA would be slightly (less than 5 percent) reduced in October (the peak spawning month) for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-24-4). The increase in long-term average spawning WUA during September (prior to the peak spawning period) under Alternative 1 would be relatively large (more than 15 percent), with smaller increases in November and December (less than 1 percent) which are after the peak spawning period for fall-run Chinook Salmon. Overall, spawning habitat availability would be similar under Alternative 1 and the No Action Alternative.

*American River*

Modeling results indicate that, in general, there would be lower amounts of spawning habitat available for fall-run Chinook Salmon in the American River from October through December under Alternative 1 as compared to the No Action Alternative; fall-run spawning WUA would be slightly (less than 5 percent) decreased in December with less than 1 percent decreases in September and October (prior to the peak spawning period in November) (Appendix 9E, Table C-25-4). Overall, spawning habitat availability would be similar under Alternative 1 and the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that pre-spawning mortality of fall-run Chinook Salmon eggs would be approximately 16 percent lower under Alternative 1, primarily due to reduced summer temperatures. Flow-related fall-run Chinook Salmon egg mortality would be increased by 8 percent under Alternative 1 compared to the No Action Alternative. Conversely, temperature-related egg mortality would be 11 percent lower under Alternative 1 (Appendix 9D, Table B-1-4). Flow (habitat)-related fry mortality would be approximately 1 percent higher under Alternative 1 as compared to the No Action Alternative. Temperature-related juvenile mortality would be approximately 21 percent lower under Alternative 1, while flow (habitat)-related mortality would be similar under Alternative 1 as compared to the No Action Alternative. Overall, potential fall-run juvenile production would be slightly (approximately 1 percent) higher under Alternative 1 as compared to the No Action Alternative (Appendix 9D, Table B-1-1).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for fall-run between Alternative 1 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.245 for Alternative 1 and 0.248 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

Fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. At the junction of Georgiana Slough and the Sacramento River, percent positive velocity was similar under both Alternative 1 and No Action Alternative in the month of April and was moderately higher for Alternative 1 relative to the No Action Alternative during May and June (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities was moderately lower under Alternative 1 relative to No Action Alternative in April and May and almost indistinguishable in June. On Old River downstream of the facilities, the proportion of positive velocities was substantially lower in April and May under Alternative 1 relative to No Action Alternative but became more similar in June (Appendix 9K). In Old River upstream of the facilities, the percent of positive velocities was moderately lower for Alternative 1 relative to No Action Alternative in April and May and moderately higher in June (Appendix 9K). On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities was moderately higher under Alternative 1 relative to No Action Alternative in April and May whereas the values were similar in June (Appendix 9K).

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough was similar under both Alternative 1 and No Action Alternative in most months but was slightly higher under Alternative 1 in the month of June (Appendix 9L). Entrainment probabilities at the Head of Old River were much lower under Alternative 1 relative to the No Action Alternative during April and May. Entrainment probabilities were similar under both Alternatives in the month of June. At the Turner Cut junction, entrainment probabilities under Alternative 1 were slightly higher than No Action Alternative in June. During April and May, entrainment probabilities were more divergent with higher values for Alternative 1 relative to No Action Alternative. Overall, entrainment was lower at the Columbia Cut junction relative to Turner Cut but patterns of entrainment between these two alternatives were similar. Entrainment was slightly greater for Alternative 1 relative to No Action Alternative during June. In April and May, entrainment was higher for Alternative 1 relative to No Action Alternative. Patterns at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 1 relative to No Action Alternative in every month (Appendix 9M). Fall-run smolts migrating through the Delta would be most susceptible in the months of April, May and June. Predicted values in April and May indicated an increased fraction of fish salvaged under Alternative 1 relative to No Action Alternative. Predicted salvage was more similar in March but still higher under Alternative 1.

*Summary of Effects on Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under Alternative 1 and the No Action Alternative. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be slightly higher in most water year types under Alternative 1 than under the No Action Alternative, and up to 12 percent greater than under the No Action Alternative in critical dry years.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 relative to No Action Alternative in every month.

In Clear Creek and the Feather and American rivers, the analysis of the effects of Alternative 1 and the No Action Alternative for fall-run Chinook Salmon relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of spawning and rearing habitat in Clear Creek and spawning habitat in the Feather and American rivers would be similar under Alternative 1 and the No Action Alternative. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in all of these streams generally would be similar under both scenarios. The water temperature threshold exceedance analysis that indicated that the water temperature thresholds for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly less frequently in the Feather River and Clear Creek under Alternative 1. Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the reduced frequency of exceedance of temperature thresholds under Alternative 1 could reduce the potential for adverse effects on the fall-run Chinook Salmon populations in Clear Creek and the Feather River. Results of the analysis using Reclamation's salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under Alternative 1 and the No Action Alternative.

These model results suggest that overall, effects on fall-run Chinook Salmon could be slightly less adverse under Alternative 1 than the No Action Alternative, with a small likelihood that fall-run Chinook Salmon production would be higher under Alternative 1. This potential distinction between the two scenarios, however, may be partially offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for winter-run and spring-run Chinook Salmon in the Sacramento River reaches downstream of Keswick Dam. This potential benefit, however, would only apply if volitional passage provides access to additional habitat for fall-run Chinook Salmon.

*Late Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect late fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table 5-5-1). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures in June at Knights Landing progressively increasing (up to 0.9°F) under Alternative 1 relative to the No Action Alternative and progressively decreasing (up to 4.6°F) in September during the wetter years.

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on late fall-run Chinook Salmon in the Sacramento River. The slightly lower water temperatures from October to December under Alternative 1 would likely have little effect on late fall-run Chinook Salmon migration and holding as water temperatures in the Sacramento River below Keswick Dam are typically low during this time period. The likelihood of adverse effects on late fall-run Chinook Salmon spawning and egg incubation would be similar under Alternative 1 and the No Action Alternative due to similar water temperatures during the January to May time period. Because late fall-run Chinook Salmon have an extended rearing period, the similar water temperatures during the summer under Alternative 1 and the No Action Alternative would have similar effects on rearing fry and juvenile late fall-run Chinook Salmon in the Sacramento River. The higher water temperatures under Alternative 1 in September of wetter years may increase the likelihood of adverse effects on fry and juvenile late fall-run Chinook Salmon in the Sacramento River during this limited time period.

*Changes in Exceedances of Water Temperature Thresholds*

Average monthly water temperatures under both Alternative 1 and the No Action Alternative indicate exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon spawning and egg incubation in October, November, and again in April. There would be no exceedances of the threshold from December to March under both Alternative 1 and the No Action Alternative. In April, model results indicate that water temperatures under Alternative 1 would exceed the threshold about 2 percent less frequently than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 1 could be slightly less likely to affect late fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold in April.

*Changes in Egg Mortality*

For late fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to range from approximately 2 to nearly 5 percent in all water year types under Alternative 1. Overall, egg mortality would be 0.4 percent lower under Alternative 1; in Below Normal water years the average egg mortality rate would be 0.1 percent higher than under Alternative 1. In other water year types, egg mortality is predicted to be from 0.1 to 0.8 percent lower under Alternative 1 as compared to the No Action Alternative (Appendix 9C, Table B-2). Overall, late fall-run Chinook Salmon egg mortality in the Sacramento River under Alternative 1 and the No Action Alternative would be similar.

*Changes in Weighted Usable Area*

Modeling results indicate that there would be slightly (less than 5 percent) reduced amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under Alternative 1 as compared to the No Action Alternative (Appendix 9E, Table C-14-4). Overall, spawning habitat availability would be similar under Alternative 1 and the No Action Alternative.

Modeling results indicate that, in general, there would be reduced amounts of suitable late fall-run Chinook Salmon fry rearing habitat available during April and May under Alternative 1 (Appendix 9E, Table C-15-4). The decrease in long-term average fry rearing WUA during these months would be relatively small (less than 5 percent). Late fall-run Chinook Salmon fry rearing WUA would be increased by about 2 percent in June under Alternative 1 as compared to the No Action Alternative. Overall, late fall-run fry rearing habitat availability would be similar under Alternative 1 and the No Action Alternative.

A substantial fraction of late fall run Chinook Salmon juveniles oversummer in the Sacramento River before emigrating, which allows them to avoid predation through both their larger size and greater swimming ability. One implication of this life history strategy is that rearing habitat is most likely the limiting factor for late-fall-run Chinook Salmon, especially if availability of cool water determines the downstream extent of spawning habitat for late-fall-run salmon. Modeling results indicate that, there would be decreased amounts of suitable juvenile rearing habitat available from December through August, but this decrease would be small (generally less than 2 percent) under Alternative 1 as compared to the No

Action Alternative. There would an increase in the amount of late fall-run Chinook Salmon juvenile rearing WUA in the other months (September through November) of up to 10 percent (Appendix 9E, Table C-16-4). Overall, late fall-run juvenile rearing habitat availability would be slightly increased under Alternative 1 relative to the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that flow-related late fall-run Chinook Salmon egg mortality would be increased by 5 percent under Alternative 1 compared to the No Action Alternative. Conversely, temperature-related egg mortality would be 4 percent lower under Alternative 1 (Appendix 9D, Table B-2-4). Flow (habitat)-related fry mortality would be approximately 3 percent higher while temperature-related fry mortality would be about 2 percent lower under Alternative 1 as compared to the No Action Alternative. Temperature-related juvenile mortality would be approximately 16 percent lower under Alternative 1, while flow (habitat)-related mortality would approximately 34 percent lower under Alternative 1 as compared to the No Action Alternative. Overall, potential juvenile production would be the similar under Alternative 1 and the No Action Alternative (Appendix 9D, Table B-2-1).

*Changes in Delta Passage Model Output*

For late fall-run Chinook Salmon, through-Delta survival was predicted to be slightly lower under Alternative 1 relative to the No Action Alternative for all 81 years simulated by the Delta Passage Model (Appendix 9J). Median Delta survival across all years was 0.199 for Alternative 1 and 0.244 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

The late fall run Chinook migration period overlaps with winter-run. See the section on hydrodynamic analysis for winter run Chinook Salmon for potential effects on late fall-run Chinook Salmon.

*Changes in Junction Entrainment*

Entrainment probabilities for late fall-run Chinook Salmon are assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Changes in Salvage*

Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Summary of Effects on Late Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under Alternative 1 and the No Action Alternative. For the purpose of analyzing effects on late fall-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar under Alternative 1 and the No Action Alternative, although production under Alternative 1 could be slightly lower in some water year types and about 4 percent higher in critical dry years than under the No Action Alternative. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be higher under Alternative 1 relative to No Action Alternative in every month.

Although survival in the Delta may be lower, given the similarity in the SALMOD outputs, it is likely that Alternative 1 and the No Action Alternative would have similar effects on fall-run Chinook Salmon.

*Steelhead*

Changes in operations that influence temperature and flow conditions that could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect steelhead in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table 5-5-1). A similar pattern of changes in temperature generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences progressively increasing (up to a 3.2°F at Red Bluff) in September during the wetter years (Appendix 6B, Table B-9-1).

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Sacramento River. Based on the life history timing for steelhead, the slightly lower water temperatures in September and October of drier years under Alternative 1 may reduce the likelihood of adverse effects on steelhead adults migrating upstream in the Sacramento River. The higher water temperatures in September of wetter years under Alternative 1 may increase the likelihood of adverse effects on steelhead migration compared to the No Action Alternative.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative 1 are generally predicted to be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative from September through April and June through August (Appendix 6B, Table B-3-1). Average monthly water temperatures during May under Alternative 1 would be higher by 0.4°F to 0.8°F than under the No Action Alternative in all water year types.

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor.

The lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into Clear Creek. While the reduction in water temperature indicated by the modeling could improve thermal conditions for steelhead, the duration of the two pulse flows under the No Action Alternative may not be of sufficient duration (3 days each) to provide biologically meaningful temperature benefits. Overall, thermal conditions for steelhead in Clear Creek would be similar under Alternative 1 and the No Action Alternative.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel under Alternative 1 relative to the No Action Alternative generally were predicted to be similar (less than 0.5°F differences), but slightly lower from October through December when average monthly water temperatures would be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Modeled water temperatures during May and June under Alternative 1 were also slightly lower, up to a maximum of 0.7°F lower in June of below normal water years. Average monthly water temperatures in July through September under Alternative 1 generally were predicted to be lower (up to 0.6°F) in drier water year types and higher (up to 1.3°F) in the wetter years. Although temperatures in the river generally become progressively higher in the downstream direction, the differences between Alternative 1 and the No Action Alternative exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 1 generally decreasing in most water year types relative to the No Action Alternative. Water temperatures under Alternative 1 are predicted to be somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the confluence with Sacramento River from July to September in wetter years than under the No Action Alternative.

Overall, the temperature differences in the Feather River between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Feather River. The slightly lower water temperatures in November and December under Alternative 1 would likely have little effect on adult steelhead migration as water temperatures in the

Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on adult steelhead migrating upstream and juveniles rearing in the Feather River, although the decreased temperatures in September of critical dry years under Alternative 1 may decrease the likelihood of adverse effects on migrating and rearing steelhead in this water year type.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 1 generally would be similar (differences less than 0.5°F) to the No Action Alternative, with the exception of during June and August, when temperatures under Alternative 1 could be as much as 0.9°F lower in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the No Action Alternative in June. In addition, average monthly water temperatures at the mouth generally would be higher under Alternative 1 than the No Action Alternative in September, especially in wetter water year types when Alternative 1 could be up to 1.7°F warmer.

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor. The (less than 0.5°F) and likely would have little effect on steelhead in the American River. The slightly cooler water temperatures in June and August under Alternative 1 may reduce the likelihood of adverse effects on steelhead rearing in the American River compared to the No Action Alternative.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for steelhead in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those streams.

*Sacramento River*

Steelhead spawning in the mainstem Sacramento River generally occurs in the upper reaches from Keswick Dam downstream to near Balls Ferry, with most spawning concentrated near Redding. Most steelhead, however, spawn in tributaries to the Sacramento River. Spawning generally takes place in the January through March period when water temperatures in the river generally do not exceed 52°F under either Alternative 1 or the No Action Alternative. While there are no established temperature thresholds for steelhead rearing in the mainstem Sacramento River, average monthly temperatures in during March through June when fry and juvenile steelhead are in the river would be below 56°F during March and April at Balls Ferry. In May and June, average monthly water temperatures would be slightly lower under Alternative 1 than they would be under the No Action Alternative in the drier years, although neither condition would exceed about 57°F. Thus, as it relates to temperature conditions for steelhead in the mainstem Sacramento River, it is unlikely that Alternative 1 and the No Action Alternative would differ in a biologically meaningful way.

*Clear Creek*

While there are no established temperature thresholds for steelhead spawning in Clear Creek, average monthly water temperatures in the river generally would not exceed 48°F during the spawning period (December to April) under Alternative 1 and the No Action Alternative. Similarly, while there are no established temperature thresholds for steelhead rearing in Clear Creek, average monthly temperatures in most months of the year would not exceed 56°F at Igo under both alternatives. Thus, as it relates to temperature conditions for steelhead in Clear Creek, it is unlikely that Alternative 1 and the No Action Alternative would differ in a biologically meaningful way.

*Feather River*

Average monthly water temperatures under both Alternative 1 and the No Action Alternative and would on occasion exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for steelhead spawning and incubation during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). There would be no exceedances of the 56°F threshold from December through February under both Alternative 1 and the No Action Alternative. However, the differences in the frequency of exceedance between Alternative 1 and No Action Alternative during March and April would be relatively small with water temperatures under Alternative 1 exceeding the threshold about 2 percent less frequently in March and the same exceedance frequency (75 percent) as the No Action Alternative in April.

The established water temperature threshold of 63°F for rearing from May through August would be exceeded often under both Alternative 1 and the No Action Alternative in May and June, but not at all in July and August. Water temperatures under Alternative 1 would exceed the rearing temperature threshold about 9 percent less frequently than under the No Action Alternative in May, but no more frequently in June. Temperature conditions in the Feather River under Alternative 1 could be less likely to affect steelhead spawning and rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F spawning threshold in March and the increased frequency of exceedance of the 63°F rearing threshold in May.

*American River*

In the American River, the water temperature threshold for steelhead rearing (May through October) is 65°F at the Watt Avenue Bridge. Average monthly water temperatures would exceed this threshold often under both Alternative 1 and No Action Alternative, especially in the July through September period when the threshold is exceeded nearly all of the time. In addition, the magnitude of the exceedance would be high, with average monthly water temperatures sometimes higher than 76°F. The differences between Alternative 1 and No Action Alternative, however, would be relatively small and only occur in June (1 percent more frequently under Alternative 1), and in September, when average monthly water temperatures under Alternative 1 would exceed 65°F about 7 percent more frequently than under the No Action Alternative. Temperature conditions in the American River under Alternative 1 could be more likely to affect steelhead rearing than under the No Action Alternative because of the increased frequency of exceedance of the 65°F rearing threshold.

*Changes in Weighted Usable Area*

The following describes changes in WUA for steelhead in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

Modeling results indicate that, in general, there would be lower amounts of suitable steelhead spawning habitat available from December through March under Alternative 1 as compared to the No Action Alternative (Appendix 9E, Table C-20-4). The decreases in long-term average steelhead spawning WUA would be relatively small (less than 3 percent). Overall, spawning habitat availability would be similar under Alternative 1 and the No Action Alternative.

*Clear Creek*

As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 1 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for steelhead (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative.

*Feather River*

Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 1 relative to the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning habitat for steelhead (as indexed by WUA) available under Alternative 1 as compared to the No Action Alternative. The majority of spawning activity by steelhead in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be lower amounts of spawning habitat for steelhead in the Feather River downstream of Thermalito available from December through April under Alternative 1 as compared to the No Action Alternative. The decreases in long-term average steelhead spawning WUA during this time period would generally be less than 3 percent (Appendix 9E, Table C-22-4). Overall, steelhead spawning habitat availability in the Feather River would be similar under Alternative 1 and the No Action Alternative.

*American River*

Modeling results indicate that, in general, there would be variable changes in the amount of spawning habitat for steelhead in the American River downstream of Nimbus Dam available from December through April under Alternative 1 as compared to the No Action Alternative. The decreases in long-term average steelhead spawning WUA during December, February and March would generally be less than 3 percent, while the increase in April would also be less than 3 percent (Appendix 9E, Table C-26-4). Overall, steelhead spawning habitat availability in the American River would be similar under Alternative 1 and the No Action Alternative.

*Summary of Effects on Steelhead*

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under Alternative 1 and the No Action Alternative. The analysis of the effects of Alternative 1 and the No Action Alternative for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities.

The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under Alternative 1 and the No Action Alternative. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead in all of these streams generally would be similar under both scenarios. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for steelhead spawning and egg incubation would be exceeded less frequently in the Feather River under Alternative 1. The water temperature threshold for steelhead rearing would also be exceeded less frequently in the Feather River. Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the reduced frequency of exceedance of temperature thresholds under Alternative 1 could reduce the potential for adverse effects on the steelhead population in the Feather River.

These model results suggest that overall, effects on steelhead could be slightly less adverse under Alternative 1 than the No Action Alternative, particularly in the Feather River. Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Keswick Dam and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers.

*Green Sturgeon*

The effects on Green Sturgeon were analyzed by comparing changes in water temperature and the frequency of temperature threshold exceedance between Alternative 1 and the No Action Alternative, as described below.

*Changes in Water Temperature*

The effects of Alternative 1 compared to the No Action Alternative on Green Sturgeon were analyzed based on water temperature model outputs and comparisons of the frequency of water temperature threshold exceedances in the Sacramento and Feather rivers.

*Sacramento River*

As described previously, long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures in June at Knights Landing progressively decreasing (up to 0.9°F) under Alternative 1 relative to the No Action Alternative and progressively increasing (up to 4.6°F) in September during the wetter years.

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor. Based (less than 0.5°F) and likely would have little effect on the life history timing for Green Sturgeon, the higher water temperatures from January through May under the Alternative 1 may increase the likelihood of adverse effects on migrating adult Green Sturgeon and spawning and egg incubation compared to the No Action Alternative.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel under Alternative 1 relative to the No Action Alternative generally were predicted to be similar (less than 0.5°F differences), but slightly lower from October through December when average monthly water temperatures would be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Modeled water temperatures during May and June under Alternative 1 were also slightly lower, up to a maximum of 0.7°F lower in June of below normal water years. Average monthly water temperatures in July through September under Alternative 1 generally were predicted to be lower (up to 0.6°F) in drier water year types and higher (up to 1.3°F) in the wetter years.

Although temperatures in the river would become progressively higher in the downstream directions, the differences between Alternative 1 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 1 generally increasing in most water year types relative to the No Action Alternative at the confluence with Sacramento River (Appendix 6B, Table B-23-1).

Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on Green Sturgeon in the Feather River. The higher water temperatures from January through April under Alternative 1 may increase the likelihood of adverse effects on migrating adult Green Sturgeon compared to the No Action Alternative. Lower water temperatures during May and June under Alternative 1 could decrease the likelihood of adverse effects on egg incubation and rearing of Green Sturgeon in the Feather River as compared to the No Action Alternative.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers. The following describes the extent of those exceedance for each of those rivers.

*Sacramento River*

Average monthly water temperatures in the Sacramento River at Bend Bridge under both Alternative 1 and the No Action Alternative would exceed the water temperature threshold of 63°F established for Green Sturgeon egg incubation in August and September, with exceedances under Alternative 1 occurring about 6 percent of the time in August and about 10 percent of the time in September. This is 1 to 2 percent less often than under the No Action Alternative. Average monthly water temperatures at Bend Bridge could exceed the threshold by up to 10 degrees (reaching 73°F) during this period. Temperature conditions in the Sacramento River under Alternative 1 could be less likely to affect Green Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 63°F threshold in August and September.

*Feather River*

Average monthly water temperatures in the Feather River at Gridley Bridge under both Alternative 1 and No Action Alternative would exceed the water temperature threshold of 64°F established for Green Sturgeon spawning, incubation, and rearing in May, June, and September; no exceedances under either scenarios would occur in July and August. The frequency of exceedances would be high, with water temperatures under both Alternative 1 and No Action Alternative exceeding the threshold in June nearly 100 percent of the time. The magnitude of the exceedance also would be substantial, with average monthly water temperatures higher than 72°F in June, and higher than 75°F in July and August. Water temperatures under Alternative 1 would exceed the threshold during May about 9 percent less frequently than the No Action Alternative and about 35 percent more frequently in September. Temperature conditions in the Feather River under Alternative 1 could be less likely to affect Green Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 64°F threshold in May. The increase in exceedance frequency in September under Alternative 1 may have little effect on rearing Green Sturgeon as many juvenile sturgeon may have migrated downstream to the lower Sacramento River and Delta by this time.

*Summary of Effects on Green Sturgeon*

The temperature model outputs for the Sacramento and Feather rivers suggest that thermal conditions and effects on Green Sturgeon in the Sacramento and Feather rivers generally would be slightly less adverse under Alternative 1. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for Green Sturgeon spawning, incubation, and rearing would be exceeded less frequently under Alternative 1 in the Sacramento River. The water temperature threshold for Green Sturgeon spawning, incubation, and rearing would also be exceeded less frequently during some months in the Feather River, but would be exceeded more frequently in September under Alternative 1. Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the reduced frequency of exceedance of temperature thresholds under Alternative 1 could reduce the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers relative to the No Action Alternative.

*White Sturgeon*

Changes in water temperature conditions in the Sacramento River would be the same as those described above for Green Sturgeon in the Sacramento River. Overall, the temperature differences between Alternative 1 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on White Sturgeon in the Sacramento River.

The water temperature threshold established for White Sturgeon spawning and egg incubation in the Sacramento River at Hamilton City is 61°F from March through June. Although there would be no exceedances of the threshold in March and April, water temperatures under both Alternative 1 and No Action Alternative would exceed this threshold in May and June. The average monthly water temperatures in May under Alternative 1 would exceed this threshold about 49 percent of the time (about 6 percent less frequently than the No Action Alternative). In June, the average monthly water temperature under Alternative 1 would exceed the threshold about 73 percent of the time (about 13 percent less frequently than under the No Action Alternative). Average monthly water temperatures during May and June under Alternative 1 would as high as about 64°F, which is below the 68°F threshold considered lethal for White Sturgeon eggs. Temperature conditions in the Sacramento River under Alternative 1 could be less likely to affect White Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 61°F threshold in May and June.

Overall, the temperature model outputs suggest that thermal conditions and effects on White Sturgeon in the Sacramento River generally would be slightly less adverse under Alternative 1. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for White Sturgeon spawning, incubation, and rearing would be exceeded less frequently under Alternative 1 in the Sacramento River. Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the reduced frequency of exceedance of temperature thresholds under Alternative 1 could reduce the potential for adverse effects on White Sturgeon in the Sacramento River relative to the No Action Alternative.

*Delta Smelt*

The potential for effects on Delta Smelt resulting from Alternative 1 as compared to the No Action Alternative were analyzed using changes in proportional entrainment and fall abiotic habitat index values.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 1 would be 9 percent (long term average percent entrainment). Percent entrainment of adult Delta Smelt under Alternative 1 would be similar to results under the No Action Alternative (but slightly higher, by 1 to 2 percent). Under the No Action Alternative, the long term average percent entrainment would be 7.6 percent.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008) was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 1 would be 15.5 percent, long-term average, and highest entrainment of 23.6 percent under Critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under Alternative 1 would be higher than results under the No Action Alternative, by 4.3 to 9.4 percent. Under the No Action Alternative, the long term average percent entrainment would be 8.6 percent, and highest entrainment would occur under Critical water year conditions, at 19.3 percent.

The predicted location of Fall X2 position (in September through December) is used as an indicator of fall abiotic habitat index for Delta Smelt. Feyrer et al. 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. 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 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 is believed to lead to more favorable growth and survival conditions for Delta Smelt in fall. 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.

Alternative 1 does not include the operations related to the 2008 USFWS BO RPA Component 3 (Action 4), Fall X2 requirement while the No Action Alternative includes it. Therefore, the average September through December X2 position under Alternative 1 would be eastward by over 6 km compared to the No Action Alternative during the wetter years. In the drier years September through December average X2 position is similar under both scenarios.

Overall, Alternative 1 likely would have adverse effects on Delta Smelt, as compared to the No Action Alternative, primarily due to the potential for increased percentage entrainment during larval and juvenile life stages, and less favorable location of Fall X2 in wetter years, and on average.

*Longfin Smelt*

The effects of the Alternative 1 as compared to the No Action Alternative were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

The OMR flows would generally be negative in all months under Alternative 1, with the long-term average ranging from -3,700 to -7,400 cfs from December through June (Appendix 5A). The OMR flows generally would be more negative during this time period under Alternative 1 as compared to the No Action Alternative. The greatest differences between alternatives would be in April and May, where long-term average OMR flows would be negative under Alternative 1 and positive under the No Action Alternative (Appendix 5A, Table C-17-4). The increase in the magnitude of negative flows, with negative flows in April and May, under Alternative 1 as compared to the No Action Alternative could increase the potential for entrainment of Longfin Smelt at the export facilities.

Under Alternative 1, Longfin Smelt abundance index values range from 947 under critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257. Under the No Action Alternative, Longfin Smelt abundance index values range from 1,147 under critical water year conditions to a high of 16,635 under wet water year conditions, with a long-term average value of 7,951.

Results indicate that the Longfin Smelt abundance index values would be lower in every water year type under Alternative 1 than they would be under the No Action Alternative, with a long-term average index for Alternative 1 that is almost 10 percent lower than the long-term average index for the No Action Alternative. For below normal, dry, and critical water years, the Longfin Smelt abundance index values would be over 20 percent lower under Alternative 1 than they would be under the No Action Alternative, with the greatest difference (26.2 percent) predicted under dry conditions. Based on the Longfin Smelt abundance indices, Alternative 1 likely would have adverse effects on Longfin Smelt, as compared to the No Action Alternative.

Overall, based on the increase in frequency and magnitude of negative OMR flows and the lower Longfin Smelt abundance index values, especially in dry and critical years, potential adverse effects on the Longfin Smelt population under Alternative 1 likely would be greater than under the No Action Alternative.

*Sacramento Splittail*

Under Alternative 1, flows entering the Yolo Bypass generally would be higher than under the No Action Alternative, especially during below normal years when flows entering the bypass under Alternative 1 would be higher (up to 2,264 cfs) than the No Action Alternative in December through March (Appendix 5A, Table C-26-1). These increases would occur during periods of relatively low flow in the bypass, and could slightly increase the frequency of potential inundation. Thus, Alternative 1 could result in a slight increase relative to the No Action Alternative in spawning habitat for Sacramento Splittail as a result of the increased area of potential habitat (inundation) and the potential for a slight increase in the frequency of inundation.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

*Changes in Available Habitat (Storage)*

Changes in CVP and SWP water supplies and operations under Alternative 1 as compared to the No Action Alternative generally would result in higher reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be higher under Alternative 1 as compared to the No Action Alternative, as summarized in Tables 5.12 through 5.14, in the fall and winter months due to the inclusion of Fall X2 criteria under the No Action Alternative.

The highest increases in Shasta Lake and Lake Oroville storage could be in excess of 20 percent. Storage in Folsom Lake and New Melones could be increased by up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within the CVP and SWP water supply reservoirs is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could increase under Alternative 1 as compared to the No Action Alternative.

*Changes in Black Bass Nesting Success*

As shown in Appendix 9F, black bass nest survival in CVP and SWP reservoirs is anticipated to be near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of nest survival for Largemouth Bass in Shasta Lake being in the 40 to 100 percent range is slightly (less than 2 percent)lower under Alternative 1 as compared to the No Action Alternative. For June, the likelihood of nest survival being greater than 40 percent for Largemouth Bass is the same under Alternative 1 and No Action Alternative; however, nest survival of greater than 40 percent is likely only in about 20 percent of the years evaluated. The likelihood of high nest survival for Smallmouth Bass in Shasta Lake exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (nearly 100 percent) in May under both Alternative 1 and the No Action Alternative. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Shasta Lake is drawn down. The likelihood of nest survival being greater than 40 percent is about 10 percent less under Alternative 1 as compared to the No Action Alternative.

For May and June, the likelihood of nest survival for Largemouth Bass in Lake Oroville being in the 40 to 100 percent range is substantially (4 to 10 percent) lower under Alternative 1 than under the No Action Alternative. However, in June, nest survival of greater than 40 percent is likely only in about 35 percent of the years evaluated under Alternative 1. The likelihood of high nest survival for Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (over 90 percent) in May under both Alternative 1 and the No Action Alternative with the likelihood of greater than 40 percent survival being about 4 percent lower under Alternative 1 than the No Action Alternative. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Lake Oroville is drawn down. The likelihood of survival being greater than 40 percent is substantially lower (nearly 20 percent) under Alternative 1 as compared to the No Action Alternative.

Black bass nest survival in Folsom Lake is near 100 percent in March, April, and May due to increasing reservoir elevations. For June, the likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the 40 to 100 percent range is about 5 percent lower under Alternative 1 than the No Action Alternative. For Spotted Bass, nest survival for June would be less than for May due to greater daily reductions in water surface elevation. However, the likelihood of survival being greater than 40 percent is somewhat (around 5 percent) lower under Alternative 1 as compared to the No Action Alternative.

*Summary of Effects on Reservoir Fishes*

The analysis of the effects of Alternative 1 and the No Action Alternative for reservoir fish relied on CalSim II output for reservoir storage levels and water surface elevation changes as described in Appendix 9F. As described above, reservoir storage is anticipated to be increased under Alternative 1 relative to the No Action Alternative and this increase could affect the amount of warm and cold water habitat available within the reservoirs. However, it is unlikely that aquatic habitat within the CVP and SWP water supply reservoirs is limiting and therefore, it is unlikely that habitat for reservoir fish in the CVP and SWP storage reservoirs under Alternative 1 and the No Action Alternative would differ in a biologically meaningful manner.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs under Alternative 1 would be similar to or slightly lower than under the No Action Alternative. This suggests that conditions in the reservoirs would be less likely to support self-sustaining populations of black bass under Alternative 1 than under the No Action Alternative.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Sacramento River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles.

*Changes in Water Temperature*

The following describes anticipated changes in average monthly water temperature in the Sacramento, Feather, and American rivers and the potential for those changes to affect Pacific Lamprey.

*Sacramento River*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative. An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table 5-5-1). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperature differences in June progressively decreasing under Alternative 1 relative to the No Action Alternative. Due to the similarity of water temperatures under Alternative 1 and the No Action Alternative from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

*Feather River*

Long-term average monthly water temperature in the Feather River in the low flow channel under Alternative relative to the No Action Alternative generally were predicted to be similar (less than 0.5°F differences), but slightly lower from October through December when average monthly water temperatures would be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Modeled water temperatures during May and June under Alternative 1 were also slightly lower, up to a maximum of 0.7°F lower in June of below normal water years. Average monthly water temperatures in July through September under Alternative 1 generally were predicted to be lower (up to 0.6°F) in drier water year types and higher (up to 1.3°F) in the wetter years. Although temperatures in the river would become progressively higher in the downstream directions, the differences in water temperatures between Alternative 1 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 1 generally increasing in most water year types relative to the No Action Alternative at the confluence with Sacramento River.

Due to the similarity of water temperatures under Alternative 1 and the No Action Alternative from January through April, there would be little difference in potential effects on Pacific Lamprey adults during their upstream migration. The slightly lower water temperatures from May through the summer may decrease the likelihood of adverse effects on Pacific Lamprey during their holding, and spawning periods.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 1 generally would be similar (differences less than 0.5°F) to the No Action Alternative, with the exception of during June and August, when differences under Alternative 1 could be as much as 0.9°F lower in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the No Action Alternative in June. In addition, average monthly water temperatures at the mouth generally would be lower under Alternative 1 than the No Action Alternative in September, especially in wetter water year types when the No Action Alternative could be up to 1.7°F cooler. Due to the similarity of water temperatures under Alternative 1 and the No Action Alternative from January through May, there would be little difference in potential effects on Pacific Lamprey adults during their upstream migration. The lower water temperatures during June and August may decrease the likelihood of adverse effects on Pacific Lamprey during their holding, and spawning periods.

*Summary of Effects on Pacific Lamprey*

In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Based on the somewhat increased flows and reduced temperatures during their spawning and incubation period under Alternative 1, it is unlikely that conditions for and effects on Pacific Lamprey in the Sacramento, Feather, and American rivers under Alternative 1 and the No Action Alternative differ in a biologically meaningful manner. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

*Striped Bass, American Shad, and Hardhead*

Changes in operations influence temperature and flow conditions that could affect Striped Bass, American Shad, and Hardhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature that affect Striped Bass, American Shad, and Hardhead could occur in the Sacramento, Feather, and American rivers. The following describes temperature conditions in those water bodies.

*Sacramento River*

Long-term average monthly water temperatures in the Sacramento River at Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F difference) to water temperatures under the No Action Alternative An exception is during September and October of critical dry years when water temperatures could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as compared to the No Action Alternative and up to 1°F warmer in September of wetter years (Appendix 6B, Table 5-5-1). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures in June progressively decreasing by a small margin under Alternative 1 relative to the No Action Alternative. In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly reduced temperatures during some months would have adverse effects on these species.

*Feather River*

Average monthly water temperature in the Feather River in the low flow channel under Alternative relative to the No Action Alternative generally were predicted to be similar (less than 0.5°F differences), but slightly lower from October through December when average monthly water temperatures would be up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Modeled water temperatures during May and June under Alternative 1 were also slightly lower, up to a maximum of 0.7°F lower in June of below normal water years. Average monthly water temperatures in July through September under Alternative 1 generally were predicted to be lower (up to 0.6°F) in drier water year types and higher (up to 1.3°F) in the wetter years. Although temperatures in the river would become progressively lower in the downstream directions, the differences between Alternative 1 and No Action Alternative would exhibit a similar pattern at the downstream locations (Appendix 6B, Table B-23-1). As described above for the Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly reduced temperatures during some months would have adverse effects on these species in the Feather River.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 1 generally would be similar (differences less than 0.5°F) to the No Action Alternative, with the exception of during June and August, when differences under Alternative 1 could be as much as 0.9°F lower in below normal years. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the No Action Alternative in June. As described above for the Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Therefore, it is unlikely that the slightly reduced temperatures during some months would have adverse effects on these species in the American River.

*Summary of Effects on Striped Bass, American Shad, and Hardhead*

In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the slightly increased flows and decreased temperatures during their spawning and incubation period under Alternative 1, it is unlikely that conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers under Alternative 1 and the No Action Alternative would differ in a biologically meaningful manner.

*Stanislaus River/Lower San Joaquin River*

*Fall-Run Chinook Salmon*

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River below Vernalis. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 1 and the No Action Alternative generally would be similar (differences less than 0.5°F), with small differences in critical dry years when Alternative 1 would 0.8°F and 1.3°F cooler on average than under the No Action Alternative during June and September, respectively, and 0.7°F warmer in November (Appendix 6B, Table B-1-1).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under Alternative 1 would be higher in all water year types than the No Action Alternative by as much as 1.9°F. In most other months, water temperatures under Alternative 1 generally would be similar, although somewhat lower, compared to the No Action Alternative. An exception to this pattern occurs in April and December when average monthly water temperatures in all water year types would be higher under Alternative 1 by as much as about 1.2°F (April) in the drier years (Appendix 6B, Table B-18-1).

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between Alternative 1 and No Action Alternative. Increases in average monthly water temperatures in October and April would be more pronounced under Alternative 1, with average differences as much as 2.7°F in October and 2.0 F in April (Appendix 6B, Table B-19-1) relative to the No Action Alternative. The magnitude of differences in average monthly water temperatures between Alternative 1 and the No Action Alternative in May and June also would increase relative to the upstream locations.

Based on the life history timing for fall-run Chinook Salmon, the higher water temperatures in October and December under Alternative 1 may increase the likelihood of adverse effects on fall-run Chinook Salmon spawning and egg incubation as compared to the No action Alternative.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally considered suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and November about 30 and 25 percent of the time, respectively at Goodwin Dam under Alternative 1 (Appendix 6B, Figures B-17-1 and B-17-2). Similar exceedances would occur under the No Action Alternative, although slightly more frequently in November. Water temperatures for rearing generally would be below 56°F, except in May when average monthly water temperatures would reach about 60°F under both Alternative 1 and the No action Alternative (Appendix 6B, Figure B-17-8).

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded frequently under both Alternative 1 and the No Action Alternative during October and November. Under Alternative 1, average monthly water temperatures would exceed 56°F about 85 percent of the time in October. This, would be about 28 percent more frequently than under the No Action Alternative. In November, average monthly water temperatures would exceed 56°F about 28 percent of the time under Alternative 1, which would be about 5 percent more frequent than under the No Action Alternative (Appendix 6B, Figure B-18-2).

From January through May, rearing fall-run Chinook Salmon would be subjected to average monthly water temperatures that exceed 56° in March (less than 10 percent of the time) and May (about 10 percent of the time) under Alternative 1, less frequently than under the No Action Alternative (about 30 percent in May) (Appendix 6B, Figure B-18-8).

*Changes in Egg Mortality (Stanislaus River)*

For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg mortality rate is predicted to be around 7 percent, with higher mortality rates (in excess of 15 percent) occurring in critical dry years under Alternative 1. Overall, egg mortality would be 0.4 percent higher under Alternative 1; in most water year types the average egg mortality rate would be higher than under the No Action Alternative by up to 1.5 percent in critical dry years (Appendix 9C, Table B-1). In water year types where there is reduced egg mortality under Alternative 1 (wet and below-normal years), the reduction would be 0.1 and 0.3 percent, respectively. Overall, the difference in egg mortality between Alternative 1 and the No Action Alternative would be relatively minor and likely would have little effect on fall-run Chinook Salmon in the Stanislaus River.

*Changes in Delta Hydrodynamics*

San Joaquin River-origin fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities was moderately lower under Alternative 1 relative to No Action Alternative in April and May and almost indistinguishable in June (Appendix 9K). On Old River downstream of the facilities, the proportion of positive velocities was substantially lower in April and May under Alternative 1 relative to No Action Alternative but became more similar in June. In Old River upstream of the facilities, the percent of positive velocities was moderately lower for Alternative 1 relative to No Action Alternative in April and May and moderately lower in June. On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities was moderately higher under Alternative 1 relative to No Action Alternative in April and May whereas values were similar in June.

*Changes in Entrainment at Junctions*

Entrainment probabilities at the Head of Old River were much greater under Alternative 1 relative to the No Action Alternative during April and May. Entrainment probabilities were similar under both alternatives in the month of June (Appendix 9L). At the Turner Cut junction, entrainment probabilities under Alternative 1 were slightly higher than No Action Alternative in June. During April and May, entrainment probabilities were more divergent with higher values for Alternative 1 relative to No Action Alternative. Overall, entrainment was lower at the Columbia Cut junction relative to Turner Cut but patterns of entrainment between these two alternatives were similar). Entrainment was slightly lower for Alternative 1 relative to No Action Alternative during June. In April and May, entrainment was higher for Alternative 1 relative to No Action Alternative. Patterns at the Middle River and Old River junctions were similar to those observed at Columbia and Turner Cut junctions.

*Summary of Effects on Fall-Run Chinook Salmon*

In the Stanislaus River, the analysis of the effects of Alternative 1 and the No Action Alternative for fall-run Chinook Salmon relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in the Stanislaus River generally would be similar under both scenarios, although water temperatures could be somewhat less suitable for fall-run Chinook Salmon spawning/egg incubation under the Second Basis of Comparison. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that suitable water temperatures for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly less frequently in November, but substantially more frequently in October under Alternative 1. Suitable water temperatures for fall-run Chinook Salmon rearing would be exceeded somewhat less frequently under Alternative 1. Results of the analysis using Reclamation's salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under Alternative 1 and the No Action Alternative.

Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the differences in the frequency of exceedance of suitable temperatures for spawning and rearing under Alternative 1 could affect the potential for adverse effects on the fall-run Chinook Salmon populations in the Stanislaus River. However, the direction and magnitude of this effect is uncertain. This potential distinction between the two scenarios, however, may be offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Sacramento River reaches downstream of Goodwin Dam. Depending on the type of passage implemented, fall-run Chinook Salmon could be benefited by implementation of the fish passage program under the No Action Alternative.

*Steelhead*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River below Vernalis could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 1 and the No Action Alternative generally would be similar (differences less than 0.5°F), with small differences in critical dry years when Alternative 1 would 0.8°F and 1.3°F cooler on average than under the No Action Alternative during June and September, respectively, and 0.7°F warmer in November (Appendix 6B, Table B-17-1).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under Alternative 1 would be higher in all water year types than the No Action Alternative by as much as 1.9°F. In most other months, water temperatures under Alternative 1 generally would be similar (less than 0.5°F differences), although lower, than the No Action Alternative, except in April when average monthly water temperatures in all water year types would be higher under Alternative 1 by as much as about 1.2°F in the drier years (Appendix 6B, Table B-18-1).

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between Alternative 1 and the No Action Alternative. Increases in average monthly water temperatures in October and April would be more pronounced under Alternative 1, with average differences as much as 2.7°F (Appendix 6B, Table B-19-1) relative to the No Action Alternative. The magnitude of differences in average monthly water temperatures between Alternative 1 and the No Action Alternative in May and June also would increase relative to the upstream locations.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both Alternative 1 and No Action Alternative during October and November. Under Alternative 1, average monthly water temperatures would exceed 56°F about 85 percent of the time in October and about 57 percent of the time under the No Action Alternative (Appendix 6B, Figure B-18-1). In November, average monthly water temperatures would exceed 56°F about 28 percent of the time under Alternative 1, which would be about 5 percent less frequent than under the No Action Alternative (Appendix 6B, Figure B-18-2).

In January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. This threshold would not be exceeded under either Alternative 1 or No Action Alternative during January or February. In March through May, however, exceedances would occur under both Alternative 1 and the No Action Alternative in each month, with the threshold most frequently exceeded (43 percent) under Alternative 1 in May (Appendix 9N). Water temperatures under Alternative 1 would exceed the threshold less frequently in March (5 percent) and May (5 percent), and more frequently (17 percent) in April than under the No Action Alternative.

From June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded by both Alternative 1 and No Action Alternative in all months but November, and would exceed the threshold by 16 percent of the time in July under both Alternative 1 and the No Action Alternative. The differences between Alternative 1 and the No Action Alternative, however, would be relatively minor, with water temperatures under Alternative 1 generally exceeding the threshold by up to 3 percent less frequently than under the No Action Alternative.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles upstream of Knights Ferry, average monthly water temperatures under Alternative 1 would exceed 52°F in March, April, and May about 9 percent, 31 percent, and 66 percent of the time, respectively. Water temperatures under Alternative 1 would result in exceedances occurring about 1 to 2 percent more frequently during the January through May period. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and would be exceeded less frequently. The magnitude of the exceedance also would be less. Average monthly water temperatures under Alternative 1 and the No Action Alternative would not exceed the threshold during January through March. In April and May, exceedances of 8 percent and 10 percent would occur under Alternative 1, which would represent a frequency of about 6 percent more than the No Action Alternative in April and about an 8 percent lower frequency in May.

Overall, the differences between Alternative 1 and No Action Alternative would be relatively small, with the exception of substantial differences in the frequency of exceedances in October when the average monthly water temperatures under Alternative 1 would exceed the threshold for adult steelhead migration about 28 percent more frequently and in April during the spawning period when the exceedance frequency would be about 17 percent more. Given the frequency of exceedance under both Alternative 1 and No Action Alternative and the generally stressful temperature conditions in the river, the substantial differences in October and April under Alternative 1 suggest that there would be more potential to adversely affect steelhead under Alternative 1 than under the No Action Alternative. Even during months when the differences would be relatively small, the slightly higher frequency of exceedances under Alternative 1 could represent a biologically meaningful and negative difference.

*Changes in Delta Hydrodynamics*

San Joaquin River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing relative to Chinook Salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for winter-run Chinook Salmon in the Sacramento Basin and fall-run Chinook Salmon in the San Joaquin River basin above.

*Changes in Entrainment at Junctions*

At the Head of Old River, entrainment under Alternative 1 was slightly higher during January and February relative to the No Action Alternative. Entrainment probabilities were much lower under Alternative 1 relative to the No Action Alternative during April and May. Entrainment probabilities were similar under both alternatives in the month of June (Appendix 9L). At the Turner Cut junction, entrainment probabilities under Alternative 1 were slightly higher than No Action Alternative in January, February March and June. During April and May, entrainment probabilities were more divergent with higher values for Alternative 1 relative to No Action Alternative. Overall, entrainment was lower at the Columbia Cut junction relative to Turner Cut but patterns of entrainment between these two alternatives were similar. Entrainment was slightly higher for Alternative 1 relative to No Action Alternative during January, February, March and June. In April and May, entrainment was greater for Alternative 1 relative to No Action Alternative. Patterns at the Middle River and Old River junctions were similar to those observed at the Columbia and Turner Cut junctions.

*Summary of Effects on Steelhead*

The analysis of the effects of Alternative 1 and the No Action Alternative for steelhead relied on the water temperature model output for the rivers at various locations downstream of Goodwin Dam. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead in all of these streams generally would be similar under both scenarios, although water temperatures could be somewhat less suitable for steelhead rearing under Alternative 1. Water temperatures could be somewhat more suitable during the adult upstream migration period under Alternative 1 than the No Action Alternative. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature threshold for steelhead migration would be exceeded substantially more frequently on October, but somewhat more frequently in November under Alternative 1. The water temperature threshold for steelhead spawning would also be exceeded substantially more frequently in May, but somewhat less frequently in other months under Alternative 1. The water temperature threshold for steelhead rearing generally would be exceeded less frequently under Alternative 1 while the temperature thresholds for smoltification would be exceeded more frequently in most months.

Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the differences in the magnitude and frequency of exceedance of suitable temperatures for the various lifestages under Alternative 1 could affect the potential for adverse effects on the steelhead populations in the Stanislaus River. However, the direction and magnitude of this effect is uncertain. Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could provide a benefit to Central Valley steelhead in the Sacramento and American rivers.

*White Sturgeon*

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP and SWP water supplies and operations under Alternative 1 as compared to the No Action Alternative would result in higher storage levels in New Melones Reservoir under Alternative 1 as compared to the No Action Alternative, as summarized in Table 5.16, due to lower instream releases to support fish flows under Alternative 1.

Storage in New Melones could be increased by up to around 10 percent in some months of some water year types under Alternative 1 compared to the No Action Alternative. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. Assuming that storage volume is an indicator of how much habitat is available to fish species inhabiting the reservoir, the amount of habitat for reservoir fishes could be increased under Alternative 1 as compared to the No Action Alternative.

As shown in Appendix 9F, the likelihood of Largemouth Bass and Smallmouth Bass nest survival being above 40 percent is 100 percent under both Alternative 1 and the No Action Alternative in March. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is reasonably high (nearly 80 percent), although substantially (about 13 percent) higher under Alternative 1 as compared to the No Action Alternative. For May, this pattern is reversed with the likelihood of high nest survival being slightly (about 3 percent) lower under Alternative 1. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones Reservoir is also somewhat (about 8 percent) lower under Alternative 1 as compared to the No Action Alternative.

For Spotted Bass, nest survival in March is anticipated to be near 100 percent in every year under both Alternative 1 and No Action Alternative. The likelihood of survival being greater than 40 percent in April is 100 percent under both Alternative 1 and the No Action Alternative. For May, the likelihood of Spotted Bass nest survival being greater than 40 percent is slightly (about 2 percent) lower under Alternative 1. For June, Spotted Bass nest survival would be greater than 40 percent in every year under Alternative 1 as compared to approximately 98 percent of the years under the No Action Alternative.

Overall, predicted nest survival is generally above 40 percent in all months evaluated, although survival under Alternative 1 would vary among months. Given the relatively high survival in general and the uncertainty caused by the inconsistency in changes in survival, it is likely that effects would be similar under both alternatives.

*Other species*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Keswick Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

As described above, average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 1 and No Action Alternative generally would be similar. Downstream at Orange Blossom Bridge, average monthly water temperatures in the November to March period under Alternative 1 generally would be similar to, although somewhat lower than, under the No Action Alternative. In April and October, average monthly water temperatures in all water year types would be higher under Alternative 1 and in September, water temperatures would be lower under Alternative 1 compared to the No Action Alternative. This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between Alternative 1 and No Action Alternative (Appendix 6B, Table B-19-1).

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could adversely affect these larval lamprey. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar under Alternative 1 and the No Action Alternative.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and

Hardhead in the Stanislaus and San Joaquin rivers would be similar under Alternative 1 and the No Action Alternative.

*San Francisco Bay Area Region*

*Killer Whale*

Southern Resident killer whales (Southern Residents) are thought to rely heavily upon salmon as their main source of prey (about 96 percent of their diet) throughout the areas and times for which reliable data on prey consumption are available (Ford and Ellis 2006). Studies have indicated that Chinook Salmon generally constitute a large percentage of the Southern Resident salmon diet, with some indications that Chinook Salmon are strongly preferred at certain times in comparison to other salmonids (Ford and Ellis 2006; Hanson et al. 2007). Results have also suggested that Chinook Salmon from ESUs from California to British Columbia are being consumed by Southern Residents (Hanson et al. 2007).

Best available data on the abundance and composition of Central Valley Chinook Salmon indicates that approximately 75 percent of all Central Valley-origin Chinook Salmon available for consumption by Southern Residents are produced by Central Valley fall-run Chinook Salmon hatcheries (Palmer-Zwhalen and Kormos 2012; Table 9). Most Central Valley hatchery fall-run Chinook Salmon production is released directly into San Francisco Bay, and thus bypass potential impacts from water project operations. Even where there might be a nexus with water project operations, the purpose of Central Valley fall-run Chinook Salmon hatchery programs is to produce large numbers of fish independent of freshwater conditions. Since fall-run Chinook Salmon hatcheries came on-line more than forty years ago, the only period of exceptionally low returns was principally attributed to unusual ocean conditions (Lindley et al. 2007).

Ocean commercial and recreational fisheries annually harvest hundreds of thousands of Chinook salmon. The Northwest Region of NMFS (NMFS 2009c) used a model that estimates prey reduction associated with the salmon fishery and which considers the metabolic requirements of Southern Residents and the remaining levels of prey availability. Their analysis concluded that the salmon fishery was not likely to result in jeopardy for Southern Residents. Given conclusions from NMFS (2009c), and the fact that at least 75 percent of fall-run Chinook Salmon available for Southern Residents are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base for killer whales would not be appreciably affected by any of the alternatives.

#### 9.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison

As described in Chapter 3, Description of Alternatives, Alternative 1 is identical to the Second Basis of Comparison.

### *9.4.3.3 Alternative 2*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative, as described in Chapter 3, Description of Alternatives. Alternative 2 would not include implementation of fish passage actions under the 2009 NMFS BO. As described in Chapter 4, Approach to Environmental Analysis, Alternative 2 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 9.4.3.3.1 Alternative 2 Compared to the No Action Alternative

*Trinity River Region*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, fish and aquatic resources conditions at Trinity Lake and along the Trinity River and lower Klamath River under Alternative 2 would be the same as under the No Action Alternative.

*Central Valley Region*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, physical conditions that affect aquatic resources under Alternative 2 be the same as under the No Action Alternative. However, salmonid survival could be less under Alternative 2 due to the lack of fish passage actions to move fish to portions of the Sacramento, American, and Stanislaus rivers that would provide cooler temperatures for spawning and rearing under the No Action Alternative.

*San Francisco Bay Area Region*

*Killer Whale*

It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### 9.4.3.3.2 Alternative 2 Compared to the Second Basis of Comparison

*Trinity River Region*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes in aquatic resources at Trinity Lake and along the Trinity River and lower Klamath River under Alternative 2 as compared to the Second Basis of Comparison would be the same as the impacts described in Section 10.4.4.1, No Action Alternative Compared to the Second Basis of Comparison.

*Central Valley Region*

The CVP and SWP operations under Alternative 2 are identical to the CVP and SWP operations under the No Action Alternative. Therefore, changes in physical conditions that affect aquatic resources in the Central Valley Region under Alternative 2 as compared to the Second Basis of Comparison would be the same as the impacts described for the No Action Alternative Compared to the Second Basis of Comparison. Actions to provide fish passage to portions of the Sacramento, American, and Stanislaus rivers upstream of their dams would not be undertaken under Alternative 2 or the Second Basis of Comparison.

*San Francisco Bay Area Region*

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### 9.4.3.4 Alternative 3

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 3 are similar to the Second Basis of Comparison with modified OMR flow criteria and New Melones Reservoir operations. Alternative 3 also includes the following items that are not included in the No Action Alternative or the Second Basis of Comparison and would affect fish and aquatic resources.

- Implement predator control programs for black bass, Striped Bass, and Sacramento Pikeminnow to protect salmonids and Delta Smelt as follows:
  - Black bass catch limit changed to allow catch of 12-inch fish with a bag limit of 10
  - Striped Bass catch limit changed to allow catch of 12-inch fish with a bag limit of 5
  - Establish a Sacramento Pikeminnow sport-fishing reward program with a 8-inch limit at $2/fish
- Establish a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River in March through June as follows:
  - Begin operation of downstream migrant fish traps upstream of the Head of Old River on the San Joaquin River
  - "Barge" all captured juvenile salmonids through the Delta, release at Chipps Island.
  - Tag subset of fish in order to quantify effectiveness of the program
  - Attempt to capture 10 percent to 20 percent of out-migrating juvenile salmonids
- Work with Pacific Fisheries Management Council, CDFW, and NMFS to minimize harvest mortality of natural origin Central Valley Chinook Salmon, including fall-run Chinook Salmon, by evaluating and modifying ocean harvest for consistency with Viable Salmonid Population Standards; including harvest management plan to show that abundance, productivity, and diversity (age-composition) are not appreciably reduced.

As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 9.4.3.4.1 Alternative 3 Compared to the No Action Alternative

*Trinity River Region*

*Coho Salmon*

The analysis of effects associated with changes in operation on Coho Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam for Coho Salmon.

Long-term average monthly water temperatures in the Trinity River at Lewiston Dam under Alternative 3 generally would be similar to, although slightly cooler (up to 0.4°F), than under the No Action Alternative (Appendix 6B, Table B-1-2). An exception occurs during November when long-term average water temperatures are increased by 0.3°F under Alternative 3 relative to the No Action Alternative, and up to 3.3°F in critical years. Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on Coho Salmon in the Trinity River. The higher water temperatures in November of critical years under Alternative 3 would likely have little effect on Coho Salmon as water temperatures in the Trinity River are typically low during this time period.

The USFWS established a water temperature threshold of 56°F for Coho Salmon spawning in the reach of the Trinity River from Lewiston to the confluence with the North Fork Trinity River from October through December. Although not entirely reflective of water temperatures throughout the reach, the temperature model provides average monthly water temperature outputs for Lewiston Dam, which may provide perspective on temperature conditions in the reach. In October, average monthly water temperatures under both Alternative 3 and the No Action Alternative would exceed 56°F at Lewiston Dam in October of some years (Appendix 6B, Table B-1-2). Under Alternative 3, the threshold would be exceeded about 6 percent of the time in October, about 2 percent less frequently than under the No Action Alternative. In November, average water temperatures under Alternative 3 would not exceed the threshold, whereas average monthly water temperatures the No Action Alternative would exceed the threshold about 2 percent of the time.

Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be less frequent under Alternative 3. While average monthly temperatures would be similar overall, the slight reduction in the frequency of threshold exceedance provided by Alternative 3 in October and November might be biologically meaningful. Thus, temperature conditions under Alternative 3 could be slightly less likely to affect Coho Salmon spawning than those under the No Action Alternative.

*Spring-run Chinook Salmon*

The analysis of effects associated with changes in operation on spring-run Chinook Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

As described above for Coho Salmon, the differences in long-term average monthly water temperatures between Alternative 3 and the No Action Alternative would be relatively small (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Trinity River. The substantially higher water temperatures in November of critical dry years under Alternative 3 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Trinity River are typically low during this time period.

In July, water temperatures in the Trinity River at Lewiston Dam would not exceed the 60°F threshold for spring-run Chinook Salmon holding under Alternative 3, although this threshold would be exceeded 1 percent of the time under the No Action Alternative. Under both Alternative 3 and the No Action Alternative, average monthly water temperatures in the Trinity River at Lewiston Dam would exceed 60°F two percent of the time in August. In September, the threshold for spawning (56°F) would be exceeded under both scenarios about 9 percent of the time. Overall, the differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative would be relatively minor. However, temperature conditions under Alternative 3 could be slightly less likely to affect spring-run Chinook Salmon holding than under the No Action Alternative because of the slightly reduced frequency of exceedance of the 60°F threshold at Lewiston Dam in July.

The majority of spring-run Chinook Salmon in the Trinity River are produced in the South Fork Trinity watershed. Although the water temperature and flow changes could have slight beneficial effects on spring-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures under Alternative 3 as compared to the No Action Alternative.

Overall, Alternative 3 is likely to have similar effects on the spring-run Chinook Salmon population in the Trinity River as compared to the No Action Alternative.

*Fall-Run Chinook Salmon*

The analysis of effects associated with changes in operation on fall-run Chinook Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam. The Reclamation Salmon Survival Model also was applied to assess changes in egg mortality.

*Changes in Water Temperature*

As described above for Coho Salmon, the temperature differences between Alternative 3 and No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the

Trinity River. In critical dry years, increased water temperatures in November under Alternative 3 could increase the likelihood of adverse effects on spawning fall-run Chinook Salmon, although water temperatures are relatively low at this time of year.

The temperature threshold and months during which it applies for fall-run Chinook Salmon are the same as those for Coho Salmon. Under Alternative 3, the 56°F threshold for fall-run Chinook Salmon would be exceeded about 6 percent of the time in October, about 2 percent less frequently than under the No Action Alternative. In November and December, average water temperatures under Alternative 3 would not exceed the threshold, whereas average monthly water temperatures the No Action Alternative would exceed the threshold about 2 percent of the time in November. Overall, the differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative would be relatively minor. Temperature conditions under the Alternative 3 could be slightly less likely to affect fall-run Chinook Salmon spawning than under the No Action Alternative because of the slightly reduced frequency of exceedance of the 56°F threshold at Lewiston Dam in October. However, this would occur prior to the peak spawning period (November-December) for fall-run Chinook Salmon.

The temperatures described above for the Trinity River downstream of Lewiston Dam are reflected in the analysis of egg mortality using the Reclamation model (Appendix 9C). For fall-run Chinook Salmon in the Trinity River, the long-term average egg mortality rate is predicted to be relatively low (around 5 percent), with higher mortality rates (nearly 15 percent) occurring in critical dry years under the No Action Alternative. Overall, egg mortality would be about 0.2 percent lower under Alternative 3; in critical dry years the average egg mortality rate would be 1.5 percent less than under the No Action Alternative and in wet years it would be 0.5 percent higher under Alternative 3 (Appendix 9C, Table B-5). Overall, egg mortality under Alternative 3 and the No Action Alternative would be similar.

Although the water temperature and flow changes suggest a lower potential for adverse effects on fall-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures (as well as egg mortality) under Alternative 3 as compared to the No Action Alternative.

Overall, Alternative 3 is likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River as compared to the No Action Alternative.

*Steelhead*

The analysis of effects associated with changes in operation on steelhead was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam.

As described above for Coho Salmon, the temperature differences between Alternative 3 and No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Trinity River. In critical dry years, increased water temperatures in November under Alternative 3 could increase the likelihood of adverse effects on migrating adult steelhead, although water temperatures are relatively low at this time of year. The slightly lower water temperatures in most months under Alternative 3 may decrease the likelihood of adverse effects on steelhead rearing in the Trinity River.

The temperature threshold and months during which it applies for steelhead are the same as those for Coho Salmon. Overall, the differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative would be relatively minor and are unlikely to affect steelhead spawning in the Trinity River. While average monthly temperatures would be similar overall, the slight reduction in the frequency of threshold exceedance provided by Alternative 3 during warm periods in October and November might be biologically meaningful. Thus, temperature conditions under Alternative 3 could be slightly less likely to affect steelhead than under the No Action Alternative.

Although water temperatures under Alternative 3 suggest a slightly lower potential for adverse effects on steelhead in the Trinity River, the relatively small differences in flows and water temperatures under Alternative 3 as compared to the No Action Alternative would likely have similar effects on the steelhead population in the Trinity River as compared to the No Action Alternative.

*Green Sturgeon*

Changes in operations that influence temperature and flow conditions in the Trinity River downstream of Lewiston Dam could influence Green Sturgeon. The following describes those changes and their potential effects.

As described in the Affected Environment, Green Sturgeon spawn in the lower reaches of the Trinity River during April through June, and water temperatures above about 63°F are believed stressful to embryos (Van Eenennaam et al. 2005). Average monthly water temperature conditions during April through June in the Trinity River at Lewiston Dam under Alternative 3 are similar and do not exceed 58°F during this period. Water temperatures in the downstream reaches where Green Sturgeon spawn would be higher, although temperature conditions likely would be controlled by other factors (e.g., ambient air temperatures and tributary inflows) rather than water operations at Trinity and Lewiston dams. Therefore, given the similarities between average monthly water temperatures at Lewiston Dam under Alternative 3 and the No Action Alternative, it is likely that temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar under both scenarios.

*Reservoir Fishes*

The analysis of effects associated with changes in operation 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 3 as compared to the No Action Alternative would result in higher reservoir storage in Trinity Lake. Storage in Trinity Lake could be increased up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

Aquatic habitat in Trinity Lake may not be limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be increased somewhat under Alternative 3 as compared to the No Action Alternative.

Results of the bass nesting success analysis are presented in Appendix 9F, Reservoir Fish Analysis Documentation. Bass nest survival in Trinity Lake is predicted to be near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of survival for Largemouth and Smallmouth Bass in Trinity Lake being in the 40 to 100 percent range would be slightly (about 2 percent) higher under Alternative 3 as compared to the No Action Alternative. For June, the likelihood of survival being greater than 40 percent for Largemouth and Smallmouth Bass would be somewhat lower than in May and would be similar (less than 1 percent difference) under Alternative 3 and the No Action Alternative. For Spotted Bass, the likelihood of survival being greater than 40 percent would be 100 percent in May under both Alternative 3 and the No Action Alternative. For June, Spotted Bass survival in Trinity Lake would be less than for May due to greater daily reductions in water surface elevation. The likelihood of survival being greater than 40 percent would be similar (near 100 percent) under Alternative 3 and the No Action Alternative.

Overall, while reservoir storage and nest survival would be slightly higher under Alternative 3, it is uncertain whether these differences would be biologically meaningful. Thus, it is likely that effects on black bass would be similar under both Alternative 3 and the No Action Alternative.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Trinity River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles. On average, the temperature of water released at Lewiston Dam under Alternative 3 would be similar to (within 0.5°F) (Appendix 6B). The highest increases in flow would be less than 10 percent in the Trinity River, with a smaller relative increase in the lower Klamath River and Klamath River estuary (Appendix 5A).

Overall, it is likely that effects on Pacific Lamprey would be similar under both Alternative 3 and the No Action Alternative. This conclusion likely also applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).

*Eulachon*

It is uncertain whether Eulachon has been extirpated from the Klamath River. Given that the highest increases in flow would be less than 10 percent in the Trinity River (Appendix 5A), with a smaller relative increase in the lower Klamath River and Klamath River estuary, and that water temperatures in the

Klamath River (Appendix 6B) would be unlikely to be affected by changes upstream at Lewiston Dam, it is likely that Alternative 3 would have a similar potential to influence Eulachon in the Klamath River as the No Action Alternative.

*Sacramento River System*

*Winter-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 generally would be similar to or cooler than(less than 0.5°F difference) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures would be similar except in wetter years when water temperatures would be increased by up to 0.8°F. Water temperatures under Alternative 3 could be decreased by up to 0.8°F in October and November of drier years. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference of about 2°F between Keswick Dam and Bend Bridge) (Appendix 6B, Table B-8-2). The differences between Alternative 3 and the No Action Alternative in September of wetter years would increase, while the differences in water temperatures during October and November associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on winter-run Chinook Salmon in the Sacramento River. The increased water temperatures in September of wetter years under Alternative 3 could increase the likelihood of adverse effects on winter-run Chinook Salmon egg incubation and fry rearing during this water year type. The slightly lower water temperatures in October and November under Alternative 3 could reduce the likelihood of adverse effects on winter-run Chinook Salmon fry rearing in or outmigrating from the Sacramento River. There would be little difference in potential effects on spawning of winter-run Chinook Salmon due to the similar water temperatures during the April to June time period under Alternative 3 as compared to the No Action Alternative.

With the exception of April, average monthly water temperatures under both Alternative 3 and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Ball's Ferry for winter-run Chinook Salmon spawning and egg incubation in every month, with exceedances under both as high as about 49 percent and 42 percent, respectively, in some months. Under Alternative 3, the temperature threshold generally would be exceeded less frequently than it would under the No Action Alternative (by about 2 percent to 4 percent) in June through August, with the temperature threshold in September exceeded about 6 percent more frequently under Alternative 3 than the No Action Alternative. Farther downstream at Bend Bridge, the frequency of exceedances would increase, with exceedances under both Alternative 3 and the No Action Alternative as high as nearly 90 percent in some months. Under Alternative 3, temperature exceedances generally would be less frequent (by up to 8 percent) than under the No Action Alternative, with the exception of September, when exceedances under Alternative 3 would be about 26 percent more frequent.

Overall, there would be substantial differences in the frequency of threshold exceedance between Alternative 3 and the No Action Alternative, particularly in September. While temperature conditions under Alternative 3 could be less likely to affect winter-run Chinook Salmon egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold from April through August, the substantial increase in the frequency of exceedance in September under Alternative 3 may increase the likelihood of adverse effects on winter-run Chinook Salmon egg incubation during this limited portion of the spawning and egg incubation period.

*Changes in Egg Mortality*

The temperatures described above for the Sacramento River downstream of Keswick Dam are reflected in the analysis of egg mortality using Reclamation's salmon mortality model (Appendix 9C). For winter-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively low (around 5 percent), with higher mortality rates (exceeding 20 percent) occurring in critical dry years under the No Action Alternative. Overall, egg mortality would be 0.8 percent lower under Alternative 3; in critical dry years the average egg mortality rate would be 6 percent less than under the No Action Alternative. In other water year types, the differences in egg mortality would range from 0.1 percent less (dry) to 0.7 percent greater (Below Normal) under Alternative 3 as compared to the No Action Alternative (Appendix 9C, Table B-4). Overall, the difference in egg mortality between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on winter-run Chinook Salmon in the Sacramento River, except in critical water years.

*Changes in Weighted Usable Area*

As an indicator of the amount of suitable spawning habitat for winter-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be lower amounts of spawning habitat available from May through August under Alternative 3 as compared to the No Action Alternative (Appendix 9E, Weighted Usable Area Analysis). The decrease in long-term average spawning WUA during these months would be relatively small (less than 5 percent), with smaller (less than 1 percent) decreases in May and July. There would be an increase in the long-term average spawning WUA in April, but this reduction is small (less than 1 percent) and would occur prior to the peak spawning period in May and June. Overall, spawning habitat availability would be similar under Alternative 3 and the No Action Alternative.

Modeling results also indicate that, in general, there would be greater amounts of suitable fry rearing habitat available from June through October under Alternative 3. The increase in long-term average fry rearing WUA during June would be relatively small (less than 5 percent), with smaller (less than 1 percent) increases in July, August, and October. There would be a decrease in the long-term average fry rearing WUA in September, but this reduction would also be small (less than 5 percent) and would occur at a time when most fry have grown into juveniles and moved into habitats with different depth and velocity characteristics as reflected in the analysis of juvenile rearing WUA below. Overall, fry rearing habitat availability would be similar under Alternative 3 and the No Action Alternative.

Similar to the results for fry rearing WUA, modeling results indicate that there would be increased amounts of suitable juvenile rearing habitat available during the early juvenile rearing period from September through December under Alternative 3. There would be decrease in the long-term average juvenile rearing WUA from January through August. The decreases in long-term average juvenile rearing WUA would be relatively small (less than 1 percent), while the increases would be somewhat higher (up to 3 percent). Overall, juvenile rearing habitat availability would be similar under Alternative 3 and the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that flow-related winter-run Chinook Salmon egg mortality would be increased by 44 percent under Alternative 3 compared to the No Action Alternative. Conversely, temperature-related egg mortality would be reduced by 20 percent under Alternative 3 (Appendix 9D, Table B-4-9). Both temperature- and flow (habitat)-related fry mortality would be reduced under Alternative 3 as compared to the No Action Alternative, by 19 and 15 percent, respectively. Temperature-related juvenile mortality would be approximately 21 percent lower under Alternative 3, while flow (habitat)-related mortality would be approximately 30 percent higher under Alternative 3 as compared to the No Action Alternative. Overall, potential juvenile production would be similar (about 1 percent difference) under Alternative 3 as compared to the No Action Alternative (Appendix 9D, Table B-4-6).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for winter-run Chinook Salmon between Alternative 3 and the No Action Alternative (Appendix 9J). Median Delta survival would be 0.354 for Alternative 3 and 0.349 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February, and March. On the Sacramento River near the confluence of Georgiana Slough, the percentage of positive velocities under Alternative 3 would be slightly lower than the No Action Alternative in January and indistinguishable in February and March (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the percent of positive velocities would be indistinguishable between these two scenarios. In Old River downstream of the facilities, the percent of positive velocities would be slightly lower under Alternative 3 during February and March, and indistinguishable in January relative to the No Action Alternative. On Old River upstream of the facilities, percent positive velocities would be slightly higher under Alternative 3 relative to the No Action Alternative in January, but similar in February and March. On the San Joaquin River downstream of Head of Old River, the percent of positive velocities would be similar for both scenarios in January, February and slightly lower for Alternative 3 relative to the No Action Alternative in March.

*Changes in Junction Entrainment*

For all junctions examined, entrainment probabilities for both scenarios would be almost indistinguishable (Appendix 9L).

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be slightly greater under Alternative 3 relative to No Action Alternative in the three months when winter-run Chinook Salmon are most abundant in the Delta (January, February, March; (Appendix 9M).

*Changes in Oncorhynchus Bayesian Analysis Output*

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Escapement was generally lower under Alternative 3 as compared to the No Action Alternative (Appendix 9I). The median abundance under Alternative 3 was higher in only 5 of the 22 years of simulation (1971 to 2002), and there was typically greater than a 25 percent chance that Alternative 3 values would be lower than under the No Action Alternative. Median delta survival was consistently lower (by approximately 7 percent) under Alternative 3 as compared to the No Action Alternative. The differences in survival were not consistent across the uncertainty in the parameter values, however, and there was a high probability of no difference between Alternative 3 and the No Action Alternative. Thus delta survival was not responsible for the temporal patterns in relative escapement. Since the ocean conditions were equivalent across, scenarios, the differences under Alternative 3 were likely due to differences in survival in the life stages upstream of the delta (i.e., due to differences in temperature and flow at Bend Bridge).

*Changes in Interactive Object-Oriented Simulation Output*

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between Alternative 3 and the No Action Alternative across the 81 years (Appendix 9H). Under Alternative 3 median adult escapement was 4,025 and under the No Action Alternative, median escapement was 3,935.

Similar to adult escapement, the IOS model predicted similar egg survival time histories for winter-run Chinook Salmon between Alternative 3 and No Action Alternative across the 81 water years. Under Alternative 3 median egg survival was 0.987 and under the No Action Alternative median egg survival was 0.990.

### *Changes in Predator Management*

The fish predator assemblage of the Delta is dominated by invasive predators, with the exception of the Sacramento Pikeminnow (Brown and Michniuk 2007; Nobriga and Feyrer 2007, National Research Council 2010; Cavallo et al. 2012, National Research Council 2012, Brown 2013). With the exception of Striped Bass, there is little population-level information for fish predators including Largemouth Bass and Sacramento Pikeminnow and there is even less information for Smallmouth Bass and White and Channel Catfish (Grossman et al. 2013). It is important to note that, in addition to predation by native and non-native fishes, there has been extensive modification of the hydrology, loss of tidal freshwater wetlands, increases in non-native submerged aquatic vegetation such as *Egeria densa*, and other effects of human population growth within the Delta, which also undoubtedly influence the survival of salmonids in the Delta (Brown and Michniuk 2007; National Research Council 2010, 2012).

Although it is well documented that Striped Bass can feed heavily on juvenile salmon and steelhead in the rivers, as they migrate seaward, many of the salmon eaten are likely to be hatchery-reared fish; juveniles from natural spawning may be more wary and encounter lower predation rates. It is thought that predation on hatchery-reared juveniles may buffer wild fish from such predation (Moyle and Bennett 2010). Much of the predation on juvenile salmon seems to take in place in conjunction with artificial structures and release practices. These include releases of fish from hatcheries and those trucked to the estuary from the export facilities in the south Delta (DWR 2010).

In general, Striped Bass are opportunistic predators that tend to forage on whatever prey are most abundant, from benthic invertebrates to their own young to juvenile salmon and American Shad (Stevens 1966, Moyle 2002, Nobriga and Feyrer 2008). Striped Bass are unlikely to be a major predator of Delta Smelt because Delta Smelt are semi-transparent (making them hard to see in turbid water) and do not school, unlike more favored prey such as Threadfin Shad, juvenile Striped Bass, and Mississippi Silverside. Delta Smelt were a minor item in Striped Bass diets when they were highly abundant in the early 1960s (Stevens 1966), as well as in recent years at record low abundance (Nobriga and Feyrer 2008).

Predator control measures are included in Alternative 3, including an increased bag limit (10/day) with a minimum size limit of 12 inches on Striped Bass and black bass. In addition, a sport reward program for Sacramento Pikeminnow ($2/fish > 8 inches) would be implemented to encourage fishing for and removal of this native predatory fish.

A number of studies have been conducted on predation effects in the Delta, and a recent (2013) workshop was held to assess the status of information and potentially establish conclusions regarding the importance of fish predation on salmonid populations in the Delta (Grossman et al. 2013). The workshop concluded that:

> "Available data and analyses have generated valuable information regarding aspects of the predation process in the Delta but do not provide unambiguous and comprehensive estimates of fish predation rates on juvenile salmon or steelhead nor on population-level effects for these species in the Delta."

And:

> "Juvenile salmon are clearly consumed by fish predators and several studies indicate that the population of predators is large enough to effectively consume all juvenile salmon production. However, given extensive flow modification, altered habitat conditions, native and non-native fish and avian predators, temperature and dissolved oxygen limitations, and overall reduction in historical salmon population size, it is not clear what proportion of juvenile mortality can be directly attributed to fish predation. Fish predation may serve as the proximate mechanism of mortality in a large proportion of the population but the ultimate causes of mortality and declines in productivity are less clear."

The proposed bag and size limits are intended and expected to encourage more fishing effort for and greater harvest of Striped Bass and black bass species, resulting in a reduction in the Striped Bass and black bass populations throughout the Delta. It is reasonable to assume that removing or relaxing restrictions on the harvest of these predatory species would lead to a substantial reduction in their number. However, whether or not this reduction would lead to a substantial benefit or population-level effect on salmonid populations is unknown (Moyle and Bennett 2010). For the proposed (under Alternative 3) predator reduction program to be effective, it must be true that predation by Striped Bass and black bass regulates populations of salmon, steelhead, and smelt, with predation by other species (other fish, birds, marine mammals, etc.) playing a minor role. The program may not be effective, or the effectiveness would be reduced if other predators exhibit compensatory increases in predation if Striped Bass and black bass are removed.

As noted above, the modification of the hydrology, loss of tidal freshwater wetlands, increases in non-native submerged aquatic vegetation, and other effects of human population growth within the Delta play a role in the survival of salmonids in the Delta and contribute to the uncertainty that any predator reduction program will have the desired results. It is unknown whether reducing Striped bass and black bass populations can measurably compensate for the large changes to the estuary and watershed, which also contribute to reduced populations of salmon, steelhead and smelt.

In addition to the proposed bag and size limits, Alternative 3 includes a proposal to implement a sport reward program for Sacramento Pikeminnow to encourage fishing for and removal of predatory Sacramento Pikeminnow. It is unknown whether a Sacramento Pikeminnow bounty would be feasible under California regulations. Currently, the Sacramento Pikeminnow is regulated under CCR Title 14, section 5.95 (no limit or season), sections 2.25 and 2.30 (bow and arrow and spear fishing) and section 1.87 (no wastage of fish). Therefore, any fishing practice, derby or bounty program in which the Sacramento Pikeminnow is wasted would be in violation of the regulations. In addition, Sacramento Pikeminnow is listed as a "game fish" in commission regulations (CCR Title 14, section 230) and a permit is required before any prizes can be offered to take them.

Regardless of whether a Sacramento Pikeminnow reward system is feasible to implement, the effectiveness of such a program is not assured. This same approach to predator reduction is ongoing in the Columbia River through the Northern Pikeminnow (*Ptychocheilus oregonensis*) Sport-Reward Program sponsored by Bonneville Power Administration that began in 1991. The program seeks to maintain 10 to 20 percent exploitation rate on Northern Pikeminnow throughout the Columbia River by paying anglers $4 to $8 to harvest fish > 228 mm (>9 inches) in total length. In 2012, a total of 158,159 fish were harvested in the sport-reward fishery. Vouchers for 156,837 untagged fish were submitted for payment totaling rewards of $1,016,672. System-wide pikeminnow exploitation efforts suggest that the desired 10 to 20 percent exploitation rate has been achieved for a number of years (Porter 2012). The program has removed over 2.2 million fish from 1998-2009 and is believed to have reduced predation on juvenile salmonids; however, predation estimates have varied widely and positive effects on salmonid populations have been difficult to detect (Carey et al. 2012).

Control of undesired and invasive fishes is a common fishery management strategy (Kolar et al. 2010). However, changes in predator abundance produced via removal, augmentation, or invasion can produce unintended consequences (Polis and Strong 1996). It is possible that other species on which Striped Bass prey, such as Mississippi Silverside, would increase in abundance, causing harm by competing with and preying on desired species, particularly Delta Smelt. Mississippi Silversides are important in the diets of 1 to 3 year old Striped Bass; predation by Striped Bass could be regulating the silverside population. Reducing Striped Bass predation pressure on Mississippi Silversides may increase their numbers, which could have negative effects on Delta Smelt through predation on eggs and larvae (Bennett and Moyle 2006).

The predator reduction program under Alternative 3 is intended to improve the survival of listed species (e.g., salmonids and Delta Smelt) by reducing predation on these species. As described above, the program may be difficult to implement, may not be effective, and may cause unintended harm to other native Delta fish species. Consequently, the outcome of the predator management program is highly uncertain. Compared to the No Action Alternative, which does not include a predator reduction program, Alternative 3 may or may not provide a benefit to salmonids and may result in an adverse effect on Delta smelt.

*Changes in Ocean Salmon Harvest*

Alternative 3 includes an action to change ocean salmon harvest for the purpose of increasing escapement of adult winter-run Chinook Salmon as well as other runs. The following outlines the benefits and challenges associated with such a program.

Central Valley origin Chinook Salmon of all races are harvested in commercial and recreational fisheries off the coast of California. Central Valley origin fall-run Chinook Salmon are the primary target of this harvest. Harvested Chinook Salmon between Point Conception and Bodega Bay were found to be composed of 89-95 percent Central Valley fall-run Chinook Salmon (Winans et al. 2001). More recent studies have shown most Central Valley fall-run Chinook Salmon are produced by hatcheries, and are not of natural origin. Barnett-Johnson et al. (2007) analyzed otolith microstructure from harvested Chinook Salmon and estimated 90 percent were of hatchery origin. Palmer-Zwhalen and Kormos (2012; Table 9) reported data indicating spawning-escapement for Central Valley fall-run Chinook Salmon was composed of 75 percent hatchery origin fish.

Despite the relatively high abundance of hatchery-produced fall-run Chinook Salmon, ocean fisheries are often constrained to protect ESA-listed Chinook Salmon stocks (including Sacramento winter-run and spring-run Chinook Salmon, and Coastal Chinook Salmon), which constitute less than 10 percent of available Chinook Salmon (Winans et al. 2001). This “mixed-stock” fishery is managed by using stock-specific differences in ocean distribution, age at maturity, size-at-date, and/or timing of river entry to help minimize harvest of sensitive stocks. However, such management strategies are only partially effective.

For example, spring-run Chinook Salmon return to freshwater in the spring and thus avoid most ocean harvest during the year in which they mature. However, spring-run Chinook Salmon that mature at age 4 (or older) are subjected to a full season of harvest at “impact levels” comparable to those directed at Central Valley fall-run Chinook Salmon. Harvest managers define “impact rate” as the proportion of a particular stock that will suffer mortality associated with the ocean fishery. Fall-run Chinook Salmon often experience impact rates between 40 and 70 percent.

Thus, the impact of ocean harvest varies considerably by stock, but all stocks are impacted by harvest directed at the most abundant Chinook Salmon population (typically hatchery origin fall-run Chinook Salmon). Several analyses are available that provide a basis for assessing how harvest management identified in Alternative 3 would affect Central Valley Chinook Salmon populations. Though there are political and societal considerations for changes in ocean harvest management, there are no technical or scientific constraints. We have the tools, the knowledge and the ability to manage Chinook ocean harvest in whatever way is needed. As such, Alternative 3 is, from a technical and scientific level, entirely feasible.

Alternative 3 calls for ocean harvest to be managed with the standard of causing no appreciable reduction in viability criteria for natural origin Chinook Salmon. This alternative is addressed separately for Central Valley spring-run, winter-run, and fall-run Chinook Salmon.

*Spring-Run Chinook Salmon.*

Fifteen years have elapsed since NMFS last updated its spring-run Chinook Salmon ocean harvest Biological Opinion (NMFS 2000). The 2000 BO did not report an estimated "impact rate" for the ocean harvest impact on spring-run Chinook Salmon. The BO reached a non-jeopardy opinion for the impacts of ocean harvest primarily by referring to the growth in Central Valley spring-run Chinook Salmon population which was occurring at that time. Though NMFS (2010) did not provide a quantitative analysis of spring-run Chinook Salmon harvest, Grover et al. (2004) estimated that two thirds of spring-run Chinook Salmon matured at age 4, indicating that a large fraction of the spring-run Chinook Salmon population is annually subject to high impact rates (40 to 70 percent), which would greatly influence population productivity and abundance. Harvest of age-3 spring-run Chinook Salmon is likely to be comparable to that experienced by winter-run Chinook Salmon (which also mature and return to fresh water, missing most of the ocean fishing season). Though a comparable analysis for spring-run Chinook Salmon is not available, Winship et al. (2013) applied a simulation model that showed a 25 percent impact rate (much less than that likely experienced by age 4 spring-run Chinook Salmon) on winter-run Chinook Salmon substantially decreased population abundance and population resiliency relative to alternatives with less harvest.

Harvest pressure of this intensity can also alter diversity in age at-maturity, a critical factor for population viability (NMFS 2010). The ocean fishery is thought to select against fish that mature later because fish that would do so are vulnerable to harvest for more years (Ricker 1981; Hankin and Healey 1986; Sierra and Lackey 2015), and age at maturity has moderate heritability (Hankin et al. 1993). As such, reduced ocean harvest would contribute substantially to age at-maturity diversity (certainly demographically, if not genetically) and thereby enhance population viability. A downward shift in size and age at maturity also affect fitness by reducing fecundity and reproductive rates (Calduch-Verdiell et al. 2014). Larger females generally have larger and more numerous eggs (Wertheimer et al. 2004), both of which provide reproductive advantages. Larger eggs produce larger juveniles, which tend to have higher survival rates (Quinn 2005) and are more resistance to temperature extremes. Since size and age-at-maturity are heritable, selection for earlier adult maturity leads to a feedback loop in which younger and smaller adults produce offspring that mature earlier at smaller sizes. Change in body size may also influence spawning habitat use where larger fish occupy areas with coarser substrate that smaller fish may not be able to use. Thus, advantages of diversity in age at-maturity could be especially important in degraded and thermally stressful habitats typical of Central Valley tributaries.

*Winter-Run Chinook Salmon*

NMFS updated their winter-run Chinook Salmon ocean harvest BO in 2010 (NMFS 2010) and concluded:

> *The effect of harvest and indirect mortality associated with the salmon ocean fishery reduces the reproductive capability of this population, and*

*subsequently the entire ESU, by 10-25 percent per brood, when ocean fisheries occur at a level similar to what has been observed for most of the last decade south of Point Arena, California.*

*There is concern about the relatively high impact rate for age-4 fish and the consequences of this relative to the genetic diversity of winter-run. If age at maturity is strongly related to a genetic component, the removal of older fish at a high rate before they can return to spawn, however few of these individuals in the population there might be, could theoretically reduce the potential for that trait to pass on to successive generation. The change in an average life history trait over time, such as age at maturity, has been suggested as evidence for fisheries induced evolution in some situations (Law 2000; Kuparinen and Merilä 2007; Hard et al. 2008).*

NMFS has since implemented changes in ocean harvest regulations intended to reduce impacts, but the effectiveness of those programs is unclear. Winship et al. (2013) applied a simulation model and showed that all current winter-run Chinook Salmon harvest alternatives substantially decreased population abundance and population extinction risk relative to closing recreational and commercial fisheries south of Point Arena. While closing these fisheries may not be a realistic management alternative, Winship et al. (2013) did not consider intermediate harvest management strategies such as a mark-selective fishery (Pyper et al. 2012) or quota based fishing seasons. Currently, about 90 percent of winter-run Chinook Salmon mature at age-3. As identified in the winter-run Chinook Salmon harvest BO (NMFS 2010), diversity in age at maturity is an important viability criterion likely to be adversely impacted by current harvest management; winter-run Chinook Salmon currently maturing at age-4 are subjected to impact rates comparable to those targeting fall-run Chinook Salmon (40 to 70 percent). Given information presented in the spring-run Chinook Salmon section, it seems likely that in the absence of this harvest, winter-run Chinook Salmon would have a larger fraction of their population maturing at age-4 or possibly older. Age-4 and older winter-run Chinook Salmon would enhance demographic population viability, but also benefit the population by more effectively spawning in coarse substrates, and producing more, larger, and more thermally tolerant eggs.

*Fall-Run Chinook Salmon.*

As indicated previously, fall-run Chinook Salmon produced by Central Valley hatcheries are the most abundant stock harvested off the coast of California. The current management of Central Valley fall-run Chinook Salmon makes no distinction between natural and hatchery fish, and, as such, harvest of natural origin fall-run Chinook Salmon appears to occur at a much higher rate than population productivity can sustain. The recently convened California HSRG concluded:

*"Fishery harvests that are sustained at high levels by targeting abundant hatchery-origin fish may over-exploit naturally reproducing salmonids and may also induce selection on maturation schedule and other traits… fishery exploitation rates must be in alignment with the productivity of*

> *naturally reproducing salmon stocks for the recommendations in this report to be successful at conserving natural salmonid populations."* *(p. 19)*

> *"The California HSRG also believes that an aggregate escapement target for [the Central Valley natural stocks] that includes returns to hatcheries lacks biological support. The target could theoretically be met if all fish returned to hatcheries and none returned to natural spawning areas, or if all fish in natural spawning areas were of hatchery origin." (p. 21)*

Quantitative analyses of current ocean harvest impacts to natural origin fall-run Chinook Salmon are not currently available. However, impact rates combined with relatively low abundances of natural origin fall-run Chinook Salmon indicate adverse impacts to population viability are likely severe. Changes in harvest strategies which could more effectively target hatchery origin fall Chinook while better protecting natural origin fish would yield substantial benefits. Pyper et al. (2012) analyzed one alternative, a mark-selective fishery, and found that natural origin spawning escapement would increase from 24 to 48 percent.

Managing ocean salmon harvest as described in Alternative 3 would contribute to the abundance, productivity and diversity viability criteria for natural origin spring-run, winter-run, and fall-run Chinook Salmon.

#### *Summary of Effects on Winter-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for winter-run Chinook Salmon and their response to change under Alternative 3 as compared to the No Action Alternative. For the purpose of analyzing effects on winter-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the two life cycle models, IOS and OBAN because they each integrate the available information to produce single estimates of winter-run Chinook Salmon escapement. The output from IOS indicated that winter-run Chinook Salmon escapement would be similar under both scenarios, whereas the OBAN results indicated that escapement under Alternative 3 would be lower than under the No Action Alternative.

These model results suggest that effects on winter-run Chinook Salmon would be similar under both scenarios, with a small likelihood that winter-run Chinook Salmon escapement would be lower under Alternative 3 than under the No Action Alternative. This potential distinction between the two scenarios, however, could be increased because Alternative 3 does not include passage at Shasta Dam. By comparison the No Action Alternative, Alternative 3 would not include the potential for providing access to better quality (temperature) habitat upstream of the dam.

The ocean harvest restriction component of Alternative could increase winter-run Chinook Salmon numbers by reducing ocean harvest and the predator control measures under Alternative 3 could reduce predation on juvenile winter-run Chinook Salmon and thereby increase survival.

Overall, given the small differences between alternatives and the uncertainty regarding the non-operational components, distinguishing a clear difference between alternatives is not possible. However, if fish passage is successful in providing access to higher quality habitat, Alternative 3 would do less than the No Action Alternative to address long-term temperature issues in the river downstream of the dam.

*Spring-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect spring-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature that could affect spring-run Chinook Salmon could occur in the Sacramento River, Clear Creek, and Feather River. The following describes temperature conditions in those water bodies.

*Sacramento River*

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar to or cooler(less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures also would be similar except in wetter years when water temperatures would be increased by up to 0.8°F. Water temperatures under Alternative 3 could be decreased by up to 0.8°F in October and November of drier years. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, and Red Bluff, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference of about 3°F between Keswick Dam and Red Bluff). The differences between Alternative 3 and the No Action Alternative in September of wetter years would increase, while the differences in water temperatures during October and November associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on spring-run Chinook Salmon in the Sacramento River. The increased water temperatures in September of wetter years under Alternative 3 could increase the likelihood of adverse effects on spring-run Chinook Salmon spawning and egg incubation during this water year type. The slightly lower water temperatures in October and November under Alternative 3 would reduce the likelihood of adverse effects on spring-run Chinook Salmon spawning and egg incubation in the Sacramento River as compared to the No Action Alternative. There would be little difference in potential effects on spring-run Chinook Salmon holding in other summer months due to the similar water temperatures during this time period under Alternative 3 and the No Action Alternative.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative 3 would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative with the exception of May when average monthly temperatures under Alternative 3 would be somewhat higher (up to about 0.8°F) than the No Action Alternative (Appendix 6B, Table B-3-2). The lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water that would be discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into the creek. Overall, water temperature conditions for spring-run Chinook Salmon in Clear Creek would be similar under Alternative 3 and the No Action Alternative.

*Feather River*

Average monthly water temperatures in the Feather River low flow channel under Alternative 3 generally would be similar (within 0.5°F) to water temperatures under the No Action Alternative in November and December (differences as much as 1.6°F lower in December in below normal water years) (Appendix 6B, Table B-20-2). In September average monthly water temperatures under Alternative 3 would be somewhat higher (up to about 1.5°F) and during May and June water temperatures would be slightly (up to 0.4°F) lower in wetter years than under the No Action Alternative. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 3 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and the No Action Alternative generally becoming more similar at the confluence with the Sacramento River, except in September when the differences between Alternative 3 and the No Action Alternative would be up to 4.4 °F higher than under the No Action Alternative (Appendix 6B, Table B-23-2).

Overall, the temperature differences in the Feather River between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the Feather River. The slightly lower water temperatures from October to in November and December under the No Action Alternative 3 would likely have little effect on spring-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on spring-run Chinook Salmon egg incubation and fry rearing in the Feather River. There would be little difference in potential for adverse effects on spring-run Chinook Salmon holding over the summer due to the similar water temperatures during this time period under Alternative 3 and the No Action Alternative.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for spring-run Chinook Salmon in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both Alternative 3 and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for spring-run Chinook Salmon (spawning and egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October, with 78 percent of the time under Alternative 3). The water temperature threshold would be exceeded less frequently in November (8 percent of the time) and not exceeded at all during December through March. As water temperatures warm in the spring, the threshold would be exceeded in April by 14 percent under Alternative 3. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate that the threshold would be exceeded less frequently (by up to 4 percent in October) under Alternative 3 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect spring-run Chinook Salmon egg incubation than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in October, November, and April.

*Clear Creek*

Average monthly water temperatures under both Alternative 3 and the No Action Alternative would not exceed the water temperature threshold of 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in June through August. However, water temperatures under Alternative 3 would exceed the water temperature threshold of 56°F established for spawning in September and October about 12 percent to 11 percent of the time, respectively. The differences between Alternative 3 and the No Action Alternative could be biologically meaningful, with water temperatures under Alternative 3 exceeding thresholds about 4 percent less frequently than under the No Action Alternative in September and about 2 percent less frequently in October. Temperature conditions in Clear Creek under Alternative 3 could be less likely to affect spring-run Chinook Salmon spawning than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in September and October.

*Feather River*

Average monthly water temperatures under both Alternative 3 and the No Action Alternative would exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg incubation and rearing) during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N). The frequency of exceedance would be highest (about 57 percent) in October, a month in which average monthly water could get as high as about 68°F. However, the differences in the frequency of exceedances between Alternative 3 and the No Action Alternative would be relatively small. Water temperatures under Alternative 3 would exceed the temperature threshold about 2 percent less frequently than the No Action Alternative in October, 5 percent less frequently in November, 2 percent less frequently in December, and 1 percent less frequently in March.

The established water temperature threshold of 63°F for rearing during May through August would be exceeded often under both Alternative 3 and the No Action Alternative in June, July and August. Water temperatures under Alternative 3 would exceed the rearing temperature threshold about 1 percent less frequently than under the No Action Alternative in June, with the same likelihood of exceedance in July and August. Temperature conditions in the Feather River under Alternative 3 could be less likely to affect spring-run Chinook Salmon spawning and rearing than under the No Action Alternative because of the decreased frequency of exceedance of the water temperature thresholds.

*Changes in Egg Mortality*

The temperature differences described above are reflected in the analysis of egg mortality using the Reclamation model (Appendix 9C). For spring-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively high (exceeding 20 percent), with high mortality rates (exceeding 80 percent) occurring in critical dry years under the No Action Alternative. Overall, egg mortality would be 0.7 percent lower under Alternative 3; in critical dry years the average egg mortality rate would be 6.6 percent less than under the No Action Alternative. In other water year types, the differences in egg mortality would range from 2.5 percent less (Below Normal) to over 2 percent greater (wet and above normal) under Alternative 3 as compared to the No Action Alternative (Appendix 9C, Table B-3). Overall, the difference in egg mortality between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on spring-run Chinook Salmon in the Sacramento River, except in critical dry water years.

*Changes in Weighted Usable Area*

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. As described above, flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that pre-spawning mortality of spring-run Chinook Salmon eggs would be approximately 21 percent less under Alternative 3, primarily due to decreased summer temperatures. Flow-related spring-run

Chinook Salmon egg mortality would be similar (less than 1 percent increase) under Alternative 3 compared to the No Action Alternative. Conversely, temperature-related egg mortality would be 7 percent less under Alternative 3 (Appendix 9D, Table B-3-9). Flow (habitat)-related fry mortality would be approximately 7 percent higher under Alternative 3 as compared to the No Action Alternative. There would be no temperature-related fry and juvenile mortality or flow (habitat)-related juvenile mortality under either alternative, as most spring-run Chinook Salmon juveniles migrate downstream as fry and are not found in the mainstem Sacramento River. Overall, potential juvenile production would be about 2 percent greater under Alternative 3 as compared to the No Action Alternative (Appendix 9D, Table B-3-6).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for spring-run Chinook Salmon between Alternative 3 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.286 for Alternative 3 and 0.296 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

Spring-run Chinook Salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough (channel 421), the percent of time that velocity would be positive was similar in the March for both scenarios (Appendix 9K). In April and May, percent positive velocity would be slightly lower under Alternative 3 relative to the No Action Alternative. Near the confluence of the San Joaquin River and the Mokelumne River (channel 45), percent positive velocity would be almost identical in March and slightly, to moderately, lower under Alternative 3 relative to the No Action Alternative in April and May. A similar pattern was observed in the San Joaquin River downstream of the Head of Old River (channel 21); however, the difference between alternatives would be even smaller (Appendix 9K, Figure V6). In Old River upstream of the facilities (channel 212), percent positive velocity would be slightly higher in May under Alternative 3 relative to No Action Alternative and similar magnitude in April and May. In Old River downstream of the facilities, (channel 94) percent positive velocity would be slightly lower in March and increasingly lower in April and May under Alternative 3 relative to the No Action Alternative.

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough would be similar under both scenarios during March, April and May when spring-run Chinook Salmon are most abundant in the Delta (Appendix 9L. At the Head of Old River, entrainment probabilities would be moderately greater under Alternative 3 during April and May, whereas probabilities would be similar in March. At the Turner Cut junction, entrainment probabilities under Alternative 3 and the No Action Alternative would be similar in March. During April and May, entrainment probabilities would be more divergent with higher values for Alternative 3 relative to the No Action Alternative. Overall, entrainment was lower at the Columbia Cut junction relative to Turner Cut, but patterns of entrainment between these two alternatives would be similar. Patterns at the Middle River and Old River junctions would be similar to those observed at Columbia and Turner Cut junctions.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 3 relative to the No Action Alternative in every month (Appendix 9). Spring-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of March, April, and May. Predicted values in April and May indicated a substantially larger fraction of fish salvaged for Alternative 3 relative to the No Action Alternative. Predicted salvage was more similar in March, but still higher under Alternative 3

*Summary of Effects on Spring-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under Alternative 3 and the No Action Alternative. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be slightly higher under Alternative 3 than under the No Action Alternative.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 3 relative to the No Action Alternative in every month.

In Clear Creek and the Feather River, the analysis of the effects of Alternative 3 and the No Action Alternative for spring-run Chinook Salmon relied on output from the WUA analysis and water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The WUA analysis suggests that there would be little difference in the availability of spawning and rearing habitat in Clear Creek. The temperature model outputs suggest that thermal conditions and effects on each of the spring-run Chinook Salmon life stages generally would be similar under both scenarios in Clear Creek and the Feather River, although water temperatures could be somewhat less suitable for spring-run Chinook Salmon holding and spawning/egg incubation in the Feather River under Alternative 3. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that water temperature thresholds for spawning and egg incubation would be exceeded slightly more frequently under Alternative 3 than under the No Action Alternative in Clear Creek and the Feather River. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the slightly greater likelihood of exceeding water temperature thresholds under Alternative 3 could increase the potential for adverse effects on the spring-run Chinook Salmon populations in the Feather River. Given the similarity of the results, Alternative 3 and the No Action Alternative are likely to have similar effects on the spring-run Chinook Salmon population in Clear Creek.

These model results suggest that overall, effects on spring-run Chinook Salmon could be slightly less adverse under Alternative 3 than under the No Action Alternative, with a small likelihood that spring-run Chinook Salmon production would be lower under the No Action Alternative. The potential differences between the two scenarios, however, may be offset by the benefits of implementation of fish passage under the No Action Alternative intended to address the limited availability of suitable habitat for spring-run Chinook Salmon in the Sacramento River reaches downstream of Shasta Dam. This potential beneficial effect and its magnitude would depend on the success of the fish passage program.

The ocean harvest restriction component of Alternative 3 could reduce winter-run Chinook Salmon mortality by reducing ocean harvest and implementing the predator control measures to reduce predation on juvenile Chinook Salmon.

Overall, given the small differences between alternatives and the uncertainty regarding the non-operational components, distinguishing a clear difference between alternatives is not possible. However, if fish passage is successful in providing access to higher quality habitat, Alternative 3 would do less than the No Action Alternative to address long-term temperature issues in the Sacramento River downstream of the Keswick Dam.

*Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River downstream of Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect fall-run Chinook Salmon in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar to or cooler(less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures also would be similar except in wetter years when water temperatures would be increased by up to 0.8°F. Water temperatures under Alternative 3 could be decreased by up to 0.8°F in October and November of drier years. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference in September of about 9°F between Keswick Dam and Knights Landing). The differences between Alternative 3 and the No Action Alternative in September of wetter years would increase, while the differences in water temperatures during October and November associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on fall-run Chinook Salmon in the Sacramento River. The increased water temperatures in September of wetter years under Alternative 3 could increase the likelihood of adverse effects on early spawning fall-run Chinook Salmon during this water year type. The slightly lower water temperatures in October and November under Alternative 3 would reduce the likelihood of adverse effects on fall-run Chinook Salmon spawning and egg incubation in the Sacramento River as compared to the No Action Alternative.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative 3 would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative with the exception of May when average monthly temperatures under Alternative 3 would be somewhat higher (up to about 0.8°F) than the No Action Alternative (Appendix 6B, Table B-3-2). Alternative 32). As described above for spring-run Chinook Salmon, the lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water that would be discharged from Whiskeytown Dam to meet the 2009 NMFS BO RPA spring attraction flow requirements.

Fall-run Chinook Salmon spawn and rear in the lower portion of Clear Creek, generally downstream of Igo. Average monthly temperatures at the confluence with the Sacramento River would exhibit a similar pattern, although temperatures in the creek would be slightly higher in general.

Under Alternative 3, temperature conditions at Igo would be slightly cooler than under the No Action Alternative. However, these temperature outputs are at a location upstream of most fall-run Chinook Salmon spawning and rearing in Clear Creek. Temperatures where fall-run Chinook Salmon inhabit the creek would be somewhat higher as indicated by average monthly temperatures at the confluence with the Sacramento River, although these temperatures would be similar under Alternative 3 as and the No Action Alternative. Overall, effects on fall-run Chinook Salmon in Clear Creek due to temperature differences between Alternative 3 and the No Action Alternative would be relatively minor.

*Feather River*

Average monthly water temperatures in the Feather River at the low flow channel under the Alternative 3 relative generally would be similar (within 0.5°F) to water temperatures under the No Action Alternative generally would be, but somewhat lower in November and December (differences as much as 1.6°F in December in below normal water years) (Appendix 6B, Table B-20-2). Water temperatures generally would be similar for the other months, except in September when average monthly water temperatures under Alternative 3 would be somewhat higher (up to about 1.5°F) and during May and June when water temperatures would be slightly (up to 0.4°F) lower in wetter years than under the No Action Alternative. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 3 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and the No Action Alternative generally becoming more similar at the confluence with the Sacramento River, except in September when the differences between Alternative 3 and the No Action Alternative would be up to 4.4 °F higher than under the No Action Alternative.

Overall, the temperature differences in the Feather River between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Feather River. The slightly lower water temperatures in November and December under Alternative 3 would likely have little effect on fall-run Chinook Salmon as water temperatures in the Feather River are typically low during this time period. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on early spawning fall-run Chinook Salmon in these water year types.

*American River*

Long term average monthly water temperatures in the American River at Nimbus Dam under Alternative 3 generally would be similar (differences less than 0.25°F) to those under the No Action Alternative (Appendix 6B, Table B-12-2). In September of wetter years, water temperatures under Alternative 3 would be increased relative to under the No Action Alternative by up to 0.4°F in some water year types. This pattern generally would persist downstream to Watt Avenue and the mouth (Appendix 6B, Tables b-13-2 and B-13-2 and B-14-2). In June water temperatures would be up to 0.7°F lower under Alternative 3 than under the No Action Alternative. In September, average monthly water temperatures at the mouth generally would be higher under Alternative 3 than under the No Action Alternative, especially in wetter water year types when the water temperatures under Alternative 3 could be up to 1.6°F warmer.

Overall, the temperature differences in the American River between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on fall-run Chinook Salmon in the American River. The lower water temperatures in June under Alternative 3 may reduce the likelihood of adverse effects on fall-run Chinook Salmon rearing in the American River if they were present. Higher water temperatures during September under Alternative 3 would have little effect on fall-run Chinook Salmon spawning in the American River because most spawning occurs later in November.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of water temperatures that are protective of fall-run Chinook Salmon in the Sacramento River, Clear Creek, Feather River, and American River. The following describes the extent of those exceedances for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both Alternative and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for fall-run Chinook Salmon (spawning and egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October, with 78 percent of the time under Alternative 3). The water temperature threshold would be exceeded less frequently in November (8 percent of the time) and not exceeded at all during December through March. As water temperatures warm in the spring, the threshold would be exceeded in April by 14 percent under Alternative 3. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate that the threshold would be exceeded less frequently (by up to 4 percent in October) under Alternative 3 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in October, November, and April.

*Clear Creek*

Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during October through December (USFWS 2015). Average monthly water temperatures at Igo during this period generally remain below 56°F, except in October. Under Alternative 3, 56°F would be exceeded in October about 10 percent of the time as compared to 12 percent under the No Action Alternative. At the confluence with the Sacramento River, average monthly water temperatures would be warmer, with 56°F exceeded about 15 percent of the time under Alternative 3 and slightly more frequently under the No Action Alternative (Appendix 6B, Figure B-4-1). During November and December, average monthly water temperatures generally would remain below 56°F at both locations. Temperature conditions in Clear Creek under Alternative 3 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold in October.

For fall-run Chinook Salmon rearing (January through August), the exceedances described previously for spring-run Chinook Salmon would apply, with the average monthly temperatures remaining below the 60°F threshold in all months Downstream at the mouth of Clear Creek, average monthly water temperatures would exceed the 60°F threshold often during the summer, but the frequency of exceedance would be similar under Alternative 3 and the No Action Alternative

(Appendix 6B Figures). Temperature conditions for fall-run Chinook Salmon rearing in Clear Creek would be similar under Alternative 3 and the No Action Alternative.

*Feather River*

Average monthly water temperatures under both Alternative 3 and the No Action Alternative would exceed the water temperature threshold of 56°F established in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and rearing during some months, particularly in October, November, March, and April, when temperature thresholds would be exceeded frequently (Appendix 6B, Table B-22-2). The frequency of exceedance would be greatest in October, when average monthly temperatures under both Alternative 3 and the No Action Alternative would be above the threshold in nearly every year. The magnitude of the exceedances would be high as well, with average monthly temperatures in October reaching about 68°F. Similarly, the threshold would be exceeded under both alternatives about 85 percent of the time in April. The differences between Alternative 3 and the No Action Alternative, however, would be relatively small, with Alternative 3 generally exceeding temperature thresholds about 1-4 percent less frequently than the No Action Alternative. Temperature conditions in the Feather River under Alternative 3 could be less likely to affect fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the reduced frequency of exceedance of the 56°F threshold from October through April.

*Changes in Egg Mortality*

The analysis of fall-run Chinook Salmon included the application of the Reclamation Salmon Survival Model. The following describes the differences in egg mortality for the Sacramento, Feather, and American rivers based on the model output.

*Sacramento River*

For fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be around 17 percent, with higher mortality rates (in excess of 35 percent) occurring in critical dry years under Alternative 3. Overall, egg mortality would be 0.2 percent lower under Alternative 3; in critical dry years the average egg mortality rate would be 2.3 percent lower than under the No Action Alternative. In other water year types, egg mortality would be reduced (up to 0.7 percent less) in drier years and increased up to 1 percent in wetter years under Alternative 3 as compared to the No Action Alternative (Appendix 9C, Table B-1). Overall, the difference in egg mortality between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on fall-run Chinook Salmon in the Sacramento River, except in critical dry water years.

*Feather River*

For fall-run Chinook Salmon in the Feather River, the long-term average egg mortality rate is predicted to be relatively low (around 6 percent), with higher mortality rates (around 14.6 percent) occurring in critical dry years under Alternative 3. Overall, egg mortality would be 1.1 percent less under Alternative 3; in critical dry years the average egg mortality rate would be 0.2 percent greater than under the No Action Alternative. In other water year types, egg mortality would be reduced (up to 2.7 percent less) in wetter years under Alternative 3 as compared to the No Action Alternative (Appendix 9C, Table B-7). Overall, the difference in egg mortality between Alternative 3 and the No Action Alternative could be biologically meaningful and reduce the likelihood of adverse effects on fall-run Chinook Salmon spawning in the Feather River, particularly in wetter years.

*American River*

For fall-run Chinook Salmon in the American River, the long-term average egg mortality rate is predicted to range from approximately 22 to 25 percent in all water year types under Alternative 3. Overall, egg mortality would be 0.1 percent lower under Alternative 3; in Below Normal water years the average egg mortality rate would be 1.7 percent less than under the No Action Alternative. In other water year types, egg mortality is predicted to be from 0.6 percent lower to 0.6 percent higher under Alternative 3 as compared to the No Action Alternative (Appendix 9C, Table B-6). Overall, the difference in egg mortality between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on fall-run Chinook Salmon in the American River.

*Changes in Weighted Usable Area*

Weighted usable area, which is influenced by flow, is a measure of habitat suitability. The following describes changes in WUA for fall-run Chinook Salmon in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

As an indicator of the amount of suitable spawning habitat for fall-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be greater amounts of spawning habitat available from September through November under Alternative 3 as compared to the No Action Alternative; fall-run spawning WUA would be slightly (less than 5 percent) decreased in December, but this is after the peak spawning period for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-11-2). The increase in long-term average spawning WUA during September (prior to the peak spawning period) would be relatively large (more than 10 percent), with smaller increases in October (less than 1 percent) and November (around 10 percent) which comprise the peak spawning period for fall-run Chinook Salmon. Results for the reach from Battle Creek to Deer Creek show the same pattern in changes in WUA for spawning fall-run Chinook Salmon between Alternative 3 and the No Action Alternative (Appendix 9E, Table C-10-2). Overall, spawning habitat availability could be increased under Alternative 3 relative to the No Action Alternative.

Modeling results indicate that, in general, there would be decreased amounts of suitable fry rearing habitat available from December to March under Alternative 3 (Appendix 9E, Table C-12-2). The decrease in long-term average fry rearing WUA during these months would be relatively small (less than 1 percent).

Overall, fry rearing habitat availability would be similar under Alternative 3 and the No Action Alternative.

Similar to the results for fry rearing WUA, modeling results indicate that, there would be decreased amounts of suitable juvenile rearing habitat available during the juvenile rearing period from February to June, but this increase would be relatively small (less than 5 percent) under Alternative 3 (Appendix 9E, Table C-13-2). Overall, the amount of juvenile rearing habitat (WUA) would be similar under Alternative 3 and the No Action Alternative.

*Clear Creek*

Flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative.

*Feather River*

Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 3 relative to the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative. The majority of spawning activity by fall-run Chinook Salmon in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be greater amounts of spawning habitat available from September to December under Alternative 3 as compared to the No Action Alternative; fall-run Chinook Salmon spawning WUA would be slightly (around 2 percent) increased in October (the peak spawning month) for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-24-2). The increase in long-term average spawning WUA during September (prior to the peak spawning period) would be relatively large (around 20 percent), with smaller increases in November and December (around 2 percent) which are after the peak spawning period for fall-run Chinook Salmon. Overall, spawning habitat availability would be somewhat higher under Alternative 3 relative to the No Action Alternative.

*American River*

Modeling results indicate that, in general, there would be greater amounts of spawning habitat available for fall-run Chinook Salmon in the American River during October and November under Alternative 3 as compared to the No Action Alternative; fall-run Chinook Salmon spawning WUA would be slightly (less than 2 percent) decreased in December with less than 1 percent increases in September (prior to the peak spawning period) and October (the peak spawning month) (Appendix 9E, Table C-25-2). Overall, spawning habitat availability would be slightly higher under Alternative 3 relative to the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that pre-spawning mortality of fall-run Chinook Salmon eggs would be approximately 24 percent less under Alternative 3, primarily due to reduced summer temperatures. Flow-related fall-run Chinook Salmon egg mortality would be increased by about 9 percent under Alternative 3 compared to the No Action Alternative, and temperature-related egg mortality would be 8 percent higher under Alternative 3 (Appendix 9D. Flow (habitat)-related fry mortality would be approximately 1 percent greater under Alternative 3 as compared to the No Action Alternative. Temperature-related juvenile mortality would be approximately 16 percent lower under Alternative 3, while flow (habitat)-related mortality would be around 4 percent lower under Alternative 3 as compared to the No Action Alternative. Overall, potential juvenile production would be about 2 percent higher under Alternative 3 as compared to the No Action Alternative.

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for fall-run Chinook Salmon between Alternative 3 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.246 for Alternative 3 and 0.245 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

Fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. At the junction of Georgiana Slough and the Sacramento River, percent positive velocity would be slightly lower in April and May under Alternative 3 relative to the No Action Alternative. In June, values would be moderately lower for Alternative 3 relative to the No Action Alternative (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities would be moderately lower under Alternative 3 relative to the No Action Alternative in April and May and slightly lower in June. On Old River downstream of the facilities, the proportion of positive velocities would be substantially lower in April and May under Alternative 3 relative to the No Action Alternative, but would become more similar in June. In Old River upstream of the facilities, the percent of positive velocities would be similar for Alternative 3 relative to the No Action Alternative in April. In May, values for Alternative 3 would be moderately higher in May and similar in June relative to the No Action Alternative. On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities would be similar under Alternative 3 relative to the No Action Alternative in April, May, and June.

*Changes in Junction Entrainment*

Entrainment at Georgiana Slough under Alternative 3 would be slightly greater in June relative to the No Action Alternative (Appendix 9L). In all other months, entrainment would be almost identical under both alternatives. At the Head of Old River junction, entrainment under Alternative 3 would be similar in all months except in April and May. In these two months, entrainment would be slightly higher under Alternative 3 relative to the No Action Alternative. Entrainment into Turner Cut would be slightly greater under Alternative 3 during April, and May and similar in June. At the Columbia Cut junction, entrainment would be higher under Alternative 3 during April and May, whereas there would be only minor differences in. Entrainment probabilities at the Middle River junction from April through June would be greater for Alternative 3 relative to the No Action Alternative. A similar pattern would be observed at the Old River junction.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 3 relative to No Action Alternative in every month (Appendix 9M). Fall-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of April, May, and June. Predicted values in April and May indicated a substantially increased fraction of fish salvaged under Alternative 3 relative to the No Action Alternative.

*Summary of Effects on Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under Alternative 3 and the No Action Alternative. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be slightly higher in most water year types under Alternative 3 than under the No Action Alternative, and up to 5 percent greater than under the No Action Alternative in critical dry years.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 3 relative to the No Action Alternative in every month.

In Clear Creek and the Feather and American rivers, the analysis of the effects of Alternative 3 and the No Action Alternative for fall-run Chinook Salmon relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of spawning and rearing habitat in Clear Creek and spawning habitat in the Feather and American rivers would be similar under Alternative 3 and the No Action Alternative. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in all of these streams generally would be similar under both scenarios. The water temperature threshold exceedance analysis that indicated that the water temperature thresholds for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly less frequently in the Feather River and Clear Creek under Alternative 3. Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the reduced frequency of exceedance of temperature thresholds under Alternative 3 could reduce the potential for adverse effects on the fall-run Chinook Salmon populations in Clear Creek and the Feather River. Results of the analysis using Reclamation's salmon mortality model indicate that there would be slightly reduced fall-run Chinook Salmon egg mortality in the Feather River under Alternative 3 compared to the No Action Alternative.

These model results suggest that overall, effects on fall-run Chinook Salmon could be slightly less adverse under Alternative 3 than the No Action Alternative, with a small likelihood that fall-run Chinook Salmon production would be higher under Alternative 3.

Implementation of fish passage under the No Action Alternative could benefit fall-run Chinook Salmon if volitional passage for adult fish is provided; whereas the ocean harvest restriction component of Alternative 3 could increase fall-run Chinook Salmon numbers by reducing ocean harvest and the predator control measures under Alternative 3 could reduce predation on juvenile fall-run Chinook Salmon and thereby increase survival.

Overall, given the small differences between alternatives and the uncertainty regarding the non-operational components, distinguishing a clear difference between alternatives is not possible.

*Late Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect late fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar to or cooler(less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures also would be similar except in wetter years when water temperatures would be increased by up to 0.8°F. Water temperatures under Alternative 3 could be decreased by up to 0.8°F in October and November of drier years. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference in September of about 9°F between Keswick Dam and Knights Landing). The differences between Alternative 3 and the No Action Alternative in September of wetter years would increase, while the differences in water temperatures during October and November associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on late fall-run Chinook Salmon in the Sacramento River. The slightly lower water temperatures from October to December under Alternative 3 would likely have little effect on late fall-run Chinook Salmon migration and holding as water temperatures in the Sacramento River below Keswick Dam are typically low during this time period. The likelihood of adverse effects on late fall-run Chinook Salmon spawning and egg incubation would be similar under Alternative 3 and the No Action Alternative due to similar water temperatures during the January to May time period. Because late fall-run Chinook Salmon have an extended rearing period, the similar water temperatures during the summer under Alternative 3 and the No Action Alternative would have similar effects on rearing fry and juvenile late fall-run Chinook Salmon in the Sacramento River. The slightly higher water temperatures under Alternative 3 in September of wetter years may increase the likelihood of adverse effects on fry and juvenile late fall-run Chinook Salmon rearing in the Sacramento River during this limited time period.

*Changes in Exceedances of Water Temperature Thresholds*

Average monthly water temperatures under both Alternative and the No Action Alternative would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for Chinook Salmon (spawning and egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October, with 78 percent of the time under Alternative 3). The water temperature threshold would be exceeded less frequently in November (8 percent of the time) and not exceeded at all during December through March. As water temperatures warm in the spring, the threshold would be exceeded in April by 14 percent under Alternative 3. In the months when the greatest frequency of exceedances occur (October, November, and April), model results generally indicate that the threshold would be exceeded less frequently (by up to 4 percent in October) under Alternative 3 than under the No Action Alternative. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect late fall-run Chinook Salmon spawning and egg incubation than under the No Action Alternative because of the decreased frequency of exceedance of the 56°F threshold in October, November, and April.

*Changes in Egg Mortality*

For late fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to range from approximately 1.8 to nearly 5 percent in all water year types under Alternative 3. Overall, egg mortality would be 0.4 percent lower under Alternative 3; in Below Normal water years the average egg mortality rate would be 0.1 percent higher than under the No Action Alternative. In other water year types, egg mortality is predicted to be from 0.1 to 0.8 percent less under Alternative 3 as compared to the No Action Alternative (Appendix 9C, Table B-2). Overall, late fall-run Chinook Salmon egg mortality in the Sacramento River under Alternative 3 and the No Action Alternative would be similar.

*Changes in Weighted Usable Area*

Modeling results indicate that there would be slightly lower amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under Alternative 3 as compared to the No Action Alternative; late fall-run Chinook Salmon spawning WUA would be slightly (less than 5 percent) decreased during this time period (Appendix 9E, Table C-14-4). Overall, spawning habitat availability would be similar under Alternative 3 and the No Action Alternative.

Modeling results indicate that, in general, there would be decreased amounts of suitable late fall-run Chinook Salmon fry rearing habitat available during April and May under Alternative 3 (Appendix 9E, Table C-15-4). The decrease in long-term average fry rearing WUA during these months would be relatively small (less than 5 percent). Late fall-run Chinook Salmon fry rearing WUA would be increased by about 1 percent in June under Alternative 3 as compared to the No Action Alternative. Overall, late fall-run fry rearing habitat availability would be similar under Alternative 3 and the No Action Alternative.

A substantial fraction of late fall run Chinook Salmon juveniles oversummer in the Sacramento River before emigrating, which allows them to avoid predation through both their larger size and greater swimming ability. One implication of this life history strategy is that rearing habitat is most likely the limiting factor for late-fall-run Chinook Salmon, especially if availability of cool water determines the downstream extent of spawning habitat for late-fall-run salmon. Modeling results indicate that, there would be decreased amounts of suitable juvenile rearing habitat available from December through August, but this increase would be small (generally less than 3 percent) under Alternative 3 as compared to the No Action Alternative. There would an increase in the amount of late fall-run Chinook Salmon juvenile rearing WUA in the other months (September through November) of up to nearly 10 percent (Appendix 9E, Table C-16-4). Overall, late fall-run juvenile rearing habitat availability would be slightly increased under Alternative 3 relative to the No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that flow-related late fall-run Chinook Salmon egg mortality would be increased by 5 percent under Alternative 3 compared to the No Action Alternative. Conversely, temperature-related egg mortality would be 9 percent lower under Alternative 3 (Appendix 9D, Table B-2-9). Flow (habitat)-related fry mortality would be approximately 2 percent higher while temperature-related fry mortality would be about 17 percent lower under Alternative 3 as compared to the No Action Alternative. Temperature-related juvenile mortality would be approximately 18 percent lower under Alternative 3, while flow (habitat)-related mortality would approximately 35 percent lower under Alternative 3 as compared to the No Action Alternative. Overall, potential juvenile production would be the same under Alternative 3 and the No Action Alternative (Appendix 9D, Table B-2-6).

*Changes in Delta Passage Model Output*

For late fall-run Chinook Salmon, Delta survival was predicted to be slightly lower for Alternative 3 versus the No Action Alternative for all 81 years simulated by the Delta Passage Model (Appendix 9J). Median Delta survival across all years was 0.199 for Alternative 3 and 0.244 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

The late fall-run Chinook Salmon migration period overlaps with the winter-run. See the section on hydrodynamic analysis for winter-run Chinook Salmon for potential effects on late fall-run Chinook Salmon.

*Changes in Junction Entrainment*

Entrainment probabilities for late fall-run Chinook Salmon are assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Changes in Salvage*

Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Summary of Effects on Late Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under Alternative 3 and the No Action Alternative. For the purpose of analyzing effects on late fall-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar under Alternative 3 and the No Action Alternative, although production under Alternative 3 could be slightly lower in some water year types and about 3 percent higher in critical years than under the No Action Alternative.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 3 relative to the No Action Alternative in every month.

Overall, it is likely that the effects on late fall-run Chinook Salmon would be similar for Alternative 3 and the No Action Alternative. The potential benefits of ocean harvest restrictions and predator management under Alternative 3 and fish passage under the No Action Alternative are uncertain. Given the small differences between alternatives and the uncertainty regarding the non-operational components, distinguishing a clear difference between alternatives is not possible.

*Steelhead*

Changes in operations that influence temperature and flow conditions that could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect steelhead in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar to or cooler(less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures also would be similar except in wetter years when water temperatures would be increased by up to 0.8°F. Water temperatures under Alternative 3 could be decreased by up to 0.8°F in October and November of drier years. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, and Red Bluff, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference of about 3°F between Keswick Dam and Red Bluff). The differences between Alternative 3 and the No Action Alternative in September of wetter years would increase, while the differences in water temperatures during October and November associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on the life history timing for steelhead, the in the Sacramento River. The increased water temperatures in September of wetter years under Alternative 3 could increase the likelihood of adverse effects on migrating adult steelhead during this water year type. The slightly lower water temperatures in December and November under Alternative 3 could reduce the likelihood of adverse effects on steelhead adults migrating upstream and juveniles migrating downstream in the Sacramento River as compared to the No Action Alternative.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative 3 would be similar to (less than 0.5°F differences) water temperatures under the No Action Alternative with the exception of May when average monthly temperatures under Alternative 3 would be somewhat higher (up to about 0.8°F) than the No Action Alternative. As described above for spring-run Chinook Salmon, the lower water temperatures in May associated with the No Action Alternative reflect the effects of the additional water that would be discharged from Whiskeytown Dam to meet the 2009 NMFS BO RPA spring attraction flow requirements. While the reduction in water temperature indicated by the modeling could improve thermal conditions for steelhead, the duration of the two pulse flows under the No Action Alternative may not be of sufficient duration (3 days each) to provide biologically meaningful temperature benefits. Overall, thermal conditions for steelhead in Clear Creek would be similar under Alternative 3 and the No Action Alternative. Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor. There would be little difference in potential effects on steelhead in Clear Creek due to the similar water temperatures under Alternative 3 as compared to the No Action Alternative

*Feather River*

Average monthly water temperatures in the Feather River at the low flow channel under the Alternative 3 relative generally would be similar (within 0.5°F) to water temperatures under the No Action Alternative generally would be, but somewhat lower in November and December (differences as much as 1.6°F in December in below normal water years) (Appendix 6B, Table B-20-2). Water temperatures generally would be similar for the other months, except in). In September when average monthly water temperatures under Alternative 3 would be somewhat higher (up to about 1.5°F) and during May and June when water temperatures would be slightly (up to 0.4°F) lower in wetter years than under the No Action Alternative. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 3 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and the No Action Alternative generally becoming more similar among months at the confluence with the Sacramento River, except in September when the differences between Alternative 3 and the No Action Alternative would be up to 4.4 °F higher than under the No Action Alternative.

Overall, the temperature differences in the Feather River between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Feather River. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on migrating adult steelhead during this water year type. The slightly lower water temperatures in October and November under Alternative 3 also could reduce the likelihood of adverse effects on steelhead adults migrating upstream and juveniles migrating downstream in the Sacramento River as compared to the No Action Alternative.

*American River*

Long term average monthly water temperatures in the American River at Nimbus Dam under Alternative 3 generally would be similar (differences less than 0.25°F) to those under the No Action Alternative (Appendix 6B, Table B-12-2). In September of wetter years, water temperatures under Alternative 3 would be increased relative to under the No Action Alternative by up to 0.4°F in some water year types. This pattern generally would persist downstream to Watt

Avenue and the mouth, although temperature differences under Alternative 3 would be greater than under the No Action Alternative (Appendix 6B, Tables B-13-2 and B-13-2 and B-14-2). In June water temperatures would be up to 0.7°F lower under Alternative 3 than under the No Action Alternative. In September, average monthly water temperatures at the mouth generally would be higher under Alternative 3 than under the No Action Alternative, especially in wetter water year types when the water temperatures under Alternative 3 could be up to 1.6°F warmer.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the American River. The somewhat higher water temperatures in September of wetter years may increase the likelihood of adverse effects on migrating adult steelhead during this water year type. The cooler water temperatures in June under Alternative 3 may reduce the likelihood of adverse effects on steelhead rearing in the American River compared to the No Action Alternative.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for steelhead in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those streams.

*Sacramento River*

As described in the life history accounts, steelhead spawning in the mainstem Sacramento River generally occurs in the upper reaches from Keswick Dam downstream to near Balls Ferry, with most spawning concentrated near Redding. Most steelhead, however, spawn in tributaries to the Sacramento River. Spawning generally takes place in the January through March period when water temperatures in the river generally do not exceed 52°F under either Alternative 3 or the No Action Alternative. While there are no established temperature thresholds for steelhead rearing in the mainstem Sacramento River, average monthly temperatures during March through June when fry and juvenile steelhead are in the river would be below 56°F during March and April at Balls Ferry. In June, average monthly water temperatures would be slightly lower under Alternative 3 than they would be under the No Action Alternative in the drier years, although conditions would not exceed about 57°F. Thus, as it relates to temperature conditions for steelhead in the mainstem Sacramento River, it is unlikely that Alternative 3 and the No Action Alternative would differ in a biologically meaningful way.

*Clear Creek*

While there are no established temperature thresholds for steelhead spawning in Clear Creek, average monthly water temperatures in the river generally would not exceed 49°F during the spawning period (December to April) under Alternative 3 and the No Action Alternative. Similarly, while there are no established temperature thresholds for steelhead rearing in Clear Creek, average monthly temperatures in most months of the year would not exceed 56°F at Igo under both alternatives. Thus, as it relates to temperature conditions for steelhead in Clear Creek, it is unlikely that Alternative 3 and the No Action Alternative would differ in a biologically meaningful way.

*Feather River*

Average monthly water temperatures in the Feather River at Robinson Riffle would on occasion exceed the water temperature threshold of 56°F established for steelhead spawning and incubation during September through April and the threshold of 63°F established for rearing during May through August. The frequency of exceedance would be highest (about 98 percent) in October, a month in which average monthly water could get as high as about 68°F. However, the differences in the frequency of exceedances between Alternative 3 and the No Action Alternative would be relatively small. Alternative 3 would exceed temperature thresholds about 1 percent less frequently than the No Action Alternative in October, November, December, and March. The established water temperature threshold of 63°F for rearing during May through August would be exceeded often under both Alternative 3 and the No Action Alternative in May and June, but not at all in July and August. Water temperatures under Alternative 3 would exceed the rearing temperature threshold about 5 percent less frequently than under the No Action Alternative in May, but no more frequently in June. Temperature conditions in the Feather River under Alternative 3 could be less likely to affect steelhead spawning and rearing than under the No Action Alternative because of the reduced frequency of exceedance of the spawning and rearing thresholds.

*American River*

In the American River, the water temperature threshold for steelhead rearing (May through October) is 65°F at the Watt Avenue Bridge. Average monthly water temperatures would exceed this threshold often under both Alternative 3 and the No Action Alternative, especially in the July when the threshold is exceeded nearly all of the time. In addition, the magnitude of the exceedance would be high, with average monthly water temperatures sometimes higher than 76°F. The differences between Alternative 3 and No Action Alternative, however, would be relatively small (differences within 2 percent), except in September, when water temperatures under Alternative 3 would exceed 65°F about 7 percent more frequent than under the No Action Alternative. Temperature conditions in the American River under Alternative 3 could be more likely to affect steelhead rearing than under the No Action Alternative because of the increased frequency of exceedance of the 65°F rearing threshold.

*Changes in Weighted Usable Area*

The following describes changes in WUA for steelhead in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

Modeling results indicate that, in general, there would be lower amounts of suitable steelhead spawning habitat available from December through March under Alternative 3 as compared to the No Action Alternative (Appendix 9E, Table C-20-2). The decreases in long-term average steelhead spawning WUA would be relatively small (less than 3 percent). Overall, spawning habitat availability would be similar under Alternative 3 and the No Action Alternative.

*Clear Creek*

Flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the No Action Alternative except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO under the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for steelhead (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative.

*Feather River*

Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 3 relative to the No Action Alternative. Therefore, there would be no change in the amount of potentially suitable spawning habitat for steelhead (as indexed by WUA) available under Alternative 3 as compared to the No Action Alternative. The majority of spawning activity by steelhead in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be slightly greater amounts of spawning habitat for steelhead in the Feather River below Thermalito available from January through April under Alternative 3 as compared to the No Action Alternative. The increases in long-term average steelhead spawning WUA during this time period would generally be less than 3 percent (Appendix 9E, Table C-22-2). Steelhead spawning WUA would be slightly increased (less than 2 percent) in December. Overall, steelhead spawning habitat availability would be similar under Alternative 3 and the No Action Alternative.

*American River*

Modeling results indicate that, in general, there would be variable changes in the amount of spawning habitat for steelhead in the American River downstream of Nimbus Dam available from December through April under Alternative 3 as compared to the No Action Alternative. The decreases in long-term average steelhead spawning WUA during December, February and March would generally be less than 3 percent, while the increase in April would also be less than 3 percent (Appendix 9E, Table C-26-2). Overall, steelhead spawning habitat availability would be similar under Alternative 3 and the No Action Alternative.

*Summary of Effects on Steelhead*

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under Alternative 3 and the No Action Alternative. The analysis of the effects of Alternative 3 and the No Action Alternative for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear

Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under Alternative 3 and the No Action Alternative. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead could be slightly less adverse for some life stages in various rivers under Alternative 3. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for steelhead spawning and egg incubation would be exceeded less frequently in the Feather River under Alternative 3. The water temperature threshold for steelhead rearing would also be exceeded less frequently in the Feather River. However, the water temperature threshold for steelhead rearing in the American River would be exceeded more frequently under Alternative 3 than under the No Action Alternative. Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the reduced frequency of exceedance of temperature thresholds under Alternative 3 could reduce the potential for adverse effects on the steelhead population in the Feather River while the increased frequency of exceedance could increase the likelihood of adverse effects on steelhead rearing in the American River.

These model results suggest that overall, effects on steelhead could be slightly less adverse under Alternative 3 than the No Action Alternative, particularly in the Feather River. Implementation of the fish passage program under the No Action Alternative intended to address the limited availability of suitable habitat for steelhead in the Sacramento River and in the American River could provide a benefit to Central Valley steelhead in the Sacramento and American rivers, although the success of a passage program is uncertain. Similarly, the ocean harvest restrictions and predator management actions under Alternative 3 are uncertain. However, if fish passage is successful in providing access to higher quality habitat, Alternative 3 would do less than the No Action Alternative to address long-term temperature issues in the Sacramento and American rivers downstream of the dams.

*Green Sturgeon*

Changes in operations that influence temperature and flow conditions could affect Green Sturgeon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect Green Sturgeon in the Sacramento and Feather rivers. The following describes temperature conditions in those water bodies.

*Sacramento River*

Average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 relative to the No Action Alternative generally would be similar to or cooler(less than 0.5°F differences) water temperatures under the No Action Alternative during most months of the year (Appendix 6B, Table B-5-2). In September, average water temperatures also would be similar except in wetter years when water temperatures would be increased by up to 0.8°F. Water temperatures under Alternative 3 could be decreased by up to 0.8°F in October and November of drier years. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, and Red Bluff, with average monthly temperatures progressively increasing in the downstream direction (e.g., average difference of about 3°F between Keswick Dam and Red Bluff). The differences between Alternative 3 and the No Action Alternative in September of wetter years would increase, while the differences in water temperatures during October and November associated with Alternative 3 during drier years would remain similar to upstream locations.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor. The similar water temperatures during most months suggest that temperature-related effects on Green Sturgeon would likely be similar under Alternative 3 and the No Action Alternative.

*Feather River*

Average monthly water temperatures in the Feather River at the low flow channel under the Alternative 3 relative generally would be similar (within 0.5°F) to water temperatures under the No Action Alternative generally would be, but somewhat lower in November and December (differences as much as 1.6°F in December in below normal water years) (Appendix 6B, Table B-20-2). In September when average monthly water temperatures under Alternative 3 would be somewhat higher (up to about 1.5°F) and during May and June when water temperatures would be slightly (up to 0.4°F) lower in wetter years than under the No Action Alternative. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 3 and the No Action Alternative would exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and the No Action Alternative generally becoming more similar among months at the confluence with the Sacramento River, except in September when the differences between Alternative 3 and the No Action Alternative would be up to 4.4 °F higher than under the No Action Alternative.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor. The similar water temperatures during most months suggest that temperature-related effects on Green Sturgeon would likely be similar under Alternative 3 and the No Action Alternative. The somewhat higher water temperatures in September under Alternative 3 could affect spawning by Green Sturgeon in the Feather River.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers. The following describes the extent of those exceedance for each of those rivers.

*Sacramento River*

Average monthly water temperatures in the Sacramento River at Bend Bridge under both Alternative 3 and the No Action Alternative would exceed the water temperature threshold of 63°F established for Green Sturgeon egg incubation in August and September, with exceedances under Alternative 3 occurring about 6 percent of the time in August relative the No Action Alternative (7 percent), and about 9 percent of the time in September relative to 12 percent under the No Action Alternative. Average monthly water temperatures at Bend Bridge could be as high as about 73°F during this period. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect Green Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 63°F threshold in August and September.

*Feather River*

Average monthly water temperatures in the Feather River at Gridley Bridge under both Alternative 3 and the No Action Alternative would exceed the water temperature threshold of 64°F established for Green Sturgeon spawning, incubation, and rearing in May, June, and September; no exceedances under either condition would occur in July and August. The frequency of exceedances would be high, with both Alternative 3 and the No Action Alternative exceeding the threshold in June nearly 100 percent of the time. The magnitude of the exceedance also would be substantial, with average monthly temperatures higher than 72°F in June, and higher than 75°F in July and August. Water temperatures under Alternative 3 would exceed the threshold for May about 7 percent less frequently than the No Action Alternative and about 35 percent more frequently in September. Temperature conditions in the Feather River under Alternative 3 could be less likely to affect Green Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 64°F threshold in May. The increase in exceedance frequency in September under Alternative 3 may have little effect on rearing Green Sturgeon as many juvenile sturgeon may have migrated downstream to the lower Sacramento River and Delta by this time.

*Summary of Effects on Green Sturgeon*

The analysis of the effects of Alternative 3 and the No Action Alternative for Green Sturgeon relied on water temperature model output for the Sacramento and Feather rivers at various locations downstream of Shasta Dam and the Thermalito complex. The temperature model outputs for each of these rivers suggest that thermal conditions and effects on Green Sturgeon in the Sacramento and Feather rivers generally would be slightly less adverse under Alternative 3. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for Green Sturgeon spawning, incubation, and rearing would be exceeded less frequently under Alternative 3 in the Sacramento River. The water temperature threshold for Green Sturgeon spawning, incubation, and rearing would also be exceeded less frequently during some months in the Feather River but would be exceeded substantially more frequently in September under Alternative 3.

Given the general similarity in results and inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the effects under Alternative 3 and the No Action Alternative likely would be similar.

*White Sturgeon*

Changes in water temperature conditions in the Sacramento and Feather rivers would be the same as those described above for Green Sturgeon. Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on White Sturgeon in the Sacramento and Feather rivers.

The water temperature threshold established for White Sturgeon spawning and egg incubation in the Sacramento River at Hamilton City is 61°F during March through June. Both Alternative 3 and the No Action Alternative would exceed this threshold in May and June. The average monthly water temperatures in May under Alternative 3 would exceed this threshold about 49 percent of the time (about 6 percent less frequently than the No Action Alternative). In June, the temperature under Alternative 3 would exceed the threshold about 74 percent of the time (about 13 percent less frequently than the No Action Alternative). Average monthly water temperatures during May and June under Alternative 3 would as high as about 65°F, which is below the 68°F threshold considered lethal for White Sturgeon eggs. Temperature conditions in the Sacramento River under Alternative 3 could be less likely to affect White Sturgeon rearing than under the No Action Alternative because of the reduced frequency of exceedance of the 61°F threshold in May and June.

The analysis of the effects of Alternative 3 and the No Action Alternative for White Sturgeon relied on water temperature model output for the Sacramento River at various locations downstream of Shasta Dam. The temperature model outputs suggest that thermal conditions and effects on White Sturgeon in the Sacramento River generally would be less adverse under Alternative 3. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for White Sturgeon spawning, incubation, and rearing would be exceeded less frequently under Alternative 3in the Sacramento River.

Given the general similarity in results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the effects under Alternative 3 and the No Action Alternative likely would be similar.

*Delta Smelt*

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under the No Action Alternative would be 7 to 8.3 percent, depending on the water year type, with a long term average percent entrainment of 7.6 percent. Percent entrainment of adult Delta Smelt under Alternative 3 would be similar to results under the No Action Alternative (differing only by 0.1 to 0.4 percent). Under Alternative 3, the long term average percent entrainment would be 7.9 percent.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008) was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under the No Action Alternative would be 1.3 to 19.3 percent, depending on the water year type, with a long term average percent entrainment of 8.6 percent, and highest entrainment under Critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under Alternative 3 would be higher than results under the No Action Alternative, by 1.3 to 6.4 percent. Under Alternative 3, the long term average percent entrainment would be 12.7 percent, and highest entrainment would occur under Critical water year conditions, at 20.5 percent. These values for Alternative 3 are similar to comparable values under the No Action Alternative (estimated to be 4.1 and 1.3 percent higher, respectively).

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. Results indicate that under the No Action Alternative, the X2 position would range from 75.9 km to 92.4 km, depending on the water year type, with a long term average X2 position of 84 km. The most eastward location of X2 is predicted under Critical water year conditions. The X2 positions predicted under Alternative 3 would be similar to results under the No Action Alternative in drier water year types. In wetter years, the X2 location would be further east under Alternative 3 than under the No Action Alternative, by 6.0 to 9.7 km. This difference is largely due to implementation of 2008 USFWS BO RPA Component 3 (Action 4), under the No Action Alternative, which requires Reclamation and DWR to provide sufficient Delta outflow to maintain a monthly average X2 no more eastward than 74 km in Above Normal and Wet years. Under Alternative 3, the long term average X2 position would be 88.1 km, a location that does not provide for the advantageous overlap of the low salinity zone with Suisun Bay/Marsh.

Overall, Alternative 3 likely would have adverse effects on Delta Smelt, as compared to the No Action Alternative, primarily due to increased percentage entrainment during larval and juvenile life stages, and less favorable location of Fall X2 in wetter years, and on average.

*Longfin Smelt*

The effects of the Alternative 3 as compared to the No Action Alternative were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

As described in Appendix 5A, OMR flows would generally be negative in all months, except April and May where OMR flows would be positive, under the No Action Alternative and the long-term average negative flow ranges from -2,700 to -6,200 cfs from December through June. Because there would be no restrictions on export pumping from December 1 to June 15 due to OMR flow criteria under Alternative 3, OMR flows would generally be more negative during this time period under Alternative 3 as compared to the No Action Alternative. The greatest differences between alternatives would be in April and May, where long-term average OMR flows would be negative under Alternative 3 instead of positive as under the No Action Alternative. The increase in the magnitude of negative flows, particularly the negative flows in April and May, under Alternative 3 as compared to the No Action Alternative could increase the potential for entrainment of Longfin Smelt at the export facilities.

Under Alternative 3, Longfin Smelt abundance index values range from 1,147 under critical water year conditions to a high of 16,635 under wet water year conditions, with a long-term average value of 7951 (Appendix 9G). Under the No Action Alternative, Longfin Smelt abundance index values range from 947 under critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257.

Results indicate that the Longfin Smelt abundance index values would be lower in every water year type under Alternative 3 than under the No Action Alternative, with a long-term average index for Alternative 3 that is 7.6 percent lower than the long-term average index under the No Action Alternative. The greatest decrease in the Longfin Smelt abundance index occurs in above normal years where the index value is 12.3 percent less under Alternative 3 than under the No Action Alternative. For below normal, dry, and critical water years, the Longfin Smelt abundance index values would be 4.6 to 9.9 percent lower under Alternative 3 than under the No Action Alternative.

Overall, based on the increase in frequency and magnitude of negative OMR flows and the lower Longfin Smelt abundance index values, potential adverse effects on the Longfin Smelt population under Alternative 3 likely would be greater than under the No Action Alternative.

*Sacramento Splittail*

Under Alternative 3, flows entering the Yolo Bypass generally would be somewhat higher than under the No Action Alternative, especially during below normal years when flows entering the bypass under Alternative 3 would be higher than the No Action Alternative in December through March (Appendix 5A, Table C-26-2). These increases would occur during periods of relatively low flow in the bypass, and could slightly increase the frequency of potential inundation. This could provide somewhat greater value to Sacramento Splittail because of the increased area of potential habitat (inundation) and the potential for a slight increase in the frequency of inundation.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP and SWP water supplies and operations under Alternative 3 as compared to the No Action Alternative generally would result in higher reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be higher under Alternative 3 as compared to the No Action Alternative (Appendix 9F).

The greatest increases in Shasta Lake storage could be as high as 15 percent. Storage in Lake Oroville could be increased by up to 30 percent in some months under Alternative 3 as compared to the No Action Alternative. Storage in Folsom Lake could be increased up to around 20 percent in some months of some water year types and could be reduced by up to 10 percent in July, August, and September. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. Although aquatic habitat within the CVP and SWP water supply reservoirs is not limiting, storage volume, as an indicator of how much habitat is available to fish species inhabiting these reservoirs, suggests that the amount of habitat for reservoir fishes could be higher under Alternative 3 as compared to the No Action Alternative.

Results of the bass nesting success analysis are presented in Appendix 9F, Reservoir Fish Analysis Documentation. Black bass nest survival in CVP and SWP reservoirs is anticipated to be near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of nest survival for Largemouth and Smallmouth Bass in Shasta Lake being in the 40 to 100 percent range is slightly lower (less than 2 percent) under Alternative 3 as compared to the No Action Alternative. For June, the likelihood of nest survival being greater than 40 percent for Largemouth and Smallmouth Bass is the same under Alternative 3 and the No Action Alternative; however, nest survival of greater than 40 percent is likely only in about 20 percent of the years evaluated. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (nearly 100 percent) in May under both Alternative 3 and the No Action Alternative. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Shasta Lake is drawn down. The likelihood of survival being greater than 40 percent is about 10 percent less under Alternative 3 as compared to the No Action Alternative.

For May and June, the likelihood of nest survival for Largemouth Bass in Lake Oroville being in the 40 to 100 percent range is substantially lower percent under Alternative 3 as compared to the No Action Alternative. However, June nest survival of greater than 40 percent is likely only in about 30 percent of the years evaluated under Alternative 3. This is about 10 percent lower likelihood than under the No Action Alternative. The likelihood of nest survival for Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (over 90 percent) in May under both Alternative 3 and the No Action Alternative with the likelihood of greater than 40 percent survival being similar under Alternative 3 as compared to the No Action Alternative. For June, Spotted Bass survival would be less than for May due to greater daily reductions in water surface elevation as Lake Oroville is drawn down. The likelihood of survival being greater than 40 percent is substantially lower (nearly 20 percent) under Alternative 3 as compared to the No Action Alternative.

Black bass nest survival in Folsom Lake is anticipated to be near 100 percent in March, April, and May due to increasing reservoir elevations. For June, the likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the 40 to 100 percent range would be about 5 percent lower under Alternative 3 than the No Action Alternative. For Spotted Bass, nest survival for June would be less than for May due to greater daily reductions in water surface elevation. However, the likelihood of survival being greater than 40 percent is somewhat (around 7 percent) lower under Alternative 3 as compared to the No Action Alternative.

##### *Summary of Effects on Reservoir Fishes*

The analysis of the effects of Alternative 3 and the No Action Alternative for reservoir fish relied on CalSim II output for reservoir storage levels and water surface elevation changes as described in Appendix 9F. As described above, reservoir storage is anticipated to be increased under Alternative 3 relative to the No Action Alternative and this increase could affect the amount of warm and cold water habitat available within the reservoirs. However, it is unlikely that aquatic habitat within the CVP and SWP water supply reservoirs is limiting and therefore, it is unlikely that habitat for reservoir fish in the CVP and SWP storage reservoirs under Alternative 3 and the No Action Alternative would differ in a biologically meaningful manner.

The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (>40 percent) nest survival in most of the reservoirs under Alternative 3 would be similar to or slightly lower than under the No Action Alternative. This suggests that conditions in the reservoirs could be less likely to support self-sustaining populations of black bass under Alternative 3 than under the No Action Alternative. However, it is uncertain whether this effect would be biologically meaningful. Thus, it is likely that effects on black bass would be similar under both Alternative 3 and the No Action Alternative.

#### *Other Species*

Several other fish species could be affected by changes in operations that influence temperature and flow. The following describes the extent of these changes and the potential effects on these species.

##### *Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Sacramento River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles.

Pacific Lamprey would be subjected to the same temperature conditions described above for salmonids. The average monthly water temperature differences under Alternative 3 and the No Action Alternative would be relatively small. In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Given the somewhat increased flows and slightly decreased temperatures under Alternative 3 during their spawning and incubation period, it is likely that Alternative 3 would have a slightly lower potential to adversely affect Pacific Lamprey in the Sacramento, Feather, and American rivers than would the No Action Alternative. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

*Other Species*

Changes in average monthly water temperature under Alternative 3 relative to the No Action Alternative would be small. In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Given the somewhat increased flows and decreased water temperatures under Alternative 3 during their spawning and incubation period, it is likely that Alternative 3 would have a lower potential to adversely affect Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers than would the No Action Alternative.

*Stanislaus River/Lower San Joaquin River*

*Fall-Run Chinook Salmon*

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River below Vernalis. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 and the No Action Alternative generally would be similar (differences less than 0.5°F), except in September and October when average monthly water temperatures would be 0.8°F and 0.5°F cooler, respectively. In critical dry years, water temperatures under Alternative 3 would be somewhat (0.7°F to 1.2°F) cooler from May to August and up to 2.9°F and 1.7°F cooler on average during September and October than under the No Action Alternative (Appendix 6B, Table B-17-2).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under Alternative 3 would similar to water temperatures under the No Action Alternative (less than 0.5°F differences) in most months in most water year types, but would be lower by up to 2.1°F in September of drier years and up to 1.5°F warmer in October. Water temperatures in June under Alternative 3 would be substantially higher (2.3°F on average) and up to 3.7°F warmer in wetter years (Appendix 6B, Table B-18-2).

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures and magnitude of temperature differences under Alternative 3 compared to the No Action Alternative would progressively increase in a downstream direction (Appendix 6B, Table B-19-1). In addition, the decreases in temperatures under Alternative 3 that would occur in the drier years of some months would diminish at this location.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the Stanislaus River. Based on the life history timing for fall-run Chinook Salmon, the lower water temperatures in September and October below Goodwin Dam under Alternative 3 likely would have little effect on fall-run Chinook Salmon spawning as the majority of spawning occurs later, in November. The higher water temperatures in June at Orange Blossom Bridge and the mouth under Alternative 3 may increase the likelihood of adverse effects on fall-run Chinook Salmon rearing in the Stanislaus River, if they are present, as compared to the No action Alternative.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October (over 30 percent of the time) and November over 20 percent of the time in the Stanislaus River at Goodwin Dam under Alternative 3 (Appendix 6B, Table B-17-1). Similar exceedances would occur under the No Action Alternative, although average monthly water temperatures under Alternative 3 would remain lower than under the No Action Alternative during the periods when the threshold is exceeded. Water temperatures under Alternative 3 also would exceed the threshold about 5 percent less frequently in November than under the No Action Alternative. Conditions for rearing generally would be below 56°F, except in May and June when average monthly water temperatures would reach about 60°F under the No Action Alternative (Appendix 6B, Figure B-17-8).

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning would be exceeded frequently under both Alternative 3 and the No Action Alternative during October and November. Under Alternative 3, average monthly water temperatures would exceed 56°F about 87 percent of the time in October. This would be about 31 percent more frequent than under the No Action Alternative. In November, average monthly water temperatures would exceed 56°F about 24 percent of the time under Alternative 3, which would be about 9 percent less frequent than under the No Action Alternative (Appendix 6B, Figure B-18-1 and B-18-2).

During January through May, rearing fall-run Chinook Salmon under Alternative 3 would occasionally encounter average monthly water temperatures that exceed 56°F at Orange Blossom Bridge; however, the differences between Alternative 3 and the No Action Alternative would be less than 0.5°F (Appendix 6B, Table B-18-2).

*Changes in Egg Mortality (Stanislaus River)*

For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg mortality rate is predicted to be around 6 percent, with higher mortality rates (in excess of 13 percent) occurring in critical dry years under Alternative 3. Overall, egg mortality would be 0.8 percent lower under Alternative 3; in most water year types the average egg mortality rate would be similar to or lower than under the No Action Alternative by up to 1.3 percent (Appendix 9C, Table B-1). Overall, the difference in egg mortality between Alternative 3 and the No Action Alternative would be relatively minor and likely would have little effect on fall-run Chinook Salmon in the Stanislaus River.

*Changes in Delta Hydrodynamics*

San Joaquin River-origin Chinook Salmon smolts are most abundant in the Delta from April through June. Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities would be moderately lower under Alternative 3 relative to the No Action Alternative in April and May, and slightly lower in June (Appendix 9K). On Old River downstream of the facilities, the proportion of positive velocities would be substantially lower in April and May under Alternative 3 relative to the No Action Alternative, but would become more similar in June. In Old River upstream of the facilities, the percent of positive velocities would be similar for Alternative 3 relative to the No Action Alternative in April. In May, values for Alternative 3 would be moderately higher in May and similar in June relative to the No Action Alternative. On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities would be similar under Alternative 3 relative to the No action Alternative in April, May and June.

*Changes in Entrainment at Junctions*

At the Head of Old River junction, entrainment under Alternative 3 would be similar in all months except in April and May (Appendix 9L). In these two months, entrainment would be slightly higher under Alternative 3 relative to the No Action Alternative. Entrainment into Turner Cut would be slightly greater under Alternative 3 during April and May, and similar in June. At the Columbia Cut junction, entrainment would be higher under Alternative 3 during April and May, whereas there would be only minor differences in June Entrainment probabilities at the Middle River junction from April through June would be greater for Alternative 3 relative to the No action Alternative. A similar pattern would be observed at the Old River junction.

*Changes in Juvenile Salmonid Passage through the Delta (Trap and Haul)*

Poor survival of juvenile salmonids in the Sacramento-San Joaquin Delta has been hypothesized as a major contributor to declines in the number of returning adults and may be a significant impediment to the recovery of threatened or endangered populations (NOAA 2009). Under Alternative 3, fish would be trapped in the San Joaquin River between the mouth of the Stanislaus River and the Head of Old River to capture juveniles migrating from natal rearing habitat in the San Joaquin River, Merced River, Tuolumne River and Stanislaus River.

Captures fish would be transported by barge through the Delta and released at locations within San Francisco Bay. Although trucks are currently used to transport hatchery reared salmonids and salvaged fishes (including salmonids), barging results in greater survival benefits (Ward et al. 1997) and may reduce straying of returning adults.

To assess the potential benefits and risks of a transportation program for salmonids in the San Joaquin River, an analysis of CWT recovery rates for Chinook Salmon reared at the Feather River Hatchery and the Mokelumne River Hatchery was performed. Based on this analysis, Alternative 3 is expected to directly benefit juvenile fall-run Chinook Salmon and steelhead smolts originating from the San Joaquin River basin by comparison to the No Action Alternative. The program would also benefit spring-run Chinook Salmon if these fish become established as part of the San Joaquin River Restoration Program, or as part of the New Melones fish passage project.

*Summary of Effects on Fall-Run Chinook Salmon*

The analysis of temperatures indicates lower temperatures and a lesser likelihood of exceedance of suitable temperatures for spawning and rearing of fall-run Chinook Salmon under Alternative 3 as compared to the No Action Alternative in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River at Vernalis. The effect of lower temperatures is reflected in the slightly lower overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model for fall-run in the Stanislaus River.

Overall, Alternative 3 likely would have slightly beneficial effects on the fall-run Chinook Salmon population in the San Joaquin River watershed as compared to the No Action Alternative. Alternative 3 could also provide beneficial effects to juvenile fall-run Chinook Salmon as a result of trap and haul passage across through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions under Alternative 3 and fish passage under the No Action Alternative would benefit fall-run Chinook Salmon.

*Steelhead*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River downstream of the Stanislaus River confluence, as measured at Vernalis could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 and the No Action Alternative generally would be similar (differences less than 0.5°F), except in September and October when average monthly water temperatures would be 0.8°F and 0.5°F cooler, respectively. In critical dry years, water temperatures under Alternative 3 would be somewhat (0.7°F to 1.2°F) cooler from May to August and up to 2.9°F and 1.7°F cooler on average during September and October than under the No Action Alternative.

Downstream at Orange Blossom Bridge, average monthly water temperatures in October under Alternative 3 would similar to water temperatures under the No Action Alternative (less than 0.5°F differences) in most months in most water year types, but would be lower by up to 2.1°F in September of drier years and up to 1.5°F warmer in October. Water temperatures in June under Alternative 3 would be substantially higher (2.3°F on average) and up to 3.7°F warmer in wetter years.

This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of temperature increase under Alternative 3 (Appendix 6B, Table B-19-1). In addition, the decreases in temperatures under Alternative 3 that would occur in the drier years of some months would diminish at this location.

Overall, the temperature differences between Alternative 3 and the No Action Alternative would be relatively minor (less than 0.5°F) and likely would have little effect on steelhead in the Stanislaus River. The higher water temperatures in June at Orange Blossom Bridge and the mouth under Alternative 3 may increase the likelihood of adverse effects on steelhead rearing in the Stanislaus River as compared to the No action Alternative.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both Alternative 3 and the No Action Alternative during October and November. Under Alternative 3, average monthly water temperatures would exceed 56°F about 87 percent of the time in October and about 57 percent of the time under the No Action Alternative. In November, average monthly water temperatures would exceed 56°F about 24 percent of the time under Alternative 3, which would be about 9 percent less frequent than under the No Action Alternative.

In January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. This threshold would be exceeded about 1 percent of the time under Alternative 3 in February. In March through May, exceedances would occur under both alternatives in each month, with the threshold most frequently exceeded (nearly half the time) in May. Compared to the No Action Alternative, water temperatures under Alternative 3 would exceed the threshold more frequently in March (3 percent), April (1 percent), and May (4 percent). During June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded by both Alternative 3 and No Action Alternative in all months but November, with the highest frequency of exceedance in July (19 percent under Alternative 3). The differences between Alternative 3 and No Action Alternative, however, would be variable depending on the month, with Alternative 3 exceeding the threshold up to about 6 percent less frequently than under the No Action Alternative in June and from August through October. Under

Alternative 3, water temperatures would exceed the rearing temperature threshold up to 4 percent more frequently in April, May, and July.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles upstream of Knights Ferry, average monthly water temperatures under Alternative 3 would exceed 52°F in March, April, and May about 12 percent, 30 percent, and 63 percent of the time, respectively and 2 percent of the time in January and February. By comparison to the No Action Alternative, Alternative 3 would result in exceedances occurring about 2 to 4 percent more frequently during the January through March period. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and would be exceeded less frequently. The magnitude of the exceedance also would be less. Average monthly water temperatures under Alternative 3 and the No Action Alternative would not exceed the threshold during January through March. In April and May, exceedances of 3 percent and 17 percent would occur under Alternative 3, which would be nearly the same (within 1 percent) as under the No Action Alternative.

Overall, the differences between Alternative 3 and the No Action Alternative would be relatively small, with the exception of substantial differences in the frequency of exceedances in October when the average monthly water temperatures under Alternative 3 would exceed the threshold for adult steelhead migration about 28 percent less frequently and in April during the spawning period when the frequency would be about 17 percent less. Given the frequency of exceedance under both Alternative 3 and the No Action Alternative and the generally stressful temperature conditions in the river, the substantial differences (improvements) in October and April under Alternative 3 suggest that there would be less potential to adversely affect steelhead under Alternative 3 than under the No Action Alternative. Even during months when the differences would be relatively small, the lower frequency of exceedances under Alternative 3 could represent a biologically meaningful and positive difference.

*Changes in Delta Hydrodynamics*

San Joaquin River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing relative to Chinook Salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for winter-run Chinook Salmon in the Sacramento Basin and fall-run Chinook Salmon in the San Joaquin River basin above.

*Changes in Entrainment at Junctions*

At the Head of Old River, entrainment under Alternative 3 would be slightly higher during January and February relative to the No Action Alternative. Entrainment probabilities would be much lower under Alternative 3 relative to the No Action Alternative during April and May. Entrainment probabilities would be similar under both alternatives in the month of June (Appendix 9L).

At the Turner Cut junction, entrainment probabilities under Alternative 3 would be slightly higher than under the No Action Alternative in January, February, March, and June. During April and May, entrainment probabilities would be more divergent with higher values for Alternative 3 relative to the No Action Alternative. Overall, entrainment would be lower at the Columbia Cut junction relative to Turner Cut, but patterns of entrainment between the two alternatives would be similar. Entrainment would be slightly higher for Alternative 3 relative to the No Action Alternative during January, February, March, and June. In April and May, entrainment would be greater for Alternative 3 relative to the No Action Alternative. Patterns at the Middle River and Old River junctions would be similar to those observed at the Columbia and Turner Cut junctions.

*Summary of Effects on Steelhead*

Given the frequency of exceedance under both Alternative 3 and the No Action Alternative, water temperature conditions for steelhead in the Stanislaus River would be generally stressful in the fall, late spring, and summer months. The differences in temperature exceedance (both positive and negative) between Alternative 3 and the No Action Alternative would be relatively small, with no clear benefit associated with either alternative. However, because Alternative 3 generally would exceed thresholds less frequently during the warmest months, it may provide slightly less impact than under the No Action Alternative.
Alternative 3 could provide additional beneficial effects to juvenile steelhead as a result of trap and haul passage across through the Delta. It remains uncertain, however, if predator management actions under Alternative 3 would benefit steelhead. However, if fish passage above New Melones Dam is successful, Alternative 3 would do less than the No Action Alternative to address long-term temperature issues in the Stanislaus River downstream of the dam.

*White Sturgeon*

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Under Alternative 3, storage in New Melones could be increased up to around 20 percent in some months of some water year types (Appendix 5A). Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within New Melones is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be increased under Alternative 3 as compared to the No Action Alternative.

Results of the bass nesting success analysis are presented in Appendix 9F. For March, the likelihood of Largemouth Bass and Smallmouth Bass nest survival in New Melones being above 40 percent is 100 percent under Alternative 3 and the No Action Alternative. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is reasonably high (around 80 percent) but is substantially (about 10 percent) higher under Alternative 3 than under the No Action Alternative. For May, the pattern is similar with the likelihood of high nest survival being about 6 percent greater under Alternative 3. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is about 3 percent higher under Alternative 3 as compared to the No Action Alternative. For Spotted Bass, nest survival in March is anticipated to be near 100 percent in every year under both Alternative 3 and the No Action Alternative. The likelihood of survival being greater than 40 percent in April is 100 percent under both Alternative 3 and the No Action Alternative. For May, the likelihood of high Spotted Bass nest survival in near 100 percent under both alternatives with the likelihood under Alternative 3 being about 1 percent higher than under the No Action Alternative. For June, Spotted Bass nest survival would be greater than 40 percent in every year under Alternative 3 as compared to approximately 98 percent of the years under the No Action Alternative.

While the analyses suggest that the effects of operation under Alternative 3 could be less than those under the No Action Alternative, it is uncertain whether these differences would be biological meaningful. Therefore, it is likely that the effects on black basses in New Melones Reservoir would be similar under both alternatives.

*Other Species*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Keswick Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

As described above, average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 and the No Action Alternative generally would be similar. Downstream at Orange Blossom Bridge, average monthly water temperatures in the November to March period under Alternative 3 generally would be similar to, although somewhat higher than, under the No Action Alternative. In June, July, and October, average monthly water temperatures in most water year types would be higher under Alternative 3 and in September, water temperatures would be lower under Alternative 3 compared to the No Action Alternative. This temperature pattern would continue downstream to the confluence with the San Joaquin River, although temperatures would progressively increase, as would the magnitude of difference between Alternative 3 and the No Action Alternative (Appendix 6B, Table B-19-1).

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could adversely affect these larval lamprey. Given the slightly lower flows and temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be somewhat greater under Alternative 3 and the No Action Alternative.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the slightly lower flows and temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be somewhat greater under Alternative 3 and the No Action Alternative.

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### 9.4.3.4.1 Alternative 3 Compared to the Second Basis of Comparison

As described in Chapter 3, Description of Alternatives, the CVP and SWP operations and ongoing operational management policies of the CVP and SWP under Alternative 3 would be similar to the operational assumptions under the Second Basis of Comparison except for changes to water demand assumptions, OMR flow criteria, and operations of New Melones Reservoir to meet SWRCB D-1641 flow requirements on the San Joaquin River at Vernalis. As a consequence, conditions for fish and aquatic resources would be relatively unchanged in most of the system under Alternative 3. The following briefly summarizes these minor changes, but focuses on portions of the CVP and SWP where changes would occur under Alternative 3 relative to the Second Basis of Comparison.

*Trinity River Region*

*Coho Salmon*

The analysis of effects associated with changes in operation on Coho Salmon was conducted using temperature model outputs for Lewiston Dam to anticipate the likely effects on conditions in the Trinity River downstream of Lewiston Dam for Coho Salmon.

Long-term average monthly water temperature in the Trinity River at Lewiston Dam under Alternative 3 would be similar (less than 0.2°F) to long-term average water temperatures under the Second Basis of Comparison in all months. The greatest differences would occur in critical years when average monthly temperatures would be 0.6°F lower in September and October and 0.8°F higher in November under Alternative 3 (Appendix 6B, Table B-1-5). The differences in the frequency with which Alternative 3 and the Second Basis of Comparison would exceed established temperature thresholds also would be small, with water temperatures under Alternative 3 exceeding thresholds about 0-2 percent less frequently than under the Second Basis of Comparison.

Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios.

*Spring-run Chinook Salmon*

As described above for Coho Salmon, water temperature differences between Alternative 3 and the Second Basis of Comparison generally would be small (less than 0.5°F). Similarly, the differences in the frequency with which water temperatures under Alternative 3 and the Second Basis of Comparison would exceed established temperature thresholds also would be small, with Alternative 3 exceeding water temperature thresholds about 1 percent less frequently than the Second Basis of Comparison in July and September.

The minor temperature differences suggest that conditions for spring-run Chinook Salmon in the Trinity River generally would be similar under Alternative 3 and the Second Basis of Comparison.

*Fall-Run Chinook Salmon*

As described above for Coho Salmon, the water temperature differences between Alternative 3 and the Second Basis of Comparison generally would be minor (Appendix 6B, Table B-1-small (less than 0.5°F). These small temperature differences are reflected in the egg mortality results, which indicate minor changes in mortality, with mortality differences less than 0.6 percent (Appendix 9C, Table 5-5). These results suggest that conditions for fall-run Chinook Salmon in the Trinity River generally would be similar under Alternative 3 and the Second Basis of Comparison.

*Steelhead*

Differences in water temperature conditions for steelhead in the Trinity River between Alternative 3 and the Second Basis of Comparison would be minor as described above for salmon. These minor differences in temperature suggest that conditions for steelhead in the Trinity River generally would be similar under Alternative 3 and the Second Basis of Comparison.

*Green Sturgeon*

Green Sturgeon would be subjected to the same water temperature conditions described above for salmonids. The minor differences in temperatures flows between Alternative 3 and the Second Basis of Comparison suggest that conditions for Green Sturgeon in the Trinity River generally would be similar under Alternative 3 and the Second Basis of Comparison.

*Reservoir Fishes*

Reservoir fishes in Trinity Lake would be exposed to relatively minor differences in storage under Alternative 3 as compared to the Second Basis of Comparison and these relatively small differences would have little effect on the amount of habitat available for these species. Black bass nesting survival would be similar under Alternative 3 and the Second Basis of Comparison. These minor differences in nest survival suggest that conditions for black bass species in Trinity Lake would be similar under both Alternative 3 and the Second Basis of Comparison.

*Other Species*

As described above for Coho Salmon, there would be only minor differences in water temperatures and flows between Alternative 3 and the Second Basis of Comparison. These minor differences suggest that water temperature conditions for Pacific Lamprey, Eulachon, and other aquatic species in the Trinity River and Klamath River downstream of the confluence generally would be similar under Alternative 3 and the Second Basis of Comparison.

*Sacramento River System*

*Winter-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Long-term average monthly water temperature in the Sacramento River at Keswick Dam under Alternative 3 and the Second Basis would be relatively unchanged, with minor differences in some months and water year types of less than 0.3°F (Appendix 6B, Table B-5-5). There would be slight differences in the frequency of exceeding temperature thresholds under Alternative 3 and the Second Basis of Comparison with the frequency of exceedance being up to 4 percent less under Alternative 3 at Balls Ferry and up to 4 percent more at Bend Bridge. Egg mortality would be unchanged in all but critical dry years, when Alternative 3 would exhibit 0.7 percent less mortality than the Second Basis of Comparison (Appendix 9C, Table B-4).

*Changes in Weighted Usable Area*

The WUA results for winter-run Chinook Salmon spawning habitat between Keswick Dam and Battle Creek indicated that the amount of spawning habitat would be similar under Alternative 3 and the Second Basis of Comparison (less than 3 percent difference), except in below normal years in which spawning WUA would be about 6 percent higher as a result of the higher flows during this period (Appendix 9E, Table C-17-5). Results were similar for fry rearing, but higher flows in below normal years during August translated into about 6 percent less WUA under Alternative 3 (Appendix 9E, Table C-18-5). Results for juvenile rearing also were similar (less than 3 percent difference) under both Alternative 3 and the Second Basis of Comparison (Appendix 9E, Table C-19-5).

*Changes in SALMOD Output*

SALMOD results indicated that the long-term annual potential production of winter-run Chinook Salmon under Alternative 3 would be essentially the same as under the Second Basis of Comparison. Differences among water year types would be less than 2 percent (Appendix 9D, Table B-4-1).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for winter-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.354 for Alternative 3 and 0.352 for the Second Basis of Comparison.

*Changes in Junction Entrainment*

Entrainment at the Georgiana Slough Junction under Alternative 3 would be almost indistinguishable from the Second Basis of Comparison (Appendix 9L). At the Head of Old River junction, entrainment would be moderately lower under Alternative 3 in January and February and slightly lower in March. At Turner Cut, entrainment would be moderately lower under Alternative 3 relative to the Second Basis of Comparison in January; however, these differences would be smaller in February and March. Entrainment at Columbia Cut, Middle River, and Old River would be moderately lower in January and February and slightly lower in March relative to the Second Basis of Comparison.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook salmon is predicted to be considerably lower under Alternative 3 relative to the Second Basis of Comparison in January (Appendix 9M). In February salvage would be only moderately lower and slightly lower in March.

*Changes in Oncorhynchus Bayesian Analysis Output*

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Differences in escapement between Alternative 3 and the Second Basis scenarios were moderately small (Appendix 9I). Escapement was generally greater under Alternative 3 relative to Second Basis of Comparison, and it was consistently greater over the 1986 to 1988 simulation period (dark gray and light gray areas above the dashed line). In most other years the difference in escapement estimates included 0 (i.e., dashed line located in the dark gray, central 0.50 probability region) (see Appendix 9I). The median delta survival was slightly higher under Alternative 3 relative to the Second Basis scenario (6 percent), although the probability of no difference between alternatives was generally high throughout the simulation time period.

*Changes in Interactive Object-Oriented Simulation Output*

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison across the 81 years (Appendix 9H). Median adult escapement under Alternative 3 was 4,025 and under the Second Basis of Comparison median escapement was 4,042.

Similar to adult escapement, the IOS model predicted similar egg survival time histories for winter-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison across the 81 water years. Median egg survival was 0.987 for both scenarios.

*Summary of Effects on Winter-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for winter-run Chinook Salmon and their response to change under Alternative 1 as compared to the Second Basis of Comparison. For the purpose of analyzing effects on winter-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the two life cycle models, IOS and OBAN because they each integrate the available information to produce single estimates of winter-run Chinook Salmon escapement. The output from IOS indicated that winter-run Chinook Salmon escapement would be similar under both scenarios, whereas the OBAN results indicated that escapement under Alternative 3 would be higher than under the Second Basis of Comparison.

These model results suggest that effects on winter-run Chinook Salmon would be similar under both scenarios, with a small likelihood that winter-run Chinook Salmon escapement would be higher under Alternative 3 than under the Second Basis of Comparison. The ocean harvest restrictions under Alternative 3 could provide additional benefit, although the effects of the predator management program are uncertain.

*Spring-run Chinook Salmon*

Operations under Alternative 3 generally would be similar to those for the Second Basis of Comparison. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Long-term average monthly water temperature in the Sacramento River under Alternative 3 and the Second Basis of Comparison would be relatively unchanged, with minor differences in some months and water year types (Appendix 6B). Differences in the frequency of exceeding temperature thresholds under Alternative 3 and the Second Basis of Comparison also would be similar (differences of about 1 percent), as would egg mortality, which would be similar in all but critical dry years, during which Alternative 3 would exhibit 3.8 percent more mortality than the Second Basis of Comparison (Appendix 9C, Table B-3).

In Clear Creek, average monthly water temperature at Igo under Alternative 3 relative to the Second Basis of Comparison would be similar (differences less than 0.2°F) (Appendix 6B, Table B-3-5). The frequency of exceeding temperature thresholds for spring-run Chinook Salmon rearing also would be similar (differences of 1 percent).

In the Feather River, average monthly water temperature at the low flow channel under Alternative 3 relative to the Second Basis of Comparison also would be similar (differences less than 0.5°F), with a slight reduction in temperature (0.7°F) in August of below normal years (Appendix 6B, Table B-20-5). Water temperatures at the downstream location also would be similar, with temperatures under Alternative 3 at Robinson Riffle up to 2°F percent cooler in August of below normal years (Appendix 6B, Table B-21-5). Changes in the frequency of temperature thresholds would be similar (differences of 1 percent or less), except in May when the temperature threshold for rearing would be exceeded about 4 percent more frequently than under the Second Basis of Comparison.

*Changes in Weighted Usable Area*

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. Flows in Clear Creek downstream of Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under the Alternative 3 as compared to the Second Basis of Comparison.

*Changes in SALMOD Output*

SALMOD results indicate that long-term annual potential production for spring-run Chinook Salmon would be essentially unchanged, with slight improvements (0-2 percent) under Alternative 3 relative to the Second Basis of Comparison, except in critical dry years when potential production under Alternative 3 would be about 8 percent lower (Appendix 9D, Table B-3-21).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for spring-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta survival would be 0.286 for both scenarios.

*Changes in Delta Hydrodynamics*

Spring-run Chinook Salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough (channel 421), the percent of time that velocity would be positive was similar for both Alternative 3 and the Second Basis of Comparison in March, April and May (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River (channel 45), percent positive velocity was almost identical in March and April and slightly lower under Alternative 3 relative to the Second Basis of Comparison in May. In the San Joaquin River downstream of the Head of Old River (channel 21), the percent of positive velocities was similar between scenarios in March, whereas values were moderately lower under Alternative 3 relative to the Second Basis of Comparison in April and. In Old River upstream of the facilities (channel 212), percent positive velocity was similar between scenarios in March and moderately higher in April and May under Alternative 3 relative to the Second Basis of Comparison. In Old River downstream of the facilities (channel 94), percent positive velocity was similar between scenarios in March and slightly higher in April and May under Alternative 3 relative to the Second Basis of Comparison.

*Changes in Junction Entrainment*

Entrainment at the Georgiana Slough Junction under Alternative 3 would be almost indistinguishable from the Second Basis of Comparison during March April and May (Appendix 9L). At the Head of Old River junction, entrainment would be slightly lower under Alternative 3 in March, whereas entrainment would be much greater under Alternative 3 relative to the Second Basis of Comparison in April and May. At Turner Cut, entrainment would be similar under Alternative 3 relative to the Second Basis of Comparison in March and moderately lower in April and May. Entrainment at Columbia Cut, Middle River, and Old River would yield similar patterns as those observed at Turner Cut.

*Changes in Salvage*

Spring-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of March, April, and May. Salvage of Sacramento River-origin Chinook salmon is predicted to be similar under Alternative 3 relative to the Second Basis of Comparison in March and April (Appendix 9M). Predicted values in May indicated a moderately greater fraction of fish salvaged for Alternative 3 relative to the Second Basis of Comparison.

*Summary of Effects on Spring-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for spring-run Chinook Salmon and their response to change under Alternative 3 and the Second Basis of Comparison. For the purpose of analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential spring-run Chinook Salmon juvenile production. The output from SALMOD indicated that spring-run Chinook Salmon production in the Sacramento River would be similar under Alternative 3 and the Second Basis of Comparison, although production under Alternative 3 could be up to 8 percent less than under the Second Basis of Comparison in critical dry years.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon generally would be higher under Alternative 3 relative to the Second Basis of Comparison.

In Clear Creek and the Feather River, the analysis of the effects of Alternative 3 and the Second Basis of Comparison for spring-run Chinook Salmon relied on output from the WUA analysis and water temperature output for Clear Creek at Igo, and in the Feather River low flow channel and downstream of the Thermalito complex. The WUA analysis suggests that there would be little difference in the availability of spawning and rearing habitat in Clear Creek. The temperature model outputs suggest that thermal conditions and effects on each of the spring-run Chinook Salmon life stages generally cannot be fully characterized in Clear Creek and the Feather River. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that water temperature thresholds for spawning and egg incubation in Clear Creek and the Feather River would be exceeded less frequently in some months and more frequently in others under Alternative 3 than under the Second Basis of Comparison. The water temperature threshold for rearing spring-run Chinook Salmon in the Feather River would also be exceeded less frequently in some months and more frequently in others under Alternative 3. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the differences in the magnitude and direction of the temperature exceedances under Alternative 3, the extent of temperature-related effects on spring-run Chinook Salmon in Clear Creek and the Feather River is uncertain.

These model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse under Alternative 3 than the Second Basis of Comparison, with a small likelihood that spring-run Chinook Salmon production would be lower under the Second Basis of Comparison. The benefits of ocean harvest restrictions under Alternative 3, however, could offset those effects. The effects of the predator management program under Alternative 3 are uncertain.

*Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River below Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Water temperature conditions in the Sacramento River, Clear Creek, and Feather River under Alternative 3 and the Second Basis of Comparison would be same as those described above for spring-run Chinook Salmon. Temperature conditions in the Sacramento River, Clear Creek, Feather River, and American River would generally be similar (differences less than 0.5°F) under Alternative 3 and the Second Basis of Comparison (Appendix 6B).

The frequency of exceeding established temperature thresholds in the Sacramento and Feather rivers for fall-run Chinook Salmon would be the same or nearly so (differences of up to 2 percent) for both Alternative 3 and the Second Basis of Comparison Exceedances. Similarly, in the American River (Appendix 9C, Table B-6), differences in the frequency of temperature threshold exceedance would be small (up to about 0.6 percent).

The results from Reclamation's salmon mortality model reflect the similarities in temperature described above. For fall-run Chinook Salmon in the Sacramento River, egg mortality would be similar (up to 0.6 percent difference) between Alternative 3 and the Second Basis of Comparison (Appendix 9C, Table B-1). Differences in the Feather River would be slightly larger, with about 2.4 percent and 2.8 lower egg mortality under Alternative 3 than under the Second Basis of Comparison in below normal and critical dry years, respectively. Differences in the American River would be similar to those in the Sacramento River, with egg mortality under Alternative 3 ranging from 0.1 percent less to 0.6 percent greater than under the Second Basis of Comparison.

*Changes in Weighted Usable Area*

Modeling results indicate that, in general, there would be similar amounts (less than 5 percent differences) of fall-run Chinook Salmon spawning habitat available in the Sacramento, Feather, and American rivers under Alternative 3 as compared to the Second Basis of Comparison; fall-run fry and juvenile rearing WUA would be less than 1 percent different under Alternative 3 relative to the Second Basis of Comparison in the Sacramento River. Overall, spawning and rearing habitat availability for fall-run Chinook Salmon would be similar under Alternative 3 and the Second Basis of Comparison.

*Changes in SALMOD Output*

SALMOD results indicate that long-term annual potential production for fall-run Chinook Salmon would be similar (1 percent difference), with slight increases potential production (0-2 percent) in some water year types under Alternative 3 relative to the Second Basis of Comparison, except in critical dry years when potential production under Alternative 3 would be about 2 percent lower (Appendix 9D, Table B-1-21).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 8-year time period for fall-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.246 for Alternative 3 and 0.245 for the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. At the junction of Georgiana Slough and the Sacramento River, percent positive velocity would be indistinguishable among scenarios in April, May, and June (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities would be slightly lower under Alternative 3 relative to the Second Basis of Comparison in the months when fall-run Chinook Salmon are most abundant. On Old River downstream of the facilities, the proportion of positive velocities would be slightly, to moderately higher in April and May, and moderately lower in June under Alternative 3 relative to the Second Basis of Comparison. In Old River upstream of the facilities, the percent of positive velocities would be considerably higher under Alternative 3 in April and May and moderately lower in June. On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities would be considerably lower under Alternative 3 relative to the Second Basis of Comparison in April and May, and moderately lower in June.

*Changes in Junction Entrainment*

Entrainment at the Georgiana Slough Junction under Alternative 3 would be almost indistinguishable from the Second Basis of Comparison in April, May, and June (Appendix 9L). At the Head of Old River junction in April and May, entrainment would be much greater under Alternative 3 relative to the Second Basis of Comparison. In June, entrainment would be indistinguishable under each alternative. Patterns of entrainment would be similar at Turner Cut, Columbia Cut, Middle River, and Old River. At these junctions, entrainment under Alternative 3 would be moderately lower in April and May, and slightly lower or almost indistinguishable in June.

*Changes in Salvage*

Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater under Alternative 3 relative to the Second Basis of Comparison in every month (Appendix 9M). Fall-run Chinook Salmon smolts migrating through the Delta would be most susceptible in the months of April, May, and June. Predicted values in April and May indicated a substantially increased fraction of fish salvaged under Alternative 3 relative to the Second Basis of Comparison.

*Summary of Effects on Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for fall-run Chinook Salmon and their response to change under Alternative 3 and the Second Basis of Comparison. For the purpose of analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD indicated that fall-run Chinook Salmon production would be slightly higher in most water year types under Alternative 3 than under the Second Basis of Comparison, and up to 2 percent less than under the Second Basis of Comparison in critical dry years.

The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon generally would be higher under Alternative 3 relative to the Second Basis of Comparison.

In Clear Creek and the Feather and American rivers, the analysis of the effects of Alternative 3 and the Second Basis of Comparison for fall-run Chinook Salmon relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of spawning and rearing habitat in Clear Creek and spawning habitat in the Feather and American rivers would be similar under Alternative 3 and the Second Basis of Comparison. The temperature model outputs for each of the fall-run Chinook Salmon life stages suggest that thermal conditions and effects on fall-run Chinook Salmon in all of these streams generally would be similar under both scenarios. The water temperature threshold exceedance analysis that indicated that the water temperature thresholds for fall-run Chinook Salmon spawning and egg incubation would be exceeded slightly less frequently in the Feather River and Clear Creek under Alternative 3. Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the reduced frequency of exceedance of temperature thresholds under Alternative 3 could reduce the potential for adverse effects on the fall-run Chinook Salmon populations in Clear Creek and the Feather River. Results of the analysis using Reclamation's salmon mortality model indicate that there would be little difference in fall-run Chinook Salmon egg mortality under Alternative 3 and the Second Basis of Comparison.

These model results suggest that overall, effects on fall-run Chinook Salmon could be slightly less adverse under Alternative 3 than the Second Basis of Comparison. Ocean harvest restrictions under Alternative 3 could provide additional benefit; however, the potential effects of the predator management program under Alternative 3 would be uncertain.

*Late Fall-Run Chinook Salmon*

Differences in temperature conditions in the Sacramento River downstream of Keswick Dam for late fall-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison generally would be similar to those described above for fall-run Chinook Salmon. Results from the SALMOD model, which reflects temperature and flow conditions in the Sacramento River, suggested that long-term annual potential production under Alternative 3 would be slightly lower (up to 2 percent) than under the Second Basis of Comparison, except in critical dry years when production under Alternative 3 would be about 4 percent higher.

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for late fall-run Chinook Salmon between Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta survival would be 0.199 for both scenarios.

*Changes in Delta Hydrodynamics*

The late fall-run Chinook Salmon migration period overlaps with the winter-run. See the section on hydrodynamic analysis for winter-run Chinook Salmon for potential effects on late fall-run Chinook Salmon.

*Changes in Junction Entrainment*

Entrainment probabilities for late fall-run Chinook Salmon are assumed to mimic that of winter-run Chinook Salmon due to the overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on late fall-run Chinook Salmon.

*Changes in Salvage*

Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run Chinook Salmon due to overlap in timing. See the section on winter-run Chinook Salmon entrainment for potential effects on the late fall-run Chinook Salmon.

*Summary of Effects on Late Fall-Run Chinook Salmon*

The multiple model and analysis outputs described above characterize the anticipated conditions for late fall-run Chinook Salmon and their response to change under Alternative 3 and the Second Basis of Comparison. For the purpose of analyzing effects on late fall-run Chinook Salmon and developing conclusions, greater reliance was placed on the outputs from the SALMOD model because it integrates the available information on temperature and flows to produce estimates of mortality for each life stage and an overall, integrated estimate of potential fall-run Chinook Salmon juvenile production. The output from SALMOD suggested that late fall-run Chinook Salmon production would be similar under Alternative 3 and the Second Basis of Comparison.

Although, potential losses of juvenile salmon at the export facilities could be higher under Alternative 3, as suggested by the analysis of salvage, it is likely that effects on the late fall-run Chinook Salmon population would be similar under Alternative 3 and the Second Basis of Comparison.

*Steelhead*

The multiple model and analysis outputs described above characterize the anticipated conditions for steelhead and their response to change under Alternative 3 and the Second Basis of Comparison. The analysis of the effects of Alternative 3 and the Second Basis of Comparison for steelhead relied on the WUA analysis for habitat and water temperature model output for the rivers at various locations downstream of the CVP and SWP facilities. The WUA analysis indicated that the availability of steelhead spawning and rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento, Feather and American rivers would be similar under Alternative 3 and the Second Basis of Comparison. The temperature model outputs for each of the steelhead life stages suggest that thermal conditions and effects on steelhead in all of these streams generally would be similar under Alternative 3 and the Second Basis of Comparison, but cannot be fully characterized in the Feather River. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for steelhead spawning and egg incubation would be exceeded less frequently in the Feather River under Alternative 3. However, the water temperature threshold for steelhead rearing in the Feather River would be exceeded less frequently in some months and more frequently in others under Alternative 3. The water temperature threshold for steelhead rearing in the American River would also be exceeded more frequently in most months under Alternative 3. Because of the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), and the differences in the magnitude and direction of the temperature exceedances under Alternative 3, the extent of temperature-related effects on steelhead in the Feather River is uncertain.

These model results suggest that overall, effects on steelhead could be slightly more adverse under Alternative 3 than the Second Basis of Comparison, particularly in the Feather and American rivers.

*Sturgeon (green and white)*

The analysis of the effects of Alternative 3 and Second Basis of Comparison for sturgeon relied on water temperature model output for the Sacramento and Feather rivers at various locations downstream of Shasta Dam and the Thermalito complex. The temperature model outputs for each of these rivers suggest that thermal conditions and effects on sturgeon in the Sacramento and Feather rivers generally would be similar under both scenarios. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for sturgeon spawning, incubation, and rearing would be exceeded slightly less frequently under Alternative 3 in the Sacramento River. The water temperature threshold for sturgeon spawning, incubation, and rearing also would be exceeded slightly less frequently in the Feather River. Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the slightly reduced frequency of exceedance of temperature thresholds under Alternative 3 could reduce the potential for adverse effects on sturgeon in the Sacramento and Feather rivers relative to the Second Basis of Comparison.

*Delta Smelt*

*Changes in Proportional Entrainment*

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under the Second Basis of Comparison would be 8.1 to 9.8 percent, depending on the water year type, with a long term average percent entrainment of 9 percent. Percent entrainment of adult Delta Smelt under Alternative 3 would be similar to results under the Second Basis of Comparison (lower by 0.8 to 1.6 percent depending on water year type). Under Alternative 3, the long term average percent entrainment would be 7.9 percent.

As described in Appendix 9G, a proportional entrainment regression model (based on Kimmerer 2008) was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under the Second Basis of Comparison would be 6.9 to 23.6 percent, depending on the water year type, with a long term average percent entrainment of 15.5 percent, and highest entrainment under Critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under Alternative 3 would be similar to results under the Second Basis of Comparison (lower by 1.3 to 4.4 percent). Under Alternative 3, the long term average percent entrainment would be 12.7 percent, and highest entrainment would occur under Critical water year conditions, at 20.5 percent. These Alternative 3 values are similar to comparable values under the Second Basis of Comparison (estimated to be 2.8 and 3.1 percent lower, respectively).

##### *Changes in Fall Abiotic Habitat Index*

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. Results indicate that under the Second Basis of Comparison, the X2 position would range from 85.6 km to 92.3 km, depending on the water year type, with a long term average X2 position of 88.1 km. The most eastward location of X2 is predicted under Critical water year conditions. The X2 positions predicted under Alternative 3 would be similar to predictions under the Second Basis of Comparison (only 0.1 to 0.3 km difference). Under Alternative 3, the long term average X2 position would be 88.1 km, a location that does not provide for the advantageous overlap of the low salinity zone with Suisun Bay/Marsh.

##### *Summary of Effects on Delta Smelt*

Overall, Alternative 3 likely would have similar effects on Delta Smelt, as compared to the Second Basis of Comparison with regard to estimated entrainment and predicted location of Fall X2.

#### *Longfin Smelt*

The effects of the Alternative 3 as compared to the Second Basis of Comparison were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

As described in Appendix 5A, OMR flows would be negative in all months under both Alternative 3 and the Second Basis of Comparison. Flows under Alternative 3 generally would be less negative than under the Second Basis of Comparison, except in June, July, and August, when OMR flows under Alternative 3 would be more negative by greater 25 percent in some months and year types. The increase in the magnitude of negative flows in June, July, and August under Alternative 3 could increase the likelihood of entrainment of Longfin Smelt at the export facilities.

Under Alternative 3, Longfin Smelt abundance index values calculated for long-term average conditions and for each water year type for the different alternatives (see Appendix 9G) range from 1,094 under critical water year conditions to a high of 15,638 under wet water year conditions, with a long-term average value of 7,345. Under the Second Basis of Comparison, Longfin Smelt abundance index values range from 947 under critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257.

Results indicate that the Longfin Smelt abundance index values would be higher in most water year types under Alternative 3 than they would be under the Second Basis of Comparison, with a long-term average index for Alternative 3 that is 1.2 percent higher than the long-term average index under the Second Basis of Comparison. The greatest increase in the Longfin Smelt abundance index occurs in critical years where it is 15.5 percent greater under Alternative 3 than under the Second Basis of Comparison. For above normal, below normal, and dry water years, the Longfin Smelt abundance index values would be 1.5 to 13.8 percent higher under Alternative 3 than under the Second Basis of Comparison. In wet years, the Longfin Smelt abundance index would be 1.2 percent lower under Alternative 3 as compared to the Second Basis of Comparison. Based on the Longfin Smelt abundance indices, Alternative 3 likely would have beneficial effects on Longfin Smelt, as compared to the Second Basis of Comparison.

Overall, based on the relative decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in critical years, Alternative 3 would be likely to positively affect the Longfin Smelt population as compared to the Second Basis of Comparison.

*Sacramento Splittail*

Under Alternative 3, flows entering the Yolo Bypass generally would be slightly less than flows under the Second Basis of Comparison (Appendix 5A, Table C-26-5). These decreases likely would be insufficient to reduce potential Sacramento Splittail spawning habitat in the bypass.

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Alternative 3 as compared to the Second Basis of Comparison generally would result in similar (differences less than 5 percent) storage levels in CVP and SWP reservoirs during the March through June period (Appendix 5A).

In general, black bass nesting success also would be similar under Alternative 3 and the Second Basis of Comparison. Nesting success of black bass would be high in March and April due to increasing water surface elevations. During May, the likelihood of high (>40 percent) nesting success would be similar to or slightly higher in most of the reservoirs under Alternative 3 as compared to the Second Basis of Comparison. This pattern is reversed in June, with the likelihood of high nesting success being somewhat lower under Alternative 3 (Appendix 9F).

Overall, the changes in nest success would be relatively small, and the decreases in June under Alternative 3 would occur after the peak in spawning. Thus, effects on nest success are expected to be similar between the two alternatives.

*Other Species*

Several other fish species could be affected by changes in operations that influence temperature and flow. Given the generally small differences in flows and water temperatures between Alternative 3 and the Second Basis of Comparison, it is anticipated that the effect on other species (including Pacific Lamprey, Striped Bass, American Shad, and Hardhead) generally would be the same under both scenarios.

*Stanislaus River/Lower San Joaquin River*

*Fall-Run Chinook Salmon*

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River below Vernalis. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 generally would similar to the Second Basis of Comparison but could be lower (up to 1.5°F) than under the Second Basis of Comparison in September, October, November, and December of drier years (Appendix 6B, Table B-17-5). Downstream at Orange Blossom Bridge, average monthly water temperatures in October through December under Alternative 3 also would be similar (less than 0.5°F difference) to under the Second Basis of Comparison except in June when the average monthly water temperature would be 2.8°F warmer and up to 4.3°F warmer in drier years. Average monthly water temperatures from August to November would be up to 1.6°F cooler in critical dry years under Alternative 3 as compared to the Second Basis of Comparison (Appendix 6B, Table B-18-5). This temperature pattern would continue downstream to the confluence with the San Joaquin River, although the magnitude of temperature decrease under Alternative 3 (Appendix 6B, Table B-19-5) would be smaller. Lower fall water temperatures in drier years would reduce the likelihood of adverse effects on spawning fall-run Chinook Salmon.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October (over 30 percent of the time) and November over 20 percent of the time in the Stanislaus River at Goodwin Dam under Alternative 3 (Appendix 6B, Table B-17-1). Similar exceedances would occur under the Second Basis of Comparison. Water temperatures for rearing generally would be below 56°F, except in May.

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning would be exceeded frequently under both Alternative 3 and the Second Basis of Comparison during October and November, but the 56°F threshold would be exceeded 2 percent more frequently in October and 4 percent less frequently in November percent.

During January through May, rearing fall-run Chinook Salmon under Alternative 3 would be subjected to average monthly water temperatures that exceed 56°F; however, the differences between Alternative 3 and the Second Basis of Comparison could be biologically meaningful, with Alternative 3 exceeding the threshold in April about 4 percent less frequently and about 7 percent more frequently in May (Appendix 6B, Figure B-18-5).

*Changes in Egg Mortality (Stanislaus River)*

For fall-run Chinook Salmon in the Stanislaus River, egg mortality rates would be similar under both scenarios, with Alternative 3 exhibiting a long-term average egg mortality rate of about 1.2 percent lower than under the Second Basis of Comparison, with predicted egg mortality rates lower (by 2.5 percent) in critical dry years (Appendix 9C, Table B-8).

*Changes in Delta Hydrodynamics*

San Joaquin River-origin fall-run Chinook Salmon smolts are most abundant in the Delta during the months of April, May and June. Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities would be slightly lower under Alternative 3 relative to the Second Basis of Comparison in the months when fall-run would be most abundant (Appendix 9K). On Old River downstream of the facilities, the proportion of positive velocities would be slightly, to moderately higher in April and May, and moderately lower in June under Alternative 3 relative to the Second Basis of Comparison. In Old River upstream of the facilities, the percent of positive velocities would be considerably higher under Alternative 3 in April and May, and moderately lower in June. On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities would be considerably lower under Alternative 3 relative to the Second Basis of Comparison in April and May, and moderately lower in June.

*Changes in Entrainment at Junctions*

Entrainment at the Georgiana Slough Junction under Alternative 3 would be almost indistinguishable from the Second Basis of Comparison in April, May, and June (Appendix 9L). At the Head of Old River junction in April and May, entrainment would be much greater under Alternative 3 relative to the Second Basis of Comparison (Appendix 9L). In June, entrainment would be indistinguishable under each alternative. Patterns of entrainment would be similar at Turner Cut, Columbia Cut, Middle River, and Old River). At these junctions, entrainment under Alternative 3 would be moderately lower in April and May, and slightly lower or almost indistinguishable in June.

*Summary of Effects on Fall-Run Chinook Salmon*

The analysis of temperatures indicates somewhat similar temperatures and a similar likelihood of exceedance of suitable temperatures for spawning and rearing of fall-run Chinook Salmon under Alternative 3 as compared to the Second Basis of Comparison in the Stanislaus River below Goodwin Dam and in the San Joaquin River at Vernalis. The effect of lower temperatures is reflected in the similar overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model for fall-run in the Stanislaus River. Overall, Alternative 3 likely would have similar effects on the fall-run Chinook Salmon population in the San Joaquin River watershed as compared to the Second Basis of Comparison.

*Steelhead*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River below Vernalis could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 3 generally would similar to the Second Basis of Comparison but could be lower (up to 1.5°F) than under the Second Basis of Comparison in September, October, November, and December of drier years. Downstream at Orange Blossom Bridge, average monthly water temperatures in October through December under Alternative 3 also would be similar (less than 0.5°F difference) to under the Second Basis of Comparison except in June when the average monthly water temperature would be 2.8°F warmer and up to 4.3°F warmer in drier years. Average monthly water temperatures from August to November would be up to 1.6°F cooler in critical dry years under Alternative 3 as compared to the Second Basis of Comparison. Second Basis of Comparison. This temperature pattern would continue downstream to the confluence with the San Joaquin River, although the magnitude of temperature decrease under Alternative 3 would be smaller.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both Alternative 3 and the Second Basis of Comparison during October and November, with the threshold being exceeded 2 percent more frequently in October and 4 percent less frequently in November percent. In January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. Under Alternative 3, this threshold would be exceeded under Alternative 3 about 8 percent and 10 percent more frequently in March and May, respectively, than under the Second Basis of Comparison. However, the threshold would be exceeded 16 percent less frequently under Alternative 3 in April.

During June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded under both Alternative 3 and the Second Basis of Comparison in all months but November, with the highest frequency of exceedance in July (19 percent under Alternative 3). The differences between Alternative 3 and the Second Basis of Comparison, however, would be variable depending on the month, with water temperatures under Alternative 3 exceeding the threshold 2 percent to 4 percent more frequently than under the Second Basis of Comparison in June and July and up to 4 percent less frequently from August to October.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry from January through May under both Alternative 3 and the Second Basis of Comparison. Differences in the likelihood of threshold exceedance between scenarios could be biologically meaningful (up to 3 percent) with the threshold being more likely to be exceeded in March and less likely to be exceeded in April and May. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F). Under Alternative 3, water temperatures would exceed the 57°F threshold about 4 percent less frequently in April and about 7 percent more frequently than under the Second Basis of Comparison in May.

*Changes in Delta Hydrodynamics*

San Joaquin River-origin steelhead generally move through the Delta during spring; however, there is less information on their timing than there is for Chinook salmon. Thus, hydrodynamics in the entire January through June period could have the potential to affect juvenile steelhead. For a description of potential hydrodynamic effects on steelhead, see the descriptions for winter-run Chinook Salmon in the Sacramento Basin and fall-run Chinook Salmon in the San Joaquin River basin, above.

*Changes in Entrainment at Junctions*

At the Head of Old River junction, entrainment would be somewhat lower under Alternative 3 in January, February, and March (Appendix 9L). In April and May, entrainment would be much greater under Alternative 3. In June, entrainment would be indistinguishable relative to the Second Basis of Comparison. At Turner Cut, entrainment would always be lower under Alternative 3 than under the Second Basis of Comparison; however, these differences would be greater in April and May relative to other months. Entrainment at Columbia Cut would be slightly lower under Alternative 3 during January, February, April, and May. In March and June, entrainment would be indistinguishable. At the Middle River junction, entrainment would be lower under Alternative 3 than under the Second Basis of Comparison during January, February, and April. Entrainment under these two scenarios would be almost indistinguishable during March, May, and June. Alternative 3 would result in lower entrainment probabilities at the Old River junction during January and February, whereas entrainment would be indistinguishable in other months.

##### *Summary of Effects on Steelhead*

Given the frequency of exceedance under both Alternative 3 and the Second Basis of Comparison, water temperature conditions for steelhead in the Stanislaus River would be similar. The differences in temperature exceedance (both positive and negative) between Alternative 3 and the Second Basis of Comparison would be relative small, with no clear benefit associated with either alternative.

#### *White Sturgeon*

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

#### *Reservoir Fishes*

##### *Changes in Available Habitat (Storage)*

As described in Chapter 5, Surface Water Resources and Water Supplies, storage levels in New Melones Reservoir would be higher under Alternative 3 as compared to the Second Basis of Comparison, as summarized in Table 5.38, due to higher allocations of water supplies to CVP water service contractors, less fisheries flows, no water quality releases under SWRCB D-1641, and no Bay-Delta flow releases under SWRCB D-1641.

Storage in New Melones could be increased up to around 20 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within New Melones is not limiting; however, storage volume is an indicator of how much habitat is available to fish species inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes could be increased under Alternative 3 as compared to the Second Basis of Comparison.

##### *Changes in Black Bass Nesting Success*

Results of the bass nesting success analysis are presented in Appendix 9F, Reservoir Fish Analysis Documentation. For March, the likelihood of Largemouth Bass and Smallmouth Bass nest survival in New Melones being above 40 percent is similar under Alternative 3 and the Second Basis of Comparison. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is reasonably high (around 80 percent) but is somewhat (about 5 percent) lower 3 under Alternative 3 as compared to the Second Basis of Comparison. For May, the pattern is reversed with the likelihood of high nest survival being about 710 percent greater under Alternative 3. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is about 38 percent greater under Alternative 3 as compared to the Second Basis of Comparison. For Spotted Bass, nest survival in March is anticipated to be near 100 percent in every year under both Alternative 3 and the Second Basis of Comparison. The likelihood of survival being greater than 40 percent in April is 100 percent under both Alternative 3 and the Second Basis of Comparison. For May, the likelihood of Spotted Bass nest survival being greater than 40 percent is slightly (about 2 percent) higher under Alternative 3. For June, Spotted Bass nest survival would be greater than 40 percent in every year under Alternative 3 and the Second Basis of Comparison.

*Other Species*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass. As described above, water temperatures would generally be similar under Alternative 3 and the Second Basis of Comparison. In general, lampreys, Striped Bass and Hardhead can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect these species in the Stanislaus and San Joaquin rivers would be similar under Alternative 3 and the Second Basis of Comparison.

*San Francisco Bay Area Region*

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### ***9.4.3.5 Alternative 4***

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1, as described in Chapter 3, Description of Alternatives. Alternative 4 also includes the following items that are not included in the No Action Alternative or the Second Basis of Comparison and would affect fish and aquatic resources.

- Implement predator control programs for black bass, Striped Bass, and Pikeminnow to protect salmonids and Delta Smelt as follows:
  - Black bass catch limit changed to allow catch of 12-inch fish with a bag limit of 10
  - Striped Bass catch limit changed to allow catch of 12-inch fish with a bag limit of 5
  - Establish a Pikeminnow sport-fishing reward program with a 8-inch limit at $2/fish

- Establish a trap and haul program for juvenile salmonids entering the Delta from the San Joaquin River in March through June as follows:
  - Begin operation of downstream migrant fish traps upstream of the Head of Old River on the San Joaquin River
  - "Barge" all captured juvenile salmonids through the Delta, release at Chipps Island.
  - Tag subset of fish in order to quantify effectiveness of the program
  - Attempt to capture 10 percent to 20 percent of outmigrating juvenile salmonids
- Work with Pacific Fisheries Management Council, CDFW, and NMFS to impose salmon harvest restrictions to reduce by-catch of winter-run and spring-run Chinook Salmon to less than 10 percent of age-3 cohort in all years

As described in Chapter 4, Approach to Environmental Analysis, Alternative 4 is compared to the No Action Alternative and the Second Basis of Comparison.

#### 9.4.3.5.1 Alternative 4 Compared to the No Action Alternative

*Trinity River Region*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in aquatic resources at Trinity Lake and along the Trinity River and lower Klamath River under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 10.4.4.2.1, Alternative 1 Compared to the No Action Alternative.

*Central Valley Region*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, changes in aquatic habitat conditions at CVP and SWP reservoirs, in the rivers downstream of the reservoirs, and in the Delta under Alternative 4 as compared to the No Action Alternative would be the same as the impacts described in Section 10.4.4.2.1, Alternative 1 Compared to the No Action Alternative.

Conditions related to salmonid survival could be improved under Alternative 4 as compared to the No Action Alternative due to implementation of: trap and haul program, changes in bag limits, and changes in PMFC/NMFS harvest limits.

*San Francisco Bay Area Region*

*Killer Whale*

As described above the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### 9.4.3.5.2 Alternative 4 Compared to the Second Basis of Comparison

*Trinity River Region*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, aquatic resources conditions at Trinity Lake and along the Trinity River and lower Klamath River under Alternative 4 be the same as under the Second Basis of Comparison.

*Central Valley Region*

The CVP and SWP operations under Alternative 4 are identical to the CVP and SWP operations under the Second Basis of Comparison and Alternative 1. Therefore, aquatic resources conditions at Trinity Lake and along the Trinity River and lower Klamath River under Alternative 4 be the same as under the Second Basis of Comparison.

Conditions related to salmonid survival could be improved under Alternative 4 as compared to the Second Basis of Comparison due to implementation of the Trap and Haul Program, changes in bag limits, and changes in PMFC/NMFS harvest limits.

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

### *9.4.3.6 Alternative 5*

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified OMR flow criteria and New Melones Reservoir operations. As described in Chapter 4, Approach to Environmental Analysis, Alternative 5 is compared to the No Action Alternative and the Second Basis of Comparison.

Alternative 5 also includes the Delta Cross Channel Temporary Closure Multi-year Study. As noted in the Finding of No Significant Impact (FONSI) document from Reclamation (Reclamation, 2012), this study proposes closing the DCC for up to 10 days during the first half of October from 2012 through 2016. The FONSI also notes that the DCC closure would not cause any adverse effects to the native aquatic and fisheries. Therefore, the effects of this study are not considered any further in the impact analyses for Alternative 5 below.

#### 9.4.3.6.1 Alternative 5 Compared to the No Action Alternative

Because of the considerable similarities between Alternative 5 and the No Action Alternative, the analysis below combines species within some regions where to reduce repetition.

*Trinity River Region*

*Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead, and Green Sturgeon*

Average monthly water temperature in the Trinity River at Lewiston Dam under Alternative 5 would be similar to the No Action Alternative (less than 0.3°F) in all months (Appendix 6B, Table B-1-3). Similarly, the differences in the frequency with which Alternative 5 and the No Action Alternative would exceed established temperature thresholds also would be small (up to 1 or 2 percent) (Appendix 9N). These temperature results are reflected in the egg mortality results for fall-run Chinook Salmon in the Trinity River, which indicate similar mortality, with differences (generally less than 0.1 percent) even in critical dry years (Appendix 9C, Table B-5).

The minor differences in temperature and mortality results suggest that conditions for Coho Salmon, spring-run Chinook Salmon, fall-run Chinook Salmon, steelhead and Green Sturgeon in the Trinity River generally would be similar under Alternative 5 and the No Action Alternative.

*Reservoir Fishes*

Reservoir fishes in Trinity Lake would be exposed to relatively minor differences in storage (less than 5 percent) under Alternative 5 (Appendix 5A) as compared to the No Action Alternative and these relatively small differences likely would have little effect on the amount of habitat available for these species. Black bass nesting survival would be similar under Alternative 5 and the No Action Alternative (Appendix 9F). The minor differences in nest survival suggest that conditions for black bass species in Trinity Lake would be similar under Alternative 5 and the No Action Alternative.

*Other Species*

The minor differences in average monthly water temperatures described above for salmonids apply to Pacific Lamprey and Eulachon. These minor differences suggest that conditions for aquatic species in the Trinity River and Klamath River downstream of the confluence generally would be similar under Alternative 5 and the No Action Alternative.

*Sacramento River System*

*Winter-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the No Action Alternative would be relatively unchanged, with minor differences in some months and water year types of less than 0.2°F (Appendix 6B, Table B-5-3). Differences in the frequency of exceeding temperature thresholds under Alternative 5 and the No Action Alternative would be similar (differences less than 3 percent) (Appendix 9N). The differences predicted at locations in the downstream reaches are similar to those predicted at Keswick Dam.

Egg mortality is anticipated to be unchanged in all but critical dry years, when Alternative 5 would result in 2.5 percent lower mortality than the No Action Alternative, leading to an overall decrease of 0.4 percent under Alternative 5 as compared to the No Action Alternative (Appendix 9C, Table B-4).

*Changes in Weighted Usable Area*

The WUA results for winter-run Chinook Salmon spawning habitat between Keswick Dam and Battle Creek indicated that available spawning habitat under Alternative 5 and the No Action Alternative would be similar (less than 2 percent difference), (Appendix 9E, Table C-17-3). The results were similar for fry and juvenile rearing (Appendix 9E, Table C-18-3 and Table C-19-3).

*Changes in SALMOD Output*

SALMOD results indicated that the long-term annual potential production for winter-run Chinook Salmon under Alternative 5 would be essentially the same as under the No Action Alternative  percent(Appendix 9D, Table B-4-11).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for winter-run Chinook Salmon between Alternative 5 and the No Action Alternative (Appendix 9J). Median Delta survival was 0.35 for Alternative 5 and 0.349 for the No Action Alternative.

*Changes in Delta Hydrodynamics*

Winter-run Chinook Salmon smolts are most abundant in the Delta during January, February and March. On the Sacramento River near the confluence of Georgiana Slough, the percent of positive velocities under Alternative 5 were indistinguishable from the No Action Alternative in January, February and March (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the percent of positive velocities was indistinguishable among these two scenarios. In Old River downstream of the facilities, the percent of positive velocities was indistinguishable in the months when winter run are present). On Old River upstream of the facilities, percent positive velocities were indistinguishable). On the San Joaquin River downstream of the Head of Old River, there was no discernable difference in the percent of positive velocities among these two scenarios.

*Changes in Junction Entrainment*

For all junctions examined, entrainment probabilities for both Alternative 5 and the No Action Alternative were almost indistinguishable (Appendix 9L).

*Changes in Salvage*

There were no discernable differences in predicted salvage between Alternative 5 and No Action Alternative (Appendix 9M).

#### *Changes in Oncorhynchus Bayesian Analysis Output*

Escapement and Delta survival was modeled by the OBAN model for winter-run Chinook salmon. Escapement was similar under Alternative 5 as compared to the No Action Alternative (Appendix 9I) as was through-Delta survival.

#### *Changes in Interactive Object-Oriented Simulation Output*

The IOS model predicted similar adult escapement trajectories for winter-run Chinook Salmon between Alternative 5 and the No Action Alternative across the 81 water years (Appendix 9H). Alternative 5 median adult escapement was 3,545 and No Action Alternative median escapement was 3,935.

Similar to adult escapement, the IOS model predicted similar egg survival time histories for winter-run Chinook Salmon between Alternative 5 and the No Action Alternative across the 81 water years (Appendix 9H). Median egg survival was 0.989 for Alternative 5 and 0.990 for the No Action Alternative.

#### *Summary of Effects on Winter-Run Chinook Salmon*

The analysis of temperatures suggested that the frequency of temperature threshold exceedance under Alternative 5 would remain similar to the No Action Alternative. This was reflected in Reclamation's salmon mortality model results, which showed minor reduction in the mortality in critical years. The analysis of flow changes under Alternative 5 suggested that availability of spawning habitat for winter-run Chinook Salmon is similar to the No Action Alternative, as also was indicated by similar potential production results from SALMOD. Through Delta survival of juvenile winter-run Chinook Salmon would be the same under both Alternative 5 and the No Action Alternative as indicated by the DPM results, and the OBAN results suggest that Delta survival would be similar. Median adult escapement to the Sacramento River would be similar under Alternative 5 compared to the No Action Alternative as indicated by the IOS and OBAN model results. Additional analyses attempting to assess the effects on routing, entrainment and salvage of juvenile salmonids in the Delta all indicate the effects would remain similar between Alternative 5 and the No Action Alternative.

Considering all the above analyses for the winter-run Chinook Salmon population, the changes in overall effects under Alternative 5 compared to No Action Alternative would remain similar.

### *Spring-run Chinook Salmon, Fall-run Chinook Salmon, Late Fall-run Chinook Salmon, Steelhead, Green Sturgeon and White Sturgeon*

#### *Changes in Water Temperature*

Average monthly water temperatures in the Sacramento River under Alternative 5 and the No Action Alternative would be relatively unchanged, with minor differences in some months and water year types of less than 0.2°F (Appendix 6B, Table B-5-3). Differences in the frequency of exceeding temperature thresholds under Alternative 5 and the No Action Alternative would be relatively small (differences less than 2 percent) for the spring-run, fall-run, and late fall-run Chinook Salmon, steelhead, and sturgeon in the Sacramento River (Appendix 9N).

In Clear Creek, average monthly water temperature at Igo under Alternative 5 relative to the No Action Alternative would be similar (differences less than 0.4°F) (Appendix 6B, Table B-3-3). The frequency of exceeding temperature thresholds for spring-run Chinook Salmon rearing also would be similar (differences of up to 1 percent) (Appendix 9N).

In the Feather River, average monthly water temperature at the low flow channel under Alternative 5 relative to the No Action Alternative would be similar (differences less than 0.2°F) (Appendix 6B, Table B-20-3). Water temperatures at the downstream location also would be similar. Changes in the frequency of exceeding temperature thresholds would be relatively small (differences of 2 percent or less) between the two scenarios for the fall-run Chinook Salmon, spring-run Chinook Salmon, steelhead, and Green Sturgeon.

In the American River at Watt Avenue, average monthly water temperature under Alternative 5 relative to the No Action Alternative would be similar (differences less than 0.5°F) (Appendix 6B, Table B-13-3). Changes in the frequency of exceeding temperature thresholds would be similar (differences of 1 percent or less) between the two scenarios for the fall-run Chinook Salmon and steelhead.

Egg mortality for fall-run Chinook Salmon within the Sacramento River system was predicted to be similar (less than 0.5 percent differences in the long-term average) under Alternative 5 compared to No Action Alternative, except in drier years (Appendix 9C, Tables B-1, B-6 and B-7). On the Sacramento River, mortality under Alternative 5 in critical years is predicted to increase by 0.6 percent, and in Feather River mortality increases by 2.3 percent in the below normal years, compared to No Action Alternative.

*Changes in SALMOD Output*

SALMOD results indicate that long-term annual production for fall-run, late fall-run, and spring-run Chinook Salmon would be essentially unchanged under Alternative 5 relative to the No Action Alternative (Appendix 9D).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81-year time period for spring-run, fall-run and late fall-run Chinook Salmon between Alternative 5 and the No Action Alternative (Appendix 9J).

*Changes in Delta Hydrodynamics*

As described in Appendix 9K, the percent of time that velocity was positive at various junctions in the Delta were projected to be similar under Alternative 5 compared to the No Action Alternative for fall-run, late fall-run, and spring-run Chinook Salmon, and steelhead.

*Changes in Junction Entrainment*

As described in Appendix 9L, entrainment at various junctions is indistinguishable or lower under Alternative 5 compared to the No Action Alternative for fall-run, late fall-run, spring-run and steelhead.

*Changes in Salvage*

As described in Appendix 9M, salvage of migrating spring-run, late-fall run and fall-run smolts is similar or better under Alternative 5 compared to the No Action Alternative.

*Summary of Effects on Spring-run Chinook Salmon, Fall-run Chinook Salmon, Late Fall-run Chinook Salmon, Steelhead, Green Sturgeon and White Sturgeon*

The analysis of temperatures indicates similar temperatures and likelihood of exceedance of temperature thresholds under Alternative 5 as compared to the No Action Alternative in the Clear Creek, and the Sacramento, Feather, and American rivers. This was reflected in Reclamation's salmon mortality model results for the fall-run on the Sacramento, Feather and American River which showed similar mortality results except in a small increase in critical dry years in the Sacramento River and in below normal years in the Feather River. There would be no change in flows in Clear Creek and Feather River low flow channel. Flows are expected to be similar in Sacramento River and American River. Flows in May in the Feather River are reduced (Appendix 5A). However, most of the spawning habitat in the Feather River is in the low flow channel; therefore, this reduction in May flow would only have minor effect on the availability of the habitat. SALMOD results indicate that the potential production for the fall-run, late fall-run and spring-run Chinook Salmon on the Sacramento River remain similar. Delta survival is expected to remain similar as indicated by the Delta Passage Model results, and the entrainment risk would be lower based on the expected changes in OMR flows under Alternative 5. Additional analyses attempting to assess the effects on routing, entrainment and salvage of juvenile salmonids in the Delta all indicate the effects would remain similar between Alternative 5 and the No Action Alternative.

Considering all the above analyses for the spring-run, fall-run, late-fall run Chinook Salmon, steelhead, Green Sturgeon, and White Sturgeon population, the changes in overall effects under Alternative 5 compared to No Action Alternative would remain similar.

*Delta Smelt*

A proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 5 will be nearly identical to the results estimated for the No Action Alternative (less than 0.02 percent different) in all water year types.

A proportional entrainment regression model (based on Kimmerer 2008) also was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 5 would be similar to that estimated for the No Action Alternative (estimated to be lower by less than 2 percent).

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. Results indicate that fall X2 values under Alternative 5 would be nearly identical to the No Action Alternative.

Overall, Alternative 5 likely would have similar effects on Delta Smelt with regard to estimated entrainment and predicted location of Fall X2, as the No Action Alternative.

*Longfin Smelt*

The effects of the Alternative 5 as compared to the No Action Alternative were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

OMR flows generally would be negative in all months under both scenarios, except in April and May when the long-term average would positive. Flows under Alternative 5 during these two months would be more positive than under the No Action Alternative, especially in dry and critical years when OMR flows under Alternative 5 would be positive and flows under the No Action Alternative would be negative. Differences in OMR flow during April and May under Alternative 5 would up to about 1,350 cfs more positive than under the No Action Alternative.

Longfin Smelt abundance index values were calculated for long-term average conditions and for each water year type for the different alternatives (see Appendix 9G). Under Alternative 5, Longfin Smelt abundance index values are higher compared to the No Action Alternative as shown in Appendix 9G, Table B-4. Under Alternative 5, Longfin Smelt abundance index values range from 1,204 under critical water year conditions to a high of 16,683 under wet water year conditions, with a long-term average value of 8,015 (Appendix 9G). Under the No Action Alternative, Longfin Smelt abundance index values range from 1,147 under critical water year conditions to a high of 16,635 under wet water year conditions, with a long-term average value of 7,951.

Results indicate that the Longfin Smelt abundance index values would be slightly higher in every water year type under Alternative 5 than they would be under the No Action Alternative, with a long-term average index for Alternative 5 that is less than 1 percent higher than the long-term average index for the No Action Alternative. For critical water years, the Longfin Smelt abundance index value would be about 5 percent higher under Alternative 5 than they would be under the No Action Alternative.

Overall, the slight decrease in magnitude of negative OMR flows and the relatively small differences in Longfin Smelt abundance index values suggest that Alternative 5 could be more likely than the No Action Alternative to positively affect conditions for Longfin Smelt. However, it is uncertain whether these effects would be biologically meaningful.

*Sacramento Splittail*

Under Alternative 5, flows entering the Yolo Bypass over the Fremont Weir generally would be similar to the No Action Alternative (Appendix 5A, Table C-26-3), thus providing similar value to Sacramento Splittail because of the similar area of potential habitat (inundation) and the similar frequency of inundation.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the No Action Alternative generally would result in similar reservoir storage in CVP and SWP reservoirs in the Central Valley Region (Appendix 5A). Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be similar under Alternative 5 as compared to the No Action Alternative. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

In general, black bass nesting success would be similar under Alternative 5 and the No Action Alternative (Appendix 9F). Nesting success of black bass would be high in March and April due to increasing water surface elevations. During May, the likelihood of high (>40 percent) nesting success would be similar to or slightly higher in most of the reservoirs under Alternative 5 as compared to the No Action Alternative. This pattern is reversed in June, with the likelihood of high nesting success being somewhat lower under Alternative 5 (Appendix 9F).

Overall, it is likely that the effects on black bass species would be similar under both Alternative 5 and the No Action Alternative.

*Other Species*

The minor differences in average monthly water temperatures and flows between Alternative 5 and the No action Alternative described above for salmonids apply to Pacific Lamprey, Striped Bass, American Shad, Hardhead, and other fish species in the Sacramento River system. These minor differences suggest that conditions for these species in the Sacramento River system generally would be similar under Alternative 5 and the No Action Alternative.

*Stanislaus River/Lower San Joaquin River*

*Fall-Run Chinook Salmon and Steelhead*

*Changes in Water Temperature*

Monthly average temperatures in the Stanislaus River at Goodwin under Alternative 5 would be similar (less than 0.5°F differences) to the No Action Alternative in most of the months and water years. In June through November months of dry years, temperatures under Alternative 5 could be higher by as much as 4°F compared to the No Action Alternative. This pattern in temperature changes under Alternative 5 were also predicted downstream at Orange Blossom Bridge. However, the differences are smaller at the San Joaquin River confluence.

Frequency of exceedance of temperature thresholds for steelhead adult migration in the fall months, steelhead smoltification thresholds in April and May at Knights Ferry, and steelhead rearing in summer and fall months are higher under (by up to 8 percent) Alternative 5 compared to the No Action Alternative. Frequency of exceedance of thresholds for steelhead spawning and smoltification at Orange Blossom Bridge in March through May are lower by up to 11 percent under Alternative 5 compared to the No Action Alternative.

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and November up to 3 percent more frequently under Alternative 5 compared to the No Action Alternative, in the Stanislaus River at Orange Blossom Bridge. During May and June, the 56°F threshold for fall-run rearing is exceeded less frequently (by up to 10 percent) under Alternative 5 compared to the No Action Alternative.

These changes in temperatures are reflected in Reclamation's salmon mortality model results for the fall-run Chinook Salmon in the Stanislaus River. As shown in Appendix 9C, the long-term average egg mortality rate is predicted to be around 8.5 percent, with higher mortality rates (in excess of 16 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality is predicted to be 1.5 percent higher under Alternative 5 compared to the No Action Alternative, and in the drier year egg mortality is predicted to be 2.5 percent higher under Alternative 5. However, these effects could be reduced by fish passage at New Melones Dam.

*Changes in Delta Hydrodynamics*

San Joaquin River-origin fall run Chinook salmon smolts are most abundant in the Delta during the months of April, May and June. San Joaquin River-origin steelhead generally move through the Delta during spring however there is less information on their timing relative to Chinook salmon. Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities was slightly higher under Alternative 5 relative to the No Action Alternative in April and almost indistinguishable in May and June (Appendix 9K). On Old River downstream of the facilities, the proportion of positive velocities was slightly higher in April and May and indistinguishable in June under Alternative 5 relative to No Action Alternative). In Old River upstream of the facilities, the percent of positive velocities was similar for Alternative 5 relative to No Action Alternative in all months). On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities was similar under Alternative 5 relative to No Action Alternative in April, May and June).

*Changes in Entrainment at Junctions*

At the Head of Old River junction, entrainment was slightly lower under Alternative 5 during April and May but was indistinguishable from No Action Alternative in June (Appendix 9L). At all other junctions with the San Joaquin River (Turner Cut, Columbia Cut, Middle River and Old River) entrainment under Alternative 5 was indistinguishable from No Action Alternative in all months).

*Summary of Effects on Fall-Run Chinook Salmon and Steelhead*

The analysis of temperatures indicates somewhat higher temperatures and a higher likelihood of exceedance of suitable temperatures for spawning, and lower likelihood of exceeding suitable temperature for rearing of fall-run Chinook Salmon under Alternative 5 as compared to the No Action Alternative in the Stanislaus River below Goodwin Dam. The effect of higher temperatures is reflected in the slightly higher overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model for fall-run Chinook Salmon in the Stanislaus River. The frequency of exceedance of temperature thresholds for steelhead smoltification and rearing would be more stressful under Alternative 5 compared to the No Action Alternative. However, with higher flows in April and May and lower temperatures in April and May under Alternative 5 may benefit steelhead spawning.

Overall, Alternative 5 likely would have adverse effects on the fall-run Chinook Salmon and steelhead population in the San Joaquin River watershed as compared to the No Action Alternative primarily because of higher water temperatures. However, these effects would be reduced due to fish passage at New Melones Reservoir.

*White Sturgeon*

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

*Reservoir Fishes*

Storage levels in New Melones Reservoir would be similar (within 5 percent) for Alternative 5 as compared to the No Action Alternative (Appendix 5A).

Results of the bass nesting success analysis indicate that for March, the likelihood of Largemouth Bass and Smallmouth Bass nest survival in New Melones generally being above 40 percent in most of the years simulated but the likelihood of high survival is 100 percent under both Alternative 5 and the No Action Alternative. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is predicted to be reasonably high but is substantially lower (about 13 percent) lower under Alternative 5 as compared to the No Action Alternative. For May, the difference between alternatives is less with the likelihood of high nest survival being about 5 percent less under Alternative 5. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is about 2 percent higher under Alternative 5 than under the No Action Alternative. For Spotted Bass, nest survival in March is anticipated to be near 100 percent in every year under both Alternative 5 and the No Action Alternative. The likelihood of survival being greater than 40 percent is high (greater than 90 percent) in April under both Alternative 5 and the No Action Alternative with the likelihood of greater than 40 percent survival being about 107 percent lower under Alternative 5 as compared to the No Action Alternative. For May and June, the likelihood of high Spotted Bass nest survival is lower (by up to 9 about 5 percent) under Alternative 5 as compared to the No Action Alternative. For June, Spotted Bass nest survival would be greater than 40 percent in every year under Alternative 5 as compared to approximately 98 percent of the years under the No Action Alternative.

Overall, the analysis suggests that conditions under Alternative 5 have the potential to adversely influence black bass nesting success, especially in April, by comparison to the No Action Alternative. However, nesting success in April under Alternative 5 would still exceed 40 percent, thus it is uncertain whether this difference would be biologically meaningful.

*Other Species*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River at Vernalis could affect other fishes such as lampreys, Hardhead, and Striped Bass.

Monthly average temperatures in the Stanislaus River at Goodwin under Alternative 5 would be similar (less than 0.5°F differences) to the No Action Alternative in most of the months and water years. In June through November months of dry years, temperatures under Alternative 5 could be higher by as much as 4°F compared to the No Action Alternative. This pattern in temperature changes under Alternative 5 were also predicted downstream at Orange Blossom Bridge. However, the differences are smaller at the San Joaquin River confluence.

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could adversely affect these larval lamprey. Given the similar or higher flows and similar or higher temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be greater under Alternative 5 compared to the No Action Alternative.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar flows and higher temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be somewhat greater under Alternative 5 compared to the No Action Alternative.

*San Francisco Bay Area Region*

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### 9.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison

As described in Chapter 3, Description of Alternatives, CVP and SWP operations under Alternative 5 are similar to the No Action Alternative with modified OMR flow criteria and New Melones Reservoir operations. Therefore, the comparison of Alternative 5 to the Second Basis of Comparison would be similar to the comparison of No Action Alternative to Second Basis of Comparison described above in Section 9.4.4.1, No Action Alternative.

*Trinity River Region*

*Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead, and Green Sturgeon*

Monthly water temperature in the Trinity River at Lewiston Dam under Alternative 5 generally would be similar (less than 0.5°F differences) to the temperatures that would occur under the Second Basis of Comparison (Appendix 6B, Table B-1-6), with the exception of drier years when temperatures under Alternative 5 could be as much as 2.2°F cooler in November and 1.5°F in December. Average monthly water temperatures could be slightly (up to 0.6°F) higher under Alternative 5 during July and August and lower (up to 0.7°F) in September. Lower September temperatures under Alternative 5 may result in slightly better conditions than the Second Basis of Comparison for spring-run Chinook Salmon spawning. Similarly, temperature conditions under Alternative 5 could be slightly better than the Second Basis of Comparison for fall-run Chinook Salmon spawning because of the reduced temperatures in November during critical dry years.

Under Alternative 5, water temperature thresholds for Coho Salmon, fall-run Chinook Salmon, and steelhead would be exceeded slightly more frequently (less than 1 percent), whereas thresholds for spring-run Chinook Salmon would be exceeded less frequently (up to 4 percent) in August in September (Appendix 9N).

These temperature results are reflected in the egg mortality results for fall-run Chinook Salmon, which indicate slightly higher mortality under Alternative 5 compared to the Second Basis of Comparison, with differences less than 0.3 percent in most year types and 1.9 percent in critical years (Appendix 9C, Table B-5).

The minor changes in water temperatures and mortality suggest that conditions for Coho Salmon, fall-run Chinook Salmon, steelhead, and Green Sturgeon in the Trinity River would be similar under both Alternative 5 and the Second Basis of Comparison. However, the reduced threshold exceedances for spring-run Chinook Salmon under Alternative 5, although small, could be biologically meaningful under some conditions.

*Reservoir Fishes*

The analysis of effects associated with changes in operation on reservoir fishes relied on evaluation of changes in available habitat (reservoir storage) and anticipated changes in black bass nesting success.

Storage levels in New Melones Reservoir would be lower under Alternative 5 as compared to the Second Basis of Comparison (Appendix 5A), especially in critical years when the difference could be as much as 23 percent. Using storage volume as an indicator of available availability for fish species inhabiting these reservoirs, these results suggest that the amount of habitat for reservoir fishes could be decreased under Alternative 5 as compared to the Second Basis of Comparison.

Black bass species in Trinity Lake would be exposed to minor differences in storage under both Alternative 5 and the Second Basis of Comparison, and these relatively small differences would have negligible effect on nest survival. The nest survival under Alternative 5 would be generally similar to Second Basis of Comparison for Largemouth Bass, Smallmouth Bass, and Spotted Bass (Appendix 9F). These negligible differences in nest survival suggest that conditions for reservoir species in Trinity Lake would be similar under Alternative 5 and the Second Basis of Comparison.

*Other Species*

The minor differences in average monthly water temperatures described above for salmonids apply to Pacific Lamprey, Eulachon, and other aquatic species in the Trinity River. These minor differences suggest that conditions for aquatic species in the Trinity River and Klamath River downstream of the confluence generally would be similar under Alternative 5 and the Second Basis of Comparison.

*Sacramento River System*

*Winter-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect winter-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative 5 and the Second Basis of Comparison generally would be similar (within about 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years (Appendix 6B). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures 5 in September progressively decreasing (up to 2.8°F at Bend Bridge) in September during the wetter years (Appendix 6B).

*Changes in Exceedances of Water Temperature Thresholds*

With the exception of April, average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Ball's Ferry for winter-run Chinook Salmon spawning and egg incubation in every month, with exceedances under both as high as about 41 percent and 54 percent, respectively, in some months (Appendix 9N). Under Alternative 5, the temperature threshold generally would be exceeded more frequently than under the Second Basis of Comparison (by about 1 percent to 3 percent) in the April through August period, with the temperature threshold in September exceeded about 11 percent less frequently under Alternative 5 than under the Second Basis of Comparison. Farther downstream at Bend Bridge, the frequency of exceedances would increase, with exceedances under both Alternative 5 and the Second Basis of Comparison as high as about 90 percent in some months. Under Alternative 5, temperature exceedances generally would be more frequent (by up to 10 percent) than under the Second Basis of Comparison, with the exception of September, when exceedances under Alternative 5 would be about 30 percent less frequent.

*Changes in Egg Mortality*

The temperatures described above for the Sacramento River below Keswick Dam are reflected in the analysis of egg mortality using the Reclamation Salmon Survival Model (Appendix 9C). For winter-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively low (around 5 percent), with higher mortality rates (exceeding 20 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality would be 0.3 percent higher under Alternative 5; in critical dry years the average egg mortality rate would be about 3 percent greater than under the Second Basis of Comparison (Appendix 9C, Table B-4).

*Changes in Weighted Usable Area*

As an indicator of the amount of suitable spawning habitat for winter-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be greater amounts of spawning habitat available from May through September under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9E, Table C-17-6). The increase in long-term average spawning WUA during these months would be relatively small (less than 5 percent), with smaller (less than 1 percent) increases in May and July. There would be a reduction in the long-term average spawning WUA in April, but this reduction is small (less than 1 percent) and would occur prior to the peak spawning period in May and June. Overall, spawning habitat availability would be similar under Alternative 5 and the Second Basis of Comparison.

Modeling results indicate that, in general, there would be reduced amounts of suitable fry rearing habitat available from June through October under Alternative 5 (Appendix 9E, Table C-18-6). The decrease in long-term average fry rearing WUA during these months would be relatively small (less than 5 percent), with smaller (less than 1 percent) increases in July and September. There would be an increase in the long-term average fry rearing WUA in September, but this reduction would be small (less than 5 percent) and would occur at a time when most fry have grown into juveniles and moved into habitats with different depth and velocity characteristics as reflected in the analysis of juvenile rearing WUA below. Overall, fry rearing habitat availability would be similar under Alternative 5 and the Second Basis of Comparison.

Similar to the results for fry rearing WUA, modeling results indicate that there would be reduced amounts of suitable juvenile rearing habitat available during the early juvenile rearing period from September through December under Alternative 5. There would be an increase in the long-term average juvenile rearing WUA from January through August (Appendix 9E, Table C-19-6). The decreases in long-term average juvenile rearing WUA would be relatively small (less than 5 percent), while the increases would be smaller (less than 1 percent). Overall, juvenile rearing habitat availability would be similar under Alternative 5 and the Second Basis of Comparison.

*Changes in SALMOD Output*

SALMOD results indicate that flow-related winter-run Chinook Salmon egg mortality would be reduced by 41 percent under Alternative 5 compared to the Second Basis of Comparison. Conversely, temperature-related egg mortality would be 6 percent higher under Alternative 5 (Appendix 9D, Table B-4-29). Both temperature- and flow (habitat)-related fry mortality would be up to 34 percent higher under Alternative 5 as compared to the Second Basis of Comparison. Temperature-related juvenile mortality would be approximately 31 percent higher under Alternative 5, while flow (habitat)-related mortality would be approximately 17 percent lower under Alternative 5 as compared to the Second Basis of Comparison. Overall, potential juvenile production would be the same under Alternative 5 and the Second Basis of Comparison (Appendix 9D, Table B-4-26).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for winter-run Chinook Salmon between Alternative 5 and the Second Basis of Comparison Alternative (Appendix 9J). Median Delta survival was 0.350 for Alternative 5 and 0.352 for the Second Basis of Comparison Alternative. Overall, there would be little change in through-Delta survival for emigrating juvenile winter-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Winter run smolts are most abundant in the Delta during the months of January February and March. On the Sacramento River near the confluence of Georgiana Slough, the percentage of positive velocity under Alternative 5 was moderately lower relative to the Second Basis of Comparison in January and indistinguishable in February and March (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the percent of positive velocities was slightly greater under Alternative 5 relative to Second Basis of Comparison in January and February and indistinguishable in March. In Old River downstream of the facilities, the percent of positive velocities was considerably higher under Alternative 5 during January and moderately higher in February. Values in March were almost indistinguishable between scenarios. On Old River upstream of the facilities, percent positive velocities were moderately lower in January and slightly lower in February and March under Alternative 5 relative to Second Basis of Comparison. On the San Joaquin River downstream of Head of Old River, the percent of positive velocities was similar for both scenarios in January, February and March.

*Changes in Junction Entrainment*

At the junction of Georgiana Slough and the Sacramento River, entrainment under Alternative 5 was slightly lower than Second Basis of Comparison in January but essentially indistinguishable in February and March (Appendix 9L). Entrainment at the Head of Old River junction was moderately lower under Alternative 5 relative to Second Basis of Comparison during the period of winter run migration through the Delta (January, February, March). For the Turner Cut junction, entrainment under Alternative 5 was moderately lower in January and February relative to Second Basis of Comparison. In March, the difference in entrainment between scenarios was similar. Similar patterns between Alternative 5 and Second Basis of Comparison were observed at the Columbia Cut, Middle River and Old River junctions. At these junctions, entrainment was moderately lower under Alternative 5 during January and February and values became more similar in March.

*Changes in Salvage*

Salvage of winter-run Chinook salmon is predicted to be considerably lower under Alternative 5 relative to the Second Basis of Comparison in January and February (Appendix 9M). In March, predicted salvage was only moderately lower under Alternative 5 relative to Second Basis of Comparison.

*Changes in Oncorhynchus Bayesian Analysis Output*

Escapement of winter-run Chinook Salmon and Delta survival was modeled by the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook salmon. Escapement was generally higher under Alternative 5 as compared to the Second Basis alternative (Appendix 9I). The median abundance under Alternative 5 was higher the Second Basis of Comparison. Median delta survival was approximately 15 percent higher under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in Interactive Object-Oriented Simulation Output*

The IOS model predicted similar adult escapement trajectories for Winter-Run Chinook salmon between Alternative 5 and the Second Basis of Comparison Alternative across the 81 water years (Appendix 9H). Alternative 5 median adult escapement was 3,545 and Second Basis of Comparison Alternative median escapement was 4,042).

Similar to adult escapement, the IOS model predicted similar egg survival time histories for Winter-Run Chinook salmon between Alternative 5 and the Second Basis of Comparison Alternative across the 81 water years (Appendix 9H). Median egg survival was 0.989 for Alternative 5 and 0.987 for the Second Basis of Comparison Alternative).

*Summary of Effects on Winter-Run Chinook Salmon*

The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison. This is reflected in the slightly lower survival of winter-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model. Flow changes under Alternative 5 would have small effects on the availability of spawning and rearing habitat for winter-run Chinook Salmon as indicated by the decrease in flow (habitat)-related mortality predicted by SALMOD under Alternative 5. Through Delta survival of juvenile winter-run Chinook Salmon would be the same under both Alternative 5 and Second Basis of Comparison as indicated by the DPM results; and the OBAN results suggest that Delta survival could be higher under Alternative 5. Entrainment may also be reduced under Alternative 5 as indicated by the OMR flow analysis. Median adult escapement to the Sacramento River would be reduced slightly under Alternative 5 as indicated by the IOS model results which incorporate temperature, flow, and mortality effects on each life stage over the entire life cycle of winter-run Chinook Salmon. However, the OBAN model results indicate an increase in escapement over a more limited time period (1971 to 2002). Considering all the above analyses for the winter-run Chinook Salmon population, the changes in overall effects under Alternative 5 compared to Second Basis of Comparison are highly uncertain. However, the upstream fish passage included under Alternative 5 could benefit the winter-run Chinook Salmon population in the Sacramento River as compared to the Second Basis of Comparison if successful.

### *Spring-run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, and Feather River downstream of Oroville Dam could affect spring-run Chinook Salmon. The following describes those changes and their potential effects.

#### *Changes in Water Temperature*

Changes in water temperature that could affect spring-run Chinook Salmon could occur in the Sacramento River, Clear Creek, and Feather River. The following describes temperature conditions in those water bodies.

##### *Sacramento River*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (within about 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. Alternative A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences in November, June, and September (in drier years) progressively increasing by up to 0.7°F at Red Bluff under Alternative 5 relative to the Second Basis of Comparison and progressively decreasing (up to 3.2°F at Red Bluff) in September during the wetter years (Appendix 6B, Table B-9-6).

##### *Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative relative to the Second Basis of Comparison are generally predicted to be similar (less than 0.5°F differences) from September through April and June through August (Appendix 6B, Table B-3-6). Average monthly water temperatures during May under Alternative 5 would be lower by 0.1°F to 0.8°F than under the Second Basis of Comparison in all water year types. The lower water temperatures in May associated with Alternative 5 reflect the effects of additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into the creek. While the reduction in May water temperatures indicated by the modeling could improve thermal conditions for spring-run Chinook Salmon, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide biologically meaningful temperature benefits.

##### *Feather River*

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences), but slightly higher (0.6°F) during December and slightly lower (0.6°F) in September. Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years (Appendix 6B, Table B-20-6) under Alternative 5. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento River (Appendix 6B, Table B-23-6). Water temperatures under Alternative 5 are somewhat (0.5°F to 1.8°F) cooler on average and up to 3.9°F cooler at the confluence with Sacramento River from July to September in wetter years.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for spring-run Chinook Salmon in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would show exceedances of the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for spring-run Chinook Salmon (egg incubation) in October, November, and again in April. The exceedances would occur at the greatest frequency in October, with 80 percent and 79 percent for Alternative 5 and Second Basis of Comparison, respectively. Temperature thresholds would be exceeded less frequently in November (7 percent) and not exceeded at all during December through March. As water temperatures warm in the spring, the thresholds would be exceeded in April by 14 percent and 13 percent under Alternative 5 and Second Basis of Comparison. In the warmer months when exceedances occur (October, November, and April), temperature thresholds generally would be exceeded more frequently (by up to 2 percent in October) under Alternative 5 than under the Second Basis of Comparison (Appendix 9N, Table 9N.B.1).

*Clear Creek*

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would not exceed the water temperature threshold of 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in June through August. However, Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established for spawning in September and October about 10 percent to 15 percent of the time. The differences between Alternative 5 and Second Basis of Comparison could be biologically meaningful, with Alternative 5 exceeding thresholds about 1 percent more frequently than under the Second Basis of Comparison in September and about 2 percent more frequently in October (Appendix 9N).

*Feather River*

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg incubation and rearing (Appendix 9N) during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently. The frequency of exceedance was highest (about 98 percent) in October, a month in which average monthly water could get as high as about 68°F. However, the differences in the frequency of exceedances between Alternative 5 and Second Basis of Comparison could be biologically meaningful. Water temperatures under Alternative 5 would exceed temperature thresholds less than 2 percent more frequently than the Second Basis of Comparison in October, November, and December, and about 1 percent less frequently in March. The established water temperature threshold of 63°F for rearing during May through August would be exceeded often under both Alternative 5 and Second Basis of Comparison in May (57 percent and 51 percent, respectively) and June (97 percent for both), but not at all in July and August.

*Changes in Egg Mortality*

These temperature differences described above are reflected in the analysis of egg mortality using the Reclamation salmon mortality model (Appendix 9C). For spring-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be relatively high (exceeding 20 percent), with high mortality rates (exceeding 80 percent) occurring in critical dry years. Overall, egg mortality would be 0.8 percent higher under Alternative 5; in critical dry years the average egg mortality rate would be 13.1 percent greater under Alternative 5 than under the Second Basis of Comparison (Appendix 9C, Table B-3).

*Changes in Weighted Usable Area*

Weighted usable area curves are available for spring-run Chinook Salmon in Clear Creek. As described above, flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in SALMOD Output*

SALMOD results indicate that pre-spawning mortality of spring-run Chinook Salmon eggs would be approximately 15 percent greater under Alternative 5, primarily due to increased summer temperatures. Flow-related spring-run Chinook Salmon egg mortality would be reduced by 20 percent under Alternative 5 compared to the Second Basis of Comparison. Conversely, temperature-related egg mortality would be 16 percent higher under Alternative 5 (Appendix 9D, Table B-3-29). Flow (habitat)-related fry mortality would be approximately 3 percent lower under Alternative 5 as compared to the Second Basis of Comparison. There would be no temperature- or flow (habitat)-related juvenile mortality under either alternative, as most spring-run Chinook Salmon juveniles have migrated downstream as fry and are not found in the mainstem Sacramento River. Overall, potential spring-run juvenile production would be slightly (approximately 2 percent) lower under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9D).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for spring-run between Alternative 5 and the Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.296 for Alternative 5 and 0.286 for the Second Basis of Comparison. Overall, there would be little change in through-Delta survival by emigrating juvenile spring-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Spring run Chinook salmon are most abundant in the Delta from March through May. Near the junction of Georgiana Slough (channel 421), the percent of time that velocity was positive was similar in March, slightly lower in April and moderately lower in May under Alternative 5 relative to the Second Basis of Comparison (Appendix 9K). Near the confluence of the San Joaquin River and the Mokelumne River (channel 45), percent positive velocity was almost identical in March and moderately higher under Alternative 5 relative to Second Basis of Comparison in April and May. In the San Joaquin River downstream of the Head of Old River (channel 21) the percent of positive velocities was considerably higher under Alternative 5 relative to Second Basis of Comparison in April and May whereas there was little variation among scenarios in March. In Old River upstream of the facilities (channel 212) percent positive velocity was moderately lower in April and May under Alternative 5 relative to Second Basis of Comparison and more similar to each other in March. In Old River downstream of the facilities (channel 94), percent positive velocity was substantially higher under Alternative 5 relative to Second Basis of Comparison in April and May and more similar to each other in March.

*Changes in Junction Entrainment*

At the junction of Georgiana Slough and the Sacramento River, entrainment under Alternative 5 was slightly lower than Second Basis of Comparison in April but essentially indistinguishable in all other months (Appendix 9L). Entrainment at the Head of Old River junction was substantially higher under Alternative 5 relative to Second Basis of Comparison during the months of April and May and slightly lower in June. For the Turner Cut junction, entrainment under Alternative 5 was moderately lower in April and May relative to Second Basis of Comparison and more similar in March. At the Columbia Cut, Middle River and Old River junctions, entrainment under Alternative 5 was slightly lower than Second Basis of Comparison in March and became moderately to considerably lower in April and May.

*Changes in Salvage*

Salvage of spring run Chinook salmon was predicted to be substantially lower under Alternative 5 relative the Second Basis of Comparison during April and May and only slightly lower in the month of March (Appendix 9M).

*Summary of Effects on Spring-Run Chinook Salmon*

The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison in the Sacramento and Feather rivers. There would be little change in flows or temperatures in Clear Creek under Alternative 5 relative to the Second Basis of Comparison. The effect of increased temperatures is reflected in the slightly lower overall survival of spring-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model for spring-run in the Sacramento River. In drier years, the likelihood of adverse temperature effects would be increased under Alternative 5 as compared to the Second Basis of Comparison. Flow changes under Alternative 5 would likely have small effects on the availability of spawning and rearing habitat for spring-run Chinook Salmon in the Sacramento River as indicated by the decrease in flow (habitat)-related mortality predicted by SALMOD under Alternative 5. Through Delta survival of juvenile spring-run Chinook Salmon would be the same under both Alternative 5 and Second Basis of Comparison as indicated by the DPM results and entrainment could be reduced as indicated by the salvage analysis. Overall, Alternative 5 likely would have similar or somewhat greater adverse effects on the spring-run Chinook Salmon population in the Sacramento River watershed as compared to the Second Basis of Comparison, particularly in drier water year types. However, given that most of the spring-run Chinook Salmon are on the tributaries where the effects of changes in Alternative 5 operations are minimal and that Alternative 5 includes the fish passage actions, which are not included in the Second Basis of Comparison, it is unlikely that Alternative 5 would result in adverse effects in comparison with the Second Basis of Comparison.

*Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam, Clear Creek downstream of Whiskeytown Dam, Feather River downstream of Oroville Dam and American River below Nimbus could affect fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect fall-run Chinook Salmon in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (within about 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures in June at Knights

Landing progressively increasing (up to 0.9°F) under Alternative 5 relative to the Second Basis of Comparison and progressively decreasing (up to 4.6°F) in September during the wetter years.

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative relative to the Second Basis of Comparison are generally predicted to be similar (less than 0.5°F differences) from September through April and June through August (Appendix 6B, Table B-3-6). Average monthly water temperatures during May under Alternative 5 would be lower by 0.1°F to 0.8°F than under the Second Basis of Comparison in all water year types. The lower water temperatures in May associated with Alternative 5 reflect the effects of additional water discharged from Whiskeytown Dam to meet the spring attraction flow requirements to promote attraction of spring-run Chinook Salmon into the creek. While the reduction in May water temperatures indicated by the modeling could improve thermal conditions for fall-run Chinook Salmon, the duration of the two pulse flows may not be of sufficient duration (3 days each) to provide biologically meaningful temperature benefits.

*Feather River*

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences), but slightly higher (0.6°F) during December and slightly lower (0.6°F) in September. Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento River (Appendix 6B, Table B-23-6). Water temperatures under Alternative 5 are somewhat (0.5°F to 1.8°F) cooler on average and up to 3.9°F cooler at the confluence with Sacramento River from July to September in wetter years.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 5 generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August, when temperatures under Alternative 5 could be as much as 0.9°F higher. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 5 would be up to 1.6°F and 2.1°F greater, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth under Alternative 5 generally would be lower than under the Second Basis of Comparison in September, especially in wetter water year types when water temperatures under Alternative 5 could be up to 1.7°F cooler.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of water temperatures that are protective of fall-run Chinook Salmon in the Sacramento River, Clear Creek, Feather River, and American River. The following describes the extent of those exceedances for each of those water bodies.

*Sacramento River*

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Sacramento River at Red Bluff for fall-run Chinook Salmon spawning and egg incubation (Table temperature targets) during some months, particularly in October, November, and April, when temperature thresholds would be exceeded. The frequency of exceedance would be greatest in October, a month in which average monthly water temperature could get as high as about 64°F. In October, average monthly water temperatures under Alternative 5 and Second Basis of Comparison would exceed the threshold 82 percent and 79 percent of the time, respectively. The differences in the frequency of exceedances between Alternative 5 and Second Basis of Comparison could be biologically meaningful. Water temperatures under Alternative 5 would exceed temperature thresholds about 2 percent more frequently than under the Second Basis of Comparison in October, 1 percent less frequently in November, and 1 percent more frequently in April.

*Clear Creek*

Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during October through December (USFWS 2015). Average monthly water temperatures at Igo during this period generally would be below 56°F, except in October. Under Alternative 5, the 56°F threshold would be exceeded in October about 12 percent of the time as compared to 10 percent under the Second Basis of Comparison. At the confluence with the Sacramento River, average monthly water temperatures in October would be warmer, with 56°F exceeded nearly 20 percent of the time under Alternative 5 and slightly (about 8 percent) less frequently under the Second Basis of Comparison. During November and December, average monthly water temperatures generally would remain below 56°F at both locations.

For fall-run Chinook Salmon rearing (January through September), the exceedances described previously for spring-run Chinook Salmon would apply, with the average monthly temperatures remaining below the 60°F threshold except in September when temperatures could increase to over 60°F. During September, water temperatures under Alternative 5 would exceed 56°F about 3 percent more frequently than under the Second Basis of Comparison. Downstream at the mouth, the average monthly temperatures would exceed 56°F more frequently, especially in July and August, when it always would be exceeded and average monthly temperatures would approach 64°F under both scenarios in September. Alternative 5

Under Alternative 5, temperature conditions at Igo would be slightly warmer than under the Second Basis of Comparison. Average monthly water temperatures likely mask daily temperatures excursions that could exceed important thresholds. Therefore, while the differences in threshold exceedance are relatively minor, the likelihood of adverse effects on fall-run Chinook Salmon under Alternative 5 would likely be greater than under the Second Basis of Comparison.

*Feather River*

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and egg incubation during some months, particularly in October, November, March, and April, when temperature thresholds would be exceeded frequently (Appendix 9N). The frequency of exceedance would be greatest in October, when average monthly temperatures under both Alternative 5 and Second Basis of Comparison would be above the threshold in nearly every year. The magnitude of the exceedances would be high as well, with average monthly temperatures in October reaching about 68°F. Similarly, the threshold would be exceeded under both Alternative 5 and the Second Basis of Comparison about 85 percent of the time in April. The differences between Alternative 5 and Second Basis of Comparison, could be biologically meaningful, with water temperatures under Alternative 5 generally exceeding temperature thresholds about 1-2 percent more frequently than the Second Basis of Comparison during the October through April period.

*Changes in Egg Mortality*

Water temperatures influence the viability of incubating fall-run Chinook Salmon eggs. The following describes the differences in egg mortality for the Sacramento, Feather, and American rivers.

*Sacramento River*

For fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to be around 17 percent, with higher mortality rates (in excess of 35 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality would be 0.2 percent lower under Alternative 5; in critical dry years the average egg mortality rate would be 3.0 percent greater than under the Second Basis of Comparison (Appendix 9C, Table B-1).

*Feather River*

For fall-run Chinook Salmon in the Feather River, the long-term average egg mortality rate is predicted to be relatively low (around 7 percent), with higher mortality rates (around 14 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality would be 0.1 percent higher under Alternative 5; in critical dry years the average egg mortality rate would be 3.6 percent lower than under the Second Basis of Comparison (Appendix 9C, Table B-7).

*American River*

For fall-run Chinook Salmon in the American River, the long-term average egg mortality rate is predicted to range from approximately 23 to 25 percent in all water year types under Alternative 5. Overall, egg mortality would be 0.1 percent lower under Alternative 5; in below normal water years the average egg mortality rate would be 1 percent greater than under the Second Basis of Comparison. In other water year types, egg mortality is predicted to be from 0.1 to 0.6 percent lower under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9C, Table B-6).

*Changes in Weighted Usable Area*

Weighted usable area, which is influenced by flow, is a measure of habitat suitability. The following describes changes in WUA for fall-run Chinook Salmon in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

As an indicator of the amount of suitable spawning habitat for fall-run Chinook Salmon between Keswick Dam and Battle Creek, modeling results indicate that, in general, there would be lesser amounts of spawning habitat available from September through November under Alternative 5 as compared to the Second Basis of Comparison; fall-run spawning WUA would be slightly (less than 5 percent) increased in December, but this is after the peak spawning period for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-11-6). The decrease in long-term average spawning WUA during September (prior to the peak spawning period) would be relatively large (more than 20 percent), with smaller decreases in October (around 2 percent) and November (around 6 percent) which comprise the peak spawning period for fall-run Chinook Salmon. Results for the reach from Battle Creek to Deer Creek show the same pattern in changes in WUA for spawning fall-run Chinook Salmon between Alternative 5 and the Second Basis of Comparison (Appendix 9E, Table C-10-6). Overall, spawning habitat availability would be slightly lower under Alternative 5 relative to the Second Basis of Comparison.

Modeling results indicate that, in general, there would be increased amounts of suitable fry rearing habitat available from December to March under Alternative 5 (Appendix 9E, Table C-12-6). The increase in long-term average fry rearing WUA during these months would be relatively small (less than 1 percent). Overall, fry rearing habitat availability would be similar under Alternative 5 and the Second Basis of Comparison.

Similar to the results for fry rearing WUA, modeling results indicate that, there would be increased amounts of suitable juvenile rearing habitat available during the early juvenile rearing period from February to April, but this increase would be small (less than 1 percent) under Alternative 5. There would a somewhat larger increase (around 3 percent) in the long-term average juvenile rearing WUA during May and June (Appendix 9E, Table C-13-6). Overall, juvenile rearing habitat availability would be similar under Alternative 5 and the Second Basis of Comparison.

*Clear Creek*

As described above, flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison.

*Feather River*

As described above, Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison. The majority of spawning activity by fall-run Chinook Salmon in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be lesser amounts of spawning habitat available in September, November, and December under Alternative 5 as compared to the Second Basis of Comparison; fall-run spawning WUA would be slightly (less than 5 percent) increased in October (the peak spawning month) for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-24-6). The decrease in long-term average spawning WUA during September (prior to the peak spawning period) would be relatively large (more than 15 percent), with smaller decreases in November and December (less than 1 percent) which are after the peak spawning period for fall-run Chinook Salmon. Overall, spawning habitat availability would be slightly lower under Alternative 5 relative to the Second Basis of Comparison.

*American River*

Modeling results indicate that, in general, there would be greater amounts of spawning habitat available for fall-run Chinook Salmon in the American River from October through December under Alternative 5 as compared to the Second Basis of Comparison; fall-run spawning WUA would be slightly (less than 5 percent) increased in December with less than 1 percent increases in September (prior to the peak spawning period) and October (the peak spawning month) (Appendix 9E, Table C-25-6). Overall, spawning habitat availability would be similar under Alternative 5 and the Second Basis of Comparison.

*Changes in SALMOD Output*

SALMOD results indicate that pre-spawning mortality of fall-run Chinook Salmon eggs would be approximately 12 percent greater under Alternative 5, primarily due to increased summer temperatures. Flow-related fall-run Chinook Salmon egg mortality would be reduced by 7 percent under Alternative 5 compared to the Second Basis of Comparison. Conversely, temperature-related egg mortality would be 39 percent higher under Alternative 5 (Appendix 9D, Table B-1-29). Flow (habitat)-related fry mortality would be approximately

1 percent lower under Alternative 5 as compared to the Second Basis of Comparison. Temperature-related juvenile mortality would be approximately 24 percent higher under Alternative 5, while flow (habitat)-related mortality would be approximately 2 percent lower under Alternative 5 as compared to the Second Basis of Comparison. Overall, potential fall-run juvenile production would be slightly (approximately 1 percent) lower under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9D, Table B-1-26).

*Changes in Delta Passage Model Output*

The Delta Passage Model predicted similar estimates of annual Delta survival across the 81 water year time period for Fall-run between Alternative 5 and the Second Basis of Comparison Alternative (Appendix 9J). Median Delta survival was 0.248 for Alternative 5 and 0.245 for the Second Basis of Comparison. Overall, there would be little change in through-Delta survival by emigrating juvenile fall-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Fall run Chinook salmon smolts are most abundant in the Delta during the months of April, May and June. At the junction of Georgiana Slough and the Sacramento River, percent positive velocity was considerably lower under Alternative 5 relative to the Second Basis of Comparison in May and June (Appendix 9K). Estimates for Alternative 5 were only slightly lower in April. Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities was considerably higher under Alternative 5 relative to Second Basis of Comparison in April and May whereas values in June were similar among the alternatives. On Old River downstream of the facilities, the proportion of positive velocities was considerably higher in April and May and moderately higher in June under Alternative 5 relative to Second Basis of Comparison. In Old River upstream of the facilities, the percent of positive velocities was moderately higher under Alternative 5 April and May and moderately lower in June. On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities was considerably lower under Alternative 5 relative to Second Basis of Comparison in April, May and slightly lower in June.

*Changes in Junction Entrainment*

At the junction of Georgiana Slough and the Sacramento River, entrainment under Alternative 5 was slightly lower than the Second Basis of Comparison in June but essentially indistinguishable in all other months (Appendix 9L). Entrainment at the Head of Old River junction was considerably higher under Alternative 5 relative to Second Basis of Comparison during the months of April and May and essentially the same in June. For the Turner Cut junction, entrainment under Alternative 5 was substantially lower in April and May relative to Second Basis of Comparison. Entrainment was lower in June as well but the magnitude of the difference was smaller. At the Columbia Cut junction, entrainment under Alternative 5 was almost indistinguishable from Second Basis of Comparison in June. Entrainment became considerably lower under Alternative 5 relative to Second Basis of Comparison in April and May. A similar pattern of entrainment under Alternative 5 relative to Second Basis of Comparison was observed at the Middle River and Old River junctions.

*Changes in Salvage*

Salvage of Sacramento River-origin fall run was predicted to be considerably lower under Alternative 5 relative to the Second Basis of Comparison in April and May (Appendix 9M). During the month of June, salvage was still lower under Alternative 5 but the magnitude of the variation relative to Second Basis of Comparison was less.

*Summary of Effects on Fall-Run Chinook Salmon*

The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison in the Sacramento and Feather rivers. There would be little change in flows or temperatures in Clear Creek under Alternative 5 relative to the Second Basis of Comparison, but as described above, these differences might not be biologically meaningful because the temperature outputs represent conditions at Igo, a location upstream of most fall-run Chinook Salmon spawning and rearing. The effect of increased temperatures is reflected in the slightly lower overall survival of fall-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model for fall-run in the Feather and American rivers. In drier years, the likelihood of adverse temperature effects would be increased under Alternative 5 as compared to the Second Basis of Comparison.

Flow changes under Alternative 5 would likely have small effects on the availability of spawning and rearing habitat for fall-run Chinook Salmon in the Sacramento River as indicated by the slight decrease in spawning WUA in the Sacramento and Feather Rivers and slight increases in spawning WUA for fall-run Chinook Salmon in the American River. Fry and juvenile rearing WUA would be increased slightly in the Sacramento River and this is reflected in a decrease in flow (habitat)-related mortality predicted by SALMOD under Alternative 5.

Through-Delta survival of juvenile fall-run Chinook Salmon would be similar under both Alternative 5 and Second Basis of Comparison as indicated by the DPM results and entrainment could be reduced as indicated by the OMR flow analysis. Overall, Alternative 5 likely would have similar or slightly greater adverse effects on the fall-run Chinook Salmon population in the Sacramento River watershed as compared to the Second Basis of Comparison, particularly in drier water year types. However, given that Alternative 5 includes fish passage actions, which are not included in the Second Basis of Comparison, it is unlikely that Alternative 5 would result in adverse effects in comparison with the Second Basis of Comparison.

*Late Fall-Run Chinook Salmon*

Changes in operations that influence temperature and flow conditions in the Sacramento River downstream of Keswick Dam could affect late fall-run Chinook Salmon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (within about 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperatures in November, June, and September (in drier years) progressively increasing by as much as 0.8°F at Red Bluff under Alternative 5 relative to the Second Basis of Comparison and progressively decreasing (up to 3.2°F at Red Bluff) in September during the wetter years.

*Changes in Exceedances of Water Temperature Thresholds*

Average monthly water temperatures under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 56°F established in the Sacramento River at Red Bluff (Table temperature targets) during some months, particularly in October, November, and April, when temperature thresholds would be exceeded. The frequency of exceedance would be greatest in October, a month in which average monthly water could get as high as about 64°F. In October, average monthly water temperatures under Alternative 5 and Second Basis of Comparison would exceed the threshold 82 percent and 79 percent of the time, respectively. However, the differences in the frequency of exceedances between Alternative 5 and Second Basis of Comparison could be biologically meaningful. Water temperatures under Alternative 5 would exceed temperature thresholds about 2 percent more frequently than under the Second Basis of Comparison in October, 1 percent less frequently in November, and 1 percent more frequently in April.

*Changes in Egg Mortality*

For late fall-run Chinook Salmon in the Sacramento River, the long-term average egg mortality rate is predicted to range from approximately 2.4 to nearly 5 percent in all water year types under Alternative 5. Overall, egg mortality would be 0.4 percent higher under Alternative 5; in below normal water years the average egg mortality rate would be 0.1 percent lower than under the Second Basis of Comparison. In other water year types, egg mortality is predicted to be from 0.2 to 0.8 percent higher under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9C, Table B-2).

*Changes in Weighted Usable Area*

Modeling results indicate that there would be slightly (less than 5 percent) greater amounts of spawning habitat available for late fall-run Chinook Salmon in the Sacramento River from January through April under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9E, Table C-14-6). Overall, spawning habitat availability would be similar under Alternative 5 and the Second Basis of Comparison.

Modeling results indicate that, in general, there would be increased amounts of suitable late fall-run Chinook Salmon fry rearing habitat available during April and May under Alternative 5 (Appendix 9E, Table C-15-6). The increase in long-term average fry rearing WUA during these months would be relatively small (less than 5 percent). Late fall-run Chinook Salmon fry rearing WUA would be decreased by about 2 percent in June under Alternative 5 as compared to the Second Basis of Comparison. Overall, late fall-run fry rearing habitat availability would be similar under Alternative 5 and the Second Basis of Comparison.

A substantial fraction of late fall run Chinook Salmon juveniles oversummer in the Sacramento River before emigrating, which allows them to avoid predation through both their larger size and greater swimming ability. One implication of this life history strategy is that rearing habitat is most likely the limiting factor for late-fall-run Chinook Salmon, especially if availability of cool water determines the downstream extent of spawning habitat for late-fall-run salmon. Modeling results indicate that, there would be increased amounts of suitable juvenile rearing habitat available from December through August, but this increase would be small (generally less than 2 percent) under Alternative 5 as compared to the Second Basis of Comparison. There would be a decrease in the amount of late fall-run Chinook Salmon juvenile rearing WUA in the other months (September through November) of up to 10 percent (Appendix 9E, Table C-16-6). Overall, late fall-run juvenile rearing habitat availability would be similar under Alternative 5 and the Second Basis of Comparison.

*Changes in SALMOD Output*

SALMOD results indicate that flow-related late fall-run Chinook Salmon egg mortality would be reduced by 6 percent under Alternative 5 compared to the Second Basis of Comparison. Conversely, temperature-related egg mortality would be 6 percent higher under Alternative 5 (Appendix 9D, Table B-2-29). Flow (habitat)-related fry mortality would be approximately 1 percent lower while temperature-related fry mortality would be about 26 percent lower under Alternative 5 as compared to the Second Basis of Comparison. Temperature-related juvenile mortality would be approximately 17 percent higher under Alternative 5, while flow (habitat)-related mortality would approximately 26 percent higher under Alternative 5 as compared to the Second Basis of Comparison. Overall, potential juvenile production would be similar under Alternative 5 and the Second Basis of Comparison (Appendix 9D, Table B-2-26).

*Changes in Delta Passage Model Output*

For Late-Fall-Run, Delta survival was predicted to be slightly higher for Alternative 5 versus the Second Basis of Comparison for all 81 water years simulated by the Delta Passage Model (Appendix 9J). Median Delta survival across all years was 0.243 for Alternative 5 and 0.199 for the Second Basis of Comparison. Overall, there would be a slight increase in through-Delta survival by emigrating juvenile late fall-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

The late fall-run Chinook migration period overlaps with that of winter-run Chinook Salmon and they are most abundant in the Delta during the months of January February and March. On the Sacramento River near the confluence of Georgiana Slough, the percentage of positive velocity under Alternative 5 was moderately lower relative to the Second Basis of Comparison in January and indistinguishable in February and March (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the percent of positive velocities was slightly greater under Alternative 5 relative to Second Basis of Comparison in January and February and indistinguishable in March. In Old River downstream of the facilities, the percent of positive velocities was considerably higher under Alternative 5 during January and moderately higher in February. Values in March were almost indistinguishable between scenarios. On Old River upstream of the facilities, percent positive velocities were moderately lower in January and slightly lower in February and March under Alternative 5 relative to Second Basis of Comparison. On the San Joaquin River downstream of Head of Old River, the percent of positive velocities was similar for both scenarios in January, February and March.

*Changes in Junction Entrainment*

At the junction of Georgiana Slough and the Sacramento River, entrainment under Alternative 5 was slightly lower than Second Basis of Comparison in January but essentially indistinguishable in February and March (Appendix 9L). Entrainment at the Head of Old River junction was moderately lower under Alternative 5 relative to Second Basis of Comparison during the period of winter run migration through the Delta (January, February, March). For the Turner Cut junction, entrainment under Alternative 5 was moderately lower in January and February relative to Second Basis of Comparison. In March, the difference in entrainment between scenarios was similar. Similar patterns between Alternative 5 and Second Basis of Comparison were observed at the Columbia Cut, Middle River and Old River junctions. At these junctions, entrainment was moderately lower under Alternative 5 during January and February and values became more similar in March.

*Changes in Salvage*

Salvage of late fall-run Chinook salmon is predicted to be considerably lower under Alternative 5 relative to the Second Basis of Comparison in January and February (Appendix 9M). In March salvage was only moderately lower under Alternative 5 relative to Second Basis of Comparison.

*Summary of Effects on Late Fall-Run Chinook Salmon*

The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison. This is reflected in the slightly lower survival of late fall-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model. Flow changes under Alternative 5 would have small effects on the availability of spawning habitat for late fall-run Chinook Salmon as indicated by the WUA analysis. Fry rearing habitat would be slightly increased under Alternative 5 but juvenile rearing WUA would decrease during some months as compared to the Second Basis of Comparison. These effects are reflected in the decrease in flow (habitat)-related and the increase in temperature-related egg and fry mortality predicted by SALMOD under Alternative 5. Juvenile rearing mortality is also predicted to increase under Alternative 5 as compared to the Second Basis of Comparison. Through Delta survival of juvenile late fall-run Chinook Salmon would be increased under Alternative 5 relative to the Second Basis of Comparison as indicated by the DPM results and entrainment may be reduced as indicated by the OMR flow analysis.

Overall, Alternative 5 is likely to have lesser adverse effects on the late fall-run Chinook Salmon population in the Sacramento River as compared to the Second Basis of Comparison. Alternative 5 also includes fish passage actions, which are not included in the Second Basis of Comparison.

*Steelhead*

Changes in operations that influence temperature and flow conditions that could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect steelhead in the Sacramento, Feather, and American rivers, and Clear Creek. The following describes temperature conditions in those water bodies.

*Sacramento River*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (within about 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years. A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with average monthly temperatures in November, June, and September (in drier years) progressively increasing by as much as 0.8°F at Red Bluff under Alternative 5 relative to the Second Basis of Comparison and progressively decreasing (up to 3.2°F at Red Bluff) in September during the wetter years (Appendix 6B, Table B-9-1).

*Clear Creek*

Average monthly water temperatures in Clear Creek at Igo under Alternative relative to the Second Basis of Comparison are generally predicted to be similar (less than 0.5°F differences) from September through April and June through August (Appendix 6B, Table B-3-6). Average monthly water temperatures during May under Alternative 5 would be lower by 0.1°F to 0.8°F than under the Second Basis of Comparison in all water year types.

*Feather River*

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences), but slightly higher (0.6°F) during December and slightly lower (0.6°F) in September. Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento. Water temperatures under Alternative 5 are somewhat (0.5°F to 1.8°F) cooler on average and up to 3.9°F cooler at the confluence with Sacramento River from July to September in wetter years.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 5 generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August, when temperatures under Alternative 5 could be as much as 0.9°F higher. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 5 would be up to 1.6°F and 2.1°F greater, respectively, than under the Second Basis of Comparison in June. In addition, average monthly water temperatures at the mouth generally would be lower than the Second Basis of Comparison in September, especially in wetter water year types when Alternative 5 could be up to 1.7°F cooler.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for steelhead in the Sacramento River, Clear Creek, and Feather River. The following describes the extent of those exceedance for each of those streams.

*Sacramento River*

As described in the life history accounts (Appendix), steelhead spawning in the mainstem Sacramento River generally occurs in the upper reaches from Keswick Dam downstream to near Balls Ferry, with most spawning concentrated near Redding. Most steelhead, however, spawn in tributaries to the Sacramento River. Spawning generally takes place in the January through March period when water temperatures in the river generally do not exceed 52°F under either Alternative 5 or Second Basis of Comparison. While there are no established temperature thresholds for steelhead rearing in the mainstem Sacramento River, average monthly temperatures in during March through June when fry and juvenile steelhead are in the river would be below 56°F during March and April at Balls Ferry. In May and June, average monthly water temperatures would be slightly higher under Alternative 5 than they would be under the Second Basis of

Comparison in the drier years, although neither condition would exceed about 57°F. Thus, as it relates to temperature for steelhead in the mainstem Sacramento River, it is unlikely that Alternative 5 and Second Basis of Comparison would differ in a biologically meaningful way.

*Clear Creek*

While there are no established temperature thresholds for steelhead spawning in Clear Creek, average monthly water temperatures in the river generally would not exceed 48°F during the spawning period (December to April) under either Alternative 5 or Second Basis of Comparison. Similarly, while there are no established temperature thresholds for steelhead rearing in Clear Creek, average monthly temperatures in throughout the year would not exceed 56°F at Igo. Thus, as it relates to temperature for steelhead in Clear Creek, it is unlikely that Alternative 5 and Second Basis of Comparison would differ in a biologically meaningful way.

*Feather River*

Average monthly water temperatures under both Alternative 5 and the Second Basis of Comparison would on occasion exceed the water temperature threshold of 56°F established in the Feather River at Robinson Riffle for steelhead spawning and incubation during some months, particularly in October and November, and March and April, when temperature thresholds could be exceeded frequently (Appendix 9N).There would be a 1 percent exceedance of the 56°F threshold in December and no exceedances of the 56°F threshold in January and February under both t Alternative 5 and the Second Basis of Comparison. However, the differences in the frequency of exceedance between Alternative 5 and Second Basis of Comparison during March and April would be relatively small with water temperatures under Alternative 5 exceeding the threshold about 1 percent more frequently in March and the same exceedance frequency (75 percent) as the Second Basis of Comparison in April. The established water temperature threshold of 63°F for rearing from May through August would be exceeded often under both Alternative 5 and Second Basis of Comparison in May and June, but not at all in July and August. Water temperatures under Alternative 5 would exceed the rearing temperature threshold about 6 percent more frequently than under the Second Basis of Comparison in May, but no more frequently in June. Temperature conditions in the Feather River under Alternative 5 could be more likely to affect steelhead spawning and rearing than under the Second Basis of Comparison because of the slightly increased frequency of exceedance of the 56°F spawning threshold in March and the somewhat increased frequency of exceedance of the 63°F rearing threshold in May.

*American River*

In the American River, the water temperature threshold for steelhead rearing (May through October) is 65°F at the Watt Avenue Bridge. Average monthly water temperatures would exceed this threshold often under both Alternative 5 and Second Basis of Comparison, especially in the July through September period when the threshold is exceeded nearly all of the time. In addition, the magnitude of the exceedance would be high, with average monthly water temperatures sometimes higher than 76°F. The differences between Alternative 5 and Second Basis of Comparison, however, would be relatively small (differences within 1 percent), except in September, when average monthly water temperatures under Alternative 5 would exceed 65°F about 6 percent less frequently than under the Second Basis of Comparison. This difference may not be as biologically important because it occurs at the lower temperature range for the month. Temperature conditions in the American River under Alternative 5 could increase the likelihood of adverse effects on steelhead rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 65°F rearing threshold in some months.

*Changes in Weighted Usable Area*

The following describes changes in WUA for steelhead in the Sacramento, Feather, and American rivers and Clear Creek.

*Sacramento River*

Modeling results indicate that, in general, there would be greater amounts of suitable steelhead spawning habitat available from December through March under Alternative 5 as compared to the Second Basis of Comparison (Appendix 9E, Table C-20-6). The increases in long-term average steelhead spawning WUA would be relatively small (less than 3 percent). Overall, spawning habitat availability would be similar under Alternative 5 and the Second Basis of Comparison.

*Clear Creek*

As described above, flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison except in May due to the release of spring attraction flows in accordance with the 2009 NMFS BO. Therefore, there would be no change in the amount of potentially suitable spawning and rearing habitat for steelhead (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison.

*Feather River*

As described above, Flows in the low flow channel of the Feather River are not anticipated to differ under Alternative 5 relative to the Second Basis of Comparison. Therefore, there would be no change in the amount of potentially suitable spawning habitat for steelhead (as indexed by WUA) available under Alternative 5 as compared to the Second Basis of Comparison. The majority of spawning activity by steelhead in the Feather River occurs in this reach with a lesser amount of spawning occurring downstream of the Thermalito Complex.

Modeling results indicate that, in general, there would be greater amounts of spawning habitat for steelhead in the Feather River below Thermalito available from December through April under Alternative 5 as compared to the Second Basis of Comparison. The increases in long-term average steelhead spawning WUA during this time period would generally be less than 3 percent (Appendix 9E, Table C-22-6). Overall, steelhead spawning habitat availability would be similar under Alternative 5 and the Second Basis of Comparison.

*American River*

Modeling results indicate that, in general, there would be variable changes in the amount of spawning habitat for steelhead in the American River below Nimbus Dam available from December through April under Alternative 5 as compared to the Second Basis of Comparison. The increases in long-term average steelhead spawning WUA during December, February and March would generally be less than 3 percent, while the decrease in April would also be less than 3 percent (Appendix 9E, Table C-26-4). Overall, steelhead spawning habitat availability would be similar under Alternative 5 and the Second Basis of Comparison.

*Changes in Delta Hydrodynamics*

Sacramento River-origin steelhead generally move through the Delta during spring however there is less information on their timing relative to Chinook salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead.

On the Sacramento River near the confluence of Georgiana Slough, the percentage of positive velocity under Alternative 5 was moderately lower relative to the Second Basis of Comparison in January and indistinguishable in February and March (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the percent of positive velocities was slightly greater under Alternative 5 relative to Second Basis of Comparison in January and February and indistinguishable in March. In Old River downstream of the facilities, the percent of positive velocities was considerably higher under Alternative 5 during January and moderately higher in February. Values in March were almost indistinguishable between scenarios. On Old River upstream of the facilities, percent positive velocities were moderately lower in January and slightly lower in February and March under Alternative 5 relative to Second Basis of Comparison. On the San Joaquin River downstream of Head of Old River, the percent of positive velocities was similar for both scenarios in January, February and March.

At the junction of Georgiana Slough and the Sacramento River, percent positive velocity was considerably lower under Alternative 5 relative to the Second Basis of Comparison in May and June. Estimates for Alternative 5 were only slightly lower in April. Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities was considerably higher under Alternative 5 relative to Second Basis of Comparison in April and May whereas values in June were similar among the alternatives. On Old River downstream of the facilities, the proportion of positive velocities was considerably higher in April and May and moderately higher in June under Alternative 5 relative to Second Basis of Comparison. In Old River upstream of the facilities, the percent of positive velocities was moderately higher under Alternative 5 April and May and moderately lower in June. On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities was considerably lower under Alternative 5 relative to Second Basis of Comparison in April, May and slightly lower in June.

*Changes in Junction Entrainment*

At the junction of Georgiana Slough and the Sacramento River, entrainment under Alternative 5 was slightly lower than Second Basis of Comparison in June but essentially indistinguishable in all other months (Appendix 9L). Entrainment at the Head of Old River junction was considerably higher under Alternative 5 relative to Second Basis of Comparison during the months of April and May and slightly lower in January and February. Entrainment in March and June was essentially the same in March and June. For the Turner Cut junction, entrainment under Alternative 5 was much lower in April and May relative to Second Basis of Comparison. Entrainment was lower in the other months as well but the magnitude of the difference was smaller. At the Columbia Cut junction, entrainment under Alternative 5 was almost indistinguishable from Second Basis of Comparison in March and June. Entrainment was slightly lower under Alternative 5 during January and February and became even lower in April and May. A similar pattern of entrainment under Alternative 5 relative to Second Basis of Comparison was observed at the Middle River and Old River junctions.

*Summary of Effects on Steelhead*

The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds under Alternative 5 as compared to the Second Basis of Comparison in the Sacramento and Feather rivers. In drier years, the likelihood of adverse temperature effects would be increased under Alternative 5 as compared to the Second Basis of Comparison. There would be little change in flows or temperatures in Clear Creek under Alternative 5 relative to the Second Basis of Comparison.

Overall, Alternative 5 is likely to have somewhat greater adverse effects on the steelhead population in the Sacramento River watershed as compared to the Second Basis of Comparison, particularly in drier water year types because of the temperature effects. Alternative 5 also includes actions to provide fish passage upstream of Shasta and Folsom dams, which are not included in the Second Basis of Comparison. Depending on the success of these actions, passage could provide additional benefit for steelhead.

*Green Sturgeon*

Changes in operations that influence temperature and flow conditions could affect Green Sturgeon. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature could affect Green Sturgeon in the Sacramento and Feather rivers. The following describes temperature conditions in those water bodies.

*Sacramento River*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (within about 0.5°F). Average monthly water temperatures in September under

Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years (Appendix 6B). A similar pattern in temperature differences generally would be exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with differences in average monthly temperatures in June at Knights Landing progressively increasing (up to 0.9°F) under Alternative 5 relative to the Second Basis of Comparison and progressively decreasing (up to 4.6°F) in September during the wetter years.

*Feather River*

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences), but slightly higher (0.6°F) during December and slightly lower (0.6°F) in September. Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento. Water temperatures under Alternative 5 are somewhat (0.5°F to 1.8°F) cooler on average and up to 3.9°F cooler at the confluence with Sacramento River from July to September in wetter years.

*Changes in Exceedances of Water Temperature Thresholds*

Changes in water temperature could result in the exceedance of established water temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers. The following describes the extent of those exceedance for each of those rivers.

*Sacramento River*

Average monthly water temperatures in the Sacramento River at Bend Bridge under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 63°F established for Green Sturgeon egg incubation in August and September, with exceedances under Alternative 5 occurring about 7 percent of the time in August and about 12 percent of the time in September relative to the Second Basis of Comparison. This is 1 to 2 percent more frequently than under the Second Basis of Comparison. Average monthly water temperatures at Bend Bridge could be as high as about 73°F during this period. Temperature conditions in the Sacramento River under Alternative 5 could be more likely to affect Green Sturgeon rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 63°F threshold in August and September.

*Feather River*

Average monthly water temperatures in the Feather River at Gridley Bridge under both Alternative 5 and Second Basis of Comparison would exceed the water temperature threshold of 64°F established for Green Sturgeon spawning, incubation, and rearing in May, June, and September; no exceedances under either scenarios would occur in July and August. The frequency of exceedances would be high, with both Alternative 5 and Second Basis of Comparison exceeding the threshold in June nearly 100 percent of the time. The magnitude of the exceedance also would be substantial, with average monthly temperatures higher than 72°F in June, and higher than 75°F in July and August. Water temperatures under Alternative 5 would exceed the threshold for May about 7 percent more frequently than the Second Basis of Comparison and about 33 percent less frequently in September. Temperature conditions in the Feather River under Alternative 5 could be more likely to affect Green Sturgeon rearing than under the Second Basis of Comparison because of the increased frequency of exceedance of the 64°F threshold in May. The reduction in exceedance frequency in September may have less effect on rearing Green Sturgeon as many juvenile sturgeon may have migrated downstream to the lower Sacramento River and Delta by this time.

*Summary of Effects on Green Sturgeon*

The temperature threshold analysis in the Sacramento and Feather rivers both suggest that average monthly water temperatures under Alternative 5 would exceed thresholds for Green Sturgeon more frequently than under the Second Basis of Comparison, although the frequency of exceedance would be relatively small (1-2 percent). However, because the average monthly temperatures may mask higher temperature excursions above the threshold, these differences could be biologically meaningful. Thus, Alternative 5 could be more likely to affect Green Sturgeon than the Second Basis of Comparison.

*White Sturgeon*

Changes in water temperature conditions in the Sacramento and Feather rivers would be the same as those described above for Green Sturgeon, with relatively minor (less than 0.5°F) differences between Alternative 5 and Second Basis of Comparison.

The water temperature threshold established for White Sturgeon spawning and egg incubation in the Sacramento River at Hamilton City is 61°F from March through June. Although there would be no exceedances of the threshold in March and April, water temperatures under both Alternative 5 and Second Basis of Comparison would exceed this threshold in May and June. The average monthly water temperatures in May under Alternative 5 would exceed this threshold about 56 percent of the time (about 7 percent more frequently than the Second Basis of Comparison). In June, the temperature under Alternative 5 would exceed the threshold about 87 percent of the time (about 13 percent more frequently than the Second Basis of Comparison). Average monthly water temperatures during May and June under Alternative 5 would as high as about 65°F.

*Summary of Effects on White Sturgeon*

Overall, based on the frequency and magnitude of temperature threshold exceedances, Alternative 5 is more likely to affect White Sturgeon than the Second Basis of Comparison.

*Delta Smelt*

A proportional entrainment regression model (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow in December through March. Results indicate that the percentage of entrainment of migrating and spawning adult Delta Smelt under Alternative 5 would be 7 to 8.3 percent, depending on the water year type, with a long-term average percent entrainment of 7.6 percent. Percent entrainment of adult Delta Smelt under Alternative 5 would be similar to results under Second Basis of Comparison (lower by 1 to 2 percent). Under the Second Basis of Comparison, the long-term average entrainment would be 9 percent.

A proportional entrainment regression model (based on Kimmerer 2008) also was used to simulate larval and early juvenile Delta Smelt entrainment, as influenced by OMR flow and location of X2 in March through June. Results indicate that the percentage of entrainment of larval and early juvenile Delta Smelt under Alternative 5 would be 1.3 to 19.3 percent, depending on the water year type, with a long term average percent entrainment of 8.6 percent, and highest entrainment under Critical water year conditions. Percent entrainment of larval and early juvenile Delta Smelt under Alternative 5 would be lower than results under the Second Basis of Comparison by 4.3 to 9.4 percent. Under the Second Basis of Comparison, the long-term average percent entrainment would be 15.5 percent, and highest entrainment would occur under critical dry water year conditions, at 23.6 percent.

Alternative 5 includes the operations related to the 2008 USFWS BO RPA Component 3 (Action 4), Fall X2 requirement, while the Second Basis of Comparison does not. Therefore, the average September through December X2 position under Alternative 5 would be westward by over 6 km compared to the Second Basis of Comparison during the wetter years. In the drier years September through December average X2 position is similar under both scenarios.

*Summary of Effects on Delta Smelt*

Overall, Alternative 5 likely would have beneficial effects on Delta Smelt, as compared to the Second Basis of Comparison, primarily due to lower percentage entrainment of larval and juvenile life stages, and more favorable location of Fall X2 in wetter years, and on average.

*Longfin Smelt*

The effects of the Alternative 5 as compared to the Second Basis of Comparison were analyzed based on the direction and magnitude of OMR flows during the period (December through June) when adult, larvae, and young juvenile Longfin Smelt are present in the Delta in the vicinity of the export facilities (Appendix 5A). The analysis was augmented with calculated Longfin Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions that lower X2 values reflect higher flows and that transporting Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The index value indicates the relative abundance of Longfin Smelt and not the calculated population.

Under Alternative 5, Longfin Smelt abundance index values range from 1,204 under critical water year conditions to a high of 16,683 under wet water year conditions, with a long-term average value of 8,015. Under the Second Basis of Comparison, Longfin Smelt abundance index values range from 947 under critical water year conditions to a high of 15,822 under wet water year conditions, with a long-term average value of 7,257.

Results indicate that the Longfin Smelt abundance index values would be greater in every water year type under Alternative 5 than under the Second Basis of Comparison, with a long-term average index for Alternative 5 that is about 10 percent higher than the long term average index for the Second Basis of Comparison. For below normal, dry, and critical water years, the Longfin Smelt abundance index values would be over 20 percent greater under Alternative 5 than under the Second Basis of Comparison, with the greatest difference (30.8 percent) predicted under dry conditions.

Overall, based on the lower frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in dry and critical years, Alternative 5 would be likely to have a positive effect on the Longfin Smelt population as compared to the Second Basis of Comparison.

*Sacramento Splittail*

Under Alternative 5, flows entering the Yolo Bypass over the Fremont Weir generally would be slightly lower compared to the Second Basis of Comparison (Appendix 5A, Table C-26-6), thus potentially providing lower value to Sacramento Splittail because of the lower area of potential habitat (inundation) and the lower frequency of inundation.

*Reservoir Fishes*

Changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison generally would result in lower reservoir storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be lower under Alternative 5 as compared to the Second Basis of Comparison in the fall and winter months due to the inclusion of Fall X2 criteria under Alternative 5.

The highest reductions in Shasta Lake and Lake Oroville storage could be in excess of 20 percent. Storage in Folsom Lake could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling. The reduction in reservoir storage under Alternative 5 may suggest that the amount of habitat for reservoir fishes could be reduced under Alternative 5 as compared to the Second Basis of Comparison.

Black bass nest survival in CVP and SWP reservoirs is anticipated to be near 100 percent in March and April due to increasing reservoir elevations. For May, the likelihood of nest survival for Largemouth Bass in Lake Shasta being in the

40 to 100 percent range is about 2 percent higher under Alternative 5 as compared to the Second Basis of Comparison. For June, the likelihood of nest survival being greater than 40 percent for Largemouth Bass is similar (within 1 percent) under Alternative 5 and Second Basis of Comparison; however, nest survival of greater than 40 percent is likely only in about 20 percent of the years evaluated. The likelihood of nest survival for Smallmouth Bass in Lake Shasta exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is high (100 percent) in May under both Alternative 5 and the Second Basis of Comparison. For June, Spotted Bass nest survival would be less than for May due to greater daily reductions in water surface elevation as Shasta Lake is drawn down. The likelihood of survival being greater than 40 percent is higher (about 12 percent) under Alternative 5 as compared to the Second Basis of Comparison.

For May and June, the likelihood of nest survival for Largemouth Bass in Lake Oroville being in the 40 to 100 percent range is higher under Alternative 5 as compared to the Second Basis of Comparison, about 13 percent higher in May and about 4 percent higher in June. However, June nest survival of greater than 40 percent is likely only in about 40 percent of the years evaluated. The likelihood of nest survival for Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest survival being greater than 40 percent is 100 percent in May under Alternative 5 as compared to about 94 percent under the Second Basis of Comparison. For June, Spotted Bass survival would be less than for May due to greater daily reductions in water surface elevation as Lake Oroville is drawn down. The likelihood of survival being greater than 40 percent is substantially higher (on the order of 20 percent) under Alternative 5 as compared to the Second Basis of Comparison.

Black bass nest survival in Folsom Lake is near 100 percent in March, April, and May due to increasing reservoir elevations. For June, the likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the 40 to 100 percent range is somewhat (around 7 percent) higher under Alternative 5 than under the Second Basis of Comparison. For Spotted Bass, nest survival for June would be less than for May due to greater daily reductions in water surface elevation. However, the likelihood of survival being greater than 40 percent is slightly (around 3 percent) greater under Alternative 5 as compared to the Second Basis of Comparison.

Based on the predicted black bass nest survival in Shasta Lake, Lake Oroville, and Folsom Lake, Alternative 5 is likely to have higher nest survival than the Second Basis of Comparison.

*Other Species*

Several other fish species could be affected by changes in operations that influence temperature and flow. The following describes the extent of these changes and the potential effects on these species.

*Pacific Lamprey*

Little information is available on factors that influence populations of Pacific Lamprey in the Sacramento River, but they are likely affected by many of the same factors as salmon and steelhead because of the parallels in their life cycles.

*Changes in Water Temperature*

The following describes anticipated changes in average monthly water temperature in the Sacramento, Feather, and American rivers and the potential for those changes to affect Pacific Lamprey.

*Sacramento River*

Monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (within about 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years (Appendix 6B, Table 5-5-1). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures in June progressively increasing by a small margin under Alternative 5 relative to the Second Basis of Comparison. Due to the similarity of water temperatures under Alternative 5 and Second Basis of Comparison from January through the summer, there would be little difference in potential effects on Pacific Lamprey adults during their migration, holding, and spawning periods.

*Feather River*

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences), but slightly higher (0.6°F) during December and slightly lower (0.6°F) in September. Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento. Water temperatures under Alternative 5 are somewhat (0.5°F to 1.8°F) cooler on average and up to 3.9°F cooler at the confluence with Sacramento River from July to September in wetter years.

Due to the similarity of water temperatures under Alternative 5 and Second Basis of Comparison from January through April, there would be little difference in potential effects on Pacific Lamprey adults during their upstream migration. The slightly higher water temperatures from May through the summer may increase the likelihood of adverse effects on Pacific Lamprey during their holding, and spawning periods.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 5 generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August, when differences under Alternative 5 could be as much as 0.9°F higher. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 5 would be up to 1.6°F and 2.1°F greater, respectively, than under the Second Basis of Comparison in June. Due to the similarity of water temperatures under Alternative 5 and Second Basis of Comparison from January through May, there would be little difference in potential effects on Pacific Lamprey adults during their upstream migration. The higher water temperatures during June and August may increase the likelihood of adverse effects on Pacific Lamprey during their holding, and spawning periods.

*Summary of Effects on Pacific Lamprey*

In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could adversely affect the larvae. Given the reduced flows and increased temperatures during their spawning and incubation period, it is likely that Alternative 5 would have a higher potential to adversely influence Pacific Lamprey in the Sacramento, Feather, and American rivers than would the Second Basis of Comparison. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

*Striped Bass, American Shad, and Hardhead*

Changes in operations influence temperature and flow conditions that could affect Striped Bass, American Shad, and Hardhead. The following describes those changes and their potential effects.

*Changes in Water Temperature*

Changes in water temperature that affect Striped Bass, American Shad, and Hardhead could occur in the Sacramento, Feather, and American rivers. The following describes temperature conditions in those water bodies.

*Sacramento River*

As described above for lampreys, monthly water temperature in the Sacramento River at Keswick Dam under Alternative and the Second Basis of Comparison generally would be similar (within about 0.5°F). Average monthly water temperatures in September under Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to 1.2°F) in drier years (Appendix 6B, Table 5-5-1). A similar temperature pattern generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures in June progressively increasing by a small margin under Alternative 5 relative to the Second Basis of Comparison.

*Feather River*

Long-term average monthly water temperature in the Feather River at the low flow channel under Alternative 5 relative to the Second Basis of Comparison generally would be similar (less than 0.5°F differences), but slightly higher (0.6°F) during December and slightly lower (0.6°F) in September. Water temperatures could be up to 1.5°F warmer in November and December of some water year types and up to 1.2°F cooler in September of wetter years. Although temperatures in the river would become progressively higher in the downstream direction, the differences between Alternative 5 and Second Basis of Comparison exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with water temperature differences under Alternative 5 generally increasing in most water year types relative to the Second Basis of Comparison at the confluence with Sacramento. Water temperatures under Alternative 5 are somewhat (0.5°F to 1.8°F) cooler on average and up to 3.9°F cooler at the confluence with Sacramento River from July to September in wetter years.

*American River*

Average monthly water temperatures in the American River at Nimbus Dam under Alternative 5 generally would be similar (differences less than 0.5°F) to the Second Basis of Comparison, with the exception of during June and August, when differences under Alternative 5 could be as much as 0.9°F higher. This pattern generally would persist downstream to Watt Avenue and the mouth, although temperatures under Alternative 5 would be up to 1.6°F and 2.1°F greater, respectively, than under the Second Basis of Comparison in June.

*Summary of Effects on Striped Bass, American Shad, and Hardhead*

Because Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids, it is unlikely that the slightly increased temperatures during some months under Alternative 5 would have substantial adverse effects on these species in the American River.

*Stanislaus River/Lower San Joaquin River*

*Fall-Run Chinook Salmon*

Changes in operations influence temperature and flow conditions that could affect fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River below Vernalis. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 5 and Second Basis of Comparison generally would be similar (differences less than 0.5°F), except in August through October when long-term average monthly temperatures could be up to 1.0°F warmer than under the Second Basis of Comparison. These differences would be of higher magnitude in drier years with average monthly water temperatures in September as much as 1.9°F warmer under Alternative 5 as compared to the Second Basis of Comparison (Appendix 6B, Table B-17-6).

Downstream at Orange Blossom Bridge, average monthly water temperatures in October and April under Alternative 5 would be lower in all water year types than the Second Basis of Comparison by as much as 1.4°F in October and 1.6°F in

April. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar, although somewhat higher (up to 0.7°F), compared to the Second Basis of Comparison. Water temperatures under Alternative 5 could be up to 1.3°F warmer in drier years from July to September than under the Second Basis of Comparison. (Appendix 6B, Table B-18-6).

Downstream at the confluence with the San Joaquin River, average monthly water temperatures in October, April and May would be lower in all water year types under Alternative 5 than the Second Basis of Comparison by as much as 2.0°F in October, 1.9°F in April and 0.8°F in May. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar, although somewhat higher (up to 1.1°F), compared to the Second Basis of Comparison in June (Appendix 6B, Table B-19-6).

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

While specific water temperature thresholds for fall-run Chinook Salmon in the Stanislaus River are not established, temperatures generally suitable for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and November over 30 percent of the time in the Stanislaus River at Goodwin Dam under Alternative 5 (Appendix 6B, Table B-17-6). Similar exceedances would occur under the Second Basis of Comparison, although slightly more frequently. Water temperatures for rearing from January to May generally would be below 56°F, except in May when average monthly water temperatures would reach about 60°F under both conditions (Appendix 6B, Figure B-17-8).

Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run Chinook Salmon spawning would be exceeded frequently under both Alternative 5 and Second Basis of Comparison during October and November. Under Alternative 5, average monthly water temperatures would exceed 56°F about 57 percent of the time in October (Appendix 6B, Figure B-18-1). This, however, would be about 28 percent less frequently than under the Second Basis of Comparison. In November, average monthly water temperatures would exceed 56°F about 33 percent of the time under Alternative 5, which would be about 5 percent more frequent than under the Second Basis of Comparison (Appendix 6B, Figure B-18-2).

During January through May, rearing fall-run Chinook Salmon under Alternative 5 would be subjected to average monthly water temperatures that exceed 56° in March (less than 10 percent of the time) and May (about 30 percent of the time) under Alternative 5 which is about 10 percent more frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-8).

*Changes in Egg Mortality (Stanislaus River)*

For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg mortality rate is predicted to be around 8.5 percent, with higher mortality rates (in excess of 15 percent) occurring in critical dry years under Alternative 5. Overall, egg mortality would be 1.0 percent higher under Alternative 5; the average egg mortality rate would be higher than under the Second Basis of Comparison by up to 2.0 percent in below normal years (Appendix 9C, Table B-8).

*Changes in Delta Hydrodynamics*

San Joaquin River-origin fall run Chinook salmon smolts are most abundant in the Delta during the months of April, May and June. Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities was considerably higher under Alternative 5 relative to Second Basis of Comparison in April and May whereas values in June were similar among the alternatives (Appendix 9K). On Old River downstream of the facilities, the proportion of positive velocities was considerably higher in April and May and moderately higher in June under Alternative 5 relative to Second Basis of Comparison. In Old River upstream of the facilities, the percent of positive velocities was moderately higher under Alternative 5 April and May and moderately lower in June. On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities was considerably lower under Alternative 5 relative to Second Basis of Comparison in April, May and slightly lower in June.

*Changes in Junction Entrainment*

Entrainment at the Head of Old River junction was considerably higher under Alternative 5 relative to Second Basis of Comparison during the months of April and May and essentially the same in June (Appendix 9L). For the Turner Cut junction, entrainment under Alternative 5 was substantially lower in April and May relative to Second Basis of Comparison. Entrainment was lower in June as well but the magnitude of the difference was smaller. At the Columbia Cut junction, entrainment under Alternative 5 was almost indistinguishable from Second Basis of Comparison in June. Entrainment became considerably lower under Alternative 5 relative to Second Basis of Comparison in April and May. A similar pattern of entrainment under Alternative 5 relative to Second Basis of Comparison was observed at the Middle River and Old River junctions.

*Summary of Effects on Fall-Run Chinook Salmon*

The analysis of temperatures indicates lower temperatures and a lesser likelihood of exceedance of suitable temperatures for spawning and rearing of fall-run Chinook Salmon under Alternative 5 as compared to the Second Basis of Comparison in the Stanislaus River below Goodwin Dam and in the San Joaquin River at Vernalis. The effect of lower temperatures is reflected in the slightly lower overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation’s salmon survival model for fall-run in the Stanislaus River. As described above, the instream flow patterns under Alternative 5 are anticipated to benefit fall-run Chinook Salmon in the Stanislaus River and downstream in the lower San Joaquin River below Vernalis.

Overall, Alternative 5 likely would have less effect on the fall-run Chinook Salmon population in the San Joaquin River watershed as compared to the Second Basis of Comparison.

*Steelhead*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Goodwin Dam and the San Joaquin River below Vernalis could affect steelhead. The following describes those changes and their potential effects.

*Changes in Water Temperature (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 5 and Second Basis of Comparison generally would be similar (differences less than 0.5°F), except in August through October when long-term average monthly temperatures could be up to 1.0°F warmer than under the Second Basis of Comparison. These differences would be of higher magnitude in drier years with average monthly water temperatures in September as much as 1.9°F warmer under Alternative 5 as compared to the Second Basis of Comparison.

Downstream at Orange Blossom Bridge, average monthly water temperatures in October and April under Alternative 5 would be lower in all water year types than the Second Basis of Comparison by as much as 1.4°F in October and 1.6°F in April. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar, although somewhat higher (up to 0.7°F), compared to the Second Basis of Comparison. Water temperatures under Alternative 5 could be up to 1.3°F warmer in drier years from July to September than under the Second Basis of Comparison. (Appendix 6B, Table B-18-6).

Downstream at the confluence with the San Joaquin River, average monthly water temperatures in October, April and May would be lower in all water year types under Alternative 5 than the Second Basis of Comparison by as much as 2.0°F in October, 1.9°F in April and 0.8°F in May. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar, although somewhat higher (up to 1.1°F), compared to the Second Basis of Comparison in June.

*Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

Average monthly water temperatures in the Stanislaus River at Orange Blossom Bridge would frequently exceed the temperature threshold (56°F) established for adult steelhead migration under both Alternative 5 and Second Basis of Comparison during October and November. Under Alternative 5, average monthly water temperatures would exceed 56°F about 57 percent of the time in October which is about 28 percent less frequently than under the Second Basis of Comparison (Appendix 6B, Figure B-18-1). In November, average monthly water temperatures would exceed 56°F about 33 percent of the time under Alternative 5, which would be about 10 percent more frequently than under the Second Basis of Comparison.

In January through May, the temperature threshold at Orange Blossom Bridge is 55°F, which is intended to support steelhead spawning. This threshold would not be exceeded under either Alternative 5 or Second Basis of Comparison during

January or February. In March through May, however, exceedances would occur under both Alternative 5 and the Second Basis of Comparison in each month, with the threshold most frequently exceeded (40 percent) under Alternative 5 in May (Appendix 9N). Average monthly water temperatures under Alternative 5 would exceed the threshold more frequently in March (4 percent) and less frequently (26 percent) in April and May (5 percent) than under the Second Basis of Comparison.

From June through November, the temperature threshold of 65°F established to support steelhead rearing would be exceeded by both Alternative 5 and Second Basis of Comparison in all months but November. The differences between Alternative 5 and Second Basis of Comparison, however, could be biologically meaningful, with average monthly water temperatures under Alternative 5 generally exceeding the threshold by 3 percent to 8 percent more frequently than under the Second Basis of Comparison.

Average monthly water temperatures also would exceed the threshold (52°F) established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles upstream of Knights Ferry, average monthly water temperatures under Alternative 5 would exceed 52°F in March, April, and May about 8 percent, 37 percent, and 68 percent of the time, respectively. Alternative 5 would result in exceedances of the smoltification threshold occurring up to 6 percent more frequently during the January through May period. Farther downstream at Orange Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and would be exceeded less frequently. The magnitude of the exceedance also would be less. Average monthly water temperatures under Alternative 5 and the Second Basis of Comparison would not exceed the threshold during January through April. In May, the threshold would be exceeded 8 percent of the time under Alternative 5. Compared to the Second Basis of Comparison, the 57°F at Orange Blossom Bridge would be exceeded about 8 percent less frequently in April and 6 percent less frequently in May under Alternative 5.

Overall, the differences between Alternative 5 and Second Basis of Comparison would be relatively small, with the exception of substantial differences in the frequency of exceedances in October when the average monthly water temperatures under Alternative 5 would exceed the threshold for adult steelhead migration about 28 percent less frequently and in April during the spawning period when the frequency would be about 26 percent less. Given the frequency of exceedance under both Alternative 5 and Second Basis of Comparison and the generally stressful temperature conditions in the river, the substantial differences (improvements) in October and April under Alternative 5 suggest that there would be less potential to adversely affect steelhead under Alternative 5 than under the Second Basis of Comparison. Even during months when the differences would be relatively small, the lower frequency of exceedances under Alternative 5 could represent a biologically meaningful and positive difference.

*Changes in Delta Hydrodynamics*

Sacramento River-origin steelhead generally move through the Delta during spring however there is less information on their timing relative to Chinook salmon. Thus, hydrodynamics in the entire January through June period have the potential to affect juvenile steelhead.

On the Sacramento River near the confluence of Georgiana Slough, the percentage of positive velocity under Alternative 5 was moderately lower relative to the Second Basis of Comparison in January and indistinguishable in February and March (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence, the percent of positive velocities was slightly greater under Alternative 5 relative to Second Basis of Comparison in January and February and indistinguishable in March. In Old River downstream of the facilities, the percent of positive velocities was considerably higher under Alternative 5 during January and moderately higher in February. Values in March were almost indistinguishable between scenarios. On Old River upstream of the facilities, percent positive velocities were moderately lower in January and slightly lower in February and March under Alternative 5 relative to Second Basis of Comparison. On the San Joaquin River downstream of Head of Old River, the percent of positive velocities was similar for both scenarios in January, February and March.

At the junction of Georgiana Slough and the Sacramento River, percent positive velocity was considerably lower under Alternative 5 relative to the Second Basis of Comparison in May and June. Estimates for Alternative 5 were only slightly lower in April. Near the confluence of the San Joaquin River and the Mokelumne River, the proportion of positive velocities was considerably higher under Alternative 5 relative to Second Basis of Comparison in April and May whereas values in June were similar among the alternatives. On Old River downstream of the facilities, the proportion of positive velocities was considerably higher in April and May and moderately higher in June under Alternative 5 relative to Second Basis of Comparison. In Old River upstream of the facilities, the percent of positive velocities was moderately higher under Alternative 5 April and May and moderately lower in June. On the San Joaquin River downstream of the Head of Old River, the percent of positive velocities was considerably lower under Alternative 5 relative to Second Basis of Comparison in April, May and slightly lower in June.

*Changes in Junction Entrainment*

Entrainment at the Head of Old River junction was considerably higher under Alternative 5 relative to Second Basis of Comparison during the months of April and May and slightly lower in January and February (Appendix 9L). Entrainment in March and June was essentially the same in March and June. For the Turner Cut junction, entrainment under Alternative 5 was much lower in April and May relative to Second Basis of Comparison. Entrainment was lower in the other months as well but the magnitude of the difference was smaller. At the Columbia Cut junction, entrainment under Alternative 5 was almost indistinguishable from Second Basis of Comparison in March and June. Entrainment was slightly lower under Alternative 5 during January and February and became even lower in April and May. A similar pattern of entrainment under Alternative 5 relative to Second Basis of Comparison was observed at the Middle River and Old River junctions.

*Summary of Effects on Steelhead*

Given the frequency of exceedance under both Alternative 5 and Second Basis of Comparison and the generally stressful temperature conditions in the river, the substantial differences (improvements) in October and April under Alternative 5 suggest that there would be less potential to adversely affect steelhead under Alternative 5 than under the Second Basis of Comparison.

*White Sturgeon*

Evidence of White Sturgeon spawning has been recorded in the San Joaquin River upstream of the confluence with the Stanislaus River. While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar under all alternatives, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.

*Reservoir Fishes*

*Changes in Available Habitat (Storage)*

As described in Chapter 5, Surface Water Resources and Water Supplies, changes in CVP and SWP water supplies and operations under Alternative 5 as compared to the Second Basis of Comparison would result in lower Storage levels in New Melones Reservoir under Alternative 5 as compared to the Second Basis of Comparison due to increased instream releases to support fish flows under the 2009 NMFS BO.

Storage in New Melones could be reduced up to around 10 percent in some months of some water year types. Additional information related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

Nest survival for black bass species in New Melones is higher than in the other reservoirs during May and June. For March, Largemouth Bass and Smallmouth Bass nest survival is predicted to be above 40 percent in all of the years simulated. For April, the likelihood that nest survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent is substantially less (about 25 percent) under Alternative 5 as compared to the Second Basis of Comparison. For May, the likelihood of high nest survival is slightly (about 3 percent) less under Alternative 5 than under the Second Basis of Comparison. For June, the likelihood of survival being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is somewhat (about 10 percent) higher under Alternative 5 as compared to the Second Basis of Comparison. For Spotted Bass, nest survival in March is anticipated to be near 100 percent in every year under both Alternative 5 and Second Basis of Comparison. The likelihood of survival being greater than 40 percent is high (>90 percent) in April under both Alternative 5 and the Second Basis of Comparison with the likelihood of greater than 40 percent survival being (about 6 percent) lower under Alternative 5 as compared to the Second Basis of Comparison (100 percent). For May, the likelihood of high Spotted Bass nest survival is approximately 3 percent lower under Alternative 5 than under the Second Basis of Comparison. For June, Spotted Bass nest survival would be greater than 40 percent in all of the simulation years under both Alternative 5 and the Second Basis of Comparison.

Overall, the reductions in nest survival in New Melones Reservoir under Alternative 5 suggest that Alternative 5 could adversely influence black bass species by comparison to the Second Basis of Comparison.

*Other species*

Changes in operations that influence temperature and flow conditions in the Stanislaus River downstream of Keswick Dam and the San Joaquin River at Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

As described above, average monthly water temperatures in the Stanislaus River at Goodwin Dam under Alternative 5 and Second Basis of Comparison generally would be similar (differences less than 0.5°F), except in August through October when long-term average monthly temperatures could be up to 1.0°F warmer than under the Second Basis of Comparison. These differences would be of higher magnitude in drier years with average monthly water temperatures in September as much as 1.9°F warmer under Alternative 5 as compared to the Second Basis of Comparison.

Downstream at Orange Blossom Bridge, average monthly water temperatures in October and April under Alternative 5 would be lower in all water year types than the Second Basis of Comparison by as much as 1.4°F in October and 1.6°F in April. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar, although somewhat higher (up to 0.7°F), compared to the Second Basis of Comparison. Water temperatures under Alternative 5 could be up to 1.3°F warmer in drier years from July to September than under the Second Basis of Comparison (Appendix 6B, Table B-18-6).

Downstream at the confluence with the San Joaquin River, average monthly water temperatures in October, April and May would be lower in all water year types under Alternative 5 than the Second Basis of Comparison by as much as 2.0°F in October, 1.9°F in April and 0.8°F in May. In most other months, long-term average monthly water temperatures under Alternative 5 generally would be similar, although somewhat higher (up to 1.1°F), compared to the Second Basis of Comparison in June.

In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72°F during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could adversely affect these larval lamprey. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar under Alternative 5 and the Second Basis of Comparison.

In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar under Alternative 5 and the Second Basis of Comparison.

*San Francisco Bay Area Region*

*Killer Whale*

As described above for the comparison of Alternative 1 to the No Action Alternative, it is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected by any of the alternatives.

#### 9.4.3.7 Summary of Environmental Consequences

The results of the environmental consequences of implementation of Alternatives 1 through 5 as compared to the No Action Alternative and the Second Basis of Comparison are presented in Tables 9.4 and 9.5, respectively.

**Table 9.4 Comparison of Alternatives 1 through 5 to No Action Alternative**

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| Alternative 1 | **Trinity River Region**<br>Coho Salmon<br>Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar under both scenarios, although the exceedance of water temperature thresholds would be slightly less frequent (1 percent). The higher water temperatures in November of critical dry years (and lower temperatures in December) would likely have little effect on Coho Salmon as water temperatures in the Trinity River are typically low during this time period. Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), likely to result in similar effects.<br>Spring-run Chinook Salmon<br>Although the water temperatures could adversely affect spring-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences water temperatures as compared to the No Action Alternative. Overall, is likely to result in similar effects.<br>Fall-run Chinook Salmon<br>Water temperature changes, not likely have adverse effects because changes would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water | Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead.<br>Coordination of CVP and SWP operations with USFWS and NMFS to reduce impacts on late fall-run Chinook Salmon, Delta Smelt, Longfin Smelt, and Reservoir Fishes on the Sacramento River System. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | temperatures (as well as egg mortality). Overall, likely to have similar effects.<br>Steelhead<br>Water temperature changes would not likely have adverse effects because these changes would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures. Overall, likely to have similar effects.<br>Green Sturgeon<br>Overall, given the similarities between average monthly water temperatures at Lewiston Dam, it is likely that temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar.<br>Reservoir Fishes<br>Overall, the comparison of storage and the analysis of nesting suggest that effects would be similar.<br>Pacific Lamprey<br>On average, the temperature of water released at Lewiston Dam generally would be similar. Given the similarities in temperature, it is likely that the effects on Pacific Lamprey would be similar. This conclusion likely applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).<br>Eulachon<br>Given that the highest increases in flow under would be less than 10 percent in the Trinity River with a smaller relative change in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River are unlikely to be affected by changes upstream at Lewiston Dam, is the changes are likely to have a similar effect to influence Eulachon in the Klamath River.<br>**Sacramento River System**<br>Winter-run Chinook Salmon<br>Effects on winter-run Chinook Salmon would be similar, with a small likelihood that winter-run Chinook Salmon escapement would be lower. This potential distinction may become more adverse due to the lack of fish passage.<br>Spring-run Chinook Salmon<br>The model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse with a small likelihood that spring-run Chinook Salmon production would be higher. This potential distinction may be partially offset and become more adverse by the lack of the benefits of implementation of fish passage.<br>Fall-run Chinook Salmon<br>The model results suggest that overall, effects on fall-run Chinook Salmon could be slightly less adverse with a small likelihood that fall-run Chinook Salmon production would be higher. This potential distinction may become more adverse by the lack of without fish passage.<br>Late Fall-run Chinook Salmon<br>The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar, although production could be slightly lower in some | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | water year types and about 4 percent higher in critical dry years. The analyses attempting to assess the effects on routing, entrainment, and salvage of juvenile salmonids in the Delta suggest that salvage (as an indicator of potential losses of juvenile salmon at the export facilities) of Sacramento River-origin Chinook Salmon is predicted to be higher in every month.<br>Although survival in the Delta may be lower, given the similarity in the SALMOD outputs, it is likely that the effects on fall-run Chinook Salmon would be similar.<br>Effects may become more adverse due to the lack of without fish passage.<br><u>Steelhead</u><br>The model results suggest that overall, effects on steelhead could be slightly less adverse, particularly in the Feather River. This potential distinction may become more adverse due to the lack of fish passage.<br><u>Green Sturgeon</u><br>The temperature model outputs for the Sacramento and Feather rivers suggest that thermal conditions and effects on Green Sturgeon in the Sacramento and Feather rivers generally would be slightly less adverse. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for Green Sturgeon spawning, incubation, and rearing would be exceeded less frequently under Alternative 1 in the Sacramento River. The water temperature threshold for Green Sturgeon spawning, incubation, and rearing would also be exceeded less frequently during some months in the Feather River, but would be exceeded more frequently in September. Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the reduced frequency of exceedance of temperature thresholds could benefit Green Sturgeon in the Sacramento and Feather rivers.<br><u>White Sturgeon</u><br>Overall, the temperature model outputs suggest that thermal conditions and effects on White Sturgeon in the Sacramento River generally would be slightly less adverse. This conclusion is supported by the water temperature threshold exceedance analysis that indicated that the water temperature thresholds for White Sturgeon spawning, incubation, and rearing would be exceeded less frequently in the Sacramento River. Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the reduced frequency of exceedance of temperature thresholds could benefit White Sturgeon in the Sacramento River.<br><u>Delta Smelt</u><br>Overall, Alt likely would result in increased adverse effects on Delta Smelt primarily due to the potential for increased percentage entrainment during larval and juvenile life stages, and less favorable location of Fall X2 in wetter years, and on average.<br><u>Longfin Smelt</u> | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Overall, based on the increase in frequency and magnitude of negative OMR flows and the lower Longfin Smelt abundance index values, especially in dry and critical dry years, potential adverse effects on the Longfin Smelt population likely would be greater.<br>Sacramento Splittail<br>Slight increase in spawning habitat for Sacramento Splittail as a result of the increased area of potential habitat (inundation) and the potential for a slight increase in the frequency of inundation.<br>Reservoir Fishes<br>The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar to or slightly lower. This suggests that conditions in the reservoirs would be less likely to support self-sustaining populations of black bass.<br>Pacific Lamprey<br>Based on the somewhat increased flows and reduced temperatures during their spawning and incubation period, it likely that conditions for and effects on Pacific Lamprey in the Sacramento, Feather, and American rivers would not differ in a biologically meaningful manner. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).<br>Striped Bass, American Shad, and Hardhead<br>In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the slightly increased flows and decreased temperatures during their spawning and incubation period, it is likely that conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would not differ in a biologically meaningful manner.<br>**Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon<br>Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the differences in the frequency of exceedance of suitable temperatures for spawning and rearing could affect the potential for adverse effects on the fall-run Chinook Salmon populations in the Stanislaus River. However, the direction and magnitude of this effect is uncertain. This potential distinction may become more adverse due to the lack of fish passage.<br>Steelhead<br>Given the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the differences in the magnitude and frequency of exceedance of suitable temperatures for the various lifestages could affect the potential for adverse effects on the steelhead populations in the Stanislaus River. However, the direction and magnitude of this effect is uncertain. This potential distinction may become more adverse due to lack of fish passage. | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | White Sturgeon<br>While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon between alternatives.<br>Reservoir Fishes<br>Overall, predicted nest survival is generally above 40 percent in all months evaluated, although survival would vary among months. Given the relatively high survival in general and the uncertainty caused by the inconsistency in changes in survival, it is likely that effects would be similar under both alternatives.<br>Other Species<br>In general, lamprey species can tolerate higher temperatures than salmonids, up to around 72ºF during their entire life history. Because lamprey ammocoetes remain in the river for several years, any substantial flow reductions or temperature increases could adversely affect these larval lamprey. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be similar.<br>In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar.<br>**Pacific Ocean**<br>Killer Whale<br>Given conclusions from NMFS (2009c), and the fact that at least 75 percent of fall-run Chinook Salmon available for Southern Residents are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base for killer whales would not be appreciably affected. | |
| Alternative 2 | **Trinity River Region**<br>Coho Salmon, spring-run and fall-run Chinook Salmon, steelhead, Green Sturgeon, Reservoir Fishes, Pacific Lamprey, River Lamprey, and Eulachon<br>Similar effects.<br>**Sacramento River System**<br>Winter-run, spring-run, fall-run, and late fall-run Chinook Salmon, and steelhead<br>The effects may become more adverse due to the lack of fish passage. | Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, River Lamprey, Striped Bass, American Shad, and Hardhead<br>Similar effects<br>**Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon and Steelhead<br>The effects may become more adverse due to the lack of fish passage.<br>White Sturgeon, Reservoir Fishes, and Other Species<br>Similar effects.<br>**Pacific Ocean**<br>Killer Whale<br>Similar effects. | |
| Alternative 3 | **Trinity River Region**<br>Coho Salmon and Spring-run Chinook Salmon<br>Although the water temperature and flow changes could have slight beneficial effects, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures. Overall, likely to result in similar effects on the spring-run Chinook Salmon population in the Trinity River.<br>Fall-run-run Chinook Salmon<br>Although the water temperature and flow changes suggest a lower potential for adverse effects on fall-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures (as well as egg mortality).  Overall, likely to have similar effects.<br>Steelhead<br>Although water temperatures suggest a slightly lower potential for adverse effects on steelhead in the Trinity River, the relatively small differences in flows and water temperatures under would likely result in similar effects on the steelhead population.<br>Green Sturgeon<br>Given the similarities between average monthly water temperatures at Lewiston Dam, it is likely that temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar.<br>Reservoir Fishes<br>Overall, while reservoir storage and nest survival would be slightly higher, it is uncertain whether these differences would be biologically meaningful. Thus, it is likely that effects on black bass would be similar.<br>Pacific Lamprey<br>Overall, it is likely that effects on Pacific Lamprey would be similar.  This conclusion likely also applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).<br>Eulachon | Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead.<br>Coordination of CVP and SWP operations with USFWS and NMFS to reduce impacts on late fall-run Chinook Salmon, Delta Smelt, Longfin Smelt, and Reservoir Fishes on the Sacramento River System; and Striped Bass and Hardhead on the Stanislaus and San Joaquin rivers. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | Given that the highest increases in flow would be less than 10 percent in the Trinity River, with a smaller relative increase in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River would unlikely to be affected by changes upstream at Lewiston Dam, it is likely that effects would have a similar potential to influence Eulachon in the Klamath River.<br>**Sacramento River System**<br>Winter-run Chinook Salmon<br>Potentially more adverse due to lack of fish passage,   The predator control measures could reduce winter-run Chinook Salmon mortality.<br>Spring-run Chinook Salmon<br>The model results suggest that overall, effects on spring-run Chinook Salmon could be slightly less adverse with a small likelihood that spring-run Chinook Salmon production would be higher.  This potential distinction may be partially offset and become more adverse by the lack of the benefits of implementation of fish passage.<br>The ocean harvest restriction component and predator control measures could reduce spring-run Chinook Salmon mortality.<br>Overall, given the small differences between Alternative 3 and the No Action Alternative conditions and the uncertainty regarding the non-operational components, distinguishing a clear difference is not possible.  This potential distinction may be partially offset and become more adverse by the lack of the benefits of implementation of fish passage.<br>Fall-run-run Chinook Salmon<br>The model results suggest that overall, effects on fall-run Chinook Salmon could be slightly less adverse with a small likelihood that fall-run Chinook Salmon production would be higher.  This potential distinction may be partially offset and become more adverse by the lack of the benefits of implementation of fish passage.<br>The ocean harvest restriction component and predator control measures could reduce fall-run Chinook Salmon mortality.<br>Overall, given the small differences between Alternative 3 and the No Action Alternative conditions and the uncertainty regarding the non-operational components, distinguishing a clear difference is not possible. This potential distinction may be partially offset and become more adverse by the lack of the benefits of implementation of fish passage.<br>Late Fall-run-run Chinook Salmon<br>It is likely that the effects on late fall-run Chinook Salmon would be similar.  This potential distinction may be partially offset and become more adverse by the lack of the benefits of implementation of fish passage.<br>The ocean harvest restriction component and predator control measures could reduce late fall-run Chinook Salmon mortality.<br>Overall, given the small differences between Alternative 3 and the No Action Alternative | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
|---|---|---|
| | conditions and the uncertainty regarding the non-operational components, distinguishing a clear difference is not possible. This potential distinction may be partially offset and become more adverse by the lack of the benefits of implementation of fish passage.<br><br><u>Steelhead</u><br><br>The model results suggest that overall, effects on steelhead could be slightly less adverse, particularly in the Feather River. This potential distinction may be partially offset and become more adverse by the lack of the benefits of implementation of fish passage.<br><br>The ocean harvest restriction component and predator control measures could reduce steelhead mortality.<br><br>Overall, given the small differences between Alternative 3 and the No Action Alternative conditions and the uncertainty regarding the non-operational components, distinguishing a clear difference is not possible.<br><br><u>Green Sturgeon</u><br><br>Given the general similarity in results and inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), the effects likely would be similar.<br><br><u>White Sturgeon</u><br><br>Given the general similarity in results and the inherent uncertainty associated with the resolution of the temperature model, the effects likely would be similar.<br><br><u>Delta Smelt</u><br><br>Overall, likely would result in adverse effects, primarily due to increased percentage entrainment during larval and juvenile life stages, and less favorable location of Fall X2 in wetter years, and on average.<br><br><u>Longfin Smelt</u><br><br>Overall, based on the increase in frequency and magnitude of negative OMR flows and the lower Longfin Smelt abundance index values, potential adverse effects likely would be greater.<br><br><u>Sacramento Splittail</u><br><br>Flows entering the Yolo Bypass generally would be somewhat higher, especially during below normal years in December through March. These increases would occur during periods of relatively low flow in the bypass, and could slightly increase the frequency of potential inundation. This could provide somewhat greater value to Sacramento Splittail because of the increased area of potential habitat (inundation) and the potential for a slight increase in the frequency of inundation.<br><br><u>Reservoir Fishes</u><br><br>The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar to or slightly lower. This suggests that conditions in the reservoirs could be less likely to support self-sustaining populations of black bass. However, it is uncertain whether this | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | effect would be biologically meaningful. Thus, it is likely that effects on black bass would be similar.<br><br><u>Pacific Lamprey</u><br><br>Pacific Lamprey would be subjected to the same temperature conditions described above for salmonids. Based on the somewhat increased flows and slightly decreased temperatures during their spawning and incubation period, it is likely that Alternative 3 would have a slightly lower potential to adversely affect Pacific Lamprey in the Sacramento, Feather, and American rivers. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).<br><br><u>Other Species</u><br><br>Changes in average monthly water temperature would be small. In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Given the somewhat increased flows and decreased water temperatures during their spawning and incubation period, it is likely to have a lower potential to adversely affect Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers.<br><br>Predation controls related to Striped Bass would result in adverse effects.<br><br>**Stanislaus River/Lower San Joaquin River**<br><br><u>Fall-run-run Chinook Salmon</u><br><br>Overall, likely would have slightly beneficial effects on the fall-run Chinook Salmon population in the San Joaquin River watershed.<br><br>Beneficial effects to juvenile fall-run Chinook Salmon as a result of trap and haul passage across through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions under would benefit fall-run Chinook Salmon.<br><br><u>Steelhead</u><br><br>Given the frequency of exceedance under both Alternative 3 and the No Action Alternative, water temperature conditions for steelhead in the Stanislaus River would be generally stressful in the fall, late spring, and summer months. The differences in temperature exceedance (both positive and negative) would be relatively small, with no clear benefit. However, because Alternative 3 generally would exceed thresholds less frequently during the warmest months, slightly improved conditions. This potential distinction may become more adverse due to the lack of fish passage.<br><br>Additional beneficial effects to juvenile steelhead as a result of trap and haul passage across through the Delta. It remains uncertain, however, if predator management actions would benefit steelhead.<br><br><u>White Sturgeon</u><br><br>While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon.<br>Reservoir Fishes<br>While the analyses suggest that the effects could be more adverse, it is uncertain whether these differences would be biological meaningful. Therefore, it is likely that the effects on black basses in New Melones Reservoir would be similar.<br>Other Species<br>In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the slightly lower flows and temperatures during their spawning and incubation period, it is likely that the potential effects to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be somewhat more adverse.<br>Predation controls related to Striped Bass would result in adverse effects.<br>**Pacific Ocean**<br>Killer Whale<br>It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected.<br>Beneficial effects due to benefits to fall-run Chinook Salmon as a result of trap and haul passage across through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions would benefit the fall-run Chinook Salmon population. | |
| Alternative 4 | **Trinity River Region**<br>Coho Salmon, spring-run and fall-run Chinook Salmon, steelhead, Green Sturgeon, Reservoir Fishes, Pacific Lamprey, River Lamprey, and Eulachon<br>The effects are identical as described under Alternative 1 as compared to the No Action Alternative.<br>**Sacramento River System**<br>Winter-run, spring-run, fall-run, and late fall-run Chinook Salmon, and steelhead<br>The effects in the Sacramento River system would be similar as described under Alternative 1 as compared to the No Action Alternative.<br>Beneficial effects to Chinook Salmon as a result of trap and haul passage across through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions would benefit the Chinook Salmon population.<br>Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, River Lamprey, American Shad, and Hardhead<br>The effects in the Sacramento River system would be similar as described under Alternative 1 as compared to the No Action Alternative.<br>Striped Bass | Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead.<br>Coordination of CVP and SWP operations with USFWS and NMFS to reduce impacts on late fall-run Chinook Salmon, Delta Smelt, Longfin Smelt, and Reservoir Fishes on the Sacramento River System. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | The effects in the Sacramento River system would be similar as described under Alternative 1 as compared to the No Action Alternative.<br>Predation controls related to Striped Bass would result in adverse effects.<br>**Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon and Steelhead<br>The effects in the Stanislaus River/Lower San Joaquin River system would be similar as described under Alternative 1 as compared to the No Action Alternative.<br>Beneficial effects to Chinook Salmon as a result of trap and haul passage across through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions would benefit the Chinook Salmon population.<br>White Sturgeon, Reservoir Fishes, and Other Species<br>The effects in the Stanislaus River/Lower San Joaquin River system would be similar as described under Alternative 1 as compared to the No Action Alternative.<br>Striped Bass<br>The effects in the Stanislaus River/Lower San Joaquin River system would be similar as described under Alternative 1 as compared to the No Action Alternative.<br>Predation controls related to Striped Bass would result in adverse effects.<br>**Pacific Ocean**<br>Killer Whale<br>It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected.<br>Beneficial effects due to benefits to fall-run Chinook Salmon as a result of trap and haul passage across through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions would benefit the fall-run Chinook Salmon population. | |
| Alternative 5 | **Trinity River Region**<br>Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead, and Green Sturgeon<br>Effects would be similar.<br>Reservoir Fishes<br>Effects would be similar.<br>Pacific Lamprey<br>Effects would be similar.<br>Eulachon<br>Effects would be similar.<br>**Sacramento River System**<br>Winter-run Chinook Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Late Fall-run Chinook Salmon, Steelhead, Green Sturgeon, and White Sturgeon<br>Effects would be similar.<br>Delta Smelt, Longfin Smelt, and Sacramento Splittail | Coordination of CVP and SWP operations with USFWS and NMFS to reduce impacts on Striped Bass and Hardhead on the Stanislaus River and San Joaquin River systems. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | Effects would be similar.<br>Reservoir Fishes<br>Effects would be similar.<br>Pacific Lamprey and Other Species<br>Effects would be similar.<br>**Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon and Steelhead<br>The analysis of temperatures indicates somewhat higher temperatures and a higher likelihood of exceedance of suitable temperatures for spawning, and lower likelihood of exceeding suitable temperature for rearing of fall-run Chinook Salmon. The effect of higher temperatures is reflected in the slightly higher overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model for fall-run Chinook Salmon in the Stanislaus River. The frequency of exceedance of temperature thresholds for steelhead smoltification and rearing would be more stressful. However, with higher flows in April and May and lower temperatures in April and May could benefit steelhead spawning. Fish passage would reduce the temperatures effects.<br>White Sturgeon<br>While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon.<br>Reservoir Fishes<br>While the analyses suggest that the effects could be more adverse, it is uncertain whether these differences would be biological meaningful. Therefore, it is likely that the effects on black basses in New Melones Reservoir would be similar.<br>Other Species<br>Given the similar or higher flows and similar or higher temperatures during their spawning and incubation period, it is likely that the potential to affect lamprey species in the Stanislaus and San Joaquin rivers would be greater.<br>Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar or higher flows and temperatures during their spawning and incubation period, it is likely that the potential effects to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be somewhat more adverse.<br>**Pacific Ocean**<br>Killer Whale<br>It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | production of fall-run Chinook Salmon, would be appreciably affected. | |

**Table 9.5 Comparison of No Action Alternative and Alternatives 1 through 5 to Second Basis of Comparison**

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| No Action Alternative | **Trinity River Region**<br>Coho Salmon<br>Overall, the temperature model outputs for each of the Coho Salmon life stages suggest that the temperature of water released at Lewiston Dam generally would be similar, although the exceedance of water temperature thresholds would be slightly more frequent (1 percent). Given the similarity of the results and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), there would be similar effects on the Coho Salmon population in the Trinity River.<br>Spring-run Chinook Salmon<br>Overall, water temperature could have adverse effects on spring-run Chinook Salmon in the Trinity River; however, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures. Thus, given these relatively minor changes in temperature and temperature threshold exceedance, and the inherent uncertainty associated with the resolution of the temperature model (average monthly outputs), likely to have similar effects on the spring-run Chinook Salmon population in the Trinity River.<br>Fall-run Chinook Salmon<br>Although the combined analysis based on water temperature suggests that operations could be slightly more adverse, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in water temperatures (as well as egg mortality). Overall, given these small differences and the inherent uncertainty in the temperature model, likely to have similar effects on the fall-run Chinook Salmon population in the Trinity River.<br>Steelhead<br>Although the water temperature and flow changes could have adverse effects on steelhead in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures under the No Action Alternative as compared to the Second Basis of Comparison. Overall, the likely to result in similar effects on the steelhead population in the Trinity River.<br>Green Sturgeon<br>Overall, given the similarities between average monthly water temperatures at Lewiston Dam, it is likely that temperature conditions for Green Sturgeon in the Trinity River or lower Klamath River and estuary would be similar. | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | <u>Reservoir Fishes</u><br>Overall, the comparison of storage and the analysis of nesting suggest that effects would be similar.<br><u>Pacific Lamprey</u><br>Given the somewhat reduced flows and similar temperatures, it is likely that the effects would be similar. This conclusion likely applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).<br><u>Eulachon</u><br>Given that the highest reductions in flow would be less than 10 percent in the Trinity River, which would represent even a smaller proportion in the lower Klamath River and Klamath River estuary, and that water temperatures in the Klamath River are unlikely to be affected by changes upstream at Lewiston Dam, it is likely the conditions would be similar for Eulachon in the Klamath River.<br>**Sacramento River System**<br><u>Winter-run Chinook Salmon</u><br>The model results suggest that effects on winter-run Chinook Salmon would be similar, with a small likelihood that winter-run Chinook Salmon escapement would be higher. This potential distinction between the two scenarios, however, may be increased by the benefits of implementation of fish passage.<br><u>Spring-run Chinook Salmon</u><br>The model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse with a small likelihood that spring-run Chinook Salmon production would be lower under the No Action Alternative. This potential distinction may be offset by the benefits of implementation of fish passage.<br><u>Fall-run Chinook Salmon</u><br>The model results suggest that overall, effects on fall-run Chinook Salmon could be slightly more adverse with a small likelihood that fall-run Chinook Salmon production would be lower. This potential distinction may be offset by the benefits of implementation of fish passage on the Sacramento and American rivers.<br><u>Late Fall-run Chinook Salmon</u><br>The model results suggest that overall, effects on late fall-run Chinook Salmon could be slightly more adverse with a small likelihood that late fall-run Chinook Salmon production would be lower. This potential distinction may be offset by the benefits of implementation of fish passage.<br><u>Steelhead</u><br>The model results suggest that overall, effects on steelhead could be slightly more adverse, particularly in the Feather River. This potential distinction may be offset by the benefits of implementation of fish passage on the Sacramento and American rivers.<br><u>Green Sturgeon</u><br>Overall, the increased frequency of exceedance of temperature thresholds could increase the potential | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | for adverse effects on Green Sturgeon in the Sacramento and Feather rivers.<br><u>White Sturgeon</u><br>Overall, the increased frequency of exceedance of temperature thresholds could increase the potential for adverse effects on White Sturgeon in the Sacramento River.<br><u>Delta Smelt</u><br>Overall, likely would result in better conditions for Delta Smelt, primarily due to lower percentage entrainment for larval and juvenile life stages, and more favorable location of Fall X2 in wetter years, and on average.<br><u>Longfin Smelt</u><br>Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in dry and critical dry years, potential adverse effects on the Longfin Smelt population likely would be less.<br><u>Sacramento Splittail</u><br>Overall, the slight adverse effects related to spawning habitat for Sacramento Splittail because of the decreased area of potential habitat (inundation) and the potential for a slight decrease in the frequency of inundation.<br><u>Reservoir Fishes</u><br>The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar or slightly higher. Overall, the results of the nest survival analysis suggest that conditions in the reservoirs would be more likely to support self-sustaining populations of black bass.<br><u>Pacific Lamprey</u><br>Based on the somewhat reduced flows and increased temperatures during their spawning and incubation period, it is unlikely that conditions for and effects on Pacific Lamprey in the Sacramento, Feather, and American rivers would differ in a biologically meaningful manner. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).<br><u>Striped Bass, American Shad, and Hardhead</u><br>In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the slightly decreased flows and increased temperatures during their spawning and incubation period, it is unlikely that conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would differ in a biologically meaningful manner.<br>**Stanislaus River/Lower San Joaquin River**<br><u>Fall-run Chinook Salmon</u><br>Given the inherent uncertainty associated with the resolution of the temperature model, the differences in the frequency of exceedance of suitable temperatures for spawning and rearing could affect the potential for adverse effects on the fall-run Chinook Salmon populations in the Stanislaus River. | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | However, the direction and magnitude of this effect is uncertain and it likely that the effects on fall-run Chinook Salmon in the Stanislaus River would be similar. Implementation of a fish passage project, likely would provide some benefit to fall-run Chinook Salmon if volitional passage were provided and additional habitat could be accessed.<br>Steelhead<br>Given the inherent uncertainty associated with the resolution of the temperature model, the differences in the magnitude and frequency of exceedance of suitable temperatures for the various life stages could affect the potential for adverse effects on the steelhead populations in the Stanislaus River. However, the direction and magnitude of this effect is uncertain. Implementation of a fish passage project, likely would provide some benefit to steelhead.<br>Reservoir Fishes<br>Overall, the potential for adverse effects on reservoir fishes could slightly higher because of the overall relative reductions in reservoir storage and the slightly improved nest survival in some months.<br>Other Species<br>In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar.<br>**Pacific Ocean**<br>Killer Whale<br>Given conclusions from NMFS (2009c), and the fact that at least 75 percent of fall-run Chinook Salmon available for Southern Residents are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base for killer whales would not be appreciably affected. | |
| Alternative 1 | No effects on aquatic resources. | Not considered for this comparison. |
| Alternative 2 | **Trinity River Region**<br>The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison.<br>**Sacramento River System**<br>Winter-run Chinook Salmon<br>The model results suggest that effects on winter-run Chinook Salmon would be similar, with a small likelihood that winter-run Chinook Salmon escapement would be higher.<br>Spring-run Chinook Salmon<br>The model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse with a small likelihood that spring-run Chinook Salmon production would be lower under the No Action Alternative.<br>Fall-run Chinook Salmon<br>The model results suggest that overall, effects on fall-run Chinook Salmon could be slightly more | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | adverse with a small likelihood that fall-run Chinook Salmon production would be lower.<br>Late Fall-run Chinook Salmon<br>The model results suggest that overall, effects on late fall-run Chinook Salmon could be slightly more adverse with a small likelihood that late fall-run Chinook Salmon production would be lower.<br>Steelhead<br>The model results suggest that overall, effects on steelhead could be slightly more adverse, particularly in the Feather River.<br>Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, Striped Bass, American Shad, and Hardhead<br>The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison.<br>**Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon<br>Given the inherent uncertainty associated with the resolution of the temperature model, the differences in the frequency of exceedance of suitable temperatures for spawning and rearing could affect the potential for adverse effects on the fall-run Chinook Salmon populations in the Stanislaus River. However, the direction and magnitude of this effect is uncertain and it likely that the effects on fall-run Chinook Salmon in the Stanislaus River would be similar.<br>Steelhead<br>Given the inherent uncertainty associated with the resolution of the temperature model, the differences in the magnitude and frequency of exceedance of suitable temperatures for the various life stages could affect the potential for adverse effects on the steelhead populations in the Stanislaus River. However, the direction and magnitude of this effect is uncertain.<br>Reservoir Fishes and Other Species<br>The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison.<br>**Pacific Ocean**<br>Killer Whale<br>The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison. | |
| Alternative 3 | **Trinity River Region**<br>Coho Salmon and Spring-run Chinook Salmon<br>Although the water temperature and flow changes could have slight beneficial effects, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures. Overall, likely to result in similar effects on the spring-run Chinook Salmon population in the Trinity River. | Not considered for this comparison. |

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| | <u>Fall-run Chinook Salmon</u><br>Although the water temperature and flow changes suggest a lower potential for adverse effects on fall-run Chinook Salmon in the Trinity River, these effects would not occur in every year and are not anticipated to be substantial based on the relatively small differences in flows and water temperatures (as well as egg mortality). Overall, likely to have similar effects.<br><u>Steelhead</u><br>Water temperatures suggest similar effects on the steelhead population.<br><u>Green Sturgeon</u><br>Water temperatures suggest similar effects on Green Sturgeon in the Trinity River or lower Klamath River and estuary.<br><u>Reservoir Fishes</u><br>Overall, reservoir storage and nest survival suggest similar effects on black bass.<br><u>Pacific Lamprey</u><br>Overall, it is likely that effects on Pacific Lamprey would be similar. This conclusion likely also applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).<br><u>Eulachon</u><br>It is likely that effects would have a similar potential to influence Eulachon in the Klamath River.<br>**Sacramento River System**<br><u>Winter-run Chinook Salmon</u><br>Potentially slightly more beneficial due to lack of fish passage, if fish passage is successful in providing access to higher quality habitat, The predator control measures could reduce winter-run Chinook Salmon mortality.<br><u>Spring-run Chinook Salmon</u><br>The model results suggest that overall, effects on spring-run Chinook Salmon could be slightly more adverse with a small likelihood that spring-run Chinook Salmon production would be lower.<br>The ocean harvest restriction component and predator control measures could reduce spring-run Chinook Salmon mortality.<br><u>Fall-run Chinook Salmon</u><br>The model results suggest that overall, effects on fall-run Chinook Salmon could be slightly less adverse with a small likelihood that fall-run Chinook Salmon production would be higher. However, the potential for salvage loss also would be higher.<br>The ocean harvest restriction component and predator control measures could reduce fall-run Chinook Salmon mortality.<br>Overall, effects on fall-run Chinook Salmon would be slightly less adverse.<br><u>Late Fall-run Chinook Salmon</u><br>Overall, it is likely that the effects on late fall-run Chinook Salmon would be similar.<br>The ocean harvest restriction component and predator control measures could reduce late fall-run Chinook Salmon mortality. | |

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| | <u>Steelhead</u><br>The model results suggest that overall, effects on steelhead could be slightly more adverse, particularly in the Feather and American rivers.<br>The ocean harvest restriction component and predator control measures could reduce steelhead mortality.<br><u>Green Sturgeon</u><br>Given the general similarity in results and inherent uncertainty associated with the resolution of the temperature model, the slightly reduced frequency of exceedance of temperature thresholds could result in beneficial effects on sturgeon.<br><u>White Sturgeon</u><br>Given the general similarity in results and inherent uncertainty associated with the resolution of the temperature model, the slightly reduced frequency of exceedance of temperature thresholds could result in beneficial effects on sturgeon.<br><u>Delta Smelt</u><br>Overall, effects would be similar based on reduced entrainment and more favorable location of Fall X2.<br><u>Longfin Smelt</u><br>Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, potential beneficial effects likely would be greater.<br><u>Sacramento Splittail</u><br>Flows entering the Yolo Bypass generally would be somewhat lower. This could provide somewhat lower value to Sacramento Splittail because of the decreased area of potential spawning habitat.<br><u>Reservoir Fishes</u><br>The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar. Thus, it is likely that effects on black bass would be similar.<br><u>Pacific Lamprey</u><br>Pacific Lamprey would be subjected to the same temperature conditions described above for salmonids. Based on the somewhat increased flows and slightly decreased temperatures during their spawning and incubation period, it is likely that Alternative 3 would have a slightly lower potential to adversely affect Pacific Lamprey in the Sacramento, Feather, and American rivers. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).<br><u>Other Species</u><br>Changes in average monthly water temperature would be small. In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Given the somewhat increased flows and decreased water temperatures during their spawning and incubation period, it is likely that Alternative 3 would have a lower potential to adversely affect Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers.<br>Predation controls related to Striped Bass would result in adverse effects. | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | **Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon<br>Overall, likely would have similar effects on the fall-run Chinook Salmon population in the San Joaquin River watershed.<br>Beneficial effects to juvenile fall-run Chinook Salmon as a result of trap and haul passage across through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions under fall-run Chinook Salmon would benefit the fall-run Chinook Salmon population.<br>Steelhead<br>Given the frequency of exceedance under both Alternative 3 and the Second Basis of Comparison, water temperature conditions for steelhead in the Stanislaus River would be generally similar.<br>Additional beneficial effects to juvenile steelhead as a result of trap and haul passage across through the Delta. It remains uncertain, however, if predator management actions would benefit steelhead.<br>White Sturgeon<br>While flows in the San Joaquin River upstream of the Stanislaus River are expected be similar, flow contributions from the Stanislaus River could influence water temperatures in the San Joaquin River where White Sturgeon eggs or larvae may occur during the spring and early summer. The magnitude of influence on water temperature would depend on the proportional flow contribution of the Stanislaus River and the temperatures in both the Stanislaus and San Joaquin rivers. The potential for an effect on White Sturgeon eggs and larvae would be influenced by the proportion of the population occurring in the San Joaquin River. In consideration of this uncertainty, it is not possible to distinguish potential effects on White Sturgeon.<br>Reservoir Fishes<br>While the analyses suggest that the effects could be more favorable, it is uncertain whether these differences would be biological meaningful. Therefore, it is likely that the effects on black basses in New Melones Reservoir would be similar.<br>Other Species<br>In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the slightly lower flows and temperatures during their spawning and incubation period, it is likely that the potential effects to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar.<br>Predation controls related to Striped Bass would result in adverse effects.<br>**Pacific Ocean**<br>Killer Whale<br>It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected. | |
| Alternative 4 | **Trinity River Region**<br>Coho Salmon, spring-run and fall-run Chinook Salmon, steelhead, Green Sturgeon, Reservoir | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | Fishes, Pacific Lamprey, River Lamprey, and Eulachon<br>The effects would be identical.<br>**Sacramento River System**<br>Winter-run, spring-run, fall-run, and late fall-run Chinook Salmon, and steelhead<br>The effects in the Sacramento River system would be similar. Beneficial effects to Chinook Salmon as a result of trap and haul passage across through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions would benefit the Chinook Salmon population.<br>Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, River Lamprey, American Shad, and Hardhead<br>The effects in the Sacramento River system would be identical.<br>Striped Bass<br>The effects in the Sacramento River system would be similar. Predation controls related to Striped Bass would result in adverse effects.<br>**Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon and Steelhead<br>The effects in the Stanislaus River/Lower San Joaquin River system would be similar. Beneficial effects to Chinook Salmon as a result of trap and haul passage across through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions would benefit the Chinook Salmon population.<br>White Sturgeon, Reservoir Fishes, and Other Species<br>The effects in the Stanislaus River/Lower San Joaquin River system would be identical.<br>Striped Bass<br>The effects in the Stanislaus River/Lower San Joaquin River system would be similar. Predation controls related to Striped Bass would result in adverse effects.<br>**Pacific Ocean**<br>Killer Whale<br>It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery production of fall-run Chinook Salmon, would be appreciably affected.<br>Beneficial effects due to benefits to fall-run Chinook Salmon as a result of trap and haul passage across through the Delta and ocean harvest restrictions. It remains uncertain, however, if predator management actions would benefit the fall-run Chinook Salmon population. | |
| Alternative 5 | **Trinity River Region**<br>Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead, and Green Sturgeon<br>Monthly water temperature generally would be similar (less than 0.5ºF differences), with the exception of drier years when temperatures could be as much as 2.2ºF cooler in November and 1.5ºF in December. Average monthly water temperatures | Not considered for this comparison. |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | could be slightly (up to 0.6ºF) higher during July and August and lower (up to 0.7ºF) in September. Lower September temperatures may result in slightly better conditions for spring-run Chinook Salmon spawning. Similarly, temperature conditions could be slightly better for fall-run Chinook Salmon spawning because of the reduced temperatures in November during critical dry years.<br>Water temperature thresholds for Coho Salmon, fall-run Chinook Salmon, and steelhead would be exceeded slightly more frequently (less than 1 percent), whereas thresholds for spring-run Chinook Salmon would be exceeded less frequently (up to 4 percent) in August in September.<br>These temperature results are reflected in the egg mortality results for fall-run Chinook Salmon, which indicate slightly higher mortality under Alternative 5 compared to the Second Basis of Comparison, with differences less than 0.3 percent in most year types and 1.9 percent in critical dry years.<br>The minor changes in water temperatures and mortality suggest that conditions for Coho Salmon, fall-run Chinook Salmon, steelhead, and Green Sturgeon in the Trinity River would be similar. However, the reduced threshold exceedances for spring-run Chinook Salmon, although small, could be biologically meaningful under some conditions.<br><u>Reservoir Fishes</u><br>Overall, the comparison of storage and the analysis of nesting suggest that effects would be similar.<br><u>Pacific Lamprey</u><br>It is likely that the effects would be similar. This conclusion likely applies to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).<br><u>Eulachon</u><br>It is likely the conditions would be similar for Eulachon in the Klamath River.<br>**Sacramento River System**<br><u>Winter-run Chinook Salmon</u><br>The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds. This is reflected in the slightly lower survival of winter-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model. Flow changes would have small effects on the availability of spawning and rearing habitat for winter-run Chinook Salmon as indicated by the decrease in flow (habitat)-related mortality predicted by SALMOD. Through Delta survival of juvenile winter-run Chinook Salmon would be similar as indicated by the DPM results; and the OBAN results suggest that Delta survival could be higher. Entrainment may also be reduced as indicated by the OMR flow analysis. Median adult escapement to the Sacramento River would be reduced slightly as indicated by the IOS model results which incorporate temperature, flow, and mortality effects on each life stage over the entire life cycle of winter-run Chinook Salmon. However, the OBAN model results indicate an increase in escapement over a more limited time period (1971 to 2002). Considering all the above analyses for the winter-run Chinook Salmon | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | population, the changes in overall effects are highly uncertain. However, the upstream fish passage could benefit the winter-run Chinook Salmon population in the Sacramento River.<br>Spring-run Chinook Salmon<br>The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds in the Sacramento and Feather rivers. There would be little change in flows or temperatures in Clear Creek. The effect of increased temperatures is reflected in the slightly lower overall survival of spring-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model for spring-run in the Sacramento River. In drier years, the likelihood of adverse temperature effects would be increased. Flow changes would likely have small effects on the availability of spawning and rearing habitat for spring-run Chinook Salmon in the Sacramento River as indicated by the decrease in flow (habitat)-related mortality predicted by SALMOD. Through Delta survival of juvenile spring-run Chinook Salmon would be similar as indicated by the DPM results, and entrainment could be reduced as indicated by the salvage analysis. Overall, similar or somewhat greater adverse effects on the spring-run Chinook Salmon population in the Sacramento River watershed, particularly in drier water year types. However, given that most of the spring-run Chinook Salmon are on the tributaries where the effects of changes are minimal and with the fish passage actions, it is likely that the effects would be similar or beneficial.<br>Fall-run Chinook Salmon<br>The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds in the Sacramento and Feather rivers. There would be little change in flows or temperatures in Clear Creek, but these differences might not be biologically meaningful because the temperature outputs represent conditions at Igo, a location upstream of most fall-run Chinook Salmon spawning and rearing. The effect of increased temperatures is reflected in the slightly lower overall survival of fall-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model for fall-run in the Feather and American rivers. In drier years, the likelihood of adverse temperature effects would be increased.<br>Flow changes would likely have small effects on the availability of spawning and rearing habitat for fall-run Chinook Salmon in the Sacramento River as indicated by the slight decrease in spawning WUA in the Sacramento and Feather Rivers and slight increases in spawning WUA for fall-run Chinook Salmon in the American River. Fry and juvenile rearing WUA would be increased slightly in the Sacramento River and this is reflected in a decrease in flow (habitat)-related mortality predicted by SALMOD.<br>Through-Delta survival of juvenile fall-run Chinook Salmon would be similar as indicated by the DPM results, and entrainment could be reduced as indicated by the OMR flow analysis. Overall, effects likely to be similar or slightly greater adverse effects on the fall-run Chinook Salmon population in the | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | Sacramento River watershed, particularly in drier water year types. Fish passage actions could result in beneficial effects.<br><br><u>Late Fall-run Chinook Salmon</u><br><br>The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds. This is reflected in the slightly lower survival of late fall-run Chinook Salmon eggs predicted by Reclamation's salmon mortality model. Flow changes would have small effects on the availability of spawning habitat for late fall-run Chinook Salmon as indicated by the WUA analysis. Fry rearing habitat would be slightly increased, but juvenile rearing WUA would decrease during some months. These effects are reflected in the decrease in flow (habitat)-related and the increase in temperature-related egg and fry mortality predicted by SALMOD. Juvenile rearing mortality is also predicted to increase. Through Delta survival of juvenile late fall-run Chinook Salmon would be increased as indicated by the DPM results, and entrainment may be reduced as indicated by the OMR flow analysis.<br><br>Overall, likely to have lesser adverse effects on the late fall-run Chinook Salmon population in the Sacramento River. Fish passage actions would increase the beneficial effects.<br><br><u>Steelhead</u><br><br>The analysis of temperatures indicates somewhat higher temperatures and greater likelihood of exceedance of thresholds in the Sacramento and Feather rivers. In drier years, the likelihood of adverse temperature effects would be increased. There would be little change in flows or temperatures in Clear Creek.<br><br>Overall, likely to have somewhat greater adverse effects on the steelhead population in the Sacramento River watershed, particularly in drier water year types because of the temperature effects. Fish passage could provide additional benefit for steelhead.<br><br><u>Green Sturgeon</u><br><br>Overall, the increased frequency of exceedance of temperature thresholds could increase the potential for adverse effects on Green Sturgeon in the Sacramento and Feather rivers.<br><br><u>White Sturgeon</u><br><br>Overall, the increased frequency of exceedance of temperature thresholds could increase the potential for adverse effects on White Sturgeon in the Sacramento River.<br><br><u>Delta Smelt</u><br><br>Overall, likely would result in better conditions for Delta Smelt, primarily due to lower percentage entrainment for larval and juvenile life stages, and more favorable location of Fall X2 in wetter years, and on average.<br><br><u>Longfin Smelt</u><br><br>Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | dry and critical dry years, potential adverse effects on the Longfin Smelt population likely would be less.<br>Sacramento Splittail<br>Overall, the slight adverse effects related to spawning habitat for Sacramento Splittail because of the decreased area of potential habitat (inundation) and the potential for a slight decrease in the frequency of inundation.<br>Reservoir Fishes<br>The analysis of black bass nest survival based on changes in water surface elevation during the spawning period indicated that the likelihood of high (greater than 40 percent) nest survival in most of the reservoirs would be similar or slightly higher. Overall, the results of the nest survival analysis suggest that conditions in the reservoirs would be more likely to support self-sustaining populations of black bass.<br>Pacific Lamprey<br>Based on the somewhat reduced flows and increased temperatures during their spawning and incubation period, it is likely that conditions for and effects on Pacific Lamprey in the Sacramento, Feather, and American rivers be more adverse. This conclusion likely applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).<br>Striped Bass, American Shad, and Hardhead<br>In general, Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than salmonids. Based on the slightly decreased flows and increased temperatures during their spawning and incubation period, it is unlikely that conditions for and effects on Striped Bass, American Shad, and Hardhead in the Sacramento, Feather, and American rivers would differ in a biologically meaningful manner.<br>**Stanislaus River/Lower San Joaquin River**<br>Fall-run Chinook Salmon<br>The analysis of temperatures indicates lower temperatures and a lesser likelihood of exceedance of suitable temperatures for spawning and rearing of fall-run Chinook Salmon in the Stanislaus River below Goodwin Dam and in the San Joaquin River at Vernalis. The effect of lower temperatures is reflected in the slightly lower overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation's salmon survival model for fall-run in the Stanislaus River. As described above, the instream flow patterns are anticipated to benefit fall-run Chinook Salmon in the Stanislaus River and downstream in the lower San Joaquin River below Vernalis.<br>Overall, would have less adverse effect on the fall-run Chinook Salmon population in the San Joaquin River watershed.<br>Steelhead<br>Given the frequency of exceedance and the generally stressful temperature conditions in the river, the substantial lower temperatures in October and April suggest that there would be less potential to adversely affect steelhead. | |

| Alternative | Potential Change | Consideration for Mitigation Measures |
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| | Reservoir Fishes<br>Overall, the potential for adverse effects on reservoir fishes could slightly higher because of the overall relative reductions in reservoir storage and the slightly reduced nest survival in some months.<br>Other Species<br>In general, Striped Bass and Hardhead also can tolerate higher temperatures than salmonids. Given the similar flows and temperatures during their spawning and incubation period, it is likely that the potential to affect Striped Bass and Hardhead in the Stanislaus and San Joaquin rivers would be similar.<br>**Pacific Ocean**<br>Killer Whale<br>Given conclusions from NMFS (2009c), and the fact that at least 75 percent of fall-run Chinook Salmon available for Southern Residents are produced by Central Valley hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base for killer whales would not be appreciably affected. | |

#### *9.4.3.8 Potential Mitigation Measures*

Changes in CVP and SWP operations under Alternatives 1 through 5 as compared to the No Action Alternative would result in adverse impacts. Potential mitigation measures that could be considered to reduce the adverse impacts include:

- Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead under Alternatives 1, 2, 3, and 4.
- Coordination of CVP and SWP operations between Reclamation, DWR, USFWS, and NMFS to reduce flow and reservoir storage impacts on late fall-run Chinook Salmon on the Sacramento River system under Alternatives 1, 3, and 4.
- Coordination of CVP and SWP operations between Reclamation, DWR, USFWS, and NMFS to reduce entrainment impacts on Delta Smelt and Longfin Smelt, and Reservoir Fishes on the Sacramento River system under Alternatives 1, 3, and 4.
- Coordination of CVP and SWP operations between Reclamation, DWR, USFWS, and NMFS to reduce impacts on bass nests at reservoirs on the Sacramento River system under Alternatives 1, 3, and 4.
- Coordination of CVP and SWP operations between Reclamation, DWR, USFWS, and NMFS to reduce temperature impacts on Striped Bass and Hardhead on the Stanislaus and San Joaquin rivers system under Alternatives 3 and 5.

#### *9.4.3.9 Cumulative Effects Analysis*

As described in Chapter 3, 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 No Action Alternative, Alternatives 1 through 5, and Second Basis of Comparison include climate change and sea level rise, implementation of general plans, and completion of ongoing projects and programs (see Chapter 3, Description of Alternatives). The effects of these items were analyzed quantitatively and qualitatively, as described in the Impact Analysis of this chapter. The discussion below focuses on the qualitative effects of the alternatives and other past, present, and reasonably foreseeable future projects identified for consideration of cumulative effects (see Chapter 3, Description of Alternatives).

##### 9.4.3.9.1 No Action Alternative and Alternatives 1 through 5

Continued coordinated long-term operation of the CVP and SWP under the No Action Alternative would result in reduced CVP and SWP water supply availability as compared to recent conditions due to climate change and sea level rise by 2030. These conditions are included in the analysis presented above.

There also are several ongoing programs that could result in changes in flow patterns in the Sacramento and San Joaquin rivers watersheds and the Delta that could reduce availability of CVP and SWP water deliveries as well as local and regional water supplies. These projects include renewals of hydroelectric generation permits issued by the Federal Energy Regulatory Commission (FERC 2015) and update of the Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary by the State Water Resources Control Board (SWRCB 2006, 2013). Based upon the available information related to these projects, the cumulative effects would be to change flow patterns in the rivers and for Delta outflow in a manner that would improve conditions for biological resources.

There were be adverse aquatic resources impacts associated with implementation of the alternatives as compared to the No Action Alternative. Therefore, Alternatives 1 through 5 would contribute cumulative impacts to aquatic resources, specifically associated with:

- Temperature impacts on Chinook Salmon and steelhead under Alternatives 1, 2, 3, and 4.
- Flow and/or reservoir storage impacts on late fall-run Chinook Salmon on the Sacramento River system under Alternatives 1, 3, and 4
- Entrainment impacts on Delta Smelt and Longfin Smelt under Alternatives 1, 3, and 4.
- Impacts on bass nests at reservoirs on the Sacramento River system under Alternatives 1, 3, and 4.

- Temperature impacts on Striped Bass and Hardhead on the Stanislaus and San Joaquin rivers system under Alternatives 3 and 5.

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