

Chapter 9**1 Fish and Aquatic Resources****2 9.1 Introduction**

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

**9 9.2 Regulatory Environment and Compliance
10 Requirements**

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

16 9.3 Affected Environment

17 This section describes fish and aquatic resources that could be affected by the
18 implementation of the alternatives considered in this EIS. Changes in aquatic
19 resources due to changes in CVP and SWP operations may occur in the Trinity
20 River, Central Valley, San Francisco Bay Area, Central Coast, and Southern
21 California regions.

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

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

30 The descriptions of species and biological and hydrodynamic processes in this
31 chapter frequently use the terms “Delta” and “San Francisco Estuary.” The Delta
32 refers to the Sacramento-San Joaquin Delta, as legally defined in the Delta
33 Protection Act. The San Francisco Estuary refers to the portion of the
34 Sacramento-San Joaquin Rivers watershed downstream of Chipps Island that is

1 influenced by tidal action and where fresh water and salt water mix, which
 2 includes the following waterbodies: Suisun, San Pablo, and San Francisco bays.

3 **9.3.1 Fish and Aquatic Species Evaluated**

4 Many fish and aquatic species use the project area during all or some portion of
 5 their lives; however, certain fish and aquatic species were selected to be the focus
 6 of the analysis of alternatives considered in this EIS based on their sensitivity and
 7 their potential to be affected by changes in the operation of the CVP and SWP
 8 implemented under the alternatives considered in this EIS, as summarized in
 9 Table 9.1. While many of the species identified in Table 9.1 also occur in
 10 tributaries to the major rivers, the focus of this EIS is on the waterbodies
 11 influenced by operations of the CVP and SWP. These focal species are fish and
 12 marine mammal species listed as threatened or endangered or at risk of being
 13 listed as endangered or threatened, legally protected, or are otherwise considered
 14 sensitive by the U.S. Fish and Wildlife Service (USFWS), National Marine
 15 Fisheries Service (NMFS), or California Department of Fish and Wildlife
 16 (CDFW) (previously known as Department of Fish and Game [DFG]) and fish
 17 that have tribal, commercial or recreational importance. Details on the status, life
 18 history, habitat requirements, and population trends for each of the aquatic focal
 19 species are provided in Appendix 9B9B.

20 **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 <i>Southern Oregon/Northern California Coast ESU</i>	Threatened	Threatened	Yes	Trinity River, Klamath River
Eulachon <i>Southern DPS</i>	Threatened	None	Yes	Klamath River
Green Sturgeon <i>Southern DPS</i>	Threatened	Species of Special Concern	Yes	Trinity River, Klamath River
Spring-run Chinook Salmon <i>Upper Klamath-Trinity River ESU</i>	None	Species of Special Concern	Yes	Trinity River, Klamath River
Steelhead (winter- and summer-run) <i>Klamath Mountains Province DPS</i>	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

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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 <i>Sacramento River ESU</i>	Endangered	Endangered	Yes	Sacramento River ^d , Delta, and Suisun Marsh
Spring-run Chinook Salmon <i>Central Valley ESU</i>	Threatened	Threatened	Yes	Clear Creek, Sacramento River, Feather River, American River, Delta, and Suisun Marsh
Steelhead <i>Central Valley DPS</i>	Threatened	None	Yes	Clear Creek, Feather River, Sacramento River, American River, Stanislaus River, San Joaquin River, Delta and Suisun Marsh
Green Sturgeon <i>Southern DPS</i>	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 <i>Bay Delta DPS</i>	Candidate	Threatened	No	Delta and Suisun Marsh
Fall-/late Fall-run Chinook Salmon <i>Central Valley ESU</i>	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

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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 Central California Coast DPS	Threatened	None	Yes	San Francisco Bay region
Killer Whale <i>Southern Resident DPS</i>	Endangered	None	No	Pacific Coast

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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.

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

14 The level of detail presented in the Affected Environment section is tailored to
 15 correspond the level of resolution of the analysis, which relies on modeling tools
 16 that broadly characterize the changes in CVP and SWP operations on reservoir
 17 storage and flows. This level of detail is intended to support an understanding of
 18 the resources potentially affected and the context within which the project is
 19 evaluated. The inclusion of unnecessary detail is avoided.

20 **9.3.2 Critical Habitat**

21 Critical habitat refers to areas designated by USFWS or NMFS for the
 22 conservation of their jurisdictional species listed as threatened or endangered
 23 under the Endangered Species Act (ESA). When a species is proposed for listing
 24 under the ESA, USFWS or NMFS considers whether there are certain areas
 25 essential to the conservation of the species. Critical habitat is defined in
 26 Section 3, Provision 5 of the ESA as follows.

27 *(5)(A) The term “critical habitat” for a threatened or endangered species*
 28 *means—*

29 *(i) the specific areas within the geographical area occupied by a*
 30 *species at the time it is listed in accordance with the Act, on which*
 31 *are found those physical or biological features (I) essential to the*
 32 *conservation of the species, and (II) which may require special*
 33 *management considerations or protection; and*

34 *(ii) specific areas outside the geographical area occupied by a*
 35 *species at the time it is listed in accordance with the provisions of*
 36 *section 4 of this Act, upon a determination by the Secretary that*
 37 *such areas are essential for the conservation of the species.*

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

41 ESA regulations state that the physical and biological features essential to the
 42 conservation of the species include space for individual and population growth
 43 and for normal behavior; food, water, air, light, minerals, or other nutritional or

1 physiological requirements; cover or shelter; sites for breeding, reproduction, and
2 rearing of offspring; and habitats that are protected from disturbance or are
3 representative of the historical geographical and ecological distribution of a
4 species. These principal biological and physical features are known as Primary
5 Constituent Elements (PCEs)¹. Specific PCEs identified for salmonids, Green
6 Sturgeon, Delta Smelt, and Eulachon are described below.

7 **9.3.2.1 Anadromous Salmonids**

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

- 11 • Freshwater spawning sites with water quantity and quality conditions and
12 substrate that support spawning, incubation, and larval development.
- 13 • Freshwater rearing sites with:
 - 14 – Water quantity and floodplain connectivity to form and maintain physical
15 habitat conditions and support juvenile growth and mobility
 - 16 – Water quality and forage supporting juvenile development
 - 17 – Natural cover such as shade, submerged and overhanging large wood, log
18 jams and beaver dams, aquatic vegetation, large rocks and boulders, side
19 channels, and undercut banks
- 20 • Freshwater migration corridors free of obstruction and excessive predation
21 with water quantity and quality conditions and natural cover such as
22 submerged and overhanging large wood, aquatic vegetation, large rocks and
23 boulders, side channels, and undercut banks supporting juvenile and adult
24 mobility and survival.
- 25 • Estuarine areas free of obstruction and excessive predation with:
 - 26 – Water quality, water quantity, and salinity conditions supporting juvenile
27 and adult physiological transitions between fresh water and salt water
 - 28 – Natural cover such as submerged and overhanging large wood, aquatic
29 vegetation, large rocks and boulders, and side channels
 - 30 – Juvenile and adult forage, including aquatic invertebrates and fishes,
31 supporting growth and maturation

32 Critical habitat in nontidal waters includes the stream channels in the designated
33 stream reaches, the lateral extent of which generally defined by the ordinary
34 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.”

1 **9.3.2.1.1 Central Valley Spring-run Chinook Salmon ESU**

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

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

25 **9.3.2.1.2 Sacramento River Winter-run Chinook Salmon ESU**

26 The Sacramento River winter-run Chinook Salmon ESU consists of only one
27 population confined to the upper Sacramento River. This ESU includes all fish
28 spawning naturally in the Sacramento River and its tributaries, as well as fish that
29 are propagated at the Livingston Stone National Fish Hatchery (NFH), operated
30 by USFWS(NMFS 2005a). Critical habitat was delineated as the Sacramento
31 River from Keswick Dam to Chipps Island at the westward margin of the Delta;
32 all waters from Chipps Island westward to the Carquinez Bridge, including
33 Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San
34 Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco
35 Bay (north of the San Francisco-Oakland Bay Bridge) to the Golden Gate Bridge
36 (NMFS 1993).

37 **9.3.2.1.3 Central Valley Steelhead DPS**

38 The California Central Valley Steelhead DPS includes all naturally spawned
39 populations of steelhead in the Sacramento and San Joaquin rivers and their
40 tributaries, excluding steelhead from San Francisco and San Pablo bays and their
41 tributaries. Two artificial propagation programs, the Coleman NFH and Feather
42 River Hatchery steelhead hatchery programs, are considered to be part of the
43 DPS. Critical habitat for Central Valley Steelhead includes stream reaches of the
44 American, Feather, Yuba, and Bear rivers and their tributaries, and tributaries of

1 the Sacramento River including Deer, Mill, Battle, Antelope, and Clear creeks in
2 the Sacramento River Basin; the Mokelumne, Calaveras, Stanislaus, Tuolumne,
3 and Merced rivers in the San Joaquin River Basin; and portions of the Sacramento
4 and San Joaquin rivers. Designated critical habitat in the Delta includes portions
5 of the DCC, Yolo Bypass, Ulati Creek, and portions of the network of channels
6 in the Sacramento River portion of the Delta; and portions of the San Joaquin,
7 Cosumnes, and Mokelumne rivers and portions of the network of channels in the
8 San Joaquin portion of the Delta.

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

16 **9.3.2.1.4 Central California Coast Steelhead DPS**

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

27 **9.3.2.1.5 Southern Oregon/Northern California Coastal Coho Salmon** 28 **ESU**

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

35 **9.3.2.2 North American Green Sturgeon Southern DPS**

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

- 1 • **Food Resources.** Abundant prey items for larval, juvenile, subadult, and
2 adult life stages.
- 3 • **Substrate Type or Size (i.e., structural features of substrates).** Substrates
4 suitable for egg deposition and development (e.g., bedrock sills and shelves,
5 cobble and gravel, or hard clean sand, with interstices or irregular surfaces to
6 “collect” eggs and provide protection from predators, and free of excessive silt
7 and debris that could smother eggs during incubation), larval development
8 (e.g., substrates with interstices or voids providing refuge from predators and
9 from high-flow conditions), and subadults and adults (e.g., substrates for
10 holding and spawning).
- 11 • **Water Flow.** A flow regime (i.e., the magnitude, frequency, duration,
12 seasonality, and rate-of-change of fresh water discharge over time) necessary
13 for normal behavior, growth, and survival of all life stages.
- 14 • **Water Quality.** Water quality, including temperature, salinity, oxygen
15 content, and other chemical characteristics, necessary for normal behavior,
16 growth, and viability of all life stages.
- 17 • **Migratory Corridor.** A migratory pathway necessary for the safe and timely
18 passage of Southern DPS fish within riverine habitats and between riverine
19 and estuarine habitats (e.g., an unobstructed river or dammed river that still
20 allows for safe and timely passage).
- 21 • **Water Depth.** Deep (greater than 5 meters [m]) holding pools for both
22 upstream and downstream holding of adult or subadult fish, with adequate
23 water quality and flow to maintain the physiological needs of the holding
24 adult or subadult fish.
- 25 • **Sediment Quality.** Sediment quality (i.e., chemical characteristics) necessary
26 for normal behavior, growth, and viability of all life stages.

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

35 Within the study area, critical habitat includes the Sacramento River from the
36 I-Street Bridge upstream to Keswick Dam, including areas in the Yolo Bypass
37 and the Sutter Bypass and the lower American River from the confluence with the
38 Sacramento River upstream to the State Route 160 bridge over the American
39 River; the lower Feather River from the confluence with the Sacramento River
40 upstream to the Fish Barrier Dam; and the lower Yuba River from the confluence
41 with the Feather River upstream to Daguerre Dam. Critical habitat also includes
42 all waterways of the Delta up to the elevation of mean higher high water except
43 for certain excluded areas and all tidally influenced areas of San Francisco Bay,

1 San Pablo Bay, and Suisun Bay up to the elevation of mean higher high water
2 (NMFS 2009b).

3 **9.3.2.3 Delta Smelt**

4 In designating critical habitat for Delta Smelt (59 FR 65256), USFWS identified
5 the following PCEs essential to the conservation of the species: (1) suitable
6 substrate for spawning; (2) water of suitable quality and depth to support survival
7 and reproduction (e.g., temperature, turbidity, lack of contaminants); (3) sufficient
8 Delta flow to facilitate spawning migrations and transport of larval Delta Smelt to
9 appropriate rearing habitats; and (4) salinity, which influences the extent and
10 location of the low salinity zone where Delta Smelt rear. The location of the low
11 salinity zone (or X2) is described in terms of the average distance of the two
12 practical salinity units isohaline from the Golden Gate Bridge. Critical habitat for
13 Delta Smelt includes all water and submerged lands below ordinary high water
14 and the entire water column bounded by and contained in Suisun Bay (including
15 the contiguous Grizzly and Honker bays); the length of Goodyear, Suisun, Cutoff,
16 First Mallard (Spring Branch), and Montezuma sloughs; and the existing
17 contiguous waters contained in the legal Delta (as defined in Section 12220 of the
18 California Water Code) (USFWS 1994a).

19 **9.3.2.4 Eulachon Southern DPS**

20 In designating critical habitat for Eulachon, NMFS (76 FR 65323) identified the
21 following physical or biological features essential to the conservation of the
22 Eulachon Southern DPS fall reflecting key life history phases of Eulachon:
23 (1) freshwater spawning and incubation sites with water flow, quality and
24 temperature conditions and substrate supporting spawning and incubation, and
25 with migratory access for adults and juveniles; (2) freshwater and estuarine
26 migration corridors associated with spawning and incubation sites that are free of
27 obstruction and with water flow, quality and temperature conditions supporting
28 larval and adult mobility, and with abundant prey items supporting larval feeding
29 after the yolk sac is depleted; and (3) nearshore and offshore marine foraging
30 habitat with water quality and available prey, supporting juveniles and adult
31 survival.

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

1 **9.3.3 Trinity River Region**

2 The Trinity River Region includes Trinity Lake, Lewiston Reservoir and the
3 Trinity River from Lewiston Reservoir to the confluence with the Klamath River;
4 and the portion of the lower Klamath River watershed in Humboldt and Del Norte
5 counties from the confluence with the Trinity River to the Pacific Ocean. The
6 CVP Trinity Lake and Lewiston Reservoir are located upstream of the
7 confluences of several Trinity River tributaries (i.e., north fork, south fork, and
8 New River) and flows on these tributaries are not affected by CVP facilities. The
9 Trinity River flows approximately 112 miles from Lewiston Reservoir to its
10 confluence with the Klamath River, traversing through Trinity and Humboldt
11 counties and the Hoopa Indian Reservation within Trinity and Humboldt counties.
12 The Trinity River is the largest tributary to the Klamath River (DOI and
13 DFG 2012).

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

24 **9.3.3.1 Trinity Lake and Lewiston Reservoir**

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

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

38 **9.3.3.2 Trinity River from Lewiston Reservoir to Klamath River**

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

1 The hydrologic and geomorphic changes following construction of the Trinity and
2 Lewiston dams changed the character of the river channel substantially and
3 altered the quantity and quality of aquatic habitat. Riparian vegetation was
4 allowed to encroach on areas that had previously been scoured by flood flows,
5 resulting in the formation of a riparian berm that armored and anchored the river
6 banks and prevented meandering of the river channel (USFWS et al. 1999). The
7 berm reduced the potential for encroachment and maturation of woody vegetation
8 along the stabilized channel.

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

30 **9.3.3.2.1 Fish in the Trinity River**

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

- 33 • Coho Salmon
- 34 • Chinook Salmon (spring- and fall-run)
- 35 • Steelhead (winter-and summer-run)
- 36 • Green Sturgeon
- 37 • White Sturgeon
- 38 • Pacific Lamprey
- 39 • American Shad

40 *Coho Salmon*

41 Coho Salmon in the Trinity River are thought to be exclusively 3-year lifecycle
42 fish, living a full year in the river as juveniles before migrating to the ocean.
43 Most returning adult Coho Salmon enter rivers between August and January.

1 Spawning in the Trinity River occurs primarily in November and December.
2 Coho Salmon eggs incubate from 35 to more than 100 days, depending on water
3 temperature, and emerge from the gravel 2 weeks to 7 weeks after hatching.
4 Because juvenile Coho Salmon remain in their spawning stream for a full year
5 after emerging from the gravel, they are exposed to a broad range of freshwater
6 conditions. Coho Salmon smolts typically migrate to the ocean between March
7 and June, with most leaving in April and May (the term “smolt” refers to young
8 salmon prior to entering the ocean that have undergone the physiological changes
9 necessary for life in salt water).

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

18 Several interrelated factors affect Coho Salmon abundance and distribution in the
19 Trinity River. These factors include water temperature, water flow, habitat
20 suitability, habitat availability, hatcheries, predation, competition, disease, ocean
21 conditions, and harvest. Current CVP operations primarily affect water
22 temperature, water flow, and habitat suitability in the Trinity River (Reclamation
23 2008a). Currently accessible habitat downstream of Lewiston Dam represents
24 about 50 percent of historically available habitat (USFWS 1999).

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

37 An estimated 21,906 Coho Salmon migrated into the Trinity River Basin
38 upstream of the Willow Creek in 2013, of which 6,631 entered Trinity River
39 Hatchery (located near Lewiston Dam) and 15,275 were estimated to have
40 spawned in the river (CDFW 2014). The run-size estimates have ranged from
41 852 fish in 1994 to 59,079 fish in 1987. The 2011 run was ranked 10th of the
42 37 years on record and is 27.6 percent of the 17,161 average (CDFW 2014).

1 *Spring-run Chinook Salmon*

2 Spring-run Chinook Salmon migrate upstream in the Trinity River from April
3 through September, with most fish arriving at the reach downstream of Lewiston
4 Dam by the end of July. These fish remain in deep pools until the onset of the
5 spawning season, which typically begins the third week of September, peaks in
6 October, and continues through November. The distribution of spawning extends
7 upstream to Lewiston Dam, and is concentrated in the reaches immediately
8 downstream of the dam. Williams et al. (2011) concluded that although
9 abundance is low compared with historical abundance, the current spring-run
10 Chinook Salmon population (which includes hatchery fish) appears to have been
11 fairly stable for the past 30 years. In 2013, an estimated 8,961 spring-run
12 Chinook Salmon entered the Trinity River upstream of Junction City, including
13 the 2,578 fish that entered the Trinity River Hatchery and 6,129 natural area
14 spawners (CDFW 2014). This run-size estimate is approximately 51 percent of the
15 34-year average spring-run Chinook Salmon run-size of 17,402, which has ranged
16 from 2,381 fish in 1991 to 62,692 fish in 1988 (CDFW 2014).

17 Emergence of spring-run Chinook Salmon fry in the Trinity River begins in
18 December and continues into mid-April. Juvenile spring-run Chinook Salmon
19 typically outmigrate after a year of growth in the Trinity River. Outmigration
20 from the lower Trinity River, as indicated by monitoring near Willow Creek,
21 peaks in May and June.

22 *Fall-run Chinook Salmon*

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

30 Like spring-run Chinook Salmon, emergence of fall-run Chinook Salmon fry
31 begins in December and continues into mid-April. Juvenile fall-run Chinook
32 Salmon typically outmigrate after a few months of growth in the Trinity River.
33 Outmigration from the upper river, as indicated by monitoring near Junction City,
34 begins in March and peaks in early May, ending by late May or early June.
35 Outmigration of fall-run Chinook Salmon fry in the lower Trinity River occurs
36 over approximately the same time period described above for the spring run.

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

42 *Steelhead*

43 Steelhead in the Trinity River exhibit two primary life history strategies: a
44 summer-run that is stream maturing and a winter-run that is ocean maturing. The

1 winter run is considered by some to be composed of a fall run and a winter run
2 based upon the timing of the adult migration. Summer steelhead runs have been
3 observed in the north and south forks of the Trinity River and in the tributaries of
4 New River and Canyon Creek (BLM 1995).

5 Adult summer steelhead enter the Trinity River from April through September
6 and over-summer in deep pools within the mainstem. Some enter the smaller
7 tributary streams during the first November rains (Hill 2010), with most fish
8 spawning in both the mainstem and tributaries from February through April
9 (USFWS et al. 2004). Summer steelhead spawner escapements for the Trinity
10 River upstream of Lewiston prior to construction of the dam were estimated to
11 average 8,000 adults annually. Post-dam survey (reported in 2004) ranged from
12 20 to 1,037 adult summer steelhead in the tributaries and Trinity River (USFWS
13 et al. 2004).

14 Juvenile summer-run steelhead may rear in fresh water for up to 3 years before
15 outmigrating. Rearing in the Trinity River is highly variable, but most summer-
16 run steelhead either outmigrate as young-of-the-year (YOY) or at age 1+ (Scheiff
17 et al. 2001, Pinnix and Quinn 2009, Pinnix et al. 2013). For juveniles that rear at
18 least a year in fresh water, survival appears to be higher for those that outmigrate
19 to the ocean at age 2+ (DFG 1998a). Juveniles outmigrating from the tributaries
20 as 0+ or age 1+ may rear in the mainstem or in nonnatal tributaries (particularly
21 during periods of poor water quality) for 1 or more years before smolting.
22 Juvenile outmigration can occur from spring through fall, with three peak
23 migration periods including March, May/June, and October/November
24 (USFWS et al. 2004).

25 Fall-run and winter-run steelhead also are widely distributed throughout the
26 Trinity River. Adult fall-run steelhead enter the Klamath River system in
27 September and October (Hill 2010) and likely spawn from January through April.
28 Adult winter-run steelhead begin their upstream migration from November
29 through March (USFWS 1997). Winter-run steelhead primarily spawn in
30 Klamath River tributaries (including the Trinity River) from January through
31 April (USFWS 1997), with peak spawn timing in February and March
32 (NRC 2004).

33 An estimated run-size of 16,594 adult fall-run steelhead migrated into the Trinity
34 River upstream of Willow Creek in 2013, including the 2,375 fish (80 natural-
35 origin and 2,295 hatchery-origin) that entered the Trinity River Hatchery and
36 13,560 natural area spawners (9,039 of natural origin and 4,521 of hatchery
37 origin) (CDFW 2014). Since 1980, run-size estimates have ranged from 2,972 in
38 1998 to 53,885 in 2007. The estimated abundance of steelhead in 2013 was
39 8.4 percent above the average since 1980 (CDFW 2014).

40 *Green Sturgeon*

41 Most information on Green Sturgeon in the Trinity River is based on data from
42 the Klamath River. Green Sturgeon in the Klamath River sampled during their
43 spawning migration ranged in age from 16 to 40 years (Van Eenennaam et al.
44 2006). Green Sturgeon are generally believed to have a life span of at least

1 50 years and spawn every 4 years on average after around age 16 (Klimley et al.
2 2007). Green Sturgeon enter the Trinity and Klamath rivers to spawn from
3 February through July, and most spawning occurs from the middle of April to the
4 middle of June (NRC 2004). After spawning, around 25 percent of Green
5 Sturgeon migrate directly back to the ocean (Benson et al. 2007), and the
6 remainder hold in mainstem pools through November. During the onset of fall
7 rainstorms and increased river flow, adult sturgeon move downstream and leave
8 the river system (Benson et al. 2007). Juvenile Green Sturgeon may rear for 1 to
9 3 years in the Klamath River system before they migrate to the estuary and Pacific
10 Ocean (NRC 2004, FERC 2007a, CALFED 2007), usually during summer and
11 fall (Emmett et al. 1991, Hardy and Addley 2001).

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

16 *White Sturgeon*

17 Small numbers of White Sturgeon occur in Klamath and Trinity rivers (NRC
18 2004). Presumably, these individuals are on feeding migrations. Historically
19 there may have been small spawning runs (Moyle 2002).

20 *Pacific Lamprey*

21 Pacific Lamprey are the only anadromous lamprey species in the Trinity River
22 Basin. This species is important to local tribes and supports a subsistence fishery
23 on the lower Trinity River. Although no systematic distribution surveys are
24 available for the Trinity River Basin, they are expected to have a distribution
25 similar to anadromous salmonids that use the mainstem Trinity River and
26 accessible reaches of larger tributaries. No current status assessments are
27 available for Pacific Lamprey in the Trinity River, but information from tribal
28 fishermen who catch lampreys in the lower Klamath River suggests a decline that
29 mirrors that observed across the species' range (Petersen Lewis 2009).

30 Adult Pacific Lampreys have been documented entering the Klamath River from
31 the ocean during all months of the year, with peak upstream migration to holding
32 areas from December through June (Larson and Belchik 1998, Petersen Lewis
33 2009). Migration up the Trinity River is expected to begin slightly later. After
34 entering fresh water as sexually immature adults and undergoing an initial
35 migration, Pacific Lampreys hold through summer and most of winter before
36 spawning the following spring when they reach sexual maturity (Robinson and
37 Bayer 2005, Clemens et al. 2012). After the holding period, individuals undergo
38 a secondary migration in the late winter or early spring from holding areas to
39 spawning grounds (Robinson and Bayer 2005, Clemens et al. 2012, Lampman
40 2011). Thus, adult Pacific Lampreys with varying levels of sexual maturity may
41 be in the Trinity River throughout the year. Ammocoetes (the larval stage of
42 lamprey) inhabit fine substrates in depositional areas, rearing in the Trinity River
43 and tributaries year-round for up to 7 years before outmigrating to the ocean
44 (Moyle 2002, Reclamation and Trinity County 2006).

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

9 *American Shad*

10 American Shad, an introduced, anadromous fish, has become established in the
11 Klamath and Trinity rivers. American Shad occur in the lowermost portions of
12 the Trinity River, but are primarily found in the lower Klamath River. Adult fish
13 enter estuaries or streams in late spring or early summer and spawn soon
14 afterward in fresh water. Juvenile shad have been captured regularly in the
15 rotary-screw traps at the Pear Tree and Willow Creek sites during salmonid
16 outmigrant monitoring (Scheiff et al. 2001, Pinnix and Quinn 2009, Pinnix et al.
17 2013). Sport fishing for American Shad occurs seasonally throughout the lower
18 Trinity River.

19 **9.3.3.2 Hatcheries on the Trinity River**

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

34 **9.3.3.3 Lower Klamath River from Trinity River to Pacific Ocean**

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

1 **9.3.3.1 Fish in the Lower Klamath River**

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

5 Eulachon is a smelt species in the Klamath River system found upstream of the
6 estuary. Eulachon are anadromous broadcast spawners that spawn in the lower
7 reaches of rivers and tributaries and usually die after spawning. Eulachon are
8 sexually mature at 2 years and spawn at ages 3, 4, and/or 5 (Scott and Crossman
9 1973). Timing of the spawning migration in the Klamath River is similar to other
10 known runs of Eulachon, beginning in December and continuing until May, with
11 a peak in March and April (YTFP 1998, Larson and Belchik 1998).

12 In the Klamath River, adult Eulachon generally migrate as high as Brooks Riffle,
13 about 40 kilometers (about 24 miles) upstream of the mouth, but have been
14 observed as high as Pecwan Creek and even Weitchpec during exceptional years
15 (YTFP 1998); specific spawning areas are unknown. Eggs hatch in 20 to 40 days
16 depending on water temperature, taking longer at cooler temperatures. After
17 hatching, the larvae are passively carried from spawning grounds to the ocean via
18 river currents (Scott and Crossman 1973).

19 This species was historically important to local tribes and supported a subsistence
20 fishery on the lower Klamath River. According to accounts of Yurok Tribal
21 elders, there were annual runs so great that one had no problem catching “as many
22 as you wanted;” however, the last noticeable runs of Eulachon were observed in
23 1988 and 1989 by Tribal fishers (Larson and Belchik 1998). In 1996, YTFP
24 sampling efforts to capture Eulachon were unsuccessful, although a Yurok Tribal
25 member gave the YTFP a Eulachon he had caught while fishing for lamprey at the
26 mouth of the river (Larson and Belchik 1998). However, it is likely that the
27 Eulachon has been extirpated or nearly so on the lower Klamath River
28 (NMFS 2015).

29 **9.3.4 Central Valley Region**

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

- 32 • Shasta Lake and Keswick Reservoir
- 33 • Whiskeytown Lake
- 34 • Clear Creek
- 35 • Sacramento River from Keswick Reservoir to the Delta (near Freeport)
- 36 • Battle Creek
- 37 • Feather River
- 38 • Yuba and Bear Rivers
- 39 • American River
- 40 • Delta

- 1 • Yolo Bypass
- 2 • Millerton Lake
- 3 • San Joaquin River from the Stanislaus River confluence to the Delta (near
- 4 Vernalis)
- 5 • New Melones Reservoir, Tulloch Reservoir, and Goodwin Lake
- 6 • Stanislaus River
- 7 • San Luis Reservoir

8 **9.3.4.1 Shasta Lake and Keswick Reservoir**

9 Shasta Lake is formed by Shasta Dam, which is located on the Sacramento River
 10 just downstream of the confluence of the Sacramento, McCloud, and Pit rivers.
 11 Shasta Dam has no fish passage facilities; however, the dam has a fish trapping
 12 facility that operates in conjunction with the Coleman NFH on Battle Creek.

13 **9.3.4.1.1 Shasta Lake**

14 Shasta Lake fish species include native and introduced warm-water and cold-
 15 water species. Major nonfish aquatic animal species assemblages in Shasta Lake
 16 include benthic macroinvertebrates and zooplankton (Reclamation 2013b).
 17 Shasta Lake is typically thermally stratified from April through November, during
 18 which time the upper layer (epilimnion) can reach a peak water temperature of
 19 80 degrees Fahrenheit (°F) (Reclamation 2003). The upper layer of Shasta Lake
 20 supports warm-water game fish, and the lower layers (metalimnion and
 21 hypolimnion) support cold-water fishes. Nonnative, warm-water fish species in
 22 Shasta Lake include Smallmouth Bass, Largemouth Bass, Spotted Bass, Black
 23 Crappie, Bluegill, Green Sunfish, Channel Catfish, White Catfish, and Brown
 24 Bullhead (DWR et al. 2013). Cold-water species include Rainbow Trout, Brown
 25 Trout, landlocked White Sturgeon, landlocked Coho Salmon (Reclamation et al.
 26 2003), and landlocked Chinook Salmon (Reclamation 2013). Other fish species
 27 in Shasta Lake include Golden Shiner, Threadfin Shad, Common Carp, and the
 28 native Hardhead, Sacramento Sucker, and Sacramento Pikeminnow (DWR et al.
 29 2013, Reclamation 2013).

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

35 Warm-water fish habitat in Shasta Lake is influenced primarily by fluctuations in
 36 the lake level and the availability of shoreline cover (Reclamation 2003). Water
 37 surface elevations in Shasta Lake can fluctuate approximately 55 feet annually as
 38 a result of operation of Shasta and Sacramento River diversions (Reclamation
 39 2003). Reservoir surface elevation fluctuations can disturb shallow, nearshore
 40 habitats, including spawning and rearing habitat for warm-water fish species. The
 41 shoreline of Shasta Lake is generally steep, which limits shallow, warm-water fish

1 habitat, and is not conducive to the establishment of vegetation or other shoreline
2 cover (Reclamation 2003).

3 **9.3.4.1.2 Keswick Reservoir**

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

11 **9.3.4.2 Whiskeytown Lake**

12 Water is diverted from the Trinity River at Lewiston Dam and discharged via the
13 Clear Creek Tunnel into Whiskeytown Lake on Clear Creek. From Whiskeytown
14 Lake, water is released into the lower portion of Clear Creek via Whiskeytown
15 Dam and into Keswick Reservoir through the Spring Creek Tunnel. There are
16 two temperature control curtains in Whiskeytown Lake: Oak Bottom and Spring
17 Creek (Reclamation 2008a). The Oak Bottom temperature control curtain serves
18 as a barrier to prevent warm water in the reservoir from mixing with cold water
19 from Lewiston Lake entering through the Carr Powerhouse. The Oak Bottom
20 curtain is damaged and cannot be fully deployed; it is scheduled to be repaired in
21 2015. The Spring Creek temperature control curtain was replaced in 2011 and
22 aids cold-water movement into the underwater intake for the Spring Creek
23 Tunnel.

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

28 **9.3.4.3 Clear Creek**

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

38 **9.3.4.3.1 Fish in Clear Creek**

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

1 *Spring-run Chinook Salmon*

2 Clear Creek currently supports a modest run of spring-run Chinook Salmon,
3 which since 1998 has ranged from 0 in 2001 to an estimated high of 659 fish in
4 2013 (CDFW 2014). Adult spring-run Chinook Salmon migrate into Clear Creek
5 from April through September. Adult fish tend to move as far upstream as
6 possible to access cooler temperatures downstream of Whiskeytown Dam and
7 hold over in summer until spawning in September through October. In the NMFS
8 2009 BO, NMFS expressed concern that spring-run Chinook Salmon unable to
9 enter Clear Creek for spawning could hybridize with fall-run Chinook Salmon
10 spawning in the Sacramento River (NMFS 2009a).

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

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

25 Based on rotary screw trap captures, juvenile spring-run Chinook Salmon
26 outmigrate from Clear Creek from May through February. Peak outmigration
27 occurs over a 9-week period from early December 2008 through early February
28 2009 (Earley et al. 2010). Trap data indicate that the majority of juveniles
29 identified as spring-run (based on length-at-date size criteria) leave as age-0 fish,
30 less than 40 millimeter (mm) in fork length (USFWS 2008b, Earley et al. 2010).

31 *Fall-/Late Fall-run Chinook Salmon*

32 Since 1995, restoration activities implemented in accordance with programs
33 implemented under the CVPIA, CALFED, and the 2009 NMFS BO have
34 increased stocks of fall-run Chinook Salmon by more than 400 percent (Brown
35 2011). In 2014, fall-run Chinook Salmon estimated escapement was 15,794
36 compared to the average baseline (1967-1991) estimated escapement of 1,689.

37 Fall/late fall-run Chinook Salmon primarily use the lower reaches of Clear Creek
38 for all life history phases. Fall-run Chinook migrate into Clear Creek between the
39 spring- and late fall-runs and spawn in October through December (USFWS
40 2015). A picket weir installed about 7.4 miles upstream of the confluence with
41 the Sacramento River from August 1 to November 1 is used to prevent fall-run
42 Chinook Salmon from spawning in the upper reaches with spring-run.

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

3 Based on rotary screw trap captures and length-at-date size criteria, fall-run
4 Chinook Salmon make up the vast majority of all Chinook Salmon outmigrating
5 from lower Clear Creek. Late fall-run juveniles constitute a small percentage of
6 juvenile Chinook Salmon leaving Clear Creek. Juvenile fall-/late fall-run
7 Chinook Salmon primarily outmigrate from Clear Creek as age-0 fish less than
8 40 mm in fork length (USFWS 2008b, Earley et al. 2010). Peak age-0
9 outmigration in 2008/2009 was from January and February for fall-run Chinook
10 Salmon and during April to May for late fall-run Chinook Salmon (Earley et al.
11 2010).

12 *Steelhead*

13 Operation of Whiskeytown Dam supports cold-water habitat for steelhead in
14 Clear Creek, the amount of which depends on flow releases which range from
15 30 to 200 cubic feet per second (cfs) depending on water year type (Reclamation
16 2008a). Steelhead have recolonized the habitat that became accessible with the
17 removal of the McCormick-Saeltzer Dam in 2000. Redd surveys conducted since
18 2003 indicate that a small, but increasing population of steelhead resides in Clear
19 Creek, with the highest density in the first mile below Whiskeytown Dam
20 (USFWS 2007).

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

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

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

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

1 *Pacific Lamprey*

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

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

20 **9.3.4.3.2 Extent and Status of Aquatic Habitat**

21 Whiskeytown Dam limits the contribution of coarse sediment for transport
22 downstream in Clear Creek, which NMFS (2009a) reported has resulted in riffle
23 coarsening, fossilization of alluvial features, loss of fine sediments available for
24 overbank deposition, and considerable loss of spawning gravels. These
25 conditions affect spawning and rearing habitat on Clear Creek. Water flows and
26 temperatures conditions on Clear Creek are presented in Chapter 5, Surface Water
27 Resources and Water Supplies, and Chapter 6, Surface Water Quality,
28 respectively.

29 *Spawning Habitat*

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

37 Brown (2011) noted that much of the degraded habitat has been restored by gravel
38 augmentation, but continued augmentation will be required. Spawning gravel is
39 annually augmented in Clear Creek downstream of Whiskeytown Dam, pursuant
40 to CVPIA implementation and Action of I.1.3 of the 2009 NMFS BO Reasonable
41 and Prudent Alternative (RPA). The CVPIA annual spawning gravel target is
42 25,000 tons per year; however, an average of 9,574 tons has been placed annually
43 since 1996. In 2012, a total of 9,974 tons of gravel was placed at four sites:

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

3 Most supplemental spawning gravel is placed into Clear Creek at long-term
4 injection sites awaiting high flows to move gravel into the creek. These gravel
5 addition projects have successfully created habitat suitable for spring-run Chinook
6 Salmon spawning as evidenced by the number of redds directly observed in
7 supplemental gravel or in supplemental gravel integrated into native gravel
8 (USFWS 2007, 2008b). Spawning area mapping performed annually since 2000
9 indicates the overall amount of area used by spawning fall-run Chinook Salmon
10 has been increasing, despite the adult population abundance remaining stable.
11 The amount of area used in 2008 was the highest measured and more than double
12 the amount used in 2000, suggesting that the gravel augmentation program has
13 been successful in creating new spawning habitat. Gravel augmentation also has
14 increased the amount of steelhead spawning habitat available in the lower reaches
15 of Clear Creek, and NMFS (2009a) has indicated that this directly relates to
16 higher fish abundance in recent years. In most locations, gravel additions created
17 spawning habitat that did not exist or had limited prior use.

18 Studies to determine the availability of fish habitat, expressed as Weighted
19 Useable Area (WUA), have been conducted by USFWS for Clear Creek
20 (USFWS 2006). For spring-run Chinook Salmon, it was determined that
21 spawning WUA peaked at the highest modeled flow (900 cfs) in the upstream
22 alluvial segment from Whiskeytown Dam to the NEED Camp Bridge. In the
23 canyon segment downstream (NEED Camp Bridge to the Clear Creek Road
24 Bridge) spawning habitat peaked at 650 cfs. The WUA for steelhead/Rainbow
25 Trout spawning habitat peaked at 350 cfs and 600 cfs in these segments,
26 respectively (USFWS 2007). In the lower reach downstream of the Clear Creek
27 Road Bridge, WUA for both fall-run Chinook Salmon and steelhead/Rainbow
28 Trout spawning habitat peaked at 300 cfs (USFWS 2011a).

29 At all flows, the amount of spawning habitat present in Clear Creek is less than
30 the amount needed to achieve the abundance recovery goal of spring-run Chinook
31 Salmon spawning (based on the original USFWS [2007] estimates). However,
32 the increased spawning habitat availability due to gravel additions since 2003
33 suggests that spawning habitat for spring-run Chinook Salmon is now more than
34 sufficient to support the recovery goal at all flows. At flows greater than 50 cfs,
35 the amount of spawning habitat present in Clear Creek is greater than the amount
36 of spawning habitat needed to achieve the abundance recovery goal for steelhead.
37 In contrast, the amount of spawning habitat present in Clear Creek is less than the
38 amount of spawning habitat needed to support 7,920 adult fall-run Chinook
39 Salmon in Clear Creek (USFWS 2015).

40 *Rearing Habitat*

41 The WUA for spring-run Chinook Salmon fry rearing peaked at 600 cfs in the
42 upstream alluvial segment from Whiskeytown Dam to the NEED Camp Bridge.
43 In the canyon segment downstream (NEED Camp Bridge to Clear Creek Road
44 Bridge), fry rearing habitat peaked at the highest modeled flow (900 cfs). The
45 WUA for steelhead/Rainbow Trout fry rearing habitat peaked at 700 cfs and

1 900 cfs (the maximum flow modeled) in these segments, respectively (USFWS
 2 2011b). The WUA for spring-run Chinook Salmon and steelhead/Rainbow Trout
 3 juvenile rearing habitat peaked at the highest modeled flow (900 cfs) in the upper
 4 alluvial segment and 650 cfs in the canyon segment downstream. In the lower
 5 reach downstream of the Clear Creek Road Bridge, WUA for both fall-run
 6 Chinook Salmon and steelhead/Rainbow Trout fry rearing habitat peaked at
 7 50 cfs; fry rearing habitat for spring-run Chinook Salmon peaked at 900 cfs.
 8 Spring-run Chinook Salmon and steelhead/Rainbow Trout juvenile rearing habitat
 9 peaked at 850 cfs, while fall-run Chinook Salmon juvenile rearing habitat peaked
 10 at 350 cfs (USFWS 2013).

11 As described above for spawning habitat, USFWS (2015) compared the total
 12 amount of rearing habitat available for spring-run Chinook Salmon and
 13 steelhead/Rainbow Trout to the amount of rearing habitat needed to support an
 14 annual escapement of 833 adults for each species. The total amount of rearing
 15 habitat available for fall-run Chinook Salmon was compared to the amount of
 16 habitat needed to support an average escapement of 7,920 fall-run Chinook
 17 Salmon. At all flows, the amount of rearing habitat present in Clear Creek is
 18 greater than the amount needed to achieve the abundance recovery goal for
 19 spring-run Chinook Salmon and steelhead. In contrast, the amount of rearing
 20 habitat present in Clear Creek is less than the amount needed to support
 21 7,920 adult fall-run Chinook Salmon in Clear Creek.

22 **9.3.4.3 Fish Passage**

23 Whiskeytown Dam blocks access to 25 miles of historical spring-run Chinook
 24 Salmon and steelhead spawning and rearing habitat (Yoshiyama et al. 1996).
 25 Until 2000, the McCormick-Saeltzer Dam was a barrier to upstream migration for
 26 anadromous salmonids. After its removal, anadromous salmonids recolonized an
 27 additional 12 miles of habitat upstream to Whiskeytown Dam. With the removal
 28 of McCormick-Saeltzer Dam, passage of spring-run Chinook Salmon has
 29 increased. Stream surveys and juvenile monitoring results also suggest that dam
 30 removal has allowed reestablishment of spring-run Chinook Salmon and
 31 steelhead. NMFS (2009a) reported that compared to fall-run Chinook Salmon,
 32 spring-run Chinook Salmon historically spawned earlier and at locations farther
 33 upstream in Clear Creek. However, NMFS (2009a) concluded that the
 34 construction of Whiskeytown Dam likely caused a high degree of spatial overlap
 35 between the fall-run and spring-run fish during spawning, resulting in a higher
 36 probability of hybridization. To address this concern, USFWS has been
 37 separating adult fall-run fish from the spring-run fish holding in the upper reaches
 38 of Clear Creek with a segregation weir that is operated from August 1 to
 39 November 1. After November 1, fall-run Chinook Salmon have access to the
 40 entire river for spawning.

41 **9.3.4.4 Sacramento River from Keswick Reservoir to the Delta near** 42 **Freeport**

43 Aquatic resources in the Sacramento River are affected by the habitat along the
 44 river and along the tributaries that connect to the river. Habitat along the river

1 ranges from artificial structures used for water supply and flood management to
2 open spaces that provide more natural types of habitat. The flow regime in the
3 Sacramento River is managed for water supply and flood management, as
4 described in Chapter 5, Surface Water Resources and Water Supplies. The
5 following discussion focuses on the fish in the Sacramento River and aquatic
6 habitat conditions.

7 **9.3.4.4.1 Fish in the Sacramento River**

8 The analysis is focused on the following species:

- 9 • Chinook Salmon (winter-, spring-, and fall/late fall-run)
- 10 • Steelhead
- 11 • Green Sturgeon
- 12 • White Sturgeon
- 13 • Sacramento Splittail
- 14 • Pacific Lamprey
- 15 • Striped Bass
- 16 • American Shad

17 *Winter-run Chinook Salmon*

18 Adult winter-run Chinook Salmon return to fresh water during winter but delay
19 spawning until spring and summer. Adults enter fresh water in an immature
20 reproductive state, similar to spring-run Chinook, but winter-run Chinook move
21 upstream much more quickly and then hold in the cool waters downstream of
22 Keswick Dam for an extended period before spawning. Juveniles spend about
23 5 to 9 months in the river and estuary systems before entering the ocean. This
24 life-history pattern differentiates the winter-run Chinook from other Sacramento
25 River Chinook runs and from all other populations within the range of Chinook
26 Salmon (DFG 1985, 1998b).

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

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

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

1 Aerial redd surveys have indicated that the winter-run Chinook Salmon spawning
2 distribution has shifted upstream since gravel introductions began in the upper
3 river near Keswick Dam; a high proportion of winter run Chinook spawn on the
4 recently placed gravel (USFWS and Reclamation 2008). Spawning occurs May
5 through July, with the peak in early June. Fry emergence occurs from mid-June
6 through mid-October and fry disperse to areas downstream for rearing. Juvenile
7 migration past RBDD may begin in late July, generally peaks in September, and
8 can continue until mid-March in drier years (Vogel and Marine 1991). The
9 majority (75 percent) of winter-run Chinook Salmon outmigrate past RBDD as
10 fry (Martin et al. 2001), where they rear before outmigrating to the Delta
11 primarily in December through April (Appendix 9B). Between 44 and 81 percent
12 (mean 65 percent) of juvenile winter-run Chinook Salmon used areas downstream
13 of RBDD for nursery habitat, and the relative usage of rearing habitat upstream
14 and downstream of RBDD appeared to be influenced by river flow during fry
15 emergence (Martin et al. 2001). Winter-run Chinook Salmon usually migrate past
16 Knight's Landing once flows at Wilkins Slough rise to about 14,000 cfs; most
17 juvenile winter-run Chinook Salmon outmigrate past Chipps Island by the end of
18 March (del Rosario et al. 2013).

19 *Spring-run Chinook Salmon*

20 Historically, spring-run Chinook Salmon in the Sacramento River Basin were
21 found in the upper and middle reaches (1,000 to 6,000 feet) of the American,
22 Yuba, Feather, Sacramento, McCloud and Pit rivers, as well as smaller tributaries
23 of the upper Sacramento River downstream of present-day Shasta Dam
24 (NMFS 2009a). Estimates indicate that 82 percent of the approximately
25 2,000 miles of salmon spawning and rearing habitat available in the mid-1800s is
26 unavailable or inaccessible today (Yoshiyama et al. 1996). Naturally spawning
27 populations of spring-run Chinook Salmon currently are restricted to accessible
28 reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum
29 Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River,
30 Mill Creek, and Yuba River (DFG 1998b). Most of these reaches are outside the
31 project area; however, all spring-run Chinook Salmon migratory life stages must
32 pass through the project area.

33 Spring-run Chinook Salmon abundance in the Sacramento River mainstem has
34 apparently declined sharply through time, with escapement estimates ranging
35 from approximately 5,000 to 23,000 fish in the 1980s, 100 to 4,100 fish in the
36 1990s, and 0 to 621 fish between 2000 and 2014 (CDFW 2015). However, the
37 criteria for run classification at RBDD have changed so no conclusions can be
38 reached about changes in the number of spring-run Chinook Salmon in the
39 Sacramento River. Chinook Salmon expressing spring-run timing do spawn in
40 the mainstem Sacramento River between RBDD and Keswick Dam (NMFS
41 2009a). The Sacramento River now serves primarily as a migratory corridor for
42 the adult and juvenile life stages of spring-run (and other runs) of Chinook
43 Salmon.

44 In fresh water, juvenile spring-run Chinook Salmon rear in natal tributaries, the
45 Sacramento River mainstem, and nonnatal tributaries to the Sacramento River

1 (DFG 1998b). Outmigration timing is highly variable, as they may migrate
2 downstream as YOY or as juveniles or yearlings. The outmigration period for
3 spring-run Chinook Salmon extends from November to early May, with up to
4 69 percent of the YOY fish outmigrating through the lower Sacramento River and
5 Delta during this period (DFG 1998b). Peak movement of juvenile (yearling)
6 spring-run Chinook Salmon in the Sacramento River at Knights Landing occurs in
7 December and again in March and April for YOY juveniles. Pulse flows that
8 occur during precipitation events tend to stimulate downstream movement along
9 the Sacramento River. Spring-run juveniles that remain in the Sacramento River
10 over summer are confined to approximately 100 miles of the upper mainstem,
11 where cool water temperatures are maintained by dam releases.

12 *Fall-/Late Fall-run Chinook Salmon*

13 The fall-run Chinook Salmon is an ocean-maturing type of salmon adapted for
14 spawning in lowland reaches of big rivers, including the mainstem Sacramento
15 River; the late fall-run Chinook Salmon is mostly a stream-maturing type
16 (Moyle 2002). Similar to spring-run, adult late fall-run Chinook Salmon typically
17 hold in the river for 1 to 3 months before spawning, while fall-run Chinook
18 Salmon generally spawn shortly after entering fresh water. Fall-run Chinook
19 Salmon migrate upstream past RBDD on the Sacramento River between July and
20 December, typically spawning in upstream reaches from October through March.
21 Late fall-run Chinook Salmon migrate upstream past RBDD from August to
22 March and spawn from January to April (NMFS 2009a, TCCA 2008). The
23 majority of young fall-run Chinook Salmon migrate to the ocean during the first
24 few months following emergence, although some may remain in fresh water and
25 migrate as yearlings. Late fall-run juveniles typically enter the ocean after 7 to
26 13 months of rearing in fresh water, at 150- to 170 mm in fork length,
27 considerably larger and older than fall-run Chinook Salmon (Moyle 2002).

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

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

34 *Steelhead*

35 Although steelhead can be divided into two life history types, summer-run
36 steelhead and winter-run steelhead, based on their state of sexual maturity at the
37 time of river entry, only winter-run steelhead are currently found in Central
38 Valley rivers and streams. Existing wild steelhead stocks in the Central Valley
39 are mostly confined to the upper Sacramento River and its tributaries, including
40 Antelope, Deer, and Mill creeks and the Yuba River. Populations may exist in
41 other tributaries, and a few naturally spawning steelhead are produced in the
42 American and Feather rivers (McEwan and Jackson 1996).

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

1 RBDD during all months of the year, but primarily during September and October
2 (NMFS 2009a). The primary spawning area used by steelhead in the Sacramento
3 River is the area from Keswick Dam downstream to RBDD. Unlike salmon,
4 steelhead may live to spawn more than once and generally rear in freshwater
5 streams for 2 to 4 years before outmigrating to the ocean. Both spawning areas
6 and migratory corridors are used by juvenile steelhead for rearing prior to
7 outmigration. The Sacramento River functions primarily as a migration channel,
8 although some rearing habitat remains in areas with setback levees (primarily
9 upstream of Colusa) and flood bypasses (e.g., Yolo Bypass) (NMFS 2009a).

10 Recent steelhead monitoring data are scarce for the upper portion of the
11 Sacramento River system. In 1989, Hallock (1989) reported that steelhead had
12 declined drastically in the Sacramento River upstream of the Feather River
13 confluence. In the 1950s, the average estimated spawning population size
14 upstream of the Feather River confluence was 20,540 fish (McEwan and Jackson
15 1996). In 1991–1992, the annual run size for the total Sacramento River system
16 was likely fewer than 10,000 adult fish (McEwan and Jackson 1996). From 1967
17 to 1993, the estimated number of steelhead passing the Red Bluff Pumping Plant
18 ranged from a low of 470 to a high of 19,615 (CHSRG 2012). Steelhead
19 escapement surveys at the site of RBDD ended in 1993.

20 *Green Sturgeon*

21 The Sacramento River provides habitat for Green Sturgeon spawning, adult
22 holding, foraging, and juvenile rearing. Suitable spawning temperatures and
23 spawning substrate exist for Green Sturgeon in the Sacramento River upstream
24 and downstream of RBDD (Reclamation 2008a). Although the upstream extent
25 of historical Green Sturgeon spawning in the Sacramento River is unknown, the
26 observed distribution of sturgeon eggs, larvae, and juveniles indicates that
27 spawning occurs from Hamilton City to as far upstream as Ink's Creek confluence
28 and possibly up to the Cow Creek confluence (Brown 2007, Poytress et al. 2013).
29 Based on the distribution of sturgeon eggs, larvae, and juveniles in the
30 Sacramento River, DFG (2002) indicated that Green Sturgeon spawn in late
31 spring and early summer. Peak spawning is believed to occur between April and
32 June.

33 Spawning migrations and spawning by Green Sturgeon in the Sacramento River
34 mainstem have been well documented over the last 15 years (Beamesderfer et al.
35 2004). Anglers fishing for White Sturgeon or salmon commonly report catches of
36 Green Sturgeon from the Sacramento River as far upstream as Hamilton City
37 (Beamesderfer et al. 2004). Eggs, larvae, and post-larval Green Sturgeon are now
38 commonly reported in sampling directed at Green Sturgeon and other species
39 (Beamesderfer et al. 2004, Brown 2007). YOY Green Sturgeon have been
40 observed annually since the late 1980s in fish sampling efforts at RBDD and the
41 Glenn-Colusa Irrigation District (GCID) intake (Beamesderfer et al. 2004).
42 Acoustically tagged Green Sturgeon were detected upstream of RBDD from 2004
43 to 2006 (Heublein et al. 2009). Adult Green Sturgeon that migrate upstream in
44 April, May, and June are completely blocked by the ACID diversion dam

1 (NMFS 2009b), rendering approximately 3 miles of spawning habitat upstream of
2 the diversion dam inaccessible.

3 Green Sturgeon from the Sacramento River are genetically distinct from their
4 northern counterparts, indicating a spawning fidelity to their natal rivers (Israel et
5 al. 2004), even though individuals can range widely (Lindley et al. 2008). Larval
6 Green Sturgeon have been regularly captured during their dispersal stage at about
7 2 weeks of age (24 to 34 mm fork length) in rotary screw traps at RBDD (DFG
8 2002a) and at about 3 weeks old when captured at the GCID intake (Van
9 Eenennaam et al. 2001).

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

14 Empirical estimates of Green Sturgeon abundance are not available for the
15 Sacramento River population or any west coast population (Reclamation 2008a),
16 and the current population status is unknown (Beamesderfer et al. 2007,
17 Adams et al. 2007). A genetic analysis of Green Sturgeon larvae captured in the
18 Sacramento River resulted in an estimate of the number of adult spawning pairs
19 upstream of RBDD ranging from 32 to 124 between 2002 and 2006 (Israel 2006).
20 NMFS (2009b) noted that, similar to winter-run Chinook Salmon, the restriction
21 of spawning habitat for Green Sturgeon to only one reach of the Sacramento
22 River increases the vulnerability of this spawning population to catastrophic
23 events. This was one of the primary reasons that the Southern DPS of Green
24 Sturgeon was federally listed as a threatened species in 2006.

25 *White Sturgeon*

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

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

1 *Sacramento Splittail*

2 Historically, splittail were widespread in the Sacramento River from Redding to
3 the Delta (Rutter 1908 as cited in Moyle et al. 2004). This distribution has
4 become somewhat reduced in recent years (Sommer et al. 1997, 2007b). During
5 drier years there is evidence that spawning occurs farther upstream (Feyrer et al.
6 2005). Adult splittail migrate upstream in the lower Sacramento River to above
7 near the mouth of the Feather River and into the Sutter and Yolo bypasses
8 (Sommer et al. 1997, Feyrer et al. 2005, Sommer et al. 2007b). Each year, mainly
9 during the spring spawning season, a small number of individuals have been
10 documented at the Red Bluff Pumping Plant and the entrance to the GCID intake
11 (Moyle et al. 2004).

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

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

31 *Pacific Lamprey*

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

1 early summer, but some outmigration is observed year-round at both RBDD and
2 the GCID diversion dam (Hanni et al. 2006).

3 *Striped Bass*

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

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

20 **9.3.4.4.2 Aquatic Habitat**

21 The mainstem Sacramento River provides habitat for native and introduced
22 (nonnative) fish and other aquatic species. The diversity of aquatic habitats
23 ranges from fast-water riffles and glides in the upper reaches to tidally influenced
24 slow-water pools and glides in the lower reaches (Vogel 2011).

25 A few miles downstream of Keswick Dam, near Redding, the river enters the
26 valley and the floodplain broadens. Historically, this area likely had wide
27 expanses of riparian forests, but much of the river's riparian zone is subject to
28 urban encroachment, particularly in the Anderson/Redding area. In the middle
29 Sacramento River between Red Bluff and Chico Landing, the mainstem channel
30 is flanked by broad floodplains (TNC 2007a). In the lower reaches downstream
31 of Verona, much of the Sacramento River is constrained by levees. Dredging,
32 dams, levee construction, urban encroachment, and other human activities in the
33 Sacramento River have modified aquatic habitat, altered sediment dynamics,
34 simplified stream bank and riparian habitat, reduced floodplain connectivity, and
35 modified hydrology (NMFS 2009a). However, some complex floodplain habitats
36 remain in the system such as reaches with setback levees and the Yolo and Sutter
37 bypasses.

38 *Holding Habitat*

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

1 during summer in deep pools in the Sacramento River near Hamilton City
2 (Vogel 2011).

3 *Spawning Habitat*

4 Spawning habitat on the Sacramento River is affected by lack of sediment and
5 flow patterns as determined by the operations of the CVP and local water
6 diverters.

7 *Sediment Conditions*

8 Shasta and Keswick dams substantially influence sediment transport in the upper
9 Sacramento River because they block sediment that would normally have been
10 transported downstream (TNC 2007a, DWR 1985). The result has been a net loss
11 of coarse sediment, including gravel particle sizes suitable for salmon spawning,
12 in the Sacramento River downstream of Keswick Dam (Reclamation 2013b). To
13 address the issue of spawning gravel loss downstream of Keswick Dam,
14 Reclamation has placed approximately 5,000 tons of washed spawning gravel into
15 the Sacramento River downstream of Keswick about every other year since 1997
16 (Reclamation 2010a).

17 *Spawning Habitat Availability*

18 Winter-run Chinook Salmon spawning in the upper reaches of the Sacramento
19 River is affected by the operations of the seasonal ACID diversion dam, which
20 involves placement of flashboards in the river between April and May. Flows in
21 the river vary with the operation of the diversion dam and releases of water from
22 Shasta Lake into the river. When the dam is installed in the river, the WUA
23 upstream of the Cow Creek confluence is higher than when the dam is removed.
24 Farther downstream, there is less variability in WUA.

25 The WUA for winter-run Chinook Salmon spawning peaks at around 10,000 cfs
26 in the upstream reach upstream of the ACID intake when the dam flashboards are
27 in. With the boards out, the peak is around 5,500 cfs. In the next reach
28 downstream (ACID intake to Cow Creek), spawning WUA also peaked at around
29 10,000 cfs. In the lower reach (Cow Creek to Battle Creek), WUA spawning
30 habitat peaks at around 5,250 cfs, but there is low variability in spawning WUA
31 from 3,250 to 8,000 cfs

32 Overall, spawning habitat WUA values differ for fall-run and late fall-run
33 Chinook Salmon, but the flow versus habitat relationship is about the same for the
34 two runs. Upstream of the ACID intake, spawning habitat WUA for fall- and late
35 fall-run Chinook Salmon peaks at the lowest flow analyzed (3,250 cfs) with the
36 dam flashboards out and at about 6,000 cfs with the flashboards in. Between the
37 ACID intake and Cow Creek, spawning habitat WUA peaks at around 5,000 cfs
38 for both runs. Between Cow Creek and Battle Creek, spawning habitat WUA for
39 both runs peaks at about 3,500 cfs. The highest density of redds for fall- and late
40 fall-run Chinook Salmon occur in the middle ACID intake to Cow Creek reach.

41 The spawning habitat WUA values for steelhead peaks at the lowest river flow
42 analyzed (3,250 cfs) in the reach upstream of the ACID intake. This habitat
43 relationship held regardless of whether the flashboards were in or out. In the

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

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

10 USFWS (2005a) developed spawning flow-habitat relationships for fall-run
11 Chinook Salmon spawning habitat in the Sacramento River between Battle Creek
12 and Deer Creek. Between Battle Creek and RBDD, spawning habitat WUA
13 values for fall-run Chinook Salmon peaked at approximately 3,750 cfs, but
14 showed little variation over flows from 3,250 cfs (the lowest flow evaluated) and
15 6,000 cfs, but declined substantially at higher flows. Between the Red Bluff
16 Pumping Plant and Deer Creek, spawning habitat WUA values for fall-run
17 Chinook salmon peaked at 5,500 cfs, with little variation at flows from 4,250 to
18 8,000 cfs (USFWS 2005a).

19 *Rearing Habitat*

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

28 Fry rearing habitat WUA for winter-run Chinook Salmon fry rearing habitat peaks
29 at around 5,500 cfs in the reach upstream of the ACID intake when the dam
30 flashboards are in. With the boards out, the peak is around 6,500 cfs. In the next
31 reach downstream (ACID intake to Cow Creek), fry rearing habitat WUA for
32 winter-run Chinook Salmon peaks at around 31,000 cfs (the highest flow
33 evaluated). In the lower reach (Cow Creek to Battle Creek), fry rearing habitat
34 WUA for winter-run Chinook Salmon also peaked at around 31,000 cfs, but there
35 was little variation at flows.

36 The fry rearing habitat WUA values differ for fall-run and late fall-run Chinook
37 Salmon, but the flow versus habitat relationship was similar for the two runs.
38 Upstream of the ACID intake, fry rearing habitat WUA for fall- and late fall-run
39 Chinook Salmon peaks at the lowest flow analyzed (3,250 cfs) with the dam
40 flashboards in. With the flashboards out, fry rearing habitat WUA peaks at
41 around 23,000 cfs for both species. Between the ACID intake and Cow Creek,
42 fry rearing habitat WUA for fall- and late fall-run Chinook Salmon peaked at
43 around 3,750 cfs for both runs, with little variation from 3,250 cfs to 6,000 cfs
44 and only slightly lower WUA values at flows greater than 21,000 cfs. Between

1 Cow Creek and Battle Creek, fry rearing habitat WUA for both runs peaks at
2 3,250 cfs (the lowest flow evaluated), declining as flows increase.

3 Juvenile rearing habitat WUA for winter-run Chinook Salmon juvenile rearing
4 habitat peaks at around 8,000 cfs in the upstream reach above the ACID intake
5 when the dam flashboards are in. With the boards out, the peak is around
6 9,000 cfs. However, there is little variation in juvenile winter-run Chinook
7 Salmon rearing habitat WUA from around 5,500 to 11,000 cfs in this reach. In
8 the next reach downstream between the ACID intake to Cow Creek, juvenile
9 rearing habitat WUA for winter-run Chinook Salmon peaks at around 31,000 cfs
10 (the highest flow evaluated). In the lower reach (Cow Creek to Battle Creek),
11 juvenile rearing habitat WUA for winter-run Chinook Salmon peaks at around
12 3,500 cfs but shows only moderate (<50 percent) reductions in WUA over the
13 entire range of flows evaluated.

14 The juvenile rearing habitat WUA values differ for fall-run and late fall-run
15 Chinook Salmon, but the flow versus habitat relationship is similar for the two
16 runs. Upstream of the ACID intake, juvenile rearing habitat WUA for fall- and
17 late fall-run Chinook Salmon peaked in the 5,000- to 6,000-cfs range with the
18 dam flashboards in or out; there were only moderate (<50 percent) reductions in
19 juvenile rearing WUA over the entire range of flows evaluated. Between the
20 ACID intake and Cow Creek, fry rearing WUA peaked at around 3,250 cfs (the
21 lowest flow evaluated) for both runs, declining to a minimum at around
22 15,000 cfs and increasing to around 70 percent of the maximum at flows above
23 21,000 cfs. Between Cow Creek and Battle Creek, fry rearing WUA for both runs
24 peaked at 3,250 cfs (the lowest flow evaluated), declining as flow increased.

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

35 The minimum required Sacramento River flow is 3,250 cfs. Flows during
36 summer generally exceed this amount in order to meet temperature requirements
37 for winter-run Chinook Salmon. The water temperature requirements established
38 for winter-run Chinook Salmon result in water temperatures also suitable for
39 year-round rearing of steelhead in the upper Sacramento River.

40 **9.3.4.4.3 Fish Passage and Entrainment**

41 Historically, anadromous salmonids had access to a minimum of approximately
42 493 miles of habitat in the Sacramento River (Yoshiyama et al. 1996). After
43 completion of Shasta Dam in 1945, access to approximately 207 miles was

1 blocked. Keswick Dam, just downstream of Shasta Dam, is now the upstream
2 extent of available habitat for anadromous fish in the Sacramento River.

3 Until recently, three large-scale, upper Sacramento River diversions, including the
4 ACID and GCID intakes and RBDD, were of particular concern as potential
5 passage or entrainment problems for Chinook Salmon, steelhead, and other
6 migratory fish species (NRC 2012, NMFS 2009a, McEwan and Jackson 1996).
7 Recently, RBDD was eliminated, the GCID fish screens were installed, and fish
8 passage at the ACID intake was improved (NRC 2012). At the ACID intake, new
9 fish ladders and fish screens were installed around the diversion and were
10 operated starting in the summer 2001 diversion period. However, adult Green
11 Sturgeon that migrate upstream in April, May, and June are completely blocked
12 by the ACID intake (NMFS 2009a), rendering approximately 3 miles of spawning
13 habitat upstream of the diversion dam inaccessible. Adult Green Sturgeon that
14 pass upstream of the intake before April are delayed for 6 months until the
15 flashboards are pulled before returning downstream to the ocean. Newly emerged
16 Green Sturgeon larvae that hatch upstream of the ACID intake would need to hold
17 for 6 months upstream of the dam or pass over it and be subjected to higher
18 velocities and turbulent flow below the intake (NMFS 2009a).

19 Numerous other diversions are located on the Sacramento River. Herren and
20 Kawasaki (2001) documented up to 431 diversions from the Sacramento River
21 between Shasta Dam and the City of Sacramento. Hanson (2001) studied juvenile
22 Chinook Salmon entrainment at unscreened diversions at the Princeton Pumping
23 Plant and documented the entrainment of approximately 0.05 percent of juvenile
24 Chinook Salmon passing the diversion. Mussen et al. (2014) examined the risk to
25 Green Sturgeon from unscreened water diversions and found that juvenile Green
26 Sturgeon entrainment susceptibility (in a laboratory setting) was high relative to
27 that estimated for Chinook Salmon, suggesting that unscreened diversions could
28 be a contributing mortality source for threatened Southern DPS Green Sturgeon.

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

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

1 **9.3.4.4.4 Hatcheries**

2 The Livingston Stone NFH, located at the foot of Shasta Dam, is a conservation
3 hatchery that has been producing and releasing juvenile winter-run Chinook
4 Salmon since 1998. There is growing concern about the potential genetic effects
5 that may result from the use of a conventional hatchery program to supplement
6 winter-run Chinook Salmon populations. To maintain a low risk of compromised
7 genetic fitness, Lindley et al. (2007) recommend that no more than 5 percent of
8 the naturally spawning population should be composed of hatchery fish. Since
9 2001, more than 5 percent of the winter-run Chinook Salmon run has been
10 composed of hatchery-origin fish, and in 2005 the contribution of hatchery fish
11 was more than 18 percent (Lindley et al. 2007).

12 The Livingston Stone NFH minimizes hatchery affects in the population by
13 preferentially collecting wild adult winter-run Chinook Salmon for brood stock
14 (USFWS 2011b). Up to 15 percent of the estimated run size for winter-run
15 Chinook Salmon run may be collected for brood stock use (up to a maximum of
16 120 natural-origin winter-run Chinook Salmon per brood year). Although there is
17 no adult production goal, Livingston Stone NFH releases up to 250,000
18 winter-run Chinook Salmon a year in late January or early February. Winter-run
19 Chinook Salmon are released at the pre-smolt stage and are intended to rear in the
20 freshwater environment prior to smoltification. The pre-smolts are released into
21 the Sacramento River at Caldwell Park in Redding, about 10 miles downstream of
22 the hatchery. All juvenile winter-run Chinook Salmon produced at Livingston
23 Stone NFH are adipose fin-clipped and coded wire-tagged (CHSRG 2012).

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

28 **9.3.4.4.5 Predation**

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

35 **9.3.4.5 Battle Creek**

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

42 Coleman NFH, located on Battle Creek, was established in 1942 by Reclamation
43 to partially mitigate habitat and fish losses from historical spawning areas caused

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

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

25 **9.3.4.6 Lake Oroville and Thermalito Complex**

26 Lake Oroville on the Feather River is formed by Oroville Dam, approximately
27 70 miles upstream from its confluence with the Sacramento River. Lake Oroville
28 is fed by the north, middle, and south forks of the Feather River. A portion of the
29 water released from Lake Oroville flows into the Thermalito Complex, as
30 described in Chapter 5, Surface Water Resources and Water Supplies.

31 **9.3.4.6.1 Fish in Lake Oroville**

32 Lake Oroville thermally stratifies in spring, destratifies in fall, and remains
33 destratified throughout winter. FERC (2007b) reports indicate that surface water
34 temperatures of the epilimnion begin to warm in the early spring, reach maximum
35 temperatures (approximately mid-80°F) during late July, and gradually decline to
36 winter minimums. The transition zone (i.e., metalimnion) between the upper
37 warmer and lower colder waters typically ranges from about 30 to 50 feet below
38 the lake surface during midsummer. The deeper water of the hypolimnion can
39 reach a temperature of about 44°F near the reservoir bottom during periods of
40 stratification (FERC 2007b). Cold-water fish species include Coho Salmon,
41 Rainbow Trout, Brown Trout, and Lake Trout. The Lake Oroville cold-water
42 fishery is not self-sustaining, possibly because of insufficient spawning and
43 rearing habitat in the reservoir and accessible tributaries; cold-water spawning is
44 not known to occur in Lake Oroville. The Coho Salmon fishery is sustained by a

1 “put-and-grow” hatchery stocking program (FERC 2007b). The Lake Oroville
 2 warm-water fishery is a regionally important self-sustaining recreational fishery
 3 and is the site of several annual bass fishing tournaments. Spotted Bass are the
 4 most abundant bass species in Lake Oroville, followed by Largemouth Bass,
 5 Redeye Bass, and Smallmouth Bass, respectively. Other important warm-water
 6 species include catfish, crappie, and sunfish. Common carp are also abundant in
 7 Lake Oroville.

8 **9.3.4.6.2 Fish in Thermalito Forebay and Afterbay**

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

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

27 **9.3.4.7 Feather River from Lake Oroville and the Thermalito Complex to** 28 **the Sacramento River**

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

35 **9.3.4.7.1 Fish in the Feather River**

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

1 The analysis is focused on the following species:

- 2 • Chinook Salmon (winter-, spring-, and fall/late fall-run)
- 3 • Steelhead
- 4 • Green Sturgeon
- 5 • White Sturgeon
- 6 • Sacramento Splittail
- 7 • Pacific Lamprey
- 8 • Striped Bass
- 9 • American Shad

10 *Spring-run Chinook Salmon*

11 Approximately two-thirds of the natural spring-run and fall-run Chinook Salmon
12 spawning occur in the low-flow channel of the lower Feather River, downstream
13 of the Fish Barrier Dam, and one-third of the spawning occurs in the high-flow
14 channel downstream of the Thermalito Afterbay Outlet (FERC 2007b). NMFS
15 (2009a) indicated that significant redd superimposition occurs in the lower
16 Feather River because of oversaturation of the natural carrying capacity of the
17 available spawning habitat (e.g., Sommer et al. 2001b) with an overproduction of
18 hatchery spring-run Chinook Salmon and a lack of physical separation between
19 spring-run and fall-run Chinook Salmon adults.

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

35 An independent population of spring-run Chinook Salmon historically occurred in
36 the lower Feather River downstream of Oroville Dam, and a naturally spawning
37 population of spring-run Chinook Salmon may persist in this reach (Lindley et al.
38 2004). The number of naturally spawning spring-run Chinook Salmon in the
39 Feather River has been estimated only periodically since the 1960s, with estimates
40 ranging from 2 fish in 1978 to 2,908 in 1964. However, the genetic integrity of
41 this population is questionable because of the significant temporal and spatial
42 overlap between spawning populations of spring-run Chinook Salmon and
43 fall-run Chinook Salmon (Good et al. 2005).

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

13 *Fall-run Chinook Salmon*

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

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

30 *Steelhead*

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

43 A moderate percentage of the steelhead fry appear to outmigrate from the lower
44 Feather River soon after emerging from the gravel. Juvenile steelhead that do not

1 outmigrate may rear in the river for up to 1 year. Juvenile steelhead in the Feather
2 River outmigrate from about February through September, with peak
3 outmigration occurring from March through mid-April. In-river juvenile rearing
4 is generally associated with secondary channels in the low-flow channel (e.g.,
5 Hatchery Ditch) (FERC 2007b).

6 *Pacific Lamprey*

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

16 Ocean-stage adults likely migrate into the lower Feather River in spring and early
17 summer, where they hold for approximately 1 year before spawning (Hanni et al.
18 2006). Hannon and Deason (2008) have documented Pacific Lamprey spawning
19 in the nearby American River from between early January and late May, with
20 peak spawning typically occurring in early April. Pacific Lamprey ammocoetes
21 rear in the lower Feather River for all or part of their 5- to 7-year freshwater
22 residence. Data from rotary screw trapping suggest that outmigration of Pacific
23 Lamprey generally occurs from early winter through early summer (Hanni et al.
24 2006), although some outmigration likely occurs year-round as observed in the
25 mainstem Sacramento River (Hanni et al. 2006) and in other river systems
26 (Moyle 2002).

27 *Sacramento Splittail*

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

40 *Green Sturgeon*

41 Historically, Green Sturgeon likely spawned in the Sacramento, Feather, and San
42 Joaquin rivers (Adams et al. 2007). A substantial amount of habitat in the Feather
43 River was lost with the construction of Oroville Dam. Although the presence of
44 Green Sturgeon in the Sacramento River has been supported by direct angler

1 observations and rotary screw trapping of eggs, larvae, and YOY Green Sturgeon,
2 only intermittent observations of Green Sturgeon have been reported in the lower
3 Feather River (Beamesderfer et al. 2007). The occasional capture of larval Green
4 Sturgeon in outmigrant traps suggests that Green Sturgeon spawn in the lower
5 Feather River (Moyle 2002). However, prior to 2011 only two records of adult
6 Green Sturgeon in the lower Feather River were confirmed (NMFS 2005b). In
7 2011, videography monitoring conducted by the Anadromous Fish Restoration
8 Program confirmed Green Sturgeon spawning activity in the lower Feather River
9 and found evidence of spawning behavior in the Yuba River (AFRP 2011).
10 Seesholtz et al. (2014) provided the first documentation of Green Sturgeon
11 spawning in the Feather River.

12 *White Sturgeon*

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

26 *Striped Bass*

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

30 *American Shad*

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

35 **9.3.4.7.2 Aquatic Habitat**

36 Historically, spawning habitat suitable for anadromous salmonid species likely
37 existed above the current location of Oroville Dam on the Feather River
38 (Yoshiyama et al. 2001). Extensive mining, irrigation, and development of
39 hydroelectric dams significantly reduced the amount of suitable habitat for these
40 species (Yoshiyama et al. 2001). Schick et al. (2005) estimated approximately
41 71 miles of suitable habitat was historically available for spring-run Chinook
42 Salmon in the lower Feather River.

1 Most Chinook Salmon and steelhead spawning is concentrated in the uppermost
2 3 miles of accessible habitat in the lower Feather River downstream of the Feather
3 River Fish Hatchery (FERC 2007b). As a result, salmonid spawning is
4 concentrated to unnaturally high levels in the low-flow channel of the lower
5 Feather River directly downstream of Oroville Dam and the Fish Barrier Dam. A
6 physical habitat simulation analysis conducted by the California Department of
7 Water Resources (DWR) in 2002 indicated that Chinook spawning habitat
8 suitability in the low-flow channel reached a maximum between 800 and 825 cfs,
9 and in the high-flow channel, it reached a maximum at 1,200 cfs. The steelhead
10 spawning habitat index in the low-flow channel had no distinct optimum over the
11 range of flow between 150 and 1,000 cfs. In the high-flow channel, spawning
12 habitat suitability was maximized at a flow just under 1,000 cfs (DWR 2004b).

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

27 **9.3.4.7.3 Fish Passage**

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

40 **9.3.4.7.4 Hatcheries**

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

1 Chinook Salmon, and steelhead. The Feather River Fish Hatchery supports the
2 only spring-run Chinook Salmon hatchery program currently in the Central Valley
3 (CHSRG 2012). Spring-run Chinook Salmon produced at the Feather River Fish
4 Hatchery are included in the listed spring-run Chinook Salmon ESU
5 (70 FR 37160). FERC is in consultation with NMFS on the effects of relicensing
6 Oroville Dam (including the effects of Feather River Fish Hatchery).

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

13 Adult hatchery-produced spring-run Chinook are intended to spawn naturally or
14 to be genetically integrated with the natural population through artificial
15 propagation. There are no specific goals for the number of adult spring-run
16 Chinook Salmon; however, the juvenile production goal is to release 2 million
17 smolts during April or May. These fish are all released into the Feather River
18 south of Yuba City at the Boyd's Pump Boat Launch (44 miles downstream of the
19 hatchery). Juvenile hatchery-produced spring-run Chinook Salmon are currently
20 100 percent marked with an adipose fin-clip and a coded wire-tag
21 (CHSRG 2012).

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

32 Prior to 2004, separation of spring-run and fall-run Chinook Salmon returning to
33 the Feather River Fish Hatchery was solely based on run timing, which resulted in
34 considerable mixing of fall-run and spring-run Chinook Salmon stocks (DWR
35 2009, NMFS 2012a). In 2005, the Feather River Fish Hatchery implemented a
36 methodology change for distinguishing spring-run Chinook Salmon from fall-run
37 Chinook Salmon (CHSRG 2012). To maintain genetic integrity, fish entering the
38 Feather River Fish Hatchery prior to July 1 receive an external tag, and only these
39 externally tagged fish are used as spring-run Chinook Salmon broodstock
40 (DWR 2009). Since 2005, the hatchery has attempted to mark 100 percent of
41 spring-run Chinook Salmon produced at the hatchery with an adipose fin-clip,
42 coded wire-tag (CHSRG 2012) and race and brood year specific otolith thermal
43 marks (DWR 2009).

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

7 **9.3.4.7.5 Disease**

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

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

33 **9.3.4.7.6 Predation**

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

1 9.3.4.8 Yuba River

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

7 Fish species found in the New Bullards Bar Reservoir include Rainbow Trout,
8 Brown Trout, Kokanee Salmon, bass, Bluegill, crappie, and bullhead (DWR et al.
9 2007). A similar mix of species is found in Englebright Reservoir. Fall-run and
10 spring-run Chinook Salmon and steelhead occur in the Yuba River downstream of
11 Englebright Dam (YCWA 2009). Sacramento Splittail have been documented
12 only in the lower Feather River and not in the Yuba River. Low numbers of
13 Green Sturgeon and White Sturgeon occasionally range into the Yuba River
14 (Beamesderfer et al. 2004). Other species found in the lower Yuba River include
15 American Shad, Smallmouth Bass, and Striped Bass (DWR et al. 2007).

16 9.3.4.9 Bear River

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

22 Fall-run and spring-run Chinook Salmon and steelhead occur in the Bear River
23 (YCWA 2009). Sacramento Splittail have been documented only in the lower
24 Feather River and not in the Bear River. Low numbers of Green Sturgeon and
25 White Sturgeon occasionally range into the Bear River (Beamesderfer et al.
26 2004). Rollins Reservoir is currently managed as a put-and-take fishery for
27 rainbow and Brown Trout. Kokanee reproduce naturally in the lake. Gill net
28 surveys from 1970 to 1983 documented numerous other species including bass,
29 catfish, sunfish, Golden Shiner, Tui Chub, Pond Smelt, crappie, and Bluegill
30 (DFG 1974-1983 in NID 2008). Native fishes found in Combie Reservoir may
31 include Sacramento Pikeminnow, Sacramento Sucker, Hardhead, Tui Chub,
32 Hitch, and Inland Silverside. Nonnative fishes likely include Bluegill, Green
33 Sunfish, Largemouth Bass, Spotted Bass, Smallmouth Bass, common carp,
34 Golden Shiner, Threadfin Shad, Black Crappie, Brown Bullhead, White Catfish,
35 Channel Catfish, Western Mosquitofish, and stocked Rainbow Trout (NID 2009).

36 9.3.4.10 Folsom Lake and Lake Natoma

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

42 Water surface elevations vary annually as a result of seasonal inflow and water
43 release and are generally the least variable during spring and most variable during

1 summer (USACE et al. 2012). Thermal stratification of the reservoir generally
2 begins during April and usually persists throughout summer until November,
3 when cooler temperatures, winter rains, and high inflows create mixing and result
4 in “turnover” (Reclamation 2005, USACE et al. 2012). During summer, a
5 thermocline develops that separates the epilimnion (i.e., upper layer of warm
6 water) and the hypolimnion (i.e., lower layer of cooler water). This thermal
7 stratification and segregation of habitats allow for both cold-water and
8 warm-water species to coexist in Folsom Lake (USACE et al. 2012).
9 Warm-water fish species include native Hardhead, California Roach, Sacramento
10 Pikeminnow, and Sacramento Sucker, as well as nonnative Largemouth Bass,
11 Smallmouth Bass, Spotted Bass, sunfish, Black Crappie, and White Crappie
12 (Reclamation 2007). Cold-water fish species include native Rainbow Trout and
13 planted Chinook and Kokanee Salmon, as well as nonnative Brown Trout
14 (Reclamation 2007).

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

26 **9.3.4.11 Lower American River between Lake Natoma and the Sacramento** 27 **River**

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

31 **9.3.4.11.1 Fish in the Lower American River**

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

34 The analysis is focused on the following species:

- 35 • Fall-run Chinook Salmon
- 36 • Steelhead
- 37 • White Sturgeon
- 38 • Sacramento Splittail
- 39 • Pacific Lamprey
- 40 • Striped Bass
- 41 • American Shad

1 *Fall-run Chinook Salmon*

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

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

24 *Steelhead*

25 Natural spawning by steelhead in the American River occurs (Hannon and
26 Deason 2008), but the population is supported primarily by the Nimbus Fish
27 Hatchery. The total estimated steelhead return to the river (spawning naturally
28 and in the hatchery) has ranged from 946 to 3,426 fish, averaging 2,184 fish per
29 year from 2002 to 2010 (CHSRG 2012). Steelhead spawning surveys have shown
30 approximately 300 steelhead spawning in the river each year (Hannon and Deason
31 2008). Lindley et al. (2007) classifies the listed (i.e., naturally spawning)
32 population of American River steelhead at a high risk of extinction because it is
33 reportedly mostly composed of steelhead originating from Nimbus Fish Hatchery.
34 NMFS views the American River population as important to the survival and
35 recovery of the species (NMFS 2009a).

36 Nielsen et al. (2005) found steelhead in the American River to be genetically
37 different from other Central Valley stocks. Eel River steelhead were used to
38 found the Nimbus Hatchery stock, and steelhead from the American River
39 (collected from both the Nimbus Fish Hatchery and the American River) are
40 genetically more similar to Eel River steelhead than other Central Valley
41 Steelhead stocks. Based on studies by Hallock et al. (1961), Staley (1976), and
42 Neilsen (2005), Lee and Chilton (2007) reported that American River winter-run
43 steelhead are genetically and phenotypically different, and demonstrate a later
44 upstream migration period than Central Valley Steelhead. Zimmerman et al.
45 (2008) also noted that there remains a strong resident component (i.e., fish that do

1 not migrate to the ocean) of the *O. mykiss* population that interacts with and
2 produces anadromous individuals. Steelhead and Rainbow Trout are the same
3 species and when juveniles of the species are found in fresh water, it is unclear if
4 they will exhibit an anadromous (steelhead) or resident (Rainbow Trout) life
5 history strategy. Thus, they are often collectively referred to as *O. mykiss* at this
6 stage to indicate this uncertainty.

7 Adult steelhead enter the American River from November through April with a
8 peak occurring from December through March (SWRI 2001). Steelhead have
9 been trapped at Nimbus Fish Hatchery as early as the first week of October.
10 Results of a spawning survey conducted from 2001 through 2007 indicate that
11 steelhead spawning occurs in the lower American River from late December
12 through early April, with the peak occurring in late February to early March
13 (Hannon and Deason 2008). Spawning density is highest in the upper 7 miles of
14 the river, but spawning occurs as far downstream as Paradise Beach. About
15 90 percent of spawning occurs upstream of the Watt Avenue Bridge (Hannon and
16 Deason 2008).

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

23 Juvenile *O. mykiss* have been documented year-round throughout the lower
24 American River, with rearing generally upstream of spawning areas. Juveniles
25 reportedly can rear in the lower American River for a year or more before
26 outmigrating as smolts from January through June (Snider and Titus 2000a,
27 SWRI 2001). However, Snider and Titus (2002) reported only 1 yearling
28 steelhead capture, and PSMFC (2014) reported capturing primarily YOY fry and
29 parr. Peak outmigration occurs from March through May (McEwan and Jackson
30 1996, SWRI 2001, PSMFC 2014).

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

40 *Pacific Lamprey*

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

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

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

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

24 *Sacramento Splittail*

25 Splittail likely spawn in the lower reaches of the American River (Sommer et al.
26 1998, 2008; Moyle et al. 2004). During wet years, upstream migration is more
27 directed and fish tend to swim farther upstream (Moyle 2002), thus more
28 individuals are expected to use the American River in wet years. Although
29 juvenile splittail are known to rear in upstream areas for a year or more (Baxter
30 1999), most move to the Delta after only a few weeks of rearing on floodplain
31 habitat (Reclamation 2008a). Most juveniles move downstream into the Delta
32 from April to August (Meng and Moyle 1995). The primary factor potentially
33 limiting the American River population of Sacramento Splittail is availability of
34 inundated floodplains for spawning and rearing habitats (Moyle et al. 2004).

35 *White Sturgeon*

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

40 *Striped Bass*

41 Striped Bass are found in the American River throughout the year, with the
42 greatest abundance in summer (SWRI 2001). Although the occurrence of
43 spawning in the American River is uncertain, the river is believed to serve as a
44 nursery area for YOY and subadult Striped Bass (SWRI 2001). Striped Bass are

1 distributed from the confluence with the Sacramento River to Nimbus Dam
2 (Moyle 2002), and they provide a locally important sportfishing resource.

3 *American Shad*

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

8 **9.3.4.11.2 Aquatic Habitat**

9 Since 1955, Nimbus Dam has blocked upstream passage by anadromous fish and
10 restricted available habitat in the lower American River to the approximately
11 23 river miles between the dam and the confluence with the Sacramento River.
12 Additionally, Folsom Dam has blocked the downstream transport of sediment that
13 contributes to the formation and maintenance of habitat for aquatic species.

14 In 2008, Reclamation, in coordination with USFWS and the Sacramento Water
15 Forum, began implementation of salmonid habitat improvement in the lower
16 American River. An estimated 5,000 cubic yards of gravel and cobble were
17 placed just upstream of Nimbus Fish Hatchery in 2008, followed by an estimated
18 7,000 cubic yards adjacent to the Nimbus Fish Hatchery in fall 2009. In
19 September 2010, approximately 11,688 cubic yards (approximately 16,200 tons)
20 of gravel and cobble were placed at Sailor Bar to enhance spawning habitat for
21 Chinook Salmon and steelhead in the lower American River (Merz et al. 2012).
22 Additionally, the 2010 augmentation site contained a constructed cobble island
23 and “scallop” in the substrate designed to add habitat heterogeneity to the main
24 channel and rearing habitat for juvenile Chinook Salmon and steelhead.
25 Additionally, approximately 5,500 tons of cleaned cobble were placed
26 downstream of the 2010 augmentation site. The specific purpose of this
27 placement was to divert flow into an adjacent, perched side channel, thereby
28 preventing the dewatering of salmonid redds in a historically important spawning
29 and rearing area during low-flow conditions.

30 During higher flows, channel geomorphology in the lower American River is
31 characterized by bar complexes and side channel areas, which may become
32 limited at lower flows (NMFS 2009a). Spawning bed materials in the lower
33 American River may begin to mobilize at flows of 30,000 cfs, with more
34 substantial mobilization at flows of 50,000 cfs or greater (Reclamation 2008a).
35 At 115,000 cfs (the highest flow modeled), particles up to 70 mm median
36 diameter would be moved in the high-density spawning areas around Sailor Bar
37 and Sunrise Avenue. Flood frequency analysis for the American River at Fair
38 Oaks gage shows that, on average, flood control releases exceed 30,000 cfs about
39 once every 4 years and exceed 50,000 cfs about once every 5 years
40 (Reclamation 2008a).

41 In 2008, Reclamation began implementing floodplain and spawning habitat
42 restoration projects in the American River to assist in meeting the requirements of
43 the 1992 CVPIA, Section 3406 (b)(13). The side channel at Upper Sunrise was

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

12 **9.3.4.11.3 Fish Passage**

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

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

29 **9.3.4.11.4 Hatcheries**

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

1 seasonally enter the trapping facilities (CHSRG 2012). These fin-clipped fish are
2 not part of the Central Valley Steelhead DPS. The Nimbus Fish Hatchery
3 Winter-run Steelhead Program propagates fish for recreational fishing
4 opportunities and harvest (CHSRG 2012).

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

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

18 Juvenile steelhead yearlings are not held past March 30 because of increasing
19 hatchery water temperatures and to encourage outmigration during spring. If
20 releases occur during periods of low flows in the Sacramento River and possibly
21 the American River, some released fish migrate back to Nimbus Fish Hatchery
22 and may take up residency rather than migrating downstream (Lee and Chilton
23 2007). Additionally, juvenile fish are released in February and early March to
24 coincide with State Water Resources Control Board (SWRCB) D-1641 closures
25 of the DCC gates from February 1 through May 20 to reduce straying into the
26 Delta. Reclamation determines the exact timing and duration of the gate closures
27 after discussion with USFWS, CDFW, and NMFS.

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

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

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

1 **9.3.4.11.5 Disease**

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

12 **9.3.4.11.6 Predation**

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

19 **9.3.4.12 Delta**

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

27 **9.3.4.12.1 Fish in the Delta**

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

38 The analysis is focused on the following species:

- 39 • Chinook Salmon (winter-, spring-, and fall-/late fall-run)
40 • Steelhead
41 • Green Sturgeon
42 • White Sturgeon

- 1 • Sacramento Splittail
- 2 • Pacific Lamprey
- 3 • Striped Bass
- 4 • American Shad
- 5 • Delta Smelt
- 6 • Longfin Smelt
- 7 • Sacramento Splittail

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

27 *Winter-run Chinook Salmon*

28 Winter-run Chinook Salmon use the Delta for upstream migration as adults and
29 for downstream migration and rearing as juveniles (del Rosario et al. 2013).
30 Adults migrate through the Delta during winter and into late spring (May/June)
31 enroute to their spawning grounds in the mainstem Sacramento River downstream
32 of Keswick Dam (USFWS 2001b, 2003b). Adults are believed to primarily use
33 the mainstem Sacramento River for passage through the Delta (NMFS 2009a).
34 After entry into the Delta, juvenile winter-run Chinook Salmon remain and rear in
35 the Delta until they are 5 to 10 months of age (based on scale analysis) (Fisher
36 1994, Myers et al. 1998). Although the duration of residence in the Delta is not
37 precisely known, del Rosario et al. (2013) suggested that it can be up to several
38 months. Winter-run Chinook Salmon juveniles have been documented in the
39 north Delta (e.g., Sacramento River, Steamboat Slough, Sutter Slough, Miner
40 Slough, Yolo Bypass, and Cache Slough complex); the central Delta (e.g.,
41 Georgiana Slough, DCC, Snodgrass Slough, and Mokelumne River complex
42 below Dead Horse Island); south Delta channels, including Old and Middle rivers,
43 and the joining waterways between Old and Middle rivers (e.g., Victoria Canal,
44 Woodward Canal, and Connection Slough); and the western central Delta,

1 including the mainstem channels of the Sacramento and San Joaquin rivers and
2 Threemile Slough (NMFS 2009a).

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

10 *Spring-run Chinook Salmon*

11 The Delta is an important migratory route for all remaining populations of spring-
12 run Chinook Salmon. Like all salmonids migrating up through the Delta, adult
13 spring-run Chinook Salmon must navigate the many channels and avoid direct
14 sources of mortality (e.g., fishing and predation), but also must minimize
15 exposure to sources of nonlethal stress (e.g., high temperatures) that can
16 contribute to prespawn mortality in adult salmonids (Budy et al. 2002, Naughton
17 et al. 2005, Cooke et al. 2006, NMFS 2009a). Habitat degradation in the Delta
18 caused by factors such as channelization and changes in water quality can present
19 challenges for outmigrating juveniles. Additionally, outmigrating juveniles are
20 subjected to predation and entrainment in the project export facilities and smaller
21 diversions (NMFS 2009a). Further detail is provided later in this section.

22 Spring-run Chinook Salmon returning to spawn in the Sacramento River system
23 enter the San Francisco Estuary from the ocean in January to late February and
24 move through the Delta prior to entering the Sacramento River. Several
25 populations of spring-run Chinook Salmon occur in the Sacramento River Basin,
26 but historical populations that occurred in the San Joaquin River and tributaries
27 have been extirpated. The Sacramento River channel is the main spring-run
28 Chinook Salmon migration route through the Delta. However, adult spring-run
29 Chinook Salmon may stray into the San Joaquin River side of the Delta in
30 response to water from the Sacramento River Basin flowing into the
31 interconnecting waterways that join the San Joaquin River channel through the
32 DCC, Georgiana Slough, and Threemile Slough. Closure of the DCC radial gates
33 is intended to minimize straying, but some southward net flow still occurs
34 naturally in Georgiana and Threemile sloughs.

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

1 from that of the fall-run due to the similarity in their spawning and emergence
2 times and size. Together, these two runs generate an extended pulse of Chinook
3 Salmon smolts outmigrating through the Delta throughout spring, frequently
4 lasting into June. Spring-run Chinook Salmon juveniles also overlap spatially
5 with juvenile winter-run Chinook Salmon in the Delta (NMFS 2009a). Typically,
6 juvenile spring-run Chinook Salmon are not found in the channels of the eastern
7 side of the Delta or the mainstem of the San Joaquin River upstream of Columbia
8 and Turner Cuts.

9 *Fall-/Late fall-run Chinook Salmon*

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

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

23 Most fall-run Chinook Salmon fry rear in fresh water from December through
24 June, with outmigration as smolts primarily from January through June. In
25 general, fall-run Chinook Salmon fry abundance in the Delta increases following
26 high winter flows. Smolts that arrive in the estuary after rearing upstream migrate
27 quickly through the Delta and Suisun and San Pablo bays. A small number of
28 juvenile fall-run Chinook Salmon spend over a year in fresh water and outmigrate
29 as yearling smolts the following November through April. Late fall-run fry rear
30 in fresh water from April through the following April and outmigrate as smolts
31 from October through February (Snider and Titus 2000b). Juvenile Chinook
32 Salmon were found to spend about 40 days migrating through the Delta to the
33 mouth of San Francisco Bay (MacFarlane and Norton 2002).

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

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

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

16 *Steelhead*

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

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

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

42 Juvenile steelhead can be found in all waterways of the Delta, but particularly in
43 the main channels leading from their natal river systems (NMFS 2009a). Juvenile
44 steelhead are recovered in trawls from October through July at Chipps Island and

1 at Mossdale. Chipps Island catch data indicate there is a difference in the
2 outmigration timing between wild and hatchery-reared steelhead smolts from the
3 Sacramento and eastside tributaries. Hatchery fish are typically recovered at
4 Chipps Island from January through March, with a peak in February and March
5 corresponding to the schedule of hatchery releases of steelhead smolts from the
6 Central Valley hatcheries (Nobriga and Cadrett 2001, Reclamation 2008a). The
7 timing of wild (unmarked) steelhead outmigration is more spread out, and based
8 on salvage records at the CVP and SWP fish collection facilities, outmigration
9 occurs over approximately 6 months with the highest levels of recovery in
10 February through June (Aasen 2011, 2012). Steelhead are salvaged annually at
11 the project export facilities (e.g., 4,631 fish were salvaged in 2010, and 1,648 in
12 2011) (Aasen 2011, 2012).

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

28 *Green Sturgeon*

29 Green Sturgeon reach maturity around 14 to 16 years of age and can live to be
30 70 years old, returning to their natal rivers every 3 to 5 years for spawning
31 (Van Eenennaam et al. 2005). Adult Green Sturgeon move through the Delta
32 from February through April, arriving at holding and spawning locations the
33 upper Sacramento River between April and June (Heublein 2006, Kelly et al.
34 2007). Following their initial spawning run upriver, adults may hold for a few
35 weeks to months in the upper river before moving back downstream in fall
36 (Vogel 2008, Heublein et al. 2009), or they may migrate immediately back
37 downstream through the Delta. Radio-tagged adult Green Sturgeon have been
38 tracked moving downstream past Knights Landing during summer and fall,
39 typically in association with pulses of flow in the river (Heublein et al. 2009),
40 similar to behavior exhibited by adult Green Sturgeon on the Rogue River and
41 Klamath River systems (Erickson et al. 2002, Benson et al. 2007).

42 Similar to other estuaries along the west coast of North America, adult and sub-
43 adult Green Sturgeon frequently congregate in the San Francisco Estuary during
44 summer and fall (Lindley et al. 2008). Specifically, adults and subadults may
45 reside for extended periods in the central Delta as well as in Suisun and San Pablo

1 bays, presumably for feeding, because bays and estuaries are preferred feeding
2 habitat rich in benthic invertebrates (e.g., amphipods, bivalves, and insect larvae).
3 In part because of their bottom-oriented feeding habits, sturgeon are at risk of
4 harmful accumulations of toxic pollutants in their tissues, especially pesticides
5 such as pyrethroids and heavy metals such as selenium and mercury (Israel and
6 Klimley 2008, Stewart et al. 2004).

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

18 After hatching, larvae and juveniles migrate downstream toward the Delta.
19 Juveniles are believed to use the Delta for rearing for the first 1 to 3 years of their
20 lives before moving out to the ocean and are likely to be found in the main
21 channels of the Delta and the larger interconnecting sloughs and waterways,
22 especially within the central Delta and Suisun Bay/Marsh. Project operations at
23 the DCC have the potential to reroute Green Sturgeon as they outmigrate through
24 the lower Sacramento River to the Delta (Israel and Klimley 2008, Vogel 2011).
25 When the DCC is open, there is no passage delay for adults, but juveniles could
26 be diverted from the Sacramento River into the interior Delta. This has been
27 shown to reduce the survival of juvenile Chinook Salmon (Brandes and McLain
28 2001, Newman and Brandes 2010, Perry et al. 2012), but it is unknown whether it
29 has similar effects on Green Sturgeon.

30 *White Sturgeon*

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

43 The Delta population of White Sturgeon spawns mainly in the Sacramento and
44 Feather rivers, with occasional spawning in the San Joaquin River (Moyle 2002,
45 Jackson 2013). Spawning-stage adults generally move into the lower reaches of

1 rivers during winter prior to spawning and migrate upstream in response to higher
2 flows to spawn from February to early June (McCabe and Tracy 1994,
3 Schaffter 1997).

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

10 Salinity tolerance increases with increasing age and size (McEnroe and Cech
11 1985), allowing White Sturgeon to access a broader range of habitat in the San
12 Francisco Estuary (Israel et al. 2008). During dry years, White Sturgeon have
13 been observed following brackish waters farther upstream, while the opposite
14 occurs in wet years (Kohlhorst et al. 1991). Adult White Sturgeon tend to
15 concentrate in deeper areas and tidal channels with soft bottoms, especially during
16 low tides, and typically move into intertidal or shallow subtidal areas to feed
17 during high tides (Moyle 2002). These shallow water habitats provide
18 opportunities for feeding on benthic organisms, such as opossum shrimp,
19 amphipods, and even invasive overbite clams, and small fishes (Israel et al. 2008,
20 Kogut 2008). White Sturgeon also have been found in tidal habitats of
21 medium-sized tributary streams to the San Francisco Estuary, such as Coyote
22 Creek and Guadalupe River in the south bay and Napa and Petaluma rivers and
23 Sonoma Creek in the north bay (Leidy 2007).

24 Numerous factors likely affect the White Sturgeon population in the Delta, similar
25 to those for Green Sturgeon. Survival during early life history stages may be
26 adversely affected by insufficient flows, lack of rearing habitat, predation, warm
27 water temperatures, decreased dissolved oxygen, chemical toxicants in the water,
28 and entrainment at diversions (Cech et al. 1984, Israel et al. 2008). Historical
29 habitats, including shallow intertidal feeding habitats, have been lost in the Delta
30 because of channelization. Over-exploitation by recreational fishing and
31 poaching also likely has been an important factor adversely affecting numbers of
32 adult sturgeon (Moyle 2002), although new regulations were implemented in
33 2007 by CDFW to reduce harvest. Like Green Sturgeon, there are substantial
34 passage problems for White Sturgeon such as the Fremont Weir
35 (Sommer et al. 2014).

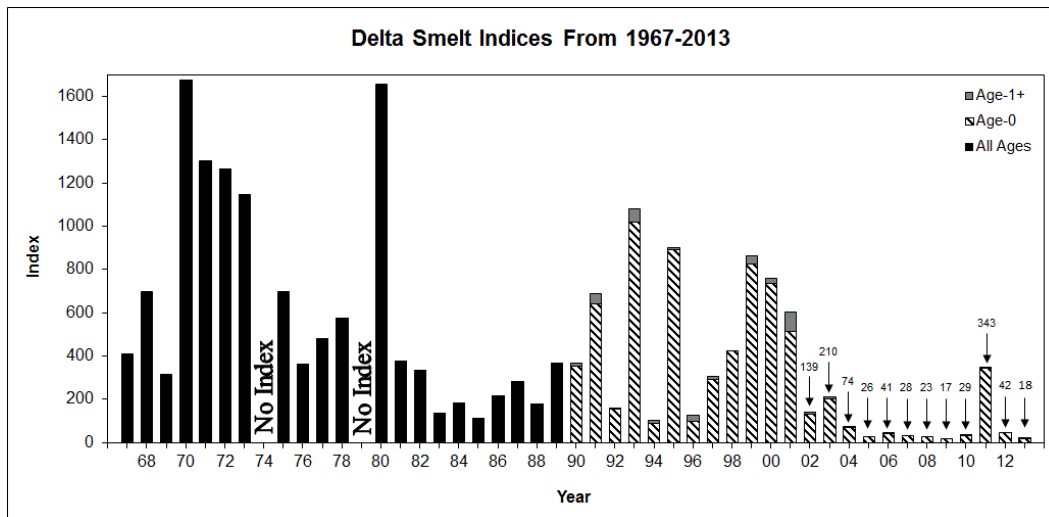
36 *Delta Smelt*

37 Delta Smelt are endemic to the Delta (Moyle et al. 1992, Bennett 2005). Delta
38 Smelt were once regarded as one of the most common pelagic fish in the Delta,
39 but declines in their population led to their listing under the ESA as threatened in
40 1993 (USFWS 2008a). Delta Smelt are one of four pelagic fish species (including
41 Longfin Smelt, Threadfin Shad, and juvenile Striped Bass) documented to be in
42 decline based on fall midwater trawl abundance indices (Sommer et al. 2007a).
43 The causes of the declines have been extensively studied and are thought to
44 include a combination of factors, such as decreased habitat quantity and quality,
45 increased mortality rates, and reduced food availability (Feyrer et al. 2007,

1 Sommer et al. 2007a, Moyle and Bennett 2008, MacNally et al. 2010, Sommer
 2 and Mejia 2013).

3 The status of the Delta Smelt is uncertain, as indicators of Delta Smelt abundance
 4 have continued to decline and the number of fish collected in sampling programs,
 5 such as the trawl surveys conducted by the IEP, have dropped even lower in
 6 recent years. The Fall Midwater Trawl (FMWT) Survey is recognized by some as
 7 the best available long-term index of Delta Smelt relative abundance
 8 (USFWS 2008). Figure 9.1 presents the FMWT abundance indices for Delta
 9 Smelt from 1967 to 2013 (CDFW 2014b). Fewer than 10 Delta Smelt were
 10 collected in these surveys in 2014; the 2014 Delta Smelt index was 9, making it
 11 the lowest in FMWT history (CDFW 2014a, Austin 2015). Results for Delta
 12 Smelt from the 2015 spring Kodiak trawl, 20-mm survey, and summer townet
 13 survey reported in the June 2015 Smelt Working Group meeting summary were
 14 similarly low (Smelt Working Group 2015).

15 **Figure 9.1 Fall Midwater Trawl Abundance Indices for Delta Smelt from 1967 to**
 16 **2013**



17
 18 Source: California Department of Fish and Wildlife, Trends in Abundance of Selected
 19 Species, January 15, 2014. <http://www.dfg.ca.gov/delta/data/fmwt/Indices/>

20 Studies conducted to synthesize available information about Delta Smelt indicate
 21 that Delta Smelt have been documented throughout their geographic range during
 22 much of the year (Merz et al. 2011, Sommer and Mejia 2013, Brown et al. 2014).
 23 Studies indicate that in fall, prior to spawning, Delta Smelt are found in the Delta,
 24 Suisun and San Pablo bays, the Sacramento River and San Joaquin River
 25 confluence, Cache Slough, and the lower Sacramento River (Murphy and
 26 Hamilton 2013). By spring, they move to freshwater areas of the Delta region,
 27 including Grizzly Bay, the Sacramento River and San Joaquin River confluence,
 28 the Upper Sacramento River, and Cache Slough (Brown et al. 2014, Murphy and
 29 Hamilton 2013).

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

15 During and after larval rearing in fresh water, many young Delta Smelt move with
16 river and tidal currents to remain in favorable rearing habitats, often moving
17 increasingly into the low salinity zone to avoid seasonally warm and highly
18 transparent waters that typify many areas in the central Delta (Nobriga et al.
19 2008). During summer and fall, many juvenile Delta Smelt continue to grow and
20 rear in the low salinity zone until maturing the following winter (Bennett 2005).
21 Some Delta Smelt also rear in upstream areas such as the Cache Slough complex,
22 depending on habitat conditions (Sommer and Mejia 2013).

23 During summer and fall, the distribution of juvenile Delta Smelt rearing is
24 influenced by the position of the low salinity zone (as indexed by the position of
25 X2), although their distribution can also be influenced by temperature and
26 turbidity (Bennett 2005; Feyrer et al. 2007, 2011; Kimmerer et al. 2009; Sommer
27 and Mejia 2013). The geographical position of the low salinity zone varies
28 primarily as a function of freshwater outflow; thus, X2 typically lies farther east
29 in summer and fall during low outflow conditions and drier water years and
30 farther west during high outflow conditions (Jassby et al. 1995).

31 Higher outflow causes X2 and the low salinity zone to more frequently overlap
32 with the Suisun Bay/Marsh region, which is broader and shallower and typically
33 has greater turbidity than the mainstem Sacramento and San Joaquin rivers. The
34 overlap of the low salinity zone (or X2) with the Suisun Bay/Marsh leads to more
35 favorable growth and survival conditions for Delta Smelt in fall (Baxter et al.
36 2010, Feyrer et al. 2011); however others have questioned the use by Feyrer et al.
37 (2013) of outflow and X2 location as an indicator of Delta Smelt habitat
38 (Manly et al. 2014) because other factors may be influencing survival.

39 In addition to salinity, turbidity is an important factor associated with habitat use;
40 Delta Smelt show a strong preference for higher turbidity water (Feyrer et al.
41 2007, 2011; Sommer and Mejia 2013). Turbidity has decreased in recent decades
42 within the Delta (Kimmerer 2004, Schoellhamer 2011), which has likely
43 contributed to declines in environmental quality of Delta Smelt habitat
44 (Feyrer et al. 2007, 2011). Higher turbidities are believed to allow Delta Smelt to
45 hide from open-water predators, such as Striped Bass (Gregory and Levings 1998,

1 Nobriga et al. 2005), and contribute to feeding success (Lindberg et al. 2000,
2 IEP 2015).

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

10 The quality and availability of food also have important effects on the abundance
11 and distribution of Delta Smelt (Sommer and Mejia 2013, Kimmerer 2008). Delta
12 Smelt feed primarily on zooplankton, and Nobriga (2002) showed that Delta
13 Smelt larvae with food in their guts typically co-occurred with higher calanoid
14 copepod densities. Food quality and availability have varied substantially, largely
15 because of the history of nonnative species introduction into the San Francisco
16 Estuary (Baxter et al. 2008, Winder and Jassby 2011). The decline of
17 zooplankton in the western Delta has been hypothesized to be related to several
18 factors, including increased ammonium concentrations from wastewater effluent
19 and agricultural runoff (Wilkerson et al. 2006; Dugdale et al. 2007; Miller et al.
20 2012; Glibert 2010; Glibert et al. 2011, 2014).

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

36 Results in prior years indicate that entrainment and salvage-related mortality of
37 Delta Smelt associated with water pumping and CVP/SWP exports from the Delta
38 occur primarily from December to July (Kimmerer 2008, Grimaldo et al. 2009,
39 Baxter et al. 2010). Entrainment occurs when migrating and spawning adult Delta
40 Smelt and their larvae overlap in time and space with reverse (southward, or
41 upstream) flows in the Old and Middle river channels (Kimmerer 2008, Grimaldo
42 et al. 2009, Baxter et al. 2010).

43 In January 2015, the IEP Management Analysis and Synthesis Team (MAST)
44 published a report to provide an assessment and conceptual model of factors

1 affecting Delta Smelt throughout its life cycle. One focus of the report was an
2 evaluation of a notable increase in abundance of all Delta Smelt life stages in
3 2011, which indicated that the Delta Smelt population could potentially rebound
4 when conditions are favorable for spawning, growth, and survival.

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

- 12 1) Adults and larvae benefitted from high winter 2010 and spring 2011
13 outflows, which reduced entrainment risk and possibly improved other
14 habitat conditions, prolonged cool spring water temperatures, and possibly
15 good food availability in late spring.
- 16 2) Juvenile Delta Smelt benefitted from cool water temperatures in late
17 spring and early summer as well as from relatively good food availability
18 and low levels of harmful *Microcystis*.
- 19 3) Subadults benefitted from good food availability and from favorable
20 habitat conditions in the large low salinity zone, located more toward
21 Suisun Bay in 2010.

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

29 *Longfin Smelt*

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

38 Longfin Smelt are anadromous and spawn in fresh water in the Delta, generally at
39 2 years of age (Moyle 2002). They migrate upstream to spawn during late fall
40 through winter, with most spawning from November through April (DFG 2009a).
41 Spawning in the Sacramento River is believed to occur from just downstream of
42 the confluence of the Sacramento and San Joaquin rivers upstream to about Rio
43 Vista. Spawning on the San Joaquin River extends from the confluence upstream

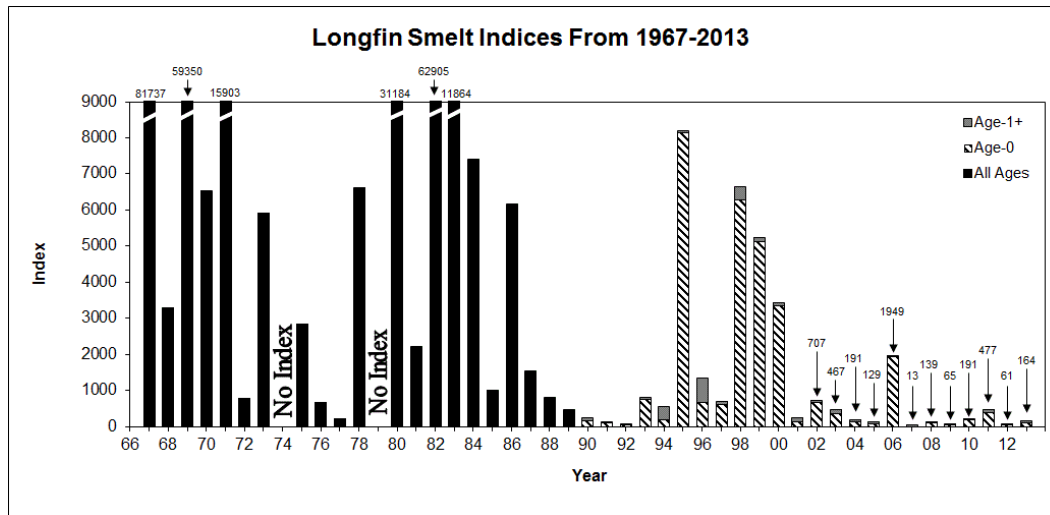
1 to about Medford Island (Moyle 2002). Spawning likely also occurs in Suisun
2 Marsh and the Napa River (DFG 2009a).

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

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

19 The relative population size of Longfin Smelt in the San Francisco Estuary is
20 measured by indices of abundance generated from different sampling programs.
21 The abundance of age 0 and older fish is best indexed by the Fall Midwater Trawl
22 and Bay Study, while the abundance of larvae and young juveniles is best indexed
23 by the 20-mm survey. The relationship between these indices and actual
24 population sizes is unknown. The abundance of Longfin Smelt in the estuary has
25 fluctuated over time but has exhibited statistically significant step-declines around
26 1989 to 1991 and in 2004 (Thomson et al. 2010). A synthesis of prior studies
27 conducted by USFWS in its 12-Month Finding on a Petition to List the San
28 Francisco Bay-Delta Population of the Longfin Smelt as Endangered or
29 Threatened (USFWS 2012) reported that increased Delta outflow in winter and
30 spring is the largest factor possibly affecting Longfin Smelt abundance. The trend
31 in Longfin Smelt abundance from 1967 through 2013 is presented on Figure 9.2.

1 **Figure 9.2 Fall Midwater Trawl Abundance Indices for Longfin Smelt from 1967 to**
 2 **2013**



3
 4 Source: California Department of Fish and Wildlife, Trends in Abundance of Selected
 5 Species, January 15, 2014. <http://www.dfg.ca.gov/delta/data/fmwt/Indices/>

6 Habitat for Longfin Smelt is open water, largely away from shorelines and
 7 vegetated inshore areas except perhaps during spawning. This includes all of the
 8 large embayments in the estuary and the deeper areas of many of the larger
 9 channels in the western Delta; habitat suitability in these areas for Longfin Smelt
 10 can be strongly influenced by variation in freshwater flow (Jassby et al. 1995,
 11 Bennett and Moyle 1996, Kimmerer 2004, Kimmerer et al. 2009).

12 Water exports and inadvertent entrainment at the SWP and CVP export facilities
 13 are anthropogenic sources of mortality for Longfin Smelt. The export facilities
 14 are known to entrain most species of fish in the Delta (Brown et al. 1996).
 15 Longfin Smelt entrainment mainly occurs from December to May, with peak
 16 adult entrainment from December to February (Grimaldo et al. 2009). In water
 17 year 2011, Aasen (2012) reported four adult Longfin Smelt were salvaged at the
 18 project export facilities, compared with much higher numbers in the early 2000s
 19 and late 1980s. The entrainment of Longfin Smelt in recent years has been
 20 reduced likely because of changes in export operations and a decline in
 21 abundance.

22 *Sacramento Splittail*

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

28 Adult Sacramento Splittail typically migrate upstream from brackish areas in
 29 January and February and spawn in fresh water, particularly on inundated
 30 floodplains when they are available, in March and April (Sommer et al. 1997,

1 Moyle et al. 2004, Sommer et al. 2008). A substantial amount of splittail
2 spawning occurs in the Yolo and Sutter bypasses and the Cosumnes River area of
3 the Delta (Moyle et al. 2004). Spawning also can occur in the San Joaquin River
4 during high-flow events (Sommer et al. 1997, 2008). However, not all adults
5 migrate significant distances to spawn as evidenced by spawning in the Napa and
6 Petaluma rivers (Feyrer et al. 2005).

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

19 *American Shad*

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

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

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

1 American Shad are entrained at the Tracy Fish Collection Facility (Bowen et al.
2 1998) and in the Clifton Court Forebay, mostly during May through December
3 when young American Shad migrate downstream. The American Shad
4 population in the Sacramento-San Joaquin River Basin has declined since the late
5 1970s, most likely because of increased diversion of water from rivers and the
6 Delta, combined with changing ocean conditions, and possibly pesticides
7 (Moyle 2002). Salvage of American Shad at project export facilities in water year
8 2011 represented nearly 659,000 fish (Aasen 2012), with similar but slightly
9 lower salvage in 2010 (545,125 fish) (Aasen 2011).

10 *Striped Bass*

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

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

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

38 The entrainment of Striped Bass has been observed at the project export facilities,
39 including Clifton Court Forebay (Stevens et al. 1985, Bowen et al. 1998,
40 Aasen 2012). In water year 2011, salvage of Striped Bass at export facilities
41 (approximately 550,000 fish) continued a generally low trend observed since the
42 mid-1990s. Prior to 1995, annual Striped Bass salvage was generally above
43 1 million fish (Aasen 2012). DWR et al. (2013) reported that Striped Bass longer
44 than 24 mm were effectively screened at Tracy Fish Collection Facility and

1 bypassed the pumps. However, planktonic eggs, larvae, and juveniles smaller
2 than 24 mm in length received no protection from entrainment.

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

20 *Pacific Lamprey*

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

31 Limited data indicate most adult Pacific Lamprey migrate through the Delta
32 enroute to upstream holding and spawning grounds in the early spring through
33 early summer (Hanni et al. 2006). As documented in other large river systems, it
34 is likely that some adult migration through the Delta occurs from late fall and
35 winter through summer and possibly over an even broader period (Robinson and
36 Bayer 2005, Hanni et al. 2006, Moyle et al. 2009, Clemens et al. 2012, Lampman
37 2011). Data from the FMWT Survey in the lower Sacramento and San Joaquin
38 rivers and Suisun Bay suggest that peak outmigration of Pacific Lamprey through
39 the Delta coincides with high-flow events from fall through spring (Hanni et al.
40 2006). Some outmigration likely occurs year-round, as observed at sites farther
41 upstream (Hanni et al. 2006), and in other river systems (Moyle 2002). Some
42 Pacific Lamprey ammocoetes likely spend part of their extended (5 to 7 years)
43 freshwater residence rearing in the Delta, particularly in the upstream, freshwater
44 portions (DWR et al. 2013).

1 **9.3.4.12.2 Aquatic Habitat**

2 Flow management in the Delta has created stress on aquatic resources by (1)
3 changing aspects of the historical flow regime (timing, magnitude, duration) that
4 supported life history traits of native species; (2) limiting access to or quality of
5 habitat; (3) contributing to conditions better suited to invasive, nonnative species
6 (reduced spring flows, increased summer inflows and exports, and low and less-
7 variable interior Delta salinity [Moyle and Bennett 2008]); and (4) causing
8 reverse flows in channels leading to project export facilities that can entrain fish
9 (Mount et al. 2012). Native species of the Delta are adapted to and depend on
10 variable flow conditions at multiple scales as influenced by the region's dramatic
11 seasonal and interannual climatic variation. In particular, most native fishes
12 evolved reproductive or outmigration timing associated with historical peak flows
13 during spring (Moyle 2002).

14 Water temperatures in the Delta follow a seasonal pattern of winter cold-water
15 conditions and summer warm-water conditions, largely because of the region's
16 Mediterranean climate, with alternating cool-wet and hot-dry seasons. Currently
17 in the Delta, the most significant changes in water temperatures have been in the
18 form of increased summer water temperatures over large areas of the Delta
19 because of high summer ambient air temperatures, the increased temperature of
20 river inflows, and to a lesser extent, reduced quantities of freshwater inflow and
21 modified tidal and groundwater hydraulics (Kimmerer 2004, Mount et al. 2012,
22 NRC 2012, Wagner et al. 2011). Water temperatures in summer now approach or
23 exceed the upper thermal tolerances (e.g., 20 to 25° Centigrade [C]) for
24 cold-water fish species such as salmonids and Delta-dependent species such as
25 Delta Smelt. This is especially true in parts of the south Delta and San Joaquin
26 River, potentially restricting the distribution of these species and precluding
27 previously important rearing areas (NRC 2012).

28 Landscape-scale changes resulting from flood management infrastructure, along
29 with flow modification, have eliminated most of the historical hydrologic
30 connectivity of floodplains and aquatic ecosystems in the Delta and its tributaries,
31 thereby degrading and diminishing Delta habitat for native plant and animal
32 communities (Mount et al. 2012). The large reduction of hydrologic variability
33 and landscape complexity, coupled with degradation of water quality, has
34 supported invasive aquatic species that have further degraded conditions for
35 native species. Due to the combination of these factors, the Delta appears to have
36 undergone an ecological regime shift unfavorable to many native species (Moyle
37 and Bennett 2008, Baxter et al. 2010). The major species influenced by current
38 Delta hydrology include Delta Smelt, Longfin Smelt, Sacramento Splittail, White
39 Sturgeon, juvenile Chinook Salmon, and Striped Bass (Jassby et al. 1995,
40 Kimmerer 2002, Rosenfield and Baxter 2007, Kimmerer et al. 2009, Fish 2010,
41 Perry et al. 2012, Thomson et al. 2010, Feyrer et al. 2011, Loboschefskey et al.
42 2012, Mount et al. 2012).

43 Salinity is a critical factor influencing plant and animal communities in the Delta.
44 Although estuarine fish species are generally tolerant of a range of salinity, this
45 varies by species and lifestage. Some species can be highly sensitive to

1 excessively low or high salinity during physiologically vulnerable periods, such
 2 as reproductive and early life history stages. Although the Delta is tidally
 3 influenced, most of the Delta is fresh water year-round, due to inflows from
 4 rivers. The south Delta can have low salinity because of agricultural return water.
 5 The tidally influenced low salinity zone can move upstream into the central Delta.

6 An important measure of the spatial geography of salinity in the western Delta is
 7 X2. The X2 has also been correlated with the amount of suitable habitat for Delta
 8 Smelt in fall (Feyrer et al. 2007, 2011; USFWS 2008a). It is also helps define the
 9 extent of habitat available for oligohaline pelagic organisms and their prey. An
 10 analysis of historical monitoring data by Feyrer et al. (2007) revealed that the
 11 abiotic habitat of Delta Smelt can be defined as a specific envelope of salinity and
 12 turbidity that changes over the course of the species' life cycle. Project operations
 13 and other potential factors (e.g., lower outflows) have tended to shift the X2
 14 position in fall farther upstream out of the wide expanse of Suisun Bay into the
 15 much narrower channels near the confluence of the Sacramento and San Joaquin
 16 rivers (near Collinsville), reducing the spatial extent of low salinity habitat
 17 important for relevant species such as Delta Smelt (USFWS 2008a, 2011a;
 18 Kimmerer et al. 2009; Baxter et al. 2010).

19 **9.3.4.12.3 Nutrients and Food Web Support**

20 Nutrients are essential components of terrestrial and aquatic environments
 21 because they provide a resource base for primary producers. Typically in
 22 freshwater aquatic environments, phosphorous is the primary limiting
 23 macronutrient, whereas in marine aquatic environments, nitrogen tends to be
 24 limiting. A balanced range of abundant nutrients provides optimal conditions for
 25 maximum primary production, a robust food web, and productive fish
 26 populations. However, changes in nutrient loadings and forms, excessive
 27 amounts of nutrients, and altered nutrient ratios can lead to eutrophication and a
 28 suite of problems in aquatic ecosystems, such as low dissolved oxygen
 29 concentrations, un-ionized ammonia, excessive growth of toxic forms of
 30 cyanobacteria, and changes in components of the food web. Nutrient
 31 concentrations in the Delta have been well studied (Jassby et al. 2002;
 32 Kimmerer 2004; Glibert 2010; Glibert et al. 2011, 2014).

33 Estuaries are commonly characterized as highly productive nursery areas for
 34 numerous aquatic organisms. Nixon (1988) noted that there is a broad continuum
 35 of primary productivity levels in different estuaries, which in turn affects fish
 36 production and abundance. Compared to other estuaries, pelagic primary
 37 productivity in the upper San Francisco Estuary is relatively poor, and a relatively
 38 low fish yield is expected (Wilkerson et al. 2006). In the Delta and Suisun Marsh,
 39 this appears to result from turbidity, clam grazing (Jassby et al. 2002), and
 40 nitrogen and phosphorus dynamics (Wilkerson et al. 2006, Van Nieuwenhuys
 41 2007, Glibert 2010, Glibert et al. 2014).

42 There has been a significant long-term decline in phytoplankton biomass
 43 (chlorophyll a) and primary productivity to low levels in the Suisun Bay region
 44 and the Delta (Jassby et al. 2002). Shifts in nutrient concentrations such as high

1 levels of ammonium and toxic contaminants such as microcystins may contribute
2 to the phytoplankton reduction and to changes in algal species composition in the
3 San Francisco Estuary (Wilkerson et al. 2006; Dugdale et al. 2007; Lehman et al.
4 2005, 2008b, 2010; Glibert 2010; Glibert et al. 2014). Low and declining primary
5 productivity in the estuary may be contributing to the long-term pattern of
6 relatively low and declining biomass of pelagic fishes (Jassby et al. 2002).

7 The introductions of two clams from Asia have led to major alterations in the food
8 web in the Delta. *Potamocorbula* is most abundant in the brackish and saline
9 water of Suisun Bay and the western Delta, and *Corbicula* is most abundant in the
10 fresh water of the central Delta. These filter feeders significantly reduce the
11 phytoplankton and zooplankton concentrations in the water column, reducing
12 food availability for native fishes, such as Delta Smelt and young Chinook
13 Salmon (Feyrer et al. 2007, Kimmerer 2002).

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

25 Studies on food quality have been relatively limited in the San Francisco Estuary,
26 with even less information on long-term trends. Nonetheless, several studies have
27 documented or suggested the food limitations for aquatic species in the estuary,
28 including zooplankton (Mueller-Solger et al. 2002, Kimmerer et al. 2005), Delta
29 Smelt (Bennett 2005, Bennett et al. 2008), Chinook Salmon (Sommer et al.
30 2001a), Sacramento Splittail (Greenfield et al. 2008), Striped Bass
31 (Loboschefskey et al. 2012), and Largemouth Bass (Nobriga 2009).

32 **9.3.4.12.4 Turbidity**

33 Turbidity is an important water quality component in the Delta that affects
34 physical habitat through sedimentation and food web dynamics through
35 attenuation of light in the water column. Light attenuation, in turn, affects the
36 extent of the photic zone where primary production can occur and the ability of
37 predators to locate prey and for prey to escape predation.

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

1 and algal blooms and overall increased eutrophic conditions in some areas
2 (Kimmerer 2004).

3 The first high-flow events of winter create turbid conditions in the Delta, which
4 can be drawn into the south Delta during reverse flow conditions in the Old and
5 Middle rivers. Delta Smelt may follow turbid waters into the southern Delta,
6 increasing their proximity to project export facilities and, therefore, their
7 entrainment risk (USFWS 2008a). USFWS and the Independent Review Panel
8 have expressed concern over the efficacy of the turbidity triggers, even though
9 Delta Smelt do show a preference for turbid waters (IRP 2011).

10 **9.3.4.12.5 Contaminants**

11 Contaminants can change ecosystem functions and productivity through
12 numerous pathways. Changes to nutrient concentrations and ratios in the Delta,
13 and their impacts on the food web and fish, have been summarized by
14 Glibert et al. (2011). The trends in other contaminant loadings and their
15 ecosystem effects are not well understood. Efforts are underway to evaluate
16 direct and indirect toxic effects on the POD fishes of manmade contaminants and
17 natural toxins associated with blooms of *Microcystis aeruginosa*, a
18 cyanobacterium or blue-green alga that releases a potent toxin known as
19 microcystin. Toxic microcystins cause food web impacts at multiple trophic
20 levels, and histopathological studies of fish liver tissue suggest that fish exposed
21 to elevated concentrations of microcystins have developed liver damage and
22 tumors (Lehman et al. 2005, 2008b, 2010.)

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

39 Baxter et al. (2008) prepared a 2007 synthesis of results as part of a POD Progress
40 Report, including a summary of prior studies of contaminants in the Delta. The
41 summary included studies that suggested that phytoplankton growth rates may be
42 inhibited by localized high concentrations of herbicides (Edmunds et al. 1999).
43 Toxicity to invertebrates has been noted in water and sediments from the Delta
44 and associated watersheds (Kuivila and Foe 1995, Weston et al. 2004). The 2004

1 Weston study of sediment toxicity recommended additional study of the effects of
2 the pyrethroid insecticides on benthic organisms. Undiluted drainwater from
3 agricultural drains in the San Joaquin River watershed can be acutely toxic
4 (quickly lethal) to fish (Chinook Salmon and Striped Bass) and have chronic
5 effects on growth, likely because of high concentrations of major ions (e.g.,
6 sodium and sulfates) and trace elements (e.g., chromium, mercury, and selenium)
7 (Saiki et al. 1992).

8 **9.3.4.12.6 Fish Passage and Entrainment**

9 The Delta presents a challenge for anadromous and resident fish during upstream
10 and downstream migration, with its complex network of channels, low eastern
11 and southern tributary inflows, and reverse currents created by pumping for water
12 exports. These complex conditions can lead to straying, extended exposure to
13 predators, and entrainment during outmigration. Tidal elevations, salinity,
14 turbidity, in-flow, meteorological conditions, season, habitat conditions, and
15 project exports all have the potential to influence fish movement, currents, and
16 ultimately the level of entrainment and fish passage success and survival, which is
17 the subject of extensive research and adaptive management efforts (IRP 2010,
18 2011). Michel et al. (2015) used acoustic telemetry to examine survival of late
19 fall-run Chinook Salmon smolts outmigrating from the Sacramento River through
20 the Delta and San Francisco Estuary. Survival was lowest in the freshwater
21 portion (Delta) and the brackish portion of the estuary relative to survival in the
22 riverine portion of the migration route.

23 *North Delta Fish Passage and Entrainment*

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

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

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

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

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

22 The SWP Barker Slough Pumping Plant, located on a tributary to Cache Slough,
23 may cause larval fish entrainment. The intake is equipped with a positive barrier
24 fish screen to prevent fish at least 25 mm in size from being entrained. CDFW
25 has monitored entrainment of larval Delta Smelt less than 20 mm at Barker
26 Slough since 1995. When the presence of Delta Smelt larvae is indicated,
27 pumping rates from Barker Slough are reduced to a 5-day running average rate of
28 65 cfs, not to exceed a 75-cfs daily average for any day, for a minimum of 5 days
29 and until monitoring shows no Delta Smelt are present.

30 *Central and South Delta Fish Passage and Entrainment*

31 The south Delta intake facilities include the CVP and SWP export facilities; local
32 agency intakes, including Contra Costa Water District intakes; and agricultural
33 intakes. Contra Costa Water District intakes and the CVP Contra Costa Canal
34 Pumping Plant include fish screens; however, most of the remaining intakes do
35 not include fish screens. Water flow patterns in the south Delta are influenced by
36 the water diversion actions and operations of the south Delta seasonal temporary
37 barriers and tides and river inflows to the Delta (Kimmerer and Nobriga 2008).
38 Delta diversions can create reverse flows, drawing fish toward project facilities
39 (Arthur et al. 1996, Kimmerer 2008, Grimaldo et al. 2009). While swimming
40 through southern Delta channels, fish can be subjected to stress from poor water
41 quality (seasonally high temperatures, low dissolved oxygen, high water
42 transparency, and *Microcystis* blooms) and slow water velocities in lake-like
43 habitats. Any of these factors can cause elevated mortality rates by weakening or
44 disorienting the fish and increasing their vulnerability to predators (Vogel 2011).
45 Cunningham et al. (2015) found a negative influence of the export/inflow ratio on

1 the survival of fall-run Chinook populations and a negative influence of increased
2 total Delta exports on the survival of spring-run Chinook populations.

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

14 A portion of fish that enter the CVP Jones Pumping Plant approach channel and
15 the SWP Clifton Court Forebay are salvaged at screening and fish salvage
16 facilities, transported downstream by trucks, and released. NMFS (2009a)
17 estimates that the direct loss of fish from the screening and salvage process is in
18 the range of 65 to 83.5 percent for fish from the point they enter Clifton Court
19 Forebay or encounter the trash racks at the CVP facilities. Additionally, mark-
20 recapture experiments indicate that most fish are probably subject to predation
21 prior to reaching the fish salvage facilities (example.g., in Clifton Court Forebay)
22 (Gingras 1997, Castillo et al. 2012). Aquatic organisms (e.g., phytoplankton and
23 zooplankton) that serve as food for fish also are entrained and removed from the
24 Delta (Jassby et al. 2002, Kimmerer et al. 2008, Brown et al. 1996). Fish
25 entrainment and salvage are particular concerns during dry years when the
26 distributions of young Striped Bass, Delta Smelt, Longfin Smelt, and other
27 migratory fish species shift closer to the project facilities (Stevens et al. 1985,
28 Sommer et al. 1997).

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

40 The life stage of the fish at which entrainment occurs may be important for
41 population dynamics (IRP 2011). For example, winter entrainment of Delta
42 Smelt, Longfin Smelt, and Threadfin Shad may correspond to migration and
43 spawning of adult fish, and spring and summer exports may overlap with
44 development of larvae and juveniles. The loss of prespawning adults and all their
45 potential progeny may have greater consequences than entrainment of the same

1 number of larvae or juvenile fish. Entrainment risk for fish tends to increase with
2 increased reverse flows in Old and Middle rivers (Kimmerer 2008, Grimaldo et al.
3 2009).

4 Research conducted during 2010 and 2011 showed that upriver movements of
5 adult Delta Smelt are achieved through a form of tidal rectification or active tidal
6 transport by using lateral movement to shallow edges of channels on ebb tides to
7 maintain their position (IRP 2010, 2011). Turbidity gradients could be involved
8 in the lateral positioning of Delta Smelt within the channels, but large-scale
9 turbidity pulses through the system may not be necessary to trigger upriver
10 migrations of Delta Smelt if they are already occupying sufficiently turbid water
11 (IRP 2011). The new understanding of potential tidal and turbidity effects on
12 Delta Smelt behavior may have important implications for the Delta Smelt
13 monitoring programs that are the basis for biological triggers for RPA Actions
14 1 and 2 by understanding the catch efficiency of mid-water trawl data in relation
15 to the lateral positioning of Delta Smelt within channels.

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

26 **9.3.4.12.7 Disease**

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

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

1 In contrast, histopathological and viral evaluation of juvenile Longfin Smelt and
2 Threadfin Shad collected in 2006 indicated no histological abnormalities and no
3 evidence of viral infections or high parasite loads (Foott et al. 2006). Parasites
4 were noted in Threadfin Shad gills at a high frequency, but the infections were not
5 considered severe. Thus, both Longfin Smelt and Threadfin Shad were
6 considered healthy in 2006 (a high-flow year). Adult Delta Smelt collected from
7 the Delta during winter 2005 also were considered healthy, showing little
8 histopathological evidence for starvation or disease (Reclamation 2008a).
9 However, there was some evidence of low frequency endocrine disruption. In
10 2005, 9 of 144 (6 percent) of adult Delta Smelt males were intersex, having
11 immature oocytes in their testes (Reclamation 2008a).

12 **9.3.4.12.8 Nonnative Invasive Species**

13 Nonnative invasive species influence the Delta ecosystem by increasing
14 competition and predation on native species, reducing habitat quality (as result of
15 invasive aquatic macrophyte growth), and reducing food supplies by altering the
16 aquatic food web. Not all nonnative species are considered invasive or harmful.
17 Some introduced species do not greatly affect the ecosystem, or have minimal
18 ability to spread or increase in abundance. Others have commercial or
19 recreational value (e.g., Striped Bass, American Shad, and Largemouth Bass).

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

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

34 **9.3.4.12.9 Predation**

35 Predation is an important factor that influences the behavior, distribution, and
36 abundance of prey species in aquatic communities to varying degrees. Predation
37 can have differing effects on a population of fish depending on the size or age
38 selectivity, mode of capture, mortality rates, and other factors. Predation is a part
39 of every food web, and native Delta fishes were part of the historical Delta food
40 web. Because of the magnitude of change in the Delta from historical times and
41 the introduction of nonnative predators, it is logical to conclude that predation
42 may have increased in importance as a mortality factor for Delta fishes, with some
43 observers suggesting that it is likely the primary source of mortality for juvenile

1 salmonids in the Delta (Vogel 2011). Predation occurs by fish, birds, and
2 mammals, including sea lions. The alternatives considered in this EIS are not
3 anticipated to modify predatory actions of birds and mammals on the focal
4 species. Therefore, the predation discussion is focused on fish predators.

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

16 Striped Bass, White Catfish, Largemouth Bass and other centrarchids, and
17 silversides are among the introduced, nonnative species that are notable predators
18 of smaller-bodied fish species and juveniles of larger species in the Delta. Along
19 with Largemouth Bass, Striped Bass are believed to be major predators on larger-
20 bodied fish in the Delta. In open-water habitats, Striped Bass are most likely the
21 primary predator of juvenile and adult Delta Smelt (DWR et al. 2013) and can be
22 an important open-water predator on juvenile salmonids (Johnston and Kumagai
23 2012). Native Sacramento Pikeminnow may also prey on juvenile salmonids and
24 other fishes. Limited sampling of smaller pikeminnows did not find evidence of
25 salmonids in the foregut of Sacramento Pikeminnow (Nobriga and Feyrer 2007),
26 but this does not mean that Sacramento Pikeminnow do not prey on salmonids in
27 the Delta.

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

40 Invasive Mississippi silversides are another potentially important predator of
41 larval and pelagic fishes in the Delta. This introduced species was not believed to
42 be an important predator on Delta Smelt, but recent studies using DNA techniques
43 detected the presence of Delta Smelt in the guts of 41 percent of Mississippi
44 silversides sampled in mid-channel trawls (Baerwald et al. 2012). This finding

1 may suggest that predation impacts could be significant, given the increasing
2 numbers of Mississippi silversides in the Delta.

3 Predation of fish in the Delta is known to occur in specific areas, for example at
4 channel junctions and areas that constrict flow or confuse migrating fish and
5 provide cover for predatory fish (Vogel 2011). DFG (1992) identified subadult
6 Striped Bass as the major predatory fish in Clifton Court Forebay. In 1993, for
7 example, Striped Bass made up 96 percent of the predators removed (Vogel
8 2011). Cavallo et al. (2012) studied tagged salmon smolts to test the effects of
9 predator removal on outmigrating juvenile Chinook Salmon in the south Delta.
10 Their results suggested that predator abundance and migration rates strongly
11 influenced survival of salmon smolts. Exposure time to predators has been found
12 to be important for influencing survival of outmigrating salmon in other studies in
13 the Delta (Perry et al. 2012).

14 **9.3.4.12.10 Aquatic Macrophytes**

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

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

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

1 **9.3.4.13 Yolo Bypass**

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

5 The Yolo Bypass provides habitat for a wide variety of fish and aquatic species,
6 including temporary migration corridors and juvenile rearing habitat for
7 anadromous salmonids and other native and anadromous fishes. Species captured
8 as adults and subsequently collected as YOY suggest that the Yolo Bypass
9 provides spawning habitat for these species, including splittail, American Shad,
10 Striped Bass, Threadfin Shad, Largemouth Bass and carp (Harrell and Sommer
11 2003, Sommer et al. 2014). The Yolo Bypass lacks suitable gravel substrate that
12 would support salmon spawning.

13 **9.3.4.13.1 Aquatic Habitat**

14 Aquatic habitats in the Yolo Basin include stream and slough channels for fish
15 migration, and when flooded, seasonal spawning habitat and productive rearing
16 habitat (Sommer et al. 2001a; CALFED 2000a, 2000b). During years when the
17 Yolo Bypass is flooded, it serves as an important migratory route for juvenile
18 Chinook Salmon and other native migratory and anadromous fishes moving
19 downstream. During these times, it provides juvenile anadromous salmonids an
20 alternative migration corridor to the lower Sacramento River (Sommer et al.
21 2003) and, sometimes, better rearing conditions than the adjacent Sacramento
22 River channel (Sommer et al. 2001a, 2005). When the floodplain is activated,
23 juvenile salmon can rear for weeks to months in the Yolo Bypass floodplain
24 before migrating to the estuary (Sommer et al. 2001a). Research on the Yolo
25 Bypass has found that juvenile salmon grow substantially faster in the Yolo
26 Bypass floodplain than in the adjacent Sacramento River, primarily because of
27 greater availability of invertebrate prey in the floodplain (Sommer et al. 2001a,
28 2005). When not flooded, the lower Yolo Bypass provides tidal habitat for young
29 fish that enter from the lower Sacramento River via Cache Slough Complex
30 (McLain and Castillo; DWR, unpublished data).

31 Sommer et al. (1997) demonstrated that the Yolo Bypass is one of the single most
32 important habitats for Sacramento Splittail. Because the Yolo Bypass is dry
33 during summer and fall, nonnative species (e.g., predatory fishes) generally are
34 not present year-round except in perennial water sources (Sommer et al. 2003). In
35 addition to providing important fish habitat, seasonal inundation of the Yolo
36 Bypass supplies phytoplankton and detritus that may benefit aquatic organisms
37 downstream in the brackish portion of the San Francisco Estuary (Sommer et al.
38 2004, Lehman et al. 2008a).

39 **9.3.4.13.2 Fish Passage**

40 The Fremont Weir is a major impediment to fish passage and a source of
41 migratory delay and loss of adult Chinook Salmon, steelhead, and sturgeon
42 (NMFS 2009a, Sommer et al. 2014). The Fremont Weir creates a migration
43 barrier for a variety of species, although fish with strong jumping capabilities

1 such as salmonids may be able to pass the weir at higher flows. Although there is
2 a fish ladder maintained by CDFW at the center of the weir, the ladder is small,
3 outdated, and inefficient. Additionally, there are no facilities at the weir to pass
4 upstream migrants at lower flows. Some adult winter-run, spring-run, and fall-run
5 Chinook Salmon and White Sturgeon migrate into Yolo Bypass when there is no
6 flow into the floodplain via the Fremont Weir. Therefore, these fish are often
7 unable to reach upstream spawning habitat in the Sacramento River and its
8 tributaries (Harrell and Sommer 2003, Sommer et al. 2014). Other structures in
9 the Yolo Bypass, such as the Toe Drain, Lisbon Weir, and irrigation dams in the
10 northern end of the Tule Canal, also may impede upstream passage of adult
11 anadromous fish (NMFS 2009a).

12 Fish are also attracted into the bypass during periods when water is not flowing
13 over the Fremont Weir. Fyke trap monitoring by DWR has shown that adult
14 salmon and steelhead migrate up the Toe Drain in autumn and winter regardless
15 of whether the Fremont Weir spills (Harrell and Sommer 2003, Sommer et al.
16 2014). The Toe Drain does not extend to the Fremont Weir because the channel
17 is blocked by roads or other higher ground at several locations. Sturgeon and
18 salmonids attracted by high flows into the basin become concentrated behind the
19 Fremont Weir, where they are subject to heavy legal and illegal fishing pressure.

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

24 **9.3.4.14 Suisun Marsh**

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

31 **9.3.4.14.1 Aquatic Habitat**

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

1 interactions, and generally the highest biomass productivity in the entire estuary
2 (Siegel et al. 2010).

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

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

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

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

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

1 **9.3.4.14.2 Fish Entrainment**

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

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

20 **9.3.4.15 San Joaquin River from Confluence of the Stanislaus River to the**
21 **Delta**

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

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

35 The San Joaquin River from the Stanislaus River to the Delta is dominated by
36 nonnative species such as Largemouth Bass, Inland Silverside, carp, and several
37 species of sunfish and catfish (Moyle 2002). Anadromous species include fall-run
38 Chinook Salmon, steelhead, Striped Bass, American Shad, White Sturgeon, and
39 several species of lamprey (Reclamation et al. 2003). The fall-run Chinook
40 Salmon population is supported in part by hatchery stock in the Merced River.
41 Spawning by anadromous salmonids in the San Joaquin River Basin occurs only
42 in the tributaries to the San Joaquin River, including the Merced, Tuolumne, and
43 Stanislaus rivers (Brown and Moyle 1993). Spring-run Chinook Salmon no
44 longer exist in the San Joaquin River, but are targeted for restoration in this

1 system under Reclamation's San Joaquin River Restoration Program. In early
 2 2015, the program experimentally released juvenile spring-run Chinook Salmon
 3 into the San Joaquin River near the Merced River. Surviving adults may return to
 4 the San Joaquin River as early as spring 2017. Because of the uncertainty of
 5 future restoration success and the current lack of natural presence in the San
 6 Joaquin River, spring-run Chinook Salmon is not included in the analysis of San
 7 Joaquin River fish.

8 **9.3.4.15.1 Fish in the San Joaquin River**

9 The analysis is focused on the following species:

- 10 • Fall-run Chinook Salmon
- 11 • Steelhead
- 12 • White Sturgeon
- 13 • Sacramento Splittail
- 14 • Pacific Lamprey
- 15 • Striped Bass
- 16 • American Shad

17 *Fall-run Chinook Salmon*

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

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

36 *Steelhead*

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

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

5 Presence of steelhead smolts from the San Joaquin River Basin is estimated
6 annually by CDFW based on the Mossdale Trawl (SJRGGA 2011). The sampling
7 trawls capture steelhead smolts, although usually in small numbers. One
8 steelhead smolt was captured and returned to the river during the 2009 sampling
9 period (SJRGGA 2010), and three steelhead were captured and returned in both
10 2010 and 2011 (Speegle et al. 2013).

11 *Sacramento Splittail*

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

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

29 *Pacific Lamprey*

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

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

40 Little information is available on factors influencing Pacific Lamprey in the San
41 Joaquin River, but they are likely adversely affected by many of the same factors
42 as salmon and steelhead because of parallels in their life cycles. Lack of access to
43 historical spawning habitats because of the mainstem dams and other migration

1 barriers, modification of spawning and rearing habitats, altered hydrology,
2 entrainment by water diversions, and predation by nonnative invasive species
3 such as Striped Bass all likely influence Pacific Lamprey in the San Joaquin River
4 and tributaries.

5 *Striped Bass*

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

11 *American Shad*

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

16 *Sturgeon*

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

24 CDFW fisheries catch information for the San Joaquin River obtained from
25 fishery report cards (DFG 2008, 2009b, 2010, 2011, 2012b; CDFW 2013, 2014)
26 documented that anglers upstream of Highway 140 caught between 8 and
27 25 mature White Sturgeon annually between 2007 and 2013. Below Highway
28 140 downstream to Stockton, anglers caught between 2 and 35 mature White
29 Sturgeon annually over the same time period; most of the White Sturgeon caught
30 were released.

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

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

1 **9.3.4.15.2 Aquatic Habitat**

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

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

14 **9.3.4.15.3 Fish Passage**

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

21 **9.3.4.15.4 Hatcheries**

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

29 **9.3.4.15.5 Predation**

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

35 **9.3.4.16 New Melones Reservoir, Tulloch Reservoir, and Goodwin Lake**

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

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

14 Tulloch Reservoir is operated as an afterbay for the New Melones Reservoir and
 15 is subject to fluctuating water levels that occur on a daily and seasonal basis.
 16 Tulloch Reservoir stratifies weakly during summer and contains a reserve of
 17 relatively cold, well-oxygenated water that is released downstream. Tulloch
 18 Reservoir supports both warm and cold freshwater habitat. Goodwin Power
 19 (2013) reported that DFG captured 15 species in Tulloch Reservoir from
 20 1969 through 1998. Five dominant species made up almost 80 percent of the
 21 catch; White Catfish (31 percent of the total), Bluegill (20 percent), Sacramento
 22 Sucker (11 percent), Smallmouth Bass (10 percent), and Black Crappie
 23 (7 percent). Of these, only the Sacramento Sucker is native. Other native species
 24 in the catch were Sacramento Hitch, Hardhead, Sacramento Pikeminnow, and
 25 Rainbow Trout (now stocked). Other nonnative fish found in Tulloch reservoir
 26 include Largemouth Bass and Threadfin Shad (DFG 2002b).

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

29 **9.3.4.17 Stanislaus River from Goodwin Dam to the San Joaquin River**

30 **9.3.4.17.1 Fish in the Stanislaus River**

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

- 35 • Fall-run Chinook Salmon
- 36 • Steelhead
- 37 • Pacific Lamprey
- 38 • Striped Bass
- 39 • American Shad

40 *Fall-run Chinook Salmon*

41 Historically, spring-run Chinook Salmon were believed to be the primary salmon
 42 run in the Stanislaus River, but the fall-run Chinook Salmon population became

1 dominant following construction of Goodwin Dam. Spring-run Chinook Salmon
2 have since been extirpated from the river. Data collected by private fishery
3 consultants, nonprofit organizations, and DFG demonstrate the majority of adults
4 migrate upstream from late September through December with peak migration
5 from late October through early November. Most Chinook Salmon spawning
6 occurs between Riverbank (River Mile 33) and Goodwin Dam (River Mile 58.4)
7 (Reclamation 2012b). For Stanislaus River salmon, spawning generally occurs
8 between October and December based on spawning surveys; however, there is
9 evidence that indicates that spawning activity may occur as early as September or
10 as late as January (Reclamation 2012).

11 Rotary screw trap data indicate that about 99 percent of salmon juveniles migrate
12 out of the Stanislaus River from January through May (SRFG 2004). Fry
13 migration generally occurs from January through March, followed by smolt
14 migration from April through May (Reclamation 2012). Watry et al. (2012)
15 found that in both 2010 and 2011, peak passage during the pre-smolt period
16 generally corresponded with flow pulses. Zeug et al. (2014) examined 14 years of
17 rotary screw trap data on the lower Stanislaus River and found a strong positive
18 response in survival, the proportion of pre-smolt migrants and the size of smolts
19 when cumulative flow and flow variance were greater and concluded that the data
20 suggested that periods of high discharge in combination with high discharge
21 variance are important for successful emigration as well as migrant size and the
22 maintenance of diverse migration strategies.

23 Mesick (2001) surmised that when water exports are high relative to San Joaquin
24 River flows, little, if any, San Joaquin River water reaches San Francisco Bay
25 where it may be needed to help attract the salmon back to the Stanislaus River.
26 During mid-October from 1987 through 1989, when export rates exceeded
27 400 percent of Vernalis flows, Mesick (2001) found that straying rates ranged
28 between 11 and 17 percent. In contrast, straying rates were estimated to be less
29 than 3 percent when Delta export rates were less than about 300 percent of San
30 Joaquin River flow at Vernalis during mid-October.

31 One of the most prominent limiting factors appears to be the high rates of
32 mortality for juveniles migrating through dredged channels in the Stanislaus River
33 and Delta, particularly the Stockton Deep Water Ship Channel (Pickard et al.
34 1982). Pickard et al. (1982) reported that the survival of juvenile fish in the deep-
35 water ship channel is highest during flood flows or when a barrier is placed at the
36 head of the Old River that more than doubles the flow in the ship channel. The
37 Stanislaus River Fish Group (SRFG) (2004) noted that escapement is also directly
38 correlated with springtime flows when each brood migrates downstream as
39 smolts. However, the cause of the mortality in the ship channel has not been
40 studied. It is possible that mortality results from the combined effects of warm
41 water temperatures, low dissolved oxygen concentrations, ammonia toxicity, and
42 predation.

43 As discussed earlier, dredging for gravel and gold, regulated flows, and the diking
44 of floodplains for agriculture have substantially limited the availability of
45 spawning and rearing habitat for fall-run Chinook Salmon. Reclamation has

1 conducted spawning gravel augmentation to improve spawning and rearing
2 habitats in the reach between Goodwin Dam and Knights Ferry most years since
3 1999. The dredged areas also contain an abundance of large predatory fish,
4 although the SRFG concluded that there is uncertainty about whether predation is
5 a substantial source of mortality for juvenile salmon.

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

11 *Steelhead*

12 Steelhead were thought to be extirpated from the San Joaquin River system
13 (NMFS 2009a). However, monitoring has detected small self-sustaining (i.e.,
14 non-hatchery origin) populations of steelhead in the Stanislaus River and other
15 streams previously thought to be devoid of steelhead (SRFG 2003, McEwan
16 2001). There is a catch-and-release steelhead fishery in the lower Stanislaus
17 River between January 1 and October 15.

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

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

38 Juvenile steelhead rear in the Stanislaus River for at least 1 year, and usually
39 2 years, before migrating to the ocean. As a result, flow, water temperature, and
40 dissolved oxygen concentration in the reach between Goodwin Dam and the
41 Orange Blossom Bridge (their primary rearing habitat) are critical during summer
42 (Reclamation 2012).

43 Small numbers of steelhead smolts have been captured in rotary screw traps at
44 Caswell State Park and near Oakdale (FISHBIO 2007; Watry et al. 2007, 2012),

1 and data indicate that steelhead outmigrate primarily from February through May.
2 Rotary screw traps are generally not considered efficient at catching fish as large
3 as steelhead smolts, and the number captured is too small to estimate capture
4 efficiency, so no steelhead smolt outmigration population estimate has been
5 calculated. The capture of these fish in downstream migrant traps and the
6 advanced smolting characteristics exhibited by many of the fish indicate that
7 some steelhead/rainbow juveniles might migrate to the ocean in spring. However,
8 it is not known whether the parents of these fish were anadromous or fluvial (they
9 migrate within fresh water). Resident populations of steelhead/rainbow in large
10 streams are typically fluvial, and migratory juveniles look much like smolts.

11 *Pacific Lamprey*

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

21 Ocean stage adults likely migrate into the Stanislaus River in spring and early
22 summer, where they hold for approximately 1 year before spawning (Hanni et al.
23 2006). Hannon and Deason (2008) have documented Pacific Lampreys spawning
24 in the American River from between early January and late May, with peak
25 spawning typically in early April. Spawning time is presumably similar in the
26 Stanislaus River. Pacific Lamprey ammocoetes are expected to rear in the
27 Stanislaus River for all or part of their 5- to 7-year freshwater residence. Data
28 from rotary screw trapping in the nearby Mokelumne and Tuolumne rivers
29 suggest that outmigration of Pacific Lamprey generally occurs from early winter
30 through early summer (Hanni et al. 2006). Catches of juvenile Pacific Lampreys
31 in trawl surveys of the mainstem San Joaquin River, near the mouth of the
32 Stanislaus River at Mossdale, occurred during winter and spring. Some
33 outmigration likely occurs year-round, as observed at sites on the mainstem
34 Sacramento River (Hanni et al. 2006). Significant numbers of lampreys of
35 unknown species and unspecified life stage have been captured during rotary
36 screw trapping on the Stanislaus River at Oakdale (FISHBIO 2007) and Caswell
37 (Watry et al. 2007).

38 *Striped Bass*

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

1 *American Shad*

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

7 **9.3.4.17.2 Aquatic Habitat**

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

18 With respect to the related need for geomorphic flows, Kondolf et al. (2001)
19 estimated bedload mobilization flows in the Stanislaus River to be around
20 5,000 to 8,000 cfs to mobilize the median particle size of the channel bed
21 material. Flows necessary to mobilize the bed material increased downstream
22 from a minimal 280 cfs where gravel had been recently added near Goodwin Dam
23 to about 5,800 cfs at Oakdale Recreation Area (Reclamation 2008a). Before
24 construction of New Melones Dam, a bed-mobilizing flow of 5,000 to 8,000 cfs
25 was equivalent to a 1.5- to 1.8-year return interval flow. Following construction
26 of the dam, 5,000 cfs represents approximately a 5-year return interval flow, and
27 8,000 cfs exceeds all flows within the 21-year study period, 1979 to 1999
28 (maximum flow = 7,350 cfs on January 3, 1997). The probability of occurrence
29 for a daily average flow exceeding 5,330 cfs (the pre-dam bankfull discharge) is
30 0.01 per year.

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

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

1 *Spawning and Rearing Habitat*

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

10 Extensive instream gravel mining removed large quantities of spawning habitat
11 (Kondolf et al. 2001). Gravel mining also has resulted in instream mine pits that
12 occur in the primary salmonid spawning areas, including a large, approximately
13 1-mile-long pit called the Oakdale Recreation Pond. Instream mine pits trap
14 bedload sediment, store large volumes of sand and silt, and pass sediment-starved
15 water downstream, where it typically erodes the channel bed and banks to regain
16 its sediment load (Kondolf et al. 2001). Reclamation restores and replenishes
17 spawning gravel and rearing habitat lost from the construction and operation of
18 dams in the Stanislaus River to restore adversely affected spawning habitat and
19 remediate sediment related loss of geomorphic function, such as channel incision.

20 *Floodplain Habitat*

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

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

33 In 2011, a habitat restoration project to increase spawning habitat also restored
34 640 feet of remnant side channel habitat, allowing water to flow at the current
35 1.5-year return interval (575 cfs), in addition to three cross channels designed to
36 inundate at higher flows (SOG 2011).

37 **9.3.4.17.3 Fish Passage and Entrainment**

38 Constructed in 1913, Goodwin Dam was probably the first permanent barrier to
39 significantly affect anadromous fish access to upstream habitat in the Stanislaus
40 River. Goodwin Dam had a fishway, but Chinook Salmon could seldom pass it,
41 and other salmonids may have been similarly affected. Yoshiyama et al. (1996)
42 estimated that historically Chinook Salmon and other salmonids had access to
43 113 miles of habitat, compared with 58 miles under current conditions.

1 There are numerous small, unscreened diversions on the lower Stanislaus River
2 (Herren and Kawasaki 2001). The effects of these diversions on fish is not clear;
3 however, in tracking the fate of 49 radio tagged fish, S.P. Cramer and Associates
4 (1998) did not detect any entrainment at several moderately sized unscreened
5 pumps in the lower Stanislaus River.

6 **9.3.4.17.4 Predation**

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

19 It is possible that predation is high for juveniles rearing in the deep-water ship
20 channel in the Delta as observed by Pickard et al. (1982). Predation rates on
21 hatchery-reared juveniles and tagged juveniles may be higher than those for
22 naturally produced fish. NMFS (2009a) made reference (without citation) to
23 predation studies on the Tuolumne River that have shown losses of up to
24 60 percent of outmigrating salmon smolts in run-of-river gravel mining ponds and
25 dredged areas. NMFS (2009a) also noted that losses on the Stanislaus River have
26 not been similarly quantified, but predation on fall-run Chinook Salmon smolts
27 and steelhead by Striped Bass and Largemouth Bass has been documented.
28 NFMS concluded that these run-of-river ponds also reduce flow velocities as
29 compared to incoming river channels, requiring outmigrating salmonids to expend
30 more energy to traverse these sections. Operational releases provide flows lower
31 than typical unimpaired flows, which NMFS indicated these conditions
32 exacerbates the effect of this stressor on outmigrating juveniles and degrades the
33 habitat value of necessary freshwater migratory corridors.

34 **9.3.4.18 San Luis Reservoir**

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

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

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

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

9 **9.3.5 San Francisco Bay Area Region**

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

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

23 **9.3.5.1 Pacific Ocean Habitat of the Killer Whale**

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

29 Southern Resident killer whales are found primarily in the coastal waters offshore
30 of British Columbia and Washington and Oregon in summer and fall (NMFS
31 2008). During winter, killer whales are sometimes found off the coast of central
32 California and more frequently off the Washington coast (Independent
33 Hilborn et al. 2012).

34 The 2005 NMFS endangerment listing (70 FR 69903) for the Southern Resident
35 killer whale distinct population segment lists several factors that may be limiting
36 the recovery of killer whales, including the quantity and quality of prey,
37 accumulation of toxic contaminants, and sound and vessel disturbance. In the
38 Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*), NMFS
39 (2008) posits that reduced prey availability forces whales to spend more time
40 foraging, which may lead to reduced reproductive rates and higher mortality rates.
41 Reduced food availability may lead to mobilization of fat stores, which can
42 release stored contaminants and adversely affect reproduction or immune function
43 (NMFS 2008).

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

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

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

1 **Table 9.2 Total Production (Number of Individuals) of Central Valley Fall-run**
 2 **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

3 Source: DOI 2012

4 **9.3.5.2 Contra Loma Reservoir**

5 The Contra Loma Reservoir is a CVP facility in Contra Costa County that
 6 provides offstream storage along the Contra Costa Canal. The 80-acre reservoir is
 7 part of 661-acre Contra Loma Regional Park and Antioch Community Park
 8 (Reclamation 2014b). There are currently 20 known fish species, including
 9 8 species of game fish, in Contra Loma Reservoir. The East Bay Parks and
 10 Recreation District (EBRPD) and CDFW stock Rainbow Trout and Channel
 11 Catfish in the reservoir. The reservoir also supports self-sustaining populations of
 12 Largemouth Bass, crappie, Redear Sunfish, and Bluegill, which are also popular
 13 with anglers (Reclamation 2014b). Other species found include White Catfish,
 14 Threadfin Shad, Bigscale Logperch, Common Carp, Sacramento Blackfish,
 15 Warmouth, Green Sunfish, Goldfish, Prickly Sculpin, and Inland Silversides
 16 (Reclamation 2014b).

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

8 **9.3.5.3 San Justo Reservoir**

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

14 **9.3.5.4 South Bay Aqueduct Reservoirs**

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

23 **9.3.5.5 Los Vaqueros Reservoir**

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

32 **9.3.5.6 East Bay Municipal Utility District Reservoirs**

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

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

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

9 **9.3.6 Central Coast Region**

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

13 **9.3.6.1 Cachuma Lake**

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

25 **9.3.7 Southern California Region**

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

36 **9.3.7.1 State Water Project Reservoirs**

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

40 Although small compared to nearby Pyramid and Castaic lakes, Quail Lake's
41 290 acres and 3 miles of shoreline offer shoreline fishing. Striped Bass, Channel

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

3 Pyramid Lake is located in the Angeles and Los Padres National Forests, about
4 60 miles northwest of downtown Los Angeles. Largemouth Bass, Smallmouth
5 Bass, and Striped Bass as well as Bluegill, crappie, Brown Bullhead, Channel
6 Catfish, and trout are caught by anglers in Pyramid Lake (OEHHA 2013a).
7 Rainbow Trout, Bluegill, Green Sunfish, Largemouth Bass, catfish, and Prickly
8 Sculpin are found in Piru Creek below the dam (DWR 2004d).

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

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

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

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

30 **9.3.7.2 Non-SWP Reservoirs in Riverside County**

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

39 **9.3.7.3 Non-SWP Reservoir in Ventura County**

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

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

3 **9.3.7.4 Non-SWP Reservoirs in San Diego County**

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

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

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

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

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

27 **9.3.7.5 Non-SWP Reservoir in San Bernardino County**

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

34 **9.4 Impact Analysis**

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

37 **9.4.1 Potential Mechanisms and Analytical Methods**

38 The impact analysis considers changes in the ecological attributes that affect fish
39 and aquatic resources related to changes in CVP and SWP operations under the

1 alternatives as compared to the No Action Alternative and the Second Basis of
2 Comparison.

3 **9.4.1.1 CVP and SWP Reservoirs**

4 Changes in CVP and SWP operations under the alternatives could result in
5 changes in reservoir storage volumes, elevations, and water temperatures in the
6 primary water supply reservoirs (i.e., Trinity Lake, Shasta Lake, Lake Oroville,
7 Folsom Lake, New Melones Lake, and San Luis Reservoir). Variation in
8 reservoir storage, elevation, and temperature is a function of water demand, water
9 quality requirements, and inflow; these attributes also change based on the water-
10 year type.

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

17 **9.4.1.1.1 Changes in CVP and SWP Reservoir Storage Volume**

18 To evaluate changes in operation, changes in reservoir storage and elevation were
19 estimated based upon modeled monthly average storage and reservoir elevation
20 output from CalSim II for the entire 82-year period under the operations defined
21 for each alternative, as described in Appendix 5A, CalSim II and DSM2
22 Modeling. The output of CalSim II served as input to the quantitative procedures
23 described below for evaluation of changes in fish habitat and bass nesting success
24 in CVP and SWP reservoirs.

25 The effects analysis in Chapter 5, Surface Water Resources and Water Supplies,
26 includes a summary of the monthly storage in each major upstream reservoir in
27 combination with a frequency of exceedance analysis for each month. Reservoir
28 storage values are characterized based on results of CalSim II hydrologic
29 modeling and presented as average monthly storage by water year type. Although
30 aquatic habitat within the CVP and SWP water supply reservoirs is not thought to
31 be limiting, storage volume is used as an indicator of how much habitat is
32 available to fish species inhabiting these reservoirs.

33 **9.4.1.1.2 Changes in CVP and SWP Reservoir Elevation**

34 Seasonal temperature stratification is a dominant feature of these reservoirs.
35 There are relatively distinct fish assemblages within the upper (warm water) and
36 lower (cold water) habitat zones, with different feeding and reproductive
37 behaviors. Flood control, water storage, and water delivery operations typically
38 result in declining water elevations during the summer through the fall months,
39 rising or stable elevations during the winter months, and rising elevations during
40 the spring months, while storing precipitation and snowmelt runoff. During
41 summer months, the relatively warm surface layer favors warm water fishes such
42 as bass and catfish. Deeper layers are cooler and are suitable for cold water
43 species. Drawdown of reservoir storage from June through October can diminish

1 the volume of cold water, thereby reducing the amount of habitat for cold water
2 fish species within these reservoirs during these months.

3 Reservoir storage and surface water elevations in the reservoirs from the CalSim
4 II model were used to analyze potential effects on reservoir fishes. Water surface
5 elevation in each reservoir was calculated from storage values and is presented as
6 average end-of-month elevation by water year type.

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

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

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

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

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

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

30 Based on the work by Lee (1999), the maximum receding water level rate
31 providing 100 percent successful nesting varied among species, with receding
32 water level rates of <0.02, <0.01, and <0.065 meters per day providing successful
33 nesting of 100 percent of the Largemouth, Smallmouth, and Spotted bass nests,
34 respectively. For this analysis, water surface elevations at the end of each month
35 from the CalSim II model were used to calculate the monthly fluctuation rates,
36 and derive the daily fluctuation rates used to compute the percentage of successful
37 nests using the equations from Lee (1999).

38 CalSim II reports end-of-month (EOM) water surface elevations; therefore, water
39 surface elevations from February to June were used in this analysis (i.e., March
40 fluctuation rate = March EOM elevation – February EOM elevation). It was
41 further assumed that the monthly change in elevation divided by the number of
42 days in that month reflected the average daily fluctuation rate that was used as
43 “X” in the above equations to compute the percentage of successful nests during

1 that month. The percentages of successful bass nests were computed based on the
2 equations from Lee (1999) for each month of the potential spawning season for
3 these species.

4 Review of the available literature suggests that bass nest failure is highly variable
5 between water bodies and between years but it is not uncommon to have up to
6 40 percent of bass nests fail (approximately 60 percent survival) (Scott and
7 Crossman 1973). Many self-sustaining black bass populations in North America
8 experience a nest success (i.e., the nest produces swim-up fry) rate of 21 to
9 96 percent, with many reporting survival rates in the 40 to 60 percent range
10 (Forbes 1981; Hunt and Annett 2002; Steinhart 2004). This would suggest that
11 much less than 100 percent survival is required to have a self-sustaining
12 population. Based on the literature review, bass nest survival probability in
13 excess of 40 percent is assumed to be sufficient to provide for a self-sustaining
14 bass fishery. For this analysis, differences between alternatives were evaluated
15 using the exceedance probability corresponding to the 40 percent level of survival
16 based on the probability of exceedance over the 82-year CalSim II modeling time
17 period.

18 **9.4.1.2 Rivers**

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

23 **9.4.1.2.1 Changes in Flows**

24 Changes in flows, in and of themselves, do not constitute an effect on aquatic
25 resources. However, changes in flow can affect the quantity and quality of
26 aquatic habitats in rivers and have direct effects on fish species through stranding
27 or dewatering events that occur when flows are reduced. In addition, changes in
28 flows can result in a reduction in ecologically important geomorphic processes
29 resulting from reduced frequency and magnitude of intermediate to high flows.

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

39 The effects analysis in Chapter 5, Surface Water Resources and Water Supplies,
40 includes a summary of the monthly flows at various points downstream of the
41 reservoirs in each major stream affected by project operations. Instream flows are
42 characterized based on results of CalSim II hydrologic modeling and presented as
43 both average monthly flows by month and water year type and monthly frequency

1 of exceedance plots to allow examination of the entire range of simulation results
2 for each of the alternatives as a means of evaluating differences among
3 alternatives. Differences in monthly average flows of greater than 5 percent
4 between alternatives are considered biologically meaningful and may affect fish
5 and aquatic resources.

6 To compare the operational flow regime and evaluate the potential effects on
7 habitat for anadromous species inhabiting streams, it was necessary to determine
8 the relationships between streamflow and habitat availability for each life stage of
9 these species in the rivers in which flows may be altered by CVP and SWP
10 operations.

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

25 WUA-flow relationships were available only for some rivers for which simulated
26 flows were available. Therefore, flow dependent habitat availability was
27 evaluated quantitatively only for Clear Creek and the Sacramento, Feather, and
28 American rivers, and was not reported for other rivers evaluated in this Draft EIS.
29 Tables of the spawning habitat-discharge relationships used in the calculations of
30 spawning WUA for these rivers are provided in Appendix 9E, Weighted Useable
31 Area Analysis. Because the WUA-flow relationships developed by the most
32 recent IFIM studies present WUA values within particular flow ranges at
33 particular variable steps, it was often the case that the monthly flow for a
34 particular reach fell between two flows for which there were WUA values. In
35 these cases, the value was determined by linear interpolation between the
36 available WUA values for the flows immediately below and above the target
37 flow. When the target flow was lower than the lowermost flow for which a WUA
38 value exists, the corresponding WUA value was determined by linear
39 interpolation between a flow of zero and the lowermost flow for which a WUA
40 value exists. When the target flow was higher than the highest flow for which a
41 WUA value exists, the corresponding WUA value was determined by assuming
42 the WUA value for the highest flow.

43 WUA values are calculated and presented only on a monthly time-step, and not as
44 seasonal or annual values. WUA values based on the monthly CalSim II flows
45 were prepared for detailed evaluation of the alternatives. Monthly WUA values

1 are presented as the average total WUA in each river segment, for the entire
2 82-year simulation period and the average total WUA in each of five water year
3 types for each alternative. Differences between the alternatives and the two bases
4 of comparison (No Action Alternative and Second Basis of Comparison) are used
5 to identify the effects of each alternative on habitat availability (WUA) for each
6 species and life stage in each river. These comparisons were made only for the
7 months in which the species and life stage are anticipated to be present in each
8 river/reach based on the life history timing presented in Appendix 9B.

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

20 **9.4.1.2.2 Changes in Water Temperatures**

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

32 The analysis of the effects of water temperature changes on fish was conducted
33 using two approaches: 1) a comparison of average monthly water temperatures
34 between the alternatives and the two bases of comparison (No Action Alternative
35 and Second Basis), and 2) a comparison of average monthly water temperatures to
36 established temperature objectives intended to be protective of fish. In addition,
37 Reclamation's salmon mortality model was applied in certain water bodies to
38 examine the effects of temperature on salmon spawning and incubation. These
39 approaches are described below.

40 *Comparison of Average Monthly Water Temperatures between Alternatives*

41 The effects analysis in Chapter 6, Surface Water Quality, includes a summary of
42 the average monthly water temperature in each major stream downstream of CVP
43 and SWP reservoirs in combination with a frequency of temperature exceedance
44 analysis (see below) for each month. Water temperatures at various locations in

1 each river were compared to determine whether mean monthly temperatures by
 2 water-year type were different between the alternatives and the two bases of
 3 comparison (No Action Alternative and Second Basis). Differences in monthly
 4 average temperatures of greater than 0.5°F between alternatives are considered
 5 biologically meaningful and may affect fish and aquatic resources.

6 *Comparison to Established Water Temperature Thresholds*

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

15 **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

1 *Changes in Egg Mortality*

2 Water temperatures also affect the survival of various life stages of the focal
3 species. Reclamation's salmon mortality model (Appendix 9C, Reclamation
4 Salmon Mortality Model Analysis Documentation) was used to estimate water
5 temperature induced mortality in the early life stages (pre-spawned eggs,
6 fertilized eggs, and pre-emergent fry) of salmonids in five rivers: Trinity,
7 Sacramento, Feather, American, and Stanislaus, based on output from the
8 temperature models. The salmon mortality model is limited to temperature effects
9 on early life stages of Chinook Salmon. It does not evaluate potential direct or
10 indirect temperature impacts on later life stages, such as emergent fry, smolts,
11 juvenile out-migrants, or adults. Also, it does not consider other factors that may
12 affect salmon mortality, such as in-stream flows, gravel sedimentation, diversion
13 structures, predation, and ocean harvest. Differences between alternatives are
14 assessed based on changes in the percent egg mortality by river over the entire
15 82-year CalSim II simulation period and by water year type (based on 40-30-30
16 indexing). Differences in the percentage of egg mortality of greater than 1
17 percent between alternatives are considered biologically meaningful and may
18 have an effect on fish populations.

19 **9.4.1.3 Delta**

20 Changes in CVP and SWP operations under the alternatives would affect Delta
21 conditions primarily through changes in volume and timing of upstream storage
22 releases and diversions, Delta exports and diversions, and DCC operations.
23 Environmental conditions such as water temperature, predation, food production
24 and availability, competition with introduced exotic fish and invertebrate species,
25 and pollutant concentrations all contribute to interactive, cumulative conditions
26 that have substantial effects on aquatic resources in the Delta. Changes in
27 ecological attributes under the alternatives that would affect fisheries and aquatic
28 resources in the Delta would primarily be related to:

29 **9.4.1.3.1 Changes in Volume and Timing of Flows through the Delta**

30 Operations of the CVP DCC and intake facilities owned by the CVP, SWP, local
31 agencies, and private parties affect Delta hydrologic flow regimes. The largest
32 effects of flow management in the Delta related to aquatic resources are the
33 modification of winter and spring inflows and outflows of the Delta, and the
34 introduction of net cross-Delta and net reverse flows in some Delta channels that
35 can alter fish movement patterns. Seasonal flows play an especially important
36 role in determining the reproductive success and survival of many estuarine
37 species including salmon, Striped Bass, American Shad, Delta Smelt, Longfin
38 Smelt, and Sacramento Splittail. In addition, changes in Delta outflow influence
39 the abundance and distribution of fish and invertebrates in the bay through
40 changes in salinity, currents, nutrient levels, and pollutant concentrations. Altered
41 flows through the Delta as a result of changes in CVP and SWP operations affect
42 water residence time, an important physical property that can influence the ability
43 of phytoplankton biomass to build up over time, with implications for higher
44 trophic level consumers such as fish.

1 **9.4.1.3.2 Changes in Water Quality**

2 Changes in water quality due to CVP and SWP operations under the alternatives
3 would affect aquatic resources in the Delta primarily through changes in water
4 temperatures, salinity, nutrient levels, pollutant concentrations and turbidity.
5 Changes in CVP and SWP operations can increase Delta water temperatures by
6 warmer reservoir releases and to a lesser extent, by reducing quantities of
7 freshwater inflow and by modifying tidal and ground water hydraulics. Changes
8 in CVP and SWP operations also can affect the location of the low salinity zone
9 (position of X2), especially during periods of low inflows and high water exports
10 (i.e., low outflow conditions) in drier water years. Nutrients, essential
11 components of terrestrial and aquatic environments because they provide a
12 resource base for primary producers, and pollutants such as selenium and mercury
13 could be affected by changes in CVP and SWP operations. Turbidity is an
14 important water quality component in the Delta that could be affected by changes
15 in operation. Changes in turbidity affect food web dynamics through attenuation
16 of light in the water column and altering predation success.

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

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

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

35 **9.4.1.3.3 Changes in Fish Entrainment**

36 Changes in CVP and SWP operations can affect through-Delta survival of
37 migratory (e.g., salmonids) and resident (e.g., Delta and Longfin smelt) fish
38 species through changes in the level of entrainment at CVP and SWP export
39 pumping facilities. The south Delta CVP and SWP facilities are the largest water
40 diversions in the Delta and in the past, have entrained large numbers of Delta fish
41 species. Tides, salinity, turbidity, in-flow, meteorological conditions, season,
42 habitat conditions, and project exports all have the potential to influence fish
43 movement, currents, and ultimately the level of entrainment and fish passage

1 success and survival. Entrainment risk for fish also tends to increase with
2 increased reverse flows in Old and Middle rivers.

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

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

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

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

40 **9.4.1.3.4 Changes in Fish Passage and Routing**

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

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

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

14 **9.4.1.3.5 Changes in Delta Smelt Habitat (X2 Location)**

15 Changes in CVP and SWP operations under the alternatives could change the
 16 location of Fall X2 position (in September through December) as an indicator of
 17 available habitat for Delta Smelt. Feyrer et al. used X2 location as an indicator of
 18 the extent of habitat available with suitable salinity and water transparency for the
 19 rearing of older juvenile Delta Smelt. Feyrer et al. concluded that when X2 is
 20 located downstream (west) of the confluence of the Sacramento and San Joaquin
 21 Rivers, at a distance of 70 to 80 km from the Golden Gate Bridge, there is a larger
 22 area of suitable habitat.

23 The overlap of the low salinity zone (or X2) with the Suisun Bay/Marsh is
 24 believed to lead to more favorable growth and survival conditions for Delta Smelt
 25 in fall. (Baxter et al 2010; Feyrer et al 2011). To evaluate fall abiotic habitat
 26 availability for Delta Smelt under the alternatives, X2 values (in km) simulated in
 27 the CALSIM II model for each alternative were averaged over September to
 28 December, and compared for differences. There are uncertainties and limitations
 29 associated with this approach, e.g., it does not evaluate other factors that influence
 30 the quality or quantity of habitat available for Delta Smelt (e.g., turbidity,
 31 temperature, food availability), nor does it take into account the relative
 32 abundance of Delta Smelt that might benefit from the available habitat in the
 33 simulated X2 areas, in any given year. Other scientists have developed and
 34 described life cycle models to evaluate Delta Smelt population responses to
 35 changes in flow-related variables (e.g., Maunder and Deriso 2011; Rose et al.
 36 2013 a, b; Reed et al 2014), but these life cycle modeling approaches were not
 37 selected for use in the current study. In this study, simulated fall X2 values are
 38 used as a tool to compare the alternatives, as one of the factors that would indicate
 39 available suitable habitat to benefit Delta Smelt.

40 **9.4.1.3.6 Changes in Salmonid Production**

41 Collectively, factors such as flow, temperature, and habitat availability affect the
 42 population dynamics of anadromous fish species during their freshwater life
 43 stages. Three different models were used to assess changes in salmonid

1 production potential: 1) SALMOD; 2) the Interactive Object-Oriented Simulation
2 (IOS) model for winter-run Chinook Salmon; and 3) the Oncorhynchus Bayesian
3 Analysis (OBAN) model for winter-run Chinook Salmon.

4 *Comparison of Annual Production Using SALMOD*

5 The SALMOD model (Appendix 9D, SALMOD Analysis Documentation) was
6 used to assess changes in the annual production potential of four races of Chinook
7 Salmon in the Sacramento River. The primary assumption of the model is that
8 egg and fish mortality is directly proportional to spatially and temporally variable
9 habitat limitations, such as water temperatures, which themselves are functions of
10 operational variables (timing and quantity of flow) and meteorological variables,
11 such as air temperature. SALMOD is a spatially explicit model that characterizes
12 habitat value and carrying capacity using the hydraulic and thermal properties of
13 individual habitat units. Inputs to SALMOD include flow, water temperature,
14 spawning distributions, spawn timing by salmon race, and the number of
15 spawners provided by the user (e.g., recent average escapement).

16 Annual production potential or the number of outmigrants, annual mortality,
17 length, and weight of the smolts are some of the reporting metrics available from
18 SALMOD. The production numbers obtained from SALMOD are best used as an
19 index in comparing to a specified baseline condition rather than absolute values.
20 Differences between alternatives are assessed based on changes in the life stage-
21 specific mortalities and annual production potential for each species by river by
22 water year type. Differences in mortality and annual production potential of
23 greater than 1 percent between alternatives are considered biologically
24 meaningful and may affect fish populations.

25 *Comparison of Annual Winter-run Chinook Salmon Escapement Using IOS*

26 IOS is a stochastic life cycle simulation model for winter run Chinook Salmon in
27 the Sacramento River. The IOS model is composed of six model stages that are
28 arranged sequentially to account for the entire life cycle of winter run, from eggs
29 to returning spawners. The primary output from the IOS model is escapement,
30 the total number of winter-run Chinook Salmon that leave the ocean and return to
31 the Sacramento River to spawn. Differences between alternatives are assessed
32 based on changes in the median annual escapement and the range of escapement
33 values encompassed in the first and second quartiles (25 to 75 percent of years)
34 over the 82-year CalSim II simulation period. Differences in escapement of
35 greater than 1 percent between alternatives are considered biologically
36 meaningful and may affect fish populations.

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

38 The Oncorhynchus Bayesian Analysis (OBAN) is a model that uses statistical
39 relationships between historical patterns in winter-run Chinook salmon abundance
40 and a number of other parameters that covary with abundance to predict future
41 population abundance. The model determines the effects of water temperature,
42 harvest, exports, striped bass abundance, and offshore upwelling using historical
43 abundance data. The set of parameters, called covariates, that provided the best
44 model fit was retained for the full model. The model then uses predicted future

1 values of these parameters, primarily from CalSim II and temperature model
2 outputs, to predict future patterns in Chinook salmon population abundance
3 (escapement). Differences in escapement of greater than 1 percent between
4 alternatives are considered biologically meaningful and may affect fish
5 populations.

6 **9.4.1.4 Constructed Water Supply Facilities that Convey and Store CVP** 7 **and SWP Water**

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

20 **9.4.1.5 Analysis of Provision of Fish Passage**

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

33 **9.4.1.6 Analysis of Predator Control Programs**

34 As described in Chapter 3, Description of Alternatives, Alternatives 3 and 4
35 include predator control actions designed to reduce predation on salmonids and
36 Delta Smelt, primarily within the Delta. Predator control measures are included
37 in Alternatives 3 and 4, including an increased bag limit and minimum size limit
38 for Striped Bass and black bass. The proposed bag and size limits are intended
39 and expected to encourage more fishing effort for and greater harvest of Striped
40 Bass and black bass, resulting in a reduction in the Striped Bass and black bass
41 populations throughout the Delta. In addition, a sport reward program for
42 Sacramento Pikeminnow would be implemented to encourage fishing for and
43 removal of predatory species. These two actions would not be implemented

1 under the No Action Alternative, Second Basis of Comparison, or other action
2 alternatives, with the exception of Alternatives 3 and 4.

3 **9.4.1.7 Analysis of Ocean Salmon Harvest Restrictions**

4 As described in Chapter 3, Description of Alternatives, Alternatives 3 and 4
5 include restrictions on the annual ocean Chinook Salmon harvest, which is
6 intended to minimize harvest mortality of natural origin Central Valley Chinook
7 Salmon, including fall-run Chinook Salmon, by evaluating and modifying ocean
8 harvest for consistency with Viable Salmonid Population² standards. This would
9 include working with the Pacific Fisheries Management Council (PFMC),
10 CDFW, and NMFS to impose salmon harvest restrictions to reduce by-catch of
11 winter-run and spring-run Chinook Salmon to less than 10 percent of age-3 cohort
12 in all years.

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

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

34 **9.4.1.8 Approach to Analyzing the Effects of Alternatives on Fish**

35 The analysis of the effects of changes in operation of the CVP and SWP on fish
36 and aquatic resources in this EIS is influenced by numerous factors related to the
37 complexity of the ecosystem, changes within the system (e.g., climate change and
38 species population trends), and the imprecision of operational controls and
39 resolution in modeling tools. These factors are further complicated by the
40 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).

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

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

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

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

33 **9.4.2 Conditions in Year 2030 without Implementation of** 34 **Alternatives 1 through 5**

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

1 **9.4.2.1 Common Changes in Conditions under the No Action Alternative**
2 **and Second Basis of Comparison**

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

- 4 • Climate change and sea level rise
- 5 • General plan development throughout California, including increased water
6 demands in portions of Sacramento Valley
- 7 • Implementation of reasonable and foreseeable water resources management
8 projects to provide water supplies

9 It is anticipated that climate change would result in more short-duration high-
10 rainfall events and less snowpack in the winter and early spring months. The
11 reservoirs would be full more frequently by the end of April or May by 2030 than
12 in recent historical conditions. However, as the water is released in the spring,
13 there would be less snowpack to refill the reservoirs. This condition would
14 reduce reservoir storage and available water supplies to downstream uses in the
15 summer. The reduced end of September storage also would reduce the ability to
16 release stored water to downstream regional reservoirs. These conditions would
17 occur for all reservoirs in the California foothills and mountains, including non-
18 CVP and SWP reservoirs.

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

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

30 The No Action Alternative and the Second Basis of Comparison assumes
31 completion of water resources management and environmental restoration
32 projects that would have occurred without implementation of Alternatives
33 1 through 5, including regional and local recycling projects, surface water and
34 groundwater storage projects, conveyance improvement projects, and desalination
35 projects, as described in Chapter 3, Description of Alternatives. The No Action
36 Alternative and the Second Basis of Comparison also assumes implementation of
37 actions included in the 2008 USFWS BO and 2009 NMFS BO that would have
38 been implemented without the BOs by 2030, as described in Chapter 3,
39 Description of Alternatives. These projects would include several projects that
40 would affect aquatic resources, including:

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

- 1 and at least 17,000 to 20,000 acres of seasonal floodplain restoration in Yolo
 2 Bypass.
- 3 – 2008 USFWS BO RPA Component 4 (Action 6). Habitat Restoration.
 - 4 – 2009 NMFS BO RPA Action I.6.1. Restoration of Floodplain Habitat.
 - 5 – 2009 NMFS BO RPA Action I.6.2. Near-Term Actions at Liberty
 6 Island/Lower Cache Slough and Lower Yolo Bypass.
 - 7 – 2009 NMFS BO RPA Action I.6.3. Lower Putah Creek Enhancements.
 - 8 – 2009 NMFS BO RPA Action I.6.4. Improvements to Lisbon Weir.
 - 9 – 2009 NMFS BO RPA Action I.7. Reduce Migratory Delays and Loss of
 10 Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in
 11 the Yolo Bypass.
 - 12 • 2009 NMFS BO RPA Action I.1.3. Clear Creek Spawning Gravel
 13 Augmentation.
 - 14 • 2009 NMFS BO RPA Action I.1.4. Spring Creek Temperature Control
 15 Curtain Replacement.
 - 16 • 2009 NMFS BO RPA Action I.2.6. Restore Battle Creek for Winter-Run,
 17 Spring-Run, and Central Valley Steelhead.
 - 18 • 2009 NMFS BO RPA Action I.3.1. Operate Red Bluff Diversion Dam with
 19 Gates Out.
 - 20 • 2009 NMFS BO RPA Action I.5. Funding for CVPIA Anadromous Fish
 21 Screen Program.
 - 22 • 2009 NMFS BO RPA Action II.1. Lower American River Flow Management.
- 23 Implementation of these common actions are described in more detail in this
 24 section under the No Action Alternative and referred under the discussion of the
 25 Second Basis of Comparison.

26 **9.4.2.2 No Action Alternative**

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

37 As described in Chapter 5, Surface Water Resources and Water Supplies, it is
 38 anticipated that climate change would result in more short-duration, high-rainfall
 39 events and less snowpack in the winter and early spring months. By 2030, the

1 reservoirs would be full more frequently by the end of April or May than in recent
2 historical conditions. However, as the water is released in the spring, there would
3 be less snowpack to refill the reservoirs. This condition would reduce reservoir
4 storage and available water supplies to downstream uses in the summer. The
5 reduced storage in fall (end of September storage) would reduce the ability to
6 release stored water to downstream regional reservoirs. These conditions would
7 occur for all reservoirs in the California foothills and mountains, including non-
8 CVP and SWP reservoirs. Sea level rise also would result in reduced CVP and
9 SWP reservoir storage because the CVP and SWP must continue to meet the
10 salinity criteria to protect Delta water users and Delta aquatic resources, including
11 the SWRCB D-1641 and other salinity criteria to protect Delta water users. To
12 meet these criteria, the amount of water released from CVP and SWP reservoirs
13 must be increased as compared to recent historical conditions.

14 **9.4.2.2.1 Trinity River Region**

15 *Aquatic Habitat Conditions in CVP and SWP Reservoirs*

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

23 *Aquatic Habitat Conditions in Trinity and Lower Klamath Rivers*

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

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

40 *Effects Related to*

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

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

3 **9.4.2.2.2 Central Valley Region**

4 *Aquatic Habitat Conditions in CVP and SWP Reservoirs*

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

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

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

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

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

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

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

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

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

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

- 23 • 2009 NMFS BO RPA Action I.1. Spring Attraction Flows
- 24 • 2009 NMFS BO RPA Action I.2. Channel Maintenance Flows
- 25 • 2009 NMFS BO RPA Action I.3. Spawning Gravel Augmentation
- 26 • 2009 NMFS BO RPA Action I.4. Spring Creek Temperature Control Curtain
- 27 • 2009 NMFS BO RPA Action I.5. Thermal Stress Reduction
- 28 • 2009 NMFS BO RPA Action I.6. Adaptively Manage to Habitat
29 Suitability/IFIM Study Results

30 Two of the actions involve additional flow releases to Clear Creek. 2009 NMFS
31 BO RPA Action I.1, requires at least two pulse flows in May and June to attract
32 adult spring-run Chinook Salmon holding in the Sacramento River. The pulse
33 flows would be continued annually, and are expected to improve conditions for
34 spring-run Chinook Salmon into the future. In addition, 2009 NMFS BO RPA
35 Action I.1.2, requires the release of channel maintenance flows of a minimum of
36 3,250 cfs into Clear Creek seven times in a ten-year period. These channel
37 maintenance flows are intended to provide the higher flows necessary to move
38 spawning gravels downstream from injection sites (locations where gravel
39 augmentation is implemented) for the purpose of increasing the amount of
40 spawning habitat available to spring-run Chinook Salmon and steelhead.
41 However, as described in Chapter 5, Surface Water Resources and Water
42 Supplies, the feasibility of releasing these flows is influenced by dam safety

1 considerations and operational constraints, and the delivery of flows of this
2 frequency may not be possible, thus the movement of gravel through mechanical
3 means may be required to achieve this objective.

4 2009 NMFS BO RPA Action I.1.3 addresses the limited availability of spawning
5 habitat in Clear Creek through the placement of gravel in selected sites in the
6 creek. This program is expected to continue under the No Action Alternative,
7 with ongoing improvements to spawning habitat for steelhead, and spring-run and
8 fall-run Chinook Salmon.

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

27 2009 NMFS BO RPA Action I.1.6 requires adaptive management of flows in
28 Clear Creek based on results of habitat suitability/IFIM studies. If warranted by
29 the studies and if sufficient water is available, this action could result in modified
30 minimum flows in Clear Creek during the fall and winter to improve conditions
31 for spawning and incubating salmonids. Whether flow requirements would be
32 modified by 2030 and the extent of any changes are currently unknown.

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

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

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

- 1 • 2009 NMFS BO RPA Action Suite I.2.1. Shasta Operations
- 2 – 2009 NMFS BO RPA Action Suite I.2.1. Performance Measures
- 3 – 2009 NMFS BO RPA Action I.2.2 (including I.2.2.A–I.2.2.C). November
- 4 through February Keswick Release Schedule (Fall Actions)
- 5 – 2009 NMFS BO RPA Action I.2.3 (including I.2.3.A–I.2.3.C). February
- 6 Forecast; March – May 14 Keswick Release Schedule (Spring Actions)
- 7 – 2009 NMFS BO RPA Action I.2.4. May 15 Through October Keswick
- 8 Release Schedule (Summer Action)
- 9 – 2009 NMFS BO RPA Action I.2.5. Winter-Run Chinook Salmon Passage
- 10 and Reintroduction Program at Shasta Dam – See “Conditions for Fish
- 11 Passage”
- 12 – 2009 NMFS BO RPA Action I.2.6. Restore Battle Creek for Winter-Run,
- 13 Spring-Run, and CV Steelhead
- 14 • 2009 NMFS BO RPA Action Suite I.3. Red Bluff Diversion Dam (RBDD)
- 15 Operations
- 16 • 2009 NMFS BO RPA Action I.4. Wilkins Slough Operations
- 17 • 2009 NMFS BO RPA Action I.5. Funding for CVPIA Anadromous Fish
- 18 Screen Program

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

33 A temperature control device has been in operation at Shasta Dam since 1998,
34 with operations capable of maintaining a water temperature of 56°F downstream
35 to Balls Ferry Bridge in most years through the summer spawning period for
36 winter-run. Under the No Action Alternative, the ability to control water
37 temperatures depends on a number of factors and management flexibility usually
38 ends in October when the cold water pool in Shasta Lake is depleted. With
39 climate change, cold water storage at the end of May in Shasta Lake is expected
40 to be reduced under the No Action Alternative for all water year types. This
41 would further reduce the already limited cold water pool in late summer. With

1 the anticipated increase in demands for water by 2030 and less water being
2 diverted from the Trinity River, it is expected that it would become increasingly
3 difficult to meet water temperature targets at the various temperature compliance
4 points.

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

13 2009 NMFS BO RPA Action Suite I.3 addresses mortality and delay of adult and
14 juvenile migration of winter-run, spring-run, steelhead, and green sturgeon caused
15 by the presence of the RBDD and the configuration of the operable gates. As
16 described in the Affected Environment, the Red Bluff Pumping Plant and fish
17 screen, which diverts water to the Tehama Colusa Canal and Corning Canal, was
18 constructed to allow year-round opening of the gates at the RBDD, and is
19 included in the 2009 NMFS BO as Action Suite I.3. Allowing the dam gates at
20 RBDD to remain open allows salmonids, sturgeon, and other fish species to pass
21 unimpeded all year. These passage improvements are completed and are
22 anticipated to benefit fish species that migrate upstream of the RBDD location
23 through improved access to spawning and rearing areas and a reduction in
24 predation due to dispersal of predator species like Striped Bass and Sacramento
25 Pikeminnow.

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

40 The No Action Alternative includes implementation of the CVPIA AFSP to
41 reduce entrainment of juvenile anadromous fish from unscreened diversions. This
42 program is also addressed in the 2009 NMFS BO RPA Action I.5. By providing
43 funding to screen priority diversions as identified in the CVPIA AFSP, the loss of
44 listed fish in water diversion channels by 2030 could be reduced. In addition, if
45 new fish screens can be constructed so that diversions can occur at low water

1 surface elevations to allow diversions below a flow of 5,000 cfs at Wilkins
2 Slough, then cold water at Shasta Lake could be conserved during critical dry
3 years for release to support winter-run and spring-run Chinook Salmon needs
4 downstream.

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

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

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

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

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

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

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

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

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

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

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

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

- 1 • 2009 NMFS BO RPA Action II.2.1. Lower American River Flow
2 Management
- 3 • 2009 NMFS BO RPA Action II.2. Lower American River Temperature
4 Management
- 5 • 2009 NMFS BO RPA Action II.3. Structural Improvements
- 6 • 2009 NMFS BO RPA Action II.4. Minimize Flow Fluctuation Effects
- 7 • 2009 NMFS BO RPA Action II.5. Fish Passage at Nimbus and Folsom dams
- 8 • 2009 NMFS BO RPA Action II.6.1. Preparation of Hatchery Genetic
9 Management Plan (HGMP) for Steelhead
- 10 • 2009 NMFS BO RPA Action II.6.2. Interim Actions Prior to Submittal of
11 Draft HGMP for Steelhead

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

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

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

40 2009 NMFS BO RPA Action II.3 requires Reclamation to evaluate physical and
41 structural modifications that may improve temperature management capability in the
42 lower American River. Structural improvements to be further evaluated and

1 potentially implemented include: improvements to the Folsom Dam TCD, cold water
 2 transport through Lake Natoma, installation of a TCD at El Dorado Irrigation
 3 District's intake or its functional equivalent, and improved temperature management
 4 decision-support tools. If one or more of these actions are implemented by 2030,
 5 they could increase the likelihood that water temperatures would be suitable for
 6 steelhead more frequently.

7 2009 NMFS BO RPA Action II.4 addresses stranding and isolation of juvenile
 8 steelhead through implementation of flow ramping protocols. Implementation of
 9 this action, including the continued monitoring for stranding and isolation of
 10 salmonids in conjunction with flow fluctuations under the No Action Alternative,
 11 could help to better predict the potential for steelhead redd dewatering and
 12 isolation, fry stranding, and fry and juvenile isolation and to potentially avoid
 13 adverse effects to salmonids.

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

19 Under the No Action Alternative, 2009 NMFS BO RPA Action Suite II.6, which
 20 addresses project effects related to the Nimbus Fish Hatchery related to
 21 introgression of out-of-basin hatchery stock with wild steelhead populations in the
 22 Central Valley, would be implemented. Implementation of an HGMP prior to
 23 2030 should minimize the effects of the ongoing steelhead hatchery program on
 24 the Central Valley steelhead DPS.

25 Implementation of the HGMP also would reduce operational effects on Killer
 26 Whale prey over the long term by improving the genetic diversity and diversity of
 27 run timing of Central Valley fall-run Chinook Salmon, decreasing the potential
 28 for localized prey depletions and increasing the likelihood that fall-run Chinook
 29 Salmon could withstand stochastic events, such as poor ocean conditions. By
 30 2030, implementation of this action could begin to contribute to a more consistent
 31 food source for Killer Whales, even in years with overall poor Chinook Salmon
 32 productivity.

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

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

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

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

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

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

- 10 • 2009 NMFS BO RPA Action III.1.1. Establish Stanislaus Operations Group
11 (SOG) for real-time operational decision-making
- 12 • 2009 NMFS BO RPA Action III.1.2. Provide cold water releases to maintain
13 suitable steelhead temperatures
- 14 • 2009 NMFS BO RPA Action III.1.3. Operate the East Side Division dams to
15 meet minimum flows
- 16 • 2009 NMFS BO RPA Action Suite III.2. Stanislaus River CV Steelhead
17 Habitat Restoration
 - 18 – 2009 NMFS BO RPA Action III.2.1. Increase and improve quality of
19 spawning habitat with addition of gravel
 - 20 – 2009 NMFS BO RPA Action III.2.2. Conduct floodplain restoration and
21 inundation flows in winter or spring to inundate steelhead juvenile rearing
22 habitat
 - 23 – 2009 NMFS BO RPA Action III.2.3. Restore freshwater migratory habitat
24 for juvenile steelhead
 - 25 – 2009 NMFS BO RPA Action III.2.4. Evaluate Fish Passage at New
26 Melones, Tulloch, and Goodwin dams

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

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

39 Under the No Action Alternative, Reclamation will continue, where feasible, to
40 manage the cold water supply within New Melones Reservoir as described in
41 2009 NMFS BO RPA Action III.1.2. The objective of these temperature criteria

1 is to provide suitable temperatures for Central Valley steelhead rearing, spawning,
2 egg incubation, smoltification, and adult migration in the Stanislaus River
3 downstream of Goodwin Dam. There are no temperature control devices at New
4 Melones, Goodwin, or Tulloch dams; thus, temperature management flexibility is
5 limited to storage and flow management under certain conditions. Access to
6 resources to offset operational temperature effects on steelhead in the Stanislaus
7 River will continue to be limited, particularly in Conference Years and in drier
8 Mid-Allocation Years. Under the No Action Alternative, steelhead would
9 continue to be vulnerable to elevated temperatures in dry and critical dry years,
10 even if actions are taken to improve temperature management. The frequency of
11 these occurrences is expected to increase with climate change-related temperature
12 increases.

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

26 Ongoing implementation of 2009 NMFS BO RPA Action Suite III.2 through
27 2030 is anticipated to improve the physical habitat conditions for steelhead,
28 although climate change may affect the types and cover rates of vegetation
29 upslope of the river, and potentially increase the rate of fine sediment transport to
30 the river and to spawning areas.

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

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

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

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

- 11 • 2009 NMFS BO RPA Action I.6.1. Restoration of Floodplain Rearing
12 Habitat.
- 13 • 2009 NMFS BO RPA Action I.6.2. Near-Term Actions at Liberty
14 Island/Lower Cache Slough and Lower Yolo Bypass.
- 15 • 2009 NMFS BO RPA Action I.6.3. Lower Putah Creek Enhancements.
- 16 • 2009 NMFS BO RPA Action I.6.4. Improvements to Lisbon Weir.
- 17 • 2009 NMFS BO RPA Action I.7. Reduce Migratory Delays and Loss of
18 Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the
19 Yolo Bypass

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

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

38 Implementation of these ecosystem restoration actions and improvements under
39 the No Action Alternative could increase growth and survival of juvenile Chinook
40 Salmon, steelhead, and other native fish by providing increased seasonal access to
41 productive foraging and high quality rearing habitat, depending on the extent and
42 duration of restoration and inundation. These actions may also reduce migratory

1 delays or losses by reducing predation, straying, and delays for salmonids and
2 other migratory native fish species.

3 *Aquatic Habitat Conditions in the Delta*

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

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

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

- 33 • 2008 USFWS BO RPA Component 1 (Actions 1 and 2). Protection of the
34 Adult Delta Smelt Life Stage.
- 35 • 2008 USFWS BO RPA Component 2 (Actions 3 and 5). Protection of Larval
36 and Juvenile Delta Smelt.
- 37 • 2008 USFWS BO RPA Component 3 (Action 4). Improve Habitat for Delta
38 Smelt Growth and Rearing (Fall X2).
- 39 • 2008 USFWS BO RPA Component 4 (Action 6). Habitat Restoration.
- 40 • 2009 NMFS BO RPA Action Suite IV.1. Modify DCC gate operations and
41 evaluate methods to control access to Georgiana Slough and the Interior Delta

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

- 3 • 2009 NMFS BO RPA Action Suite IV.2. Control the net negative flows
4 toward the export pumps in Old and Middle rivers to reduce the likelihood
5 that fish will be diverted from the San Joaquin or Sacramento River into the
6 southern or central Delta.
- 7 • 2009 NMFS BO RPA Action IV.3. Curtail exports when protected fish are
8 observed near the export facilities to reduce mortality from entrainment and
9 salvage.
- 10 • 2009 NMFS BO RPA Action Suite IV.4. Improve fish screening and salvage
11 operations to reduce mortality from entrainment and salvage.

12 Component 1 of the 2008 USFWS BO RPA is designed to reduce entrainment of
13 pre-spawning adult Delta Smelt during December to March by controlling OMR
14 flows during vulnerable periods, including adaptive management of OMR flows
15 based on input and guidance from the Smelt Working Group to further reduce
16 entrainment. Action 1 is designed to protect upmigrating Delta Smelt and Action
17 2 is designed to protect adult Delta Smelt that have migrated upstream and are
18 residing in the Delta prior to spawning. Overall, RPA Component 1 is expected
19 to increase the suitability of spawning habitat for Delta Smelt by decreasing the
20 amount of Delta habitat affected by export pumping prior to, and during, the
21 critical spawning period.

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

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

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

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

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

31 Conditions under the No Action Alternative would be influenced by
32 implementation of Action Suite IV.2 of the 2009 NMFS BO RPA. This action
33 suite requires the maintenance of adequate flows in both the Sacramento River
34 and San Joaquin River basins to increase survival of steelhead emigrating to the
35 estuary from the San Joaquin River, and of Chinook Salmon, steelhead, and
36 Green Sturgeon emigrating from the Sacramento River through the Delta to
37 Chipps Island. This action suite includes actions to reduce the vulnerability of
38 emigrating steelhead within the lower San Joaquin River to entrainment into the
39 channels of the South Delta and at the export facilities by increasing the inflow to
40 export ratio. In addition, there are actions to enhance the likelihood of salmonids
41 successfully exiting the Delta at Chipps Island by creating more suitable hydraulic
42 conditions in the main stem of the San Joaquin River for emigrating fish,
43 including greater net downstream flows. Historical data suggest that high San
44 Joaquin River flows in the spring result in higher survival of outmigrating
45 Chinook Salmon smolts and greater returns of adults. The data also suggest that
46 when the ratio between spring flows and exports increase, Chinook Salmon

1 production increases. Increased flows within the San Joaquin River portion of the
2 Delta could also enhance the survival of Sacramento River salmonids. Those fish
3 from the Sacramento River that have been diverted through the interior Delta to
4 the San Joaquin River could benefit by the increased net flow towards the ocean
5 caused by the higher flows in the San Joaquin River from upstream and the
6 reduced influence of the export pumps.

7 2009 NMFS BO RPA Action Suite IV.2 also includes flow management for the
8 Old and Middle rivers that would be implemented in conjunction with the
9 restrictions on exports under the 2008 USFWS BO RPA. Old and Middle river
10 flow management is designed to ensure that emigrating steelhead from the San
11 Joaquin Basin and the east-side tributaries remain in the mainstem of the San
12 Joaquin River to the greatest extent possible and reduce their exposure to the
13 adverse effects that are present in the channels leading south toward the export
14 facilities. This is anticipated to increase the likelihood of survival of steelhead
15 emigrating from the San Joaquin River. Reducing the risk of diversion into the
16 central and southern Delta waterways also could increase survival of listed
17 salmonids and Green Sturgeon entering the San Joaquin River via Georgiana
18 Slough and the lower Mokelumne River.

19 2009 NMFS BO RPA Action IV.3 requires operations of the Tracy and Skinner
20 Fish Collection Facilities to be modified according to monitoring data from
21 upstream of the Delta. In conjunction with the two alerts for closure of the DCC
22 (Action IV.1.1), a third alert would be used to signal that export operations may
23 need to be altered due to large numbers of juvenile Chinook Salmon migrating
24 into the upper Delta region, increasing their risk of entrainment into the central
25 and south Delta and then to the export pumps. When more fish are present, more
26 fish are at risk of diversion and losses would be higher. The third alert is
27 important for real-time operation of the export facilities because the collection
28 and dissemination of field data to the resource agencies and coordination of
29 response actions could take several days. This action is designed to work in
30 concert with the Old and Middle River flow management in action suite IV.2.
31 Under the No Action Alternative, implementation of this action is anticipated to
32 reduce losses of winter-run and spring-run Chinook Salmon, steelhead, and Green
33 Sturgeon by reducing exports when large numbers of juvenile Chinook Salmon
34 are migrating into the upper Delta region.

35 Action Suite IV.4 of the 2009 NMFS BO RPA is designed to increase the
36 efficiency of the Tracy and Skinner Fish Collection Facilities to improve the
37 overall salvage survival of winter-run and spring-run Chinook Salmon, steelhead,
38 and Green Sturgeon to achieve a 75 percent performance goal for whole facility
39 salvage at both state and Federal facilities. Reclamation and DWR will (1)
40 conduct studies to evaluate current operations and salvage criteria to reduce take
41 associated with salvage, (2) develop new procedures and modifications to
42 improve the current operations, and (3) implement changes to the physical
43 infrastructure of the facilities where information indicates such changes need to
44 be made. In addition, Reclamation would continue to fund and implement the
45 CVPIA Tracy Fish Facility Program. Reclamation and DWR would fund quality

1 control and quality assurance programs, genetic analysis, louver cleaning loss
 2 studies, release site studies and predation studies. Funding would also be
 3 provided for new studies to estimate Green Sturgeon screening efficiency at both
 4 facilities and survival through the trucking and handling process. Under the No
 5 Action Alternative, implementation of measures to fund fish screens, reduce pre-
 6 screen loss, improve screening efficiency, and improve reporting could reduce
 7 entrainment and salvage, and result in improved survival for juvenile Salmonids
 8 migrating downstream through the Delta, as well as for Sacramento Splittail,
 9 Delta Smelt, and other native fish species.

10 Abundance and habitat conditions for Delta Smelt and other fish species in the
 11 Delta under the No Action Alternative in 2030 are difficult to predict. Abundance
 12 levels for Delta Smelt, Longfin Smelt, Striped Bass, Threadfin Shad, and
 13 American Shad under recent conditions are very low compared to pre-POD levels,
 14 as evidenced by the number of fish collected in sampling programs such as the
 15 FMWT surveys conducted by the IEP. Numbers of fish collected have continued
 16 to decline in recent years, even with implementation of the RPAs. Annual
 17 reviews conducted by the Delta Science Program Independent Review Panel
 18 (IRP) for the Long-Term Operations Biological Opinions have called for better
 19 metrics to measure the effects of the BO RPAs on the protected species (IRP
 20 2011, 2013, 2014) to allow more informed decision-making, while
 21 acknowledging challenges, constraints, and the complexity of the issues.

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

32 **9.4.2.2.3 Special Status Species and Critical Habitat**

33 *Clear Creek*

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

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

3 *Sacramento River*

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

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

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

28 *American River*

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

38 *Stanislaus River*

39 The lower Stanislaus River downstream of Goodwin Dam is designated critical
40 habitat for Central Valley steelhead. The PCEs of critical habitat in the Stanislaus
41 River include freshwater spawning sites, freshwater rearing areas, and freshwater
42 migration corridors. Flow and temperature changes under the No Action
43 Alternative and the effects on spawning and rearing habitat quality were described
44 previously. The PCEs for spawning and rearing habitat have been adversely

1 affected by elimination of geomorphic processes that replenish and rejuvenate
2 spawning riffles and inundate floodplain terraces to provide nutrients and rearing
3 habitat for juvenile salmonids. In addition, moderation of flood events also
4 eliminates or reduces the intensity and duration of freshets and storm flows,
5 which adversely affects the PCE for migration corridors. The influence of climate
6 change could begin to alter hydrologic and temperature conditions in the region
7 and adversely affect the PCEs for Central Valley steelhead critical habitat in the
8 Stanislaus River, primarily through increased water temperatures.

9 *Delta*

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

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

31 **9.4.2.2.4 Effects Related to Cross Delta Water Transfers**

32 Because all water transfers would be required to avoid adverse impacts to other
33 water users and biological resources (see Section 3.A.6.3, Transfers), including
34 impacts associated with changes in reservoir storage and river flow patterns.
35 Potential effects to aquatic resources could be similar to those identified in a
36 recent environmental analysis conducted by Reclamation for long-term water
37 transfers from the Sacramento to San Joaquin valleys (Reclamation 2014d).
38 Potential effects were identified as changes to fish in the reservoirs and in the
39 rivers downstream of the reservoirs and the Delta. The analysis indicated that the
40 reservoirs did not support primary populations of fish species of management
41 concern, and that the reservoirs would continue to be operated within the
42 historical range of operations. The analysis also indicated that mean monthly
43 flows in the major rivers or creeks in the Sacramento and San Joaquin rivers
44 watersheds would be similar (less than 10 percent change) with water transfers as

1 compared to without water transfers; and therefore, changes to aquatic resources
2 would be less than substantial. Delta conditions also would be similar with water
3 transfers as compared to without water transfers, including less than 5 percent
4 changes in Delta exports and less than 1.3 percent changes in Delta outflow and
5 X2 position. Therefore, changes to aquatic resources would be less than
6 substantial. For the purposes of this EIS, it is anticipated that similar conditions
7 would occur due to cross Delta water transfers under the No Action Alternative
8 and the Second Basis of Comparison.

9 Under the No Action Alternative, the timing of cross Delta water transfers would
10 be limited to July through September in accordance with the 2008 USFWS BO
11 and 2009 NMFS BO. The maximum amount of water to be transferred would be
12 600,000 acre-feet/year in critical dry years or in dry years following a dry or
13 critical dry year. In all other water year types, the maximum amount of water
14 would be 360,000 acre-feet/year.

15 **9.4.2.2.5 Conditions for Fish Passage**

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

27 As described in the Affected Environment, Reclamation is currently developing
28 near-term and long-term fish passage solutions to provide access by anadromous
29 salmonids to habitat upstream of Shasta Lake (2009 NMFS BO RPA
30 Action I.2.5). The evaluation includes assessments of amount, suitability, and
31 location of potential habitat, potential risks (e.g., predation by resident fish,
32 disease transmission), as well as feasibility of providing upstream and
33 downstream passage. There are approximately 60 mainstem miles and the
34 McCloud River upstream of Shasta Lake. Reclamation (2014c) estimated
35 approximately 9 river-miles of suitable winter-run Chinook Salmon spawning
36 habitat in the upper Sacramento River below Box Canyon Dam, and
37 approximately 12 river-miles of suitable spawning habitat for winter-run Chinook
38 Salmon in the McCloud River below McCloud Dam. By 2030, access to this
39 habitat could not only expand the amount of habitat available for winter-run
40 Chinook Salmon relative to recent conditions, but provide access to areas of
41 temperature refuge at a time when water temperatures in the river downstream of
42 Keswick Dam are anticipated to increase. This could be particularly beneficial as
43 winter-run Chinook Salmon are currently at high risk of extinction. Extinction
44 factors include: winter-run Chinook Salmon is composed of only one population,
45 which has been blocked from all of its historic spawning habitat; the potential for

1 catastrophic risks associated with proximity to Mt. Lassen and the population's
2 dependency on the cold water management of Shasta Lake; and the population
3 has a "high" hatchery influence (Lindley et al. 2007). Combined with
4 improvements on Battle Creek that are expected to support a second population
5 component of winter-run Chinook Salmon, the provision for fish passage
6 upstream of Shasta Dam may support a third population, which is consistent with
7 the NMFS Recovery Plan for this species (NMFS 2014).

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

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

34 **9.4.2.2.6 Ocean Conditions**

35 Operation of the CVP and SWP would not directly affect ocean conditions;
36 however, operations have the potential to affect Southern Resident Killer Whales
37 indirectly by influencing the number of Chinook Salmon (produced in the
38 Sacramento-San Joaquin River and associated tributaries) that enter the Pacific
39 Ocean and become available as a food supply for the whales. The No Action
40 Alternative would not directly affect critical habitat for Killer Whales. However,
41 under the No Action Alternative, production of wild Chinook Salmon could
42 increase with increased area and quality of habitat for Chinook Salmon, as
43 discussed previously. Chinook Salmon from the Central Valley rivers and
44 streams likely represent only a very small proportion of the diet of this Killer
45 Whale population because most of their feeding is on Fraser River and Puget

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

5 **9.4.2.3 Second Basis of Comparison**

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

- 8 • Coordinated long-term operation of the CVP and SWP in 2030 without
9 implementation of the 2008 USFWS BO and the 2009 NMFS BO RPAs
- 10 • Changes in CVP and SWP operations due to climate change and sea level rise,
11 and increased CVP and water rights water demand in portions of the
12 Sacramento Valley
- 13 • Implementation of reasonable and foreseeable non-CVP and -SWP water
14 resources projects to provide additional water supplies, as described in
15 Section 7.4.3.1, No Action Alternative
- 16 • Implementation of RPA actions that address programs and projects that were
17 ongoing prior to issuance of the 2008 USFWS BO and 2009 NMFS BO,
18 including restoration of Battle Creek for salmonids; replacement of the Red
19 Bluff Diversion Dam; restoration of more than 10,000 acres of intertidal and
20 associated subtidal wetlands in Suisun Marsh and Cache Slough; and
21 17,000 to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass.

22 Overall, under the Second Basis of Comparison, long-term average CVP and
23 SWP water supply deliveries by 2030 through the Delta would increase, and late
24 summer and fall reservoir storage probably would decrease as compared to recent
25 historical conditions without consideration for climate change. However, the
26 Second Basis of Comparison also includes changes not related to the coordinated
27 long-term operation of the CVP and SWP, including changes in CVP and SWP
28 operations due to climate change and sea level rise, increased CVP and water
29 rights water demand in portions of the Sacramento Valley, and implementation of
30 reasonable and foreseeable non-CVP or SWP water resources management
31 projects to provide water supplies, as described under the No Action Alternative.
32 Therefore, primarily due to climate change, both CVP and SWP reservoir storage
33 and long-term average CVP and SWP water supply deliveries would decrease by
34 2030 as compared to historical long-term average deliveries.

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

1 **9.4.2.3.1 Trinity River Region**

2 *Aquatic Habitat Conditions in CVP and SWP Reservoirs*

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

9 *Fish Habitat Conditions in Trinity and Lower Klamath Rivers*

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

20 *Effects Related to Water Transfers*

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

25 **9.4.2.3.2 Central Valley Region**

26 *Aquatic Habitat Conditions in CVP and SWP Reservoirs*

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

37 Under the Second Basis of Comparison, the magnitude of changes in seasonal
38 surface elevation and reservoir storage could be slightly more pronounced
39 because of changes in the timing and intensity of storm events due to climate
40 change and an overall reduction in snow pack. By 2030, fish in these reservoirs
41 that spawn in shallow water (e.g., various species of black bass) could be subject
42 to a hydrologic regime that increases the frequency of reductions in surface
43 elevation during the spring spawning period, reducing spawning success. In

1 addition, reduced storage volumes and reduction of the cold water pools could
2 reduce the amount and suitability of habitat for cold water fishes (e.g., trout)
3 within the reservoirs relative to recent historical conditions.

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

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

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

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

21 The Second Basis of Comparison assumes that one of the 2009 NMFS BO RPA
22 actions intended to improve conditions for salmonids would be implemented,
23 2009 NMFS BO RPA Action I.3 Spawning Gravel Augmentation, which is
24 currently being implemented as part of the CVPIA. This action addresses the
25 limited availability of spawning habitat in Clear Creek through the placement of
26 gravel in selected sites in the creek. The gravel augmentation program is
27 expected to continue under the Second Basis of Comparison, resulting in
28 continued improvements to physical spawning habitat for steelhead, and spring-
29 run and fall-run Chinook Salmon by 2030.

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

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

41 Under the Second Basis of Comparison, flow, water temperature, and aquatic
42 habitat conditions in the Sacramento River downstream of Keswick Dam would
43 continue to be influenced by CVP and SWP operations. Shasta Lake would
44 continue to be operated to convey water from the Sacramento River to the Delta

1 and release flows to the Sacramento River to support anadromous fish.
2 Reclamation would continue to operate Shasta Lake to optimize use of the cold
3 water pool and maintain carryover storage for temperature control in the
4 Sacramento River downstream of Shasta and Keswick dams. As described above
5 for the No Action Alternative, it is likely that temperature-related effects in the
6 Sacramento River under the Second Basis of Comparison also would be
7 unavoidable in some years; however, restoration of habitat in Battle Creek (see
8 below) may compensate for these periods of unavoidably high temperatures by
9 providing passage and habitat conditions to support a second population of
10 winter-run Chinook Salmon.

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

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

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

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

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

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

10 Reclamation releases water to the lower American River consistent with flood
11 control requirements; existing water rights; CVP operations; the Lower American
12 River Flow Management Standard; and SWRCB Decision 893 (D-893). Under
13 the Second Basis of Comparison, American River flows would be influenced by
14 releases for regulation to meet water temperature criteria, and to coordinate timed
15 Folsom Lake releases and Delta exports. It is anticipated that conditions for fish
16 in the lower American River under the Second Basis of Comparison would
17 worsen relative to recent past operations of the American River Division of the
18 CVP because of continued operation of the American River Division through
19 2030 to meet increasing water demands. In addition, the influence of climate
20 change could alter hydrologic conditions in the region and affect habitat
21 conditions for fish in the American River.

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

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

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

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

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

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

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

25 Dam operations would continue to suppress channel-forming flows that replenish
26 spawning beds. The physical presence of the dams impedes normal sediment
27 transportation processes. Climate change may affect the types and cover rates of
28 vegetation upslope of the river, potentially increasing the rate of fine sediment
29 transport to the river and to spawning areas Ongoing gravel augmentation through
30 2030 is anticipated to maintain or improve physical spawning habitat conditions
31 for steelhead.

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

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

1 *Aquatic Habitat Conditions in the Delta*

2 As described in Chapter 3, Description of Alternatives, the Second Basis of
3 Comparison is based on coordinated long-term operation of the CVP and SWP in
4 2030 without implementation of the 2008 USFWS BO and the 2009 NMFS BO
5 RPAs. Similar to the No Action Alternative, reasonable and foreseeable non-
6 CVP and -SWP water resources projects to provide additional water supplies
7 would be implemented, in addition to restoration of more than 10,000 acres of
8 intertidal and associated subtidal wetlands in Suisun Marsh and Cache Slough;
9 and up to 20,000 acres of seasonal floodplain restoration in the Yolo Bypass.

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

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

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

36 **9.4.2.3.3 Special Status Species and Critical Habitat**

37 *Clear Creek*

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

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

8 *Sacramento River*

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

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

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

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

38 *American River*

39 The lower American River downstream of Nimbus Dam is designated critical
40 habitat for Central Valley steelhead. The PCEs of critical habitat in the lower
41 American River include freshwater spawning sites, freshwater rearing areas, and
42 freshwater migration corridors. Flow and temperature changes under the Second
43 Basis of Comparison and the effects on spawning and rearing habitat quality were
44 described previously. In addition, the influence of climate change is expected to

1 alter hydrologic and temperature conditions in the region and adversely affect the
2 PCEs for Central Valley steelhead critical habitat in the American River,
3 primarily through increased water temperatures.

4 *Stanislaus River*

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

19 *Delta*

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

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

38 **9.4.2.3.4 Effects Related to Cross Delta Water Transfers**

39 As described under the No Action Alternative, all water transfers would be
40 required to avoid adverse impacts to other water users and biological resources
41 (see Section 3.A.6.3, Transfers), including impacts associated with changes in
42 reservoir storage and river flow patterns. Potential effects to aquatic resources
43 could be similar to those identified in a recent environmental analysis conducted
44 by Reclamation for long-term water transfers from the Sacramento to San Joaquin

1 valleys (Reclamation 2014d). Potential effects were identified as changes to fish
 2 in the reservoirs and in the rivers downstream of the reservoirs and the Delta. The
 3 analysis indicated that the reservoirs did not support primary populations of fish
 4 species of management concern, and that the reservoirs would continue to be
 5 operated within the historical range of operations. The analysis also indicated that
 6 mean monthly flows in the major rivers or creeks in the Sacramento and San
 7 Joaquin rivers watersheds would be similar (less than 10 percent change) with
 8 water transfers as compared to without water transfers; and therefore, changes to
 9 aquatic resources would be less than substantial. Delta conditions also would be
 10 similar with water transfers as compared to without water transfers, including less
 11 than 5 percent changes in Delta exports and less than 1.3 percent changes in Delta
 12 outflow and X2 position. Therefore, changes to aquatic resources would be less
 13 than substantial. For the purposes of this EIS, it is anticipated that similar
 14 conditions would occur due to cross Delta water transfers under the No Action
 15 Alternative and the Second Basis of Comparison.

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

19 **9.4.2.3.5 Conditions for Fish Passage**

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

27 **9.4.2.3.6 Ocean Conditions**

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

31 **9.4.3 Evaluation of Alternatives**

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

35 **9.4.3.1 No Action Alternative Compared to the Second Basis of** 36 **Comparison**

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

38 **9.4.3.1.1 Trinity River Region**

39 *Coho Salmon*

40 The analysis of effects associated with changes in operation on Coho Salmon was
 41 conducted using temperature model outputs for Lewiston Dam to anticipate the

1 likely effects on conditions in the Trinity River downstream of Lewiston Dam for
2 Coho Salmon.

3 Long term average monthly water temperatures in the Trinity River at Lewiston
4 Dam under No Action Alternative generally would be similar to, although slightly
5 higher (up to 0.4°F) than the temperatures that would occur under the Second
6 Basis of Comparison (Appendix 6B, Table B-1-4). Average monthly
7 temperatures generally would be slightly higher during November through
8 February under the No Action Alternative, with the exception of critical years
9 when temperatures under the No Action Alternative could be as much as 2.4°F
10 cooler (November) and in December when water temperatures could be as much
11 as 1.5°F warmer in below normal years (Appendix 6B, Table B-1-4). Average
12 monthly water temperatures generally would be slightly (less than 0.5°F) higher
13 under the No Action Alternative during July through September, except in wet
14 years and critical years in September when temperatures would be slightly lower
15 (0.6°F and 0.3°F, respectively).

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

23 The USFWS established a water temperature threshold of 56°F for Coho Salmon
24 spawning in the reach of the Trinity River from Lewiston Dam to the confluence
25 with the North Fork Trinity River from October through December. Although not
26 entirely reflective of water temperatures throughout the reach, the temperature
27 model provides average monthly water temperature outputs for releases from
28 Lewiston Dam, which may provide perspective on temperature conditions in the
29 reach. In October and November, average monthly water temperatures under
30 both the No Action Alternative and Second Basis of Comparison would exceed
31 56°F at Lewiston Dam in some years (Appendix 9N). Under the No Action
32 Alternative, the threshold would be exceeded about 8 percent of the time in
33 October, about 1 percent more frequently than under the Second Basis of
34 Comparison. In November, both conditions would result in an exceedance
35 frequency of about 2 percent. There would be no exceedance of the threshold in
36 December under both the No Action Alternative and the Second Basis of
37 Comparison.

38 Overall, the temperature model outputs for each of the Coho Salmon life stages
39 suggest that the temperature of water released at Lewiston Dam generally would
40 be similar under both scenarios, although the exceedance of water temperature
41 thresholds would be slightly more frequent (1 percent) under the No Action
42 Alternative. Given the similarity of the results and the inherent uncertainty
43 associated with the resolution of the temperature model (average monthly

1 outputs), the No Action Alternative and Second Basis of Comparison are likely to
2 have similar effects on the Coho Salmon population in the Trinity River.

3 *Spring-run Chinook Salmon*

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

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

21 The differences in the frequency of threshold exceedance between the No Action
22 Alternative and Second Basis of Comparison would be relatively minor, although
23 temperature conditions under the No Action Alternative could be slightly less
24 likely to affect spring-run Chinook Salmon spawning than under the Second Basis
25 of Comparison because of the slightly reduced frequency of exceedance of the
26 56°F threshold at Lewiston Dam in September. The biological significance of
27 this difference, however, is uncertain.

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

38 *Fall-Run Chinook Salmon*

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

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

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

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

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

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

1 *Steelhead*

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

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

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

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

25 *Green Sturgeon*

26 As described in the Affected Environment and species accounts (Appendix 9B)
27 Green Sturgeon spawn in the lower reaches of the Trinity River during April
28 through June, and water temperatures above about 63°F are believed stressful to
29 embryos (Van Eenennaam et al. 2005). Average monthly water temperature
30 conditions during April through June in the Trinity River at Lewiston Dam under
31 the No Action Alternative would be similar to temperatures under the Second
32 Basis of Comparison and would not exceed 58°F during this period (Appendix
33 6B). In addition, water temperatures in the reach of the river where Green
34 Sturgeon spawn are likely controlled by other factors (e.g., ambient air
35 temperatures and tributary inflows) more than water operations at Trinity and
36 Lewiston dams.

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

1 *Reservoir Fishes*

2 The analysis of effects associated with changes in operation on reservoir fishes in
3 Trinity Lake relied on evaluation of changes in available habitat (reservoir
4 storage) and anticipated changes in black bass nesting success.
5 Changes in CVP water supplies and operations under the No Action Alternative
6 as compared to the Second Basis of Comparison would result in lower reservoir
7 storage in Trinity Lake. Storage in Trinity Lake could be reduced up to around
8 10 percent in some months of some water year types. Additional information
9 related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and
10 DSM2 Modeling. Using storage volume is an indicator of how much habitat is
11 available to fish species inhabiting these reservoirs, the amount of habitat for
12 reservoir fishes could be reduced under the No Action Alternative as compared to
13 the Second Basis of Comparison.
14 As shown in Appendix 9F, bass nest survival in Trinity Lake is near 100 percent
15 in March and April in response to increasing reservoir elevations. For May, the
16 likelihood of survival for Largemouth Bass in Trinity Lake being in the 40 to
17 100 percent range is slightly (about 1-2 percent) lower under the No Action
18 Alternative as compared to the Second Basis of Comparison. For June, the
19 likelihood of survival being greater than 40 percent for Largemouth Bass is lower
20 than in May and is slightly (about 3 percent) higher under the No Action
21 Alternative than the Second Basis of Comparison. For Spotted Bass, the
22 likelihood of survival being greater than 40 percent is 100 percent in May and
23 June under both the No Action Alternative and the Second Basis of Comparison.
24 Overall, the comparison of storage and the analysis of nesting suggest that effects
25 of the No Action Alternative on reservoir fishes would be similar to those under
26 the Second Basis of Comparison.

27 *Pacific Lamprey*

28 Little information is available on factors that influence populations of Pacific
29 Lamprey in the Trinity River, but they are likely affected by many of the same
30 factors as salmon and steelhead because of the parallels in their life cycles. On
31 average, the temperature of water released at Lewiston Dam under the No Action
32 Alternative would be similar to (within 0.5°F) water temperatures under the
33 Second Basis of Comparison. Changes in CVP water supplies and operations
34 under the No Action Alternative would result in lower reservoir storage in Trinity
35 Lake and somewhat reduced Trinity River flows in December through February
36 in wetter years as compared to the Second Basis of Comparison. The highest
37 reductions in flow would be less than 10 percent in the Trinity River
38 (Appendix 5A), with a smaller relative reduction in the lower Klamath River and
39 Klamath River estuary.
40 Given the somewhat reduced flows and similar temperatures, it is likely that the
41 No Action Alternative would have a similar potential to affect Pacific Lamprey in
42 the Trinity River as the Second Basis of Comparison. This conclusion likely
43 applies to other species of lamprey that inhabit the Trinity and lower Klamath
44 rivers (e.g., River Lamprey).

1 *Eulachon*

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

11 **9.4.3.1.2 Sacramento River System**12 *Winter-run Chinook Salmon*

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

16 *Changes in Water Temperature*

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

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

41 *Changes in Exceedances of Water Temperature Thresholds*

42 With the exception of April, average monthly water temperatures under both the
 43 No Action Alternative and Second Basis of Comparison would show exceedances

1 of the water temperature threshold of 56°F established in the Sacramento River at
2 Ball's Ferry from April to September for winter-run Chinook Salmon spawning
3 and egg incubation, with exceedances under both as high as about 42 percent and
4 52 percent, respectively, in some months (Appendix 9N). Under the No Action
5 Alternative, the temperature threshold generally would be exceeded more
6 frequently than under the Second Basis of Comparison (by about 1 percent to
7 3 percent) in the April through August period, with the temperature threshold in
8 September exceeded about 10 percent less frequently under the No Action
9 Alternative than the Second Basis of Comparison.

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

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

27 *Changes in Egg Mortality*

28 The temperatures described above for the Sacramento River downstream of
29 Keswick Dam are reflected in the analysis of egg mortality using the Reclamation
30 salmon mortality model (Appendix 9C). For winter-run Chinook Salmon in the
31 Sacramento River, the long-term average temperature induced egg mortality rate
32 is predicted to be relatively low (around 5 percent), with higher mortality rates
33 (exceeding 20 percent) occurring in critical dry years under the No Action
34 Alternative. Overall, temperature induced egg mortality would be 0.7 percent
35 higher under the No Action Alternative compared to the Second Basis of
36 Comparison, but in critical dry years the average egg mortality rate would be
37 5.4 percent greater under the No Action Alternative compared to the Second Basis
38 of Comparison (Appendix 9C, Table B-4). Overall, egg mortality in the
39 Sacramento River under the No Action Alternative and the Second Basis of
40 Comparison would be similar, except in critical dry water years.

41 *Changes in Weighted Usable Area*

42 As described above for the assessment methodology, Weighted Usable Area
43 (WUA) is a function of flow, but the relationship is not linear due to differences
44 in depths and velocities present in the wetted channel at different flows. Because

1 the combination of depths, velocities, and substrates preferred by species and life
2 stages varies, WUA values at a given flow can differ substantially for the life
3 stages evaluated.

4 As an indicator of the amount of suitable spawning habitat for winter-run Chinook
5 Salmon between Keswick Dam and Battle Creek, modeling results indicate that,
6 in general, there would be greater amounts of spawning habitat available from
7 May through September under the No Action Alternative as compared to the
8 Second Basis of Comparison (Appendix 9E). The increase in long-term average
9 spawning WUA during these months would be relatively small (less than
10 5 percent), with smaller (less than 1 percent) increases in May and July. There
11 would a reduction in the long-term average spawning WUA in April, but this
12 reduction is small (less than 1 percent) and would occur prior to the peak
13 spawning period in May and June. Overall, spawning habitat availability
14 generally would be similar under the No Action Alternative and the Second Basis
15 of Comparison.

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

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

36 *Changes in SALMOD Output*

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

1 17 percent lower under the No Action Alternative as compared to the Second
2 Basis of Comparison. Overall, potential juvenile production would be the same
3 under the No Action Alternative as compared to the Second Basis of Comparison
4 (Appendix 9D).

5 *Changes in Delta Passage Model Output*

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

11 *Changes in Oncorhynchus Bayesian Analysis Output*

12 Escapement of winter-run Chinook Salmon and Delta survival was modeled by
13 the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook
14 salmon. Escapement was generally higher under the No Action Alternative as
15 compared to the Second Basis alternative (Appendix 9I). The median abundance
16 under the No Action Alternative was higher in 19 of the 22 years of simulation
17 (1971 to 2002), and there was typically greater than a 25 percent chance that the
18 No Action Alternative values would be greater than under the Second Basis of
19 Comparison. Median delta survival was approximately 12 percent higher under
20 the No Action Alternative as compared to the Second Basis of Comparison
21 (Appendix 9I). The differences in survival, although not consistent across the
22 uncertainty in the parameter values, suggest a high probability of no difference
23 between these two bases of comparison.

24 *Changes in Interactive Object-Oriented Simulation Output*

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

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

35 *Changes in Delta Hydrodynamics*

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

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

7 *Changes in Junction Entrainment*

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

19 *Changes in Salvage*

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

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

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

41 If a fish passage program could establish self-sustaining populations of winter-run
 42 Chinook Salmon, spring-run Chinook Salmon, and steelhead, it would contribute
 43 substantially to satisfaction of the spatial diversity viability standard. The passage
 44 program could also contribute to abundance and productivity, if average returns

1 consistently exceeded approximately 500 individuals. However, the passage
2 program could also function as a population sink if fish transported above the
3 reservoir achieved a cohort replacement rate of less than 1.

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

10 *Summary of Effects on Winter-Run Chinook Salmon*

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

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

33 *Spring-run Chinook Salmon*

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

39 *Changes in Water Temperature*

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

1 *Sacramento River*

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

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

32 *Clear Creek*

33 Average monthly water temperatures in Clear Creek at Igo under the No Action
34 Alternative relative to the Second Basis of Comparison are generally predicted to
35 be similar (less than 0.5°F differences) from September through April and June
36 through August (Appendix 6B, Table B-3-4). Average monthly water
37 temperatures during May under the No Action Alternative would be lower by
38 0.4°F to 0.8°F than under the Second Basis of Comparison in all water year types.
39 The lower water temperatures in May associated with the No Action Alternative
40 reflect the effects of additional water discharged from Whiskeytown Dam to meet
41 the spring attraction flow requirements to promote attraction of spring-run
42 Chinook Salmon into the creek. While the reduction in May water temperatures
43 indicated by the modeling could improve thermal conditions for spring-run
44 Chinook Salmon, the duration of the two pulse flows may not be of sufficient
45 duration (3 days each) to provide biologically meaningful temperature benefits.

1 *Feather River*

2 Average monthly water temperature in the Feather River in the low flow channel
3 under the No Action Alternative relative to the Second Basis of Comparison
4 generally were predicted to be similar (less than 0.5°F differences), but slightly
5 higher from October through December when average monthly water
6 temperatures would be up to 1.4°F higher in some water year types
7 (Appendix 6B, Table B-20-4). Modeled water temperatures during May and June
8 under the No Action Alternative were also slightly higher, up to a maximum of
9 0.7°F higher in June of below normal water years. Average monthly water
10 temperatures in July through September under the No Action Alternative
11 generally were predicted to be higher (up to 0.6°F) in drier water year types and
12 lower (up to 1.3°F) in the wetter years. Although temperatures in the river
13 generally become progressively higher in the downstream direction, the
14 differences between the No Action Alternative and Second Basis of Comparison
15 exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley
16 Bridge), with water temperature differences under the No Action Alternative
17 generally increasing in most water year types relative to the Second Basis of
18 Comparison. Water temperatures under the No Action Alternative would be
19 somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F cooler at the
20 confluence with Sacramento River from July to September in wetter years
21 (Appendix 6B, Table B-23-4).

22 Overall, the temperature differences in the Feather River between the No Action
23 Alternative and Second Basis of Comparison would be relatively minor (less than
24 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the
25 Feather River. The slightly higher water temperatures in November and
26 December under the No Action Alternative would likely have little effect on
27 spring-run Chinook Salmon as water temperatures in the Feather River are
28 typically low during this time period. The somewhat lower water temperatures in
29 September of wetter years may reduce the likelihood of adverse effects on
30 spring-run Chinook Salmon spawning, although the increased temperatures in
31 September of critical dry years under the No Action Alternative may increase the
32 likelihood of adverse effects on spring-run Chinook Salmon spawning in this
33 water year type. There would be little difference in potential effects on spring-run
34 Chinook Salmon holding over the summer due to the similar water temperatures
35 during this time period under the No Action Alternative as compared and the
36 Second Basis of Comparison.

37 *Changes in Exceedances of Water Temperature Thresholds*

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

42 *Sacramento River*

43 Average monthly water temperatures under both the No Action Alternative and
44 Second Basis of Comparison indicate exceedances of the water temperature

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

17 *Clear Creek*

18 Average monthly water temperatures under both the No Action Alternative and
19 Second Basis of Comparison would not exceed the water temperature threshold of
20 60°F established in Clear Creek at Igo for spring-run Chinook Salmon pre-
21 spawning and rearing in June through August. However, water temperatures
22 under the No Action Alternative and Second Basis of Comparison would exceed
23 the water temperature threshold of 56°F established for spawning in September
24 and October about 10 percent to 15 percent of the time. The differences between
25 the No Action Alternative and Second Basis of Comparison could be biologically
26 meaningful, with water temperatures under the No Action Alternative exceeding
27 thresholds about 3 percent more frequently than under the Second Basis of
28 Comparison in September and about 2 percent more frequently in October,
29 respectively (Appendix 9N). Temperature conditions in Clear Creek under the No
30 Action Alternative could be more likely to affect spring-run Chinook Salmon
31 spawning than under the Second Basis of Comparison because of the increased
32 frequency of exceedance of the 56°F threshold in September and October.

33 *Feather River*

34 Average monthly water temperatures under both the No Action Alternative and
35 the Second Basis of Comparison would exceed the water temperature threshold of
36 56°F established in the Feather River at Robinson Riffle for spring-run Chinook
37 Salmon egg incubation and rearing during some months, particularly in October
38 and November, and March and April, when temperature thresholds could be
39 exceeded frequently (Appendix 9N). The frequency of exceedance was highest in
40 October, a month in which average monthly water could get as high as about
41 68°F. However, the differences in the frequency of exceedance between the No
42 Action Alternative and Second Basis of Comparison would be relatively small.
43 Water temperatures under the No Action Alternative would exceed the spawning
44 temperature threshold about 1 percent more frequently than under the Second

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

3 The established water temperature threshold of 63°F for rearing from May
4 through August would be exceeded often under both the No Action Alternative
5 and Second Basis of Comparison in May and June, but not at all in July and
6 August. Water temperatures under the No Action Alternative would exceed the
7 rearing temperature threshold about 1 percent more frequently than under the
8 Second Basis of Comparison in October, November, and December, and about
9 2 percent less frequently in March. Temperature conditions in the Feather River
10 under the No Action Alternative could be more likely to affect spring-run
11 Chinook Salmon spawning and rearing than under the Second Basis of
12 Comparison because of the increased frequency of exceedance of the 56°F
13 threshold from October through December.

14 *Changes in Egg Mortality*

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

26 *Changes in Weighted Usable Area*

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

35 *Changes in SALMOD Output*

36 SALMOD results indicate that pre-spawning mortality of spring-run Chinook
37 Salmon eggs would be approximately 22 percent greater under the No Action
38 Alternative, primarily due to increased summer temperatures. Flow-related
39 spring-run Chinook Salmon egg mortality would be reduced by 9 percent under
40 the No Action Alternative compared to the Second Basis of Comparison.
41 Conversely, temperature-related egg mortality would be 11 percent higher under
42 the No Action Alternative (Appendix 9D, Table B-3-19). Flow (habitat)-related
43 fry mortality would be approximately 7 percent lower under the No Action
44 Alternative as compared to the Second Basis of Comparison. There would be no

1 temperature- or flow (habitat)-related juvenile mortality under either alternative,
2 as most spring-run Chinook Salmon juveniles have migrated downstream as fry
3 and are not found in the mainstem Sacramento River. Overall, potential juvenile
4 spring-run production would be slightly (approximately 2 percent) lower under
5 the No Action Alternative as compared to the Second Basis of Comparison
6 (Appendix 9D, Table B-3-16).

7 *Changes in Delta Passage Model Output*

8 The Delta Passage Model predicted similar estimates of annual Delta survival
9 across the 81-year time period for spring-run between the No Action Alternative
10 and the Second Basis of Comparison (Appendix 9J). Median Delta survival was
11 0.296 for the No Action Alternative and 0.286 for the Second Basis of
12 Comparison.

13 *Changes in Delta Hydrodynamics*

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

32 *Changes in Junction Entrainment*

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

1 *Changes in Salvage*

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

9 *Summary of Effects on Spring-Run Chinook Salmon*

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

28 In Clear Creek and the Feather River, the analysis of the effects of the No Action
29 Alternative and Second Basis of Comparison for spring-run Chinook Salmon
30 relied on output from the WUA analysis and water temperature output for Clear
31 Creek at Igo, and in the Feather River low flow channel and downstream of the
32 Thermalito complex. The WUA analysis suggests that there would be little
33 difference in the availability of spawning and rearing habitat in Clear Creek. The
34 temperature model outputs suggest that thermal conditions and effects on each of
35 the spring-run Chinook Salmon life stages generally would be similar under both
36 scenarios in Clear Creek and the Feather River, although water temperatures
37 could be somewhat less suitable for spring-run Chinook Salmon holding and
38 spawning/egg incubation in the Feather River under the No Action Alternative.
39 This conclusion is supported by the water temperature threshold exceedance
40 analysis that indicated that water temperature thresholds for spawning and egg
41 incubation would be exceeded slightly more frequently under the No Action
42 Alternative in Clear Creek and the Feather River. The water temperature
43 threshold for rearing spring-run Chinook Salmon would also be exceeded slightly
44 more frequently in the Feather River. Because of the inherent uncertainty
45 associated with the resolution of the temperature model (average monthly

1 outputs), the slightly greater likelihood of exceeding water temperature thresholds
2 under the No Action Alternative could increase the potential for adverse effects
3 on the spring-run Chinook Salmon populations in the Feather River. Given the
4 similarity of the results, the No Action Alternative and Second Basis of
5 Comparison are likely to have similar effects on the spring-run Chinook Salmon
6 population in Clear Creek.

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

17 *Fall-Run Chinook Salmon*

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

23 *Changes in Water Temperature*

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

27 *Sacramento River*

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

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

15 *Clear Creek*

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

28 The lower water temperatures in May associated with the No Action Alternative
29 reflect the effects of the additional water discharged from Whiskeytown Dam to
30 meet the spring attraction flow requirements to promote attraction of spring-run
31 Chinook Salmon into Clear Creek. While the reduction in water temperature
32 indicated by the modeling could improve thermal conditions for fall-run Chinook
33 Salmon, the duration of the two pulse flows may not be of sufficient duration
34 (3 days each) to provide biologically meaningful temperature benefits. Overall,
35 thermal conditions for fall-run Chinook Salmon in Clear Creek would be similar
36 under the No Action Alternative and the Second Basis of Comparison.

37 *Feather River*

38 Long-term average monthly water temperatures in the Feather River in the low
39 flow channel under the No Action Alternative relative to the Second Basis of
40 Comparison generally are predicted to be similar (less than 0.5°F differences), but
41 slightly higher from October through December when average monthly water
42 temperatures would be up to 1.4°F higher in some water year types. Modeled
43 water temperatures during May and June under the No Action Alternative were
44 also slightly higher, up to a maximum of 0.7°F higher in June of below normal

1 water years. Average monthly water temperatures in July through September
2 under the No Action Alternative generally were predicted to be higher (up to
3 0.6°F) in drier water year types and lower (up to 1.3°F) in the wetter years.
4 Although temperatures in the river generally become progressively higher in the
5 downstream direction, the differences between the No Action Alternative and
6 Second Basis of Comparison exhibit a similar pattern at the downstream locations
7 (Robinson Riffle and Gridley Bridge), with water temperature differences under
8 the No Action Alternative generally decreasing in most water year types relative
9 to the Second Basis of Comparison. Water temperatures under the No Action
10 Alternative are somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F
11 cooler at the confluence with Sacramento River from July to September in
12 wetter years.

13 Overall, the temperature differences in the Feather River between the No Action
14 Alternative and Second Basis of Comparison would be relatively minor (less than
15 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the
16 Feather River. The slightly higher water temperatures in November and
17 December under the No Action Alternative would likely have little effect on
18 fall-run Chinook Salmon as water temperatures in the Feather River are typically
19 low during this time period. The somewhat lower water temperatures in
20 September of wetter years may reduce the likelihood of adverse effects on early
21 spawning fall-run Chinook Salmon, although the increased temperatures in
22 September of critical dry years under the No Action Alternative may increase the
23 likelihood of adverse effects on fall-run Chinook Salmon spawning in this water
24 year type.

25 *American River*

26 Average monthly water temperatures in the American River at Nimbus Dam
27 under the No Action Alternative generally would be similar (differences less than
28 0.5°F) to the Second Basis of Comparison, with the exception of June and
29 August, when temperatures under the No Action Alternative could be as much as
30 0.9°F higher in below normal years (Appendix 6B, Table B-12-4). This pattern
31 generally would persist downstream to Watt Avenue and the mouth, although
32 temperatures under the No Action Alternative would be up to 1.6°F and 2.0°F
33 greater, respectively, than under the Second Basis of Comparison in June. In
34 addition, average monthly water temperatures at the mouth generally would be
35 lower under the No Action Alternative than the Second Basis of Comparison in
36 September, especially in wetter water year types when water temperatures under
37 the No Action Alternative could be up to 1.7°F cooler (Appendix 6B,
38 Table B-14-4).

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

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

5 *Changes in Exceedances of Water Temperature Thresholds*

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

10 *Sacramento River*

11 Average monthly water temperatures under both the No Action Alternative and
12 Second Basis of Comparison indicate exceedances of the water temperature
13 threshold of 56°F established in the Sacramento River at Red Bluff for Chinook
14 Salmon spawning and egg incubation in October, November, and again in April.
15 In the months when the greatest frequency of exceedances occur (October,
16 November, and April), model results generally indicate more frequent
17 exceedances (by up to 4 percent in October) under the No Action Alternative than
18 under the Second Basis of Comparison. Temperature conditions in the
19 Sacramento River under the No Action Alternative could be more likely to affect
20 fall-run Chinook Salmon spawning and egg incubation than under the Second
21 Basis of Comparison because of the increased frequency of exceedance of the
22 56°F threshold in October, November, and April.

23 *Clear Creek*

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

42 For fall-run Chinook Salmon rearing (January through August), the exceedances
43 described previously for spring-run Chinook Salmon would apply, with the

1 average monthly temperatures at Igo remaining below the 60°F threshold in all
2 months. Downstream at the mouth of Clear Creek, average monthly water
3 temperatures would exceed the 60°F threshold often during the summer, but the
4 frequency of exceedance would be similar under the No Action Alternative and
5 the Second Basis of Comparison (Appendix 6B). Temperature conditions for
6 fall-run Chinook Salmon rearing in Clear Creek would be similar under the No
7 Action Alternative and the Second Basis of Comparison.

8 *Feather River*

9 Average monthly water temperatures under both the No Action Alternative and
10 Second Basis of Comparison would exceed the water temperature threshold of
11 56°F established in the Feather River at Gridley Bridge for fall-run Chinook
12 Salmon spawning and egg incubation during some months, particularly in
13 October, November, March, and April, when water temperature thresholds would
14 be exceeded frequently (Appendix 9N). The frequency of exceedance would be
15 greatest in October, when average monthly temperatures under both the No
16 Action Alternative and Second Basis of Comparison would be above the
17 threshold in nearly every year. The magnitude of the exceedances would be high
18 as well, with average monthly temperatures in October reaching about 68°F.
19 Similarly, the threshold would be exceeded under both the No Action Alternative
20 and Second Basis of Comparison about 85 percent of the time in April. The
21 differences between the No Action Alternative and Second Basis of Comparison,
22 however, would be relatively small, with the No Action Alternative generally
23 exceeding temperature thresholds about 1-2 percent more frequently than the
24 Second Basis of Comparison during the October through April period.
25 Temperature conditions in the Feather River under the No Action Alternative
26 could be more likely to affect fall-run Chinook Salmon spawning and egg
27 incubation than under the Second Basis of Comparison because of the increased
28 frequency of exceedance of the 56°F threshold from October through April.

29 *Changes in Egg Mortality*

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

33 *Sacramento River*

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

1 *Feather River*

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

11 *American River*

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

22 *Changes in Weighted Usable Area*

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

26 *Sacramento River*

27 As an indicator of the amount of suitable spawning habitat for fall-run Chinook
28 Salmon between Keswick Dam and Battle Creek, WUA modeling results indicate
29 that, in general, there would be lesser amounts of spawning habitat available from
30 September through November under the No Action Alternative as compared to
31 the Second Basis of Comparison. Although fall-run spawning WUA would be
32 slightly (less than 5 percent) increased in December under the No Action
33 Alternative, this increase would occur after the peak spawning period for fall-run
34 Chinook Salmon in this reach (Appendix 9E, Table C-11-4). Lesser amounts in
35 long-term average spawning WUA during September (prior to the peak spawning
36 period) under the No Action Alternative compared to the Second Basis of
37 Comparison would be relatively large (more than 20 percent), with smaller
38 decreases predicted for October (around 2 percent) and November (around
39 6 percent). The latter month comprises the peak spawning period for fall-run
40 Chinook Salmon in the Sacramento River. Results for the reach from Battle
41 Creek to Deer Creek show the same pattern in changes in WUA for spawning
42 fall-run Chinook Salmon between the No Action Alternative and the Second
43 Basis of Comparison (Appendix 9E, Table C-10-4). Overall, spawning habitat

1 availability would be somewhat lower under the No Action Alternative relative to
2 the Second Basis of Comparison.

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

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

15 *Clear Creek*

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

23 *Feather River*

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

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

1 *American River*

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

10 *Changes in SALMOD Output – Sacramento River*

11 SALMOD results indicate that pre-spawning mortality of fall-run Chinook
12 Salmon eggs in the Sacramento River would be approximately 20 percent greater
13 under the No Action Alternative, primarily due to increased summer
14 temperatures. Flow-related fall-run Chinook Salmon egg mortality would be
15 reduced by 7 percent under the No Action Alternative compared to the Second
16 Basis of Comparison. Conversely, temperature-related egg mortality would be
17 13 percent higher under the No Action Alternative (Appendix 9D, Table B-1-19).
18 Flow (habitat)-related fry mortality would be approximately 1 percent lower
19 under the No Action Alternative as compared to the Second Basis of Comparison.
20 Temperature-related juvenile mortality would be approximately 27 percent higher
21 under the No Action Alternative, while flow (habitat)-related mortality would be
22 the same under the No Action Alternative as compared to the Second Basis of
23 Comparison. Overall, potential juvenile production would be slightly
24 (approximately 1 percent) lower under the No Action Alternative as compared to
25 the Second Basis of Comparison (Appendix 9D, Table B-1-16).

26 *Changes in Delta Passage Model Output*

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

32 *Changes in Delta Hydrodynamics*

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

1 relative to the Second Basis of Comparison in April and May and moderately
2 lower in June. On the San Joaquin River downstream of the Head of Old River,
3 the percent of positive velocities was moderately lower under the No Action
4 Alternative relative to the Second Basis of Comparison in April and May,
5 whereas the values were similar in June.

6 *Changes in Junction Entrainment*

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

24 *Changes in Salvage*

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

33 *Summary of Effects on Fall-Run Chinook Salmon*

34 The multiple model and analysis outputs described above characterize the
35 anticipated conditions for fall-run Chinook Salmon and their response to change
36 under the No Action Alternative as compared to the Second Basis of Comparison.
37 For the purpose of analyzing effects on fall-run Chinook Salmon in the
38 Sacramento River, greater reliance was placed on the outputs from the SALMOD
39 model because it integrates the available information on temperature and flows to
40 produce estimates of mortality for each life stage and an overall, integrated
41 estimate of potential fall-run Chinook Salmon juvenile production. The output
42 from SALMOD indicated that fall-run Chinook Salmon production would be
43 slightly lower in most water year types under the No Action Alternative than
44 under the Second Basis of Comparison, and up to 7 percent less than under the
45 Second Basis of Comparison in critical dry years. The analyses attempting to

1 assess the effects on routing, entrainment, and salvage of juvenile salmonids in
2 the Delta suggest that salvage (as an indicator of potential losses of juvenile
3 salmon at the export facilities) of Sacramento River-origin Chinook Salmon is
4 predicted to be lower under the No Action Alternative relative to the Second
5 Basis of Comparison in every month.

6 In Clear Creek and the Feather and American rivers, the analysis of the effects of
7 the No Action Alternative and Second Basis of Comparison for fall-run Chinook
8 Salmon relied on the WUA analysis for habitat and water temperature model
9 output for the rivers at various locations downstream of the CVP and SWP
10 facilities. The WUA analysis indicated that the availability of spawning and
11 rearing habitat in Clear Creek and spawning habitat in the Feather and American
12 rivers would be similar under the No Action Alternative and the Second Basis of
13 Comparison. The temperature model outputs for each of the fall-run Chinook
14 Salmon life stages suggest that thermal conditions and effects on fall-run Chinook
15 Salmon in all of these streams generally would be similar under both scenarios.
16 The water temperature threshold exceedance analysis that indicated that the water
17 temperature thresholds for fall-run Chinook Salmon spawning and egg incubation
18 would be exceeded slightly more frequently in the Feather River and Clear Creek
19 under the No Action Alternative. Given the inherent uncertainty associated with
20 the resolution of the temperature model (average monthly outputs), the increased
21 frequency of exceedance of temperature thresholds under the No Action
22 Alternative could increase the potential for adverse effects on the fall-run
23 Chinook Salmon populations in Clear Creek and the Feather River. Results of the
24 analysis using Reclamation's salmon mortality model indicate that there would be
25 little difference in fall-run Chinook Salmon egg mortality under the No Action
26 Alternative and the Second Basis of Comparison.

27 These model results suggest that overall, effects on fall-run Chinook Salmon
28 could be slightly more adverse under the No Action Alternative than under the
29 Second Basis of Comparison, with a small likelihood that fall-run Chinook
30 Salmon production would be lower under the No Action Alternative.

31 The implementation of fish passage under the No Action Alternative intended to
32 address the limited availability of suitable habitat for winter-run and spring-run
33 Chinook Salmon in the Sacramento River reaches downstream of Shasta Dam is
34 unlikely to benefit fall-run Chinook Salmon unless volitional access is provided to
35 adult fish. Similar fish passage at Folsom Dam would also be uncertain for the
36 same reason.

37 *Late Fall-Run Chinook Salmon*

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

41 *Changes in Water Temperature*

42 As described above, long-term average monthly water temperatures in the
43 Sacramento River at Keswick Dam under the No Action Alternative would
44 generally be similar (less than 0.5°F difference) to water temperatures under the

1 Second Basis of Comparison. An exception is during September and October of
 2 critical dry years when water temperatures could be up to 1.1°F and 0.8°F higher,
 3 respectively, under the No Action Alternative as compared to the Second Basis of
 4 Comparison and up to 1°F cooler in September of wetter years under the No
 5 Action Alternative. Water temperatures below Keswick Dam are slightly higher
 6 from October to December under the No Action Alternative than under the
 7 Second Basis of Comparison in most water year types, but by less than 0.5°F on
 8 average (Appendix 6B, Table 5-5-4). A similar pattern in temperature differences
 9 generally would be exhibited at downstream locations along the Sacramento River
 10 (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and
 11 Knights Landing), with differences in average monthly temperatures in June at
 12 Knights Landing progressively increasing (up to 0.9°F) under the No Action
 13 Alternative relative to the Second Basis of Comparison and progressively
 14 decreasing (up to 4.6°F) in September during the wetter years.

15 Overall, the temperature differences between the No Action Alternative and
 16 Second Basis of Comparison would be relatively minor (less than 0.5°F) and
 17 likely would have little effect on late fall-run Chinook Salmon in the Sacramento
 18 River. Spawning of late fall-run Chinook Salmon in the Sacramento River takes
 19 place from December to mid-April with incubation occurring over the same time
 20 period and extending into June. The slightly higher water temperatures from
 21 October to December under the No Action Alternative would likely have little
 22 effect on late fall-run Chinook Salmon migration and holding as water
 23 temperatures in the Sacramento River below Keswick Dam are typically low
 24 during this time period. The likelihood of adverse effects on late fall-run Chinook
 25 Salmon spawning and egg incubation would be similar under the No Action
 26 Alternative and the Second Basis of Comparison due to similar water
 27 temperatures during the January to May time period.

28 Because late fall-run Chinook Salmon have an extended rearing period, the
 29 similar water temperatures during the summer under the No Action Alternative
 30 and Second Basis of Comparison would have similar effects on rearing fry and
 31 juvenile late fall-run Chinook Salmon in the Sacramento River. The lower water
 32 temperatures under the No Action Alternative in September of wetter years may
 33 reduce the likelihood of adverse effects on fry and juvenile late fall-run Chinook
 34 Salmon in the Sacramento River during this limited time period.

35 *Changes in Exceedances of Water Temperature Thresholds*

36 Average monthly water temperatures under both the No Action Alternative and
 37 Second Basis of Comparison indicate exceedances of the water temperature
 38 threshold of 56°F established in the Sacramento River at Red Bluff for Chinook
 39 Salmon spawning and egg incubation in October, November, and again in April.
 40 There would be no exceedances of the threshold from December to March under
 41 both the No Action Alternative and the Second Basis of Comparison. In April,
 42 model results indicate that water temperatures under the No Action Alternative
 43 would exceed the threshold about 2 percent more frequently than under the
 44 Second Basis of Comparison. Temperature conditions in the Sacramento River

1 under the No Action Alternative could be slightly more likely to affect late
2 fall-run Chinook Salmon spawning and egg incubation than under the Second
3 Basis of Comparison because of the increased frequency of exceedance of the
4 56°F threshold in April.

5 *Changes in Egg Mortality*

6 For late fall-run Chinook Salmon in the Sacramento River, the long-term average
7 egg mortality rate is predicted to range from approximately 2.5 to nearly 5 percent
8 in all water year types under the No Action Alternative. Overall, egg mortality
9 would be 0.4 percent higher under the No Action Alternative; in Below Normal
10 water years the average egg mortality rate would be 0.1 percent lower than under
11 the Second Basis of Comparison. In other water year types, egg mortality is
12 predicted to be from 0.1 to 0.8 percent higher under the No Action Alternative as
13 compared to the Second Basis of Comparison (Appendix 9C, Table B-2).
14 Overall, late fall Chinook Salmon egg mortality in the Sacramento River under
15 the No Action Alternative and the Second Basis of Comparison would be similar.

16 *Percent Changes in Weighted Usable Area*

17 Modeling results indicate that there would be slightly (less than 5 percent) greater
18 amounts of spawning habitat available for late fall-run Chinook Salmon in the
19 Sacramento River from January through April under the No Action Alternative as
20 compared to the Second Basis of Comparison late (Appendix 9E, Table C-14-4).
21 Overall, spawning habitat availability would be similar under the No Action
22 Alternative and the Second Basis of Comparison.

23 Modeling results indicate that, in general, there would be increased amounts of
24 suitable late fall-run Chinook Salmon fry rearing habitat available in the
25 Sacramento River during April and May under the No Action Alternative
26 (Appendix 9E, Table C-15-4). The increase in long-term average fry rearing
27 WUA during these months would be relatively small (less than 5 percent). Late
28 fall-run Chinook Salmon fry rearing WUA would be decreased by about 2 percent
29 in June under the No Action alternative as compared to the Second Basis of
30 Comparison. Overall, late fall-run fry rearing habitat availability would be
31 similar under the No Action Alternative and the Second Basis of Comparison.

32 A substantial fraction of late fall run Chinook Salmon juveniles oversummer in
33 the Sacramento River before emigrating, which allows them to avoid predation
34 through both their larger size and greater swimming ability. One implication of
35 this life history strategy is that rearing habitat is most likely the limiting factor for
36 late-fall-run Chinook Salmon, especially if availability of cool water determines
37 the downstream extent of spawning habitat for late-fall-run Chinook Salmon.
38 Modeling results indicate that, there would be increased amounts of suitable
39 juvenile rearing habitat available from December through August, but this
40 increase would be small (generally less than 2 percent) under the No Action
41 Alternative as compared to the Second Basis of Comparison. There would be
42 decreases in the amount of late fall-run Chinook Salmon juvenile rearing WUA in
43 the other months (September through November) of up to 10 percent (Appendix
44 9E, Table C-16-4). Overall, late fall-run juvenile rearing habitat availability

1 would be similar under the No Action Alternative relative to the Second Basis of
2 Comparison.

3 *Changes in SALMOD Output – Sacramento River*

4 SALMOD results indicate that flow-related late fall-run Chinook Salmon egg
5 mortality would be reduced by 4 percent under the No Action Alternative
6 compared to the Second Basis of Comparison. Conversely, temperature-related
7 egg mortality would be 4 percent higher under the No Action Alternative
8 (Appendix 9D, Table B-2-4). Flow (habitat)-related fry mortality would be
9 approximately 3 percent lower while temperature-related fry mortality would be
10 about 2 percent higher under the No Action Alternative as compared to the
11 Second Basis of Comparison. Temperature-related juvenile mortality would be
12 approximately 19 percent higher under the No Action Alternative, while flow
13 (habitat)-related mortality would approximately 51 percent higher under the No
14 Action Alternative as compared to the Second Basis of Comparison. Overall,
15 potential juvenile production would be the similar under the No Action
16 Alternative and the Second Basis of Comparison (Appendix 9D, Table B-2-16).

17 *Changes in Delta Passage Model Output*

18 For late fall-run Chinook Salmon, through-Delta survival was predicted to be
19 slightly higher under the No Action Alternative relative to the Second Basis of
20 Comparison for all 81 years simulated by the Delta Passage Model (Appendix 9J).
21 Median Delta survival across all years was 0.244 for the No Action Alternative
22 and 0.199 for the Second Basis of Comparison.

23 *Changes in Hydrodynamics*

24 The late fall-run Chinook Salmon migration period overlaps with winter-run
25 Chinook Salmon. See the section on hydrodynamic analysis for winter-run
26 Chinook Salmon for potential effects on late fall-run Chinook Salmon.

27 *Changes in Junction Entrainment*

28 Entrainment probabilities for late fall-run are assumed to mimic that of winter-run
29 Chinook Salmon due to overlap in timing. See the section on winter-run Chinook
30 Salmon entrainment for potential effects on late fall-run Chinook Salmon.

31 *Changes in Salvage*

32 Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run
33 Chinook Salmon due to overlap in timing. See the section on winter-run Chinook
34 Salmon entrainment for potential effects on late fall-run Chinook Salmon.

35 *Summary of Effects on Late Fall-Run Chinook Salmon*

36 The multiple model and analysis outputs described above characterize the
37 anticipated conditions for late fall-run Chinook Salmon and their response to
38 change under the No Action Alternative as compared to the Second Basis of
39 Comparison. For the purpose of analyzing effects on late fall-run Chinook
40 Salmon and developing conclusions, greater reliance was placed on the outputs
41 from the SALMOD model because it integrates the available information on
42 temperature and flows to produce estimates of mortality for each life stage and an
43 overall, integrated estimate of potential fall-run Chinook Salmon juvenile

1 production. The output from SALMOD indicated that late fall-run Chinook
2 Salmon production would be slightly lower under the No Action Alternative than
3 under the Second Basis of Comparison, although production under the No Action
4 Alternative could be slightly higher in some water year types and about 4 percent
5 less in critical dry years than under the Second Basis of Comparison. The
6 analyses attempting to assess the effects on routing, entrainment, and salvage of
7 juvenile salmonids in the Delta suggest that salvage (as an indicator of potential
8 losses of juvenile salmon at the export facilities) of Sacramento River-origin
9 Chinook Salmon is predicted to be lower under the No Action Alternative relative
10 to the Second Basis of Comparison in every month.

11 These model results suggest that overall, effects on late fall-run Chinook Salmon
12 could be slightly more adverse under the No Action Alternative than under the
13 Second Basis of Comparison, with a small likelihood that late fall-run Chinook
14 Salmon production would be lower under the No Action Alternative.

15 *Steelhead*

16 Changes in operations that influence temperature and flow conditions could affect
17 steelhead. The following describes those changes and their potential effects.

18 *Changes in Water Temperature*

19 Changes in water temperature could affect steelhead in the Sacramento, Feather,
20 and American rivers, and Clear Creek. The following describes temperature
21 conditions in those water bodies.

22 *Sacramento River*

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

38 Overall, the temperature differences between the No Action Alternative and
39 Second Basis of Comparison would be relatively minor (less than 0.5°F) and
40 likely would have little effect on steelhead in the Sacramento River. Based on the
41 life history timing for steelhead, the slightly higher water temperatures in
42 September of drier years under the No Action Alternative may increase the
43 likelihood of adverse effects on steelhead adults migrating upstream in the

1 Sacramento River. The lower water temperatures in September of wetter years
2 under the No Action Alternative may decrease the likelihood of adverse effects on
3 steelhead migration compared to the Second Basis of Comparison.

4 *Clear Creek*

5 Long-term average monthly water temperatures in Clear Creek at Igo under the
6 No Action Alternative and the Second Basis of Comparison generally would be
7 similar (less than 0.5°F differences). Water temperatures would be slightly higher
8 (up to about 0.5°F in dry years) during October (Appendix 6B, Table B-3-4).

9 Modeled average monthly water temperatures during May under the No Action
10 Alternative would be 0.4°F to 0.8°F lower than under the Second Basis of
11 Comparison depending on water year type.

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

21 *Feather River*

22 Long-term average monthly water temperature in the Feather River in the low
23 flow channel under the No Action Alternative relative to the Second Basis of
24 Comparison generally are predicted to be similar (less than 0.5°F differences), but
25 slightly higher from October through December when average monthly water
26 temperatures would be up to 1.4°F higher in some water year types. Modeled
27 water temperatures during May and June under the No Action Alternative were
28 also slightly higher, up to a maximum of 0.7°F higher in June of below normal
29 water years. Average monthly water temperatures in July through September
30 under the No Action Alternative generally were predicted to be higher (up to
31 0.6°F) in drier water year types and lower (up to 1.3°F) in the wetter years.

32 Although temperatures in the river generally become progressively higher in the
33 downstream direction, the differences between the No Action Alternative and
34 Second Basis of Comparison exhibit a similar pattern at the downstream locations
35 (Robinson Riffle and Gridley Bridge), with water temperature differences under
36 the No Action Alternative generally decreasing in most water year types relative
37 to the Second Basis of Comparison. Water temperatures under the No Action
38 Alternative are somewhat (0.7°F to 1.6°F) cooler on average and up to 4.0°F
39 cooler at the confluence with Sacramento River from July to September in wetter
40 years.

41 Overall, the temperature differences in the Feather River between the No Action
42 Alternative and Second Basis of Comparison would be relatively minor (less than
43 0.5°F) and likely would have little effect on steelhead in the Feather River. The
44 slightly higher water temperatures in November and December under the No

1 Action Alternative would likely have little effect on adult steelhead migration as
2 water temperatures in the Feather River are typically low during this time period.
3 The somewhat lower water temperatures in September of wetter years may reduce
4 the likelihood of adverse effects on adult steelhead migrating upstream and
5 juveniles rearing in the Feather River, although the increased temperatures in
6 September of critical dry years under the No Action Alternative may increase the
7 likelihood of adverse effects on migrating and rearing steelhead in this water year
8 type.

9 *American River*

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

22 Overall, the temperature differences between the No Action Alternative and
23 Second Basis of Comparison would be relatively minor (less than 0.5°F) and
24 likely would have little effect on steelhead in the American River. The slightly
25 warmer water temperatures in June and August under the No Action Alternative
26 may increase the likelihood of adverse effects on steelhead rearing in the
27 American River compared to the Second Basis of Comparison.

28 *Changes in Exceedances of Water Temperature Thresholds*

29 Changes in water temperature could result in the exceedance of established water
30 temperature thresholds for steelhead in the Sacramento River, Clear Creek, and
31 Feather River. The following describes the extent of exceedance for each of those
32 streams.

33 *Sacramento River*

34 As described in the life history accounts (Appendix), steelhead spawning in the
35 mainstem Sacramento River generally occurs in the upper reaches from Keswick
36 Dam downstream to near Balls Ferry, with most spawning concentrated near
37 Redding. Most steelhead, however, spawn in tributaries to the Sacramento River.
38 Spawning generally takes place in the January through March period when water
39 temperatures in the river generally do not exceed 52°F under either the No Action
40 Alternative or Second Basis of Comparison. While there are no established
41 temperature thresholds for steelhead rearing in the mainstem Sacramento River,
42 average monthly temperatures in during March through June when fry and
43 juvenile steelhead are in the river would be below 56°F during March and April at
44 Balls Ferry. In May and June, average monthly water temperatures would be

1 slightly higher under the No Action Alternative than they would be under the
2 Second Basis of Comparison in the drier years, although neither condition would
3 exceed about 57°F. Thus, as it relates to temperature conditions for steelhead in
4 the mainstem Sacramento River, it is unlikely that No Action Alternative and
5 Second Basis of Comparison would differ in a biologically meaningful way.

6 *Clear Creek*

7 While there are no established temperature thresholds for steelhead spawning in
8 Clear Creek, average monthly water temperatures in the river generally would not
9 exceed 48°F during the spawning period (December to April) under either the No
10 Action Alternative or Second Basis of Comparison. Similarly, while there are no
11 established temperature thresholds for steelhead rearing in Clear Creek, average
12 monthly temperatures in throughout the year would not exceed 56°F at Igo. Thus,
13 as it relates to temperature for steelhead in Clear Creek, it is unlikely that the No
14 Action Alternative and Second Basis of Comparison would differ in a biologically
15 meaningful way.

16 *Feather River*

17 Average monthly water temperatures under both the No Action Alternative and
18 the Second Basis of Comparison would on occasion exceed the water temperature
19 threshold of 56°F established in the Feather River at Robinson Riffle for steelhead
20 spawning and incubation during some months, particularly in October and
21 November, and March and April, when temperature thresholds could be exceeded
22 frequently (Appendix 9N). There would be a 1 percent exceedance of the 56°F
23 threshold in December and no exceedances of the 56°F threshold in January and
24 February under both the No Action Alternative and the Second Basis of
25 Comparison. However, the differences in the frequency of exceedance between
26 the No Action Alternative and Second Basis of Comparison during March and
27 April would be relatively small with water temperatures under the No Action
28 Alternative exceeding the threshold about 2 percent more frequently in March and
29 the same exceedance frequency (75 percent) as the Second Basis of Comparison
30 in April. Average monthly water temperatures under the

31 The established water temperature threshold of 63°F for rearing from May
32 through August would be exceeded often under both the No Action Alternative
33 and Second Basis of Comparison in May and June, but not at all in July and
34 August. Water temperatures under the No Action Alternative would exceed the
35 rearing temperature threshold about 9 percent more frequently than under the
36 Second Basis of Comparison in May, but no more frequently in June.
37 Temperature conditions in the Feather River under the No Action Alternative
38 could be more likely to affect steelhead spawning and rearing than under the
39 Second Basis of Comparison because of the slightly increased frequency of
40 exceedance of the 56°F spawning threshold in March and the somewhat increased
41 frequency of exceedance of the 63°F rearing threshold in May.

1 *American River*

2 In the American River, the water temperature threshold for steelhead rearing
3 (May through October) is 65°F at the Watt Avenue Bridge. Average monthly
4 water temperatures would exceed this threshold often under both the No Action
5 Alternative and Second Basis of Comparison, especially in the July through
6 September period when the threshold is exceeded nearly all of the time. In
7 addition, the magnitude of the exceedance would be high, with average monthly
8 water temperatures sometimes higher than 76°F. The differences between the No
9 Action Alternative and Second Basis of Comparison, however, would be
10 relatively small and occur only in June (1 percent less frequent under the No
11 Action Alternative), and in September, when average monthly water temperatures
12 under the No Action Alternative would exceed 65°F about 7 percent less
13 frequently than under the Second Basis of Comparison. Temperature conditions
14 in the American River under the No Action Alternative could be less likely to
15 affect steelhead rearing than under the Second Basis of Comparison because of
16 the reduced frequency of exceedance of the 65°F rearing threshold.

17 *Changes in Weighted Usable Area*

18 The following describes changes in WUA for steelhead in the Sacramento,
19 Feather, and American rivers and Clear Creek.

20 *Sacramento River*

21 Modeling results indicate that, in general, there would be greater amounts of
22 suitable steelhead spawning habitat available from December through March
23 under the No Action Alternative as compared to the Second Basis of Comparison
24 (Appendix 9E, Table C-20-4). The increases in long-term average steelhead
25 spawning WUA would be relatively small (less than 3 percent). Overall,
26 spawning habitat availability would be similar under the No Action Alternative
27 and the Second Basis of Comparison.

28 *Clear Creek*

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

36 *Feather River*

37 As described above, flows in the low flow channel of the Feather River are not
38 anticipated to differ under the No Action Alternative relative to the Second Basis
39 of Comparison. Therefore, there would be no change in the amount of potentially
40 suitable spawning habitat for steelhead (as indexed by WUA) available under the
41 No Action Alternative as compared to the Second Basis of Comparison. The
42 majority of spawning activity by steelhead in the Feather River occurs in this

1 reach with a lesser amount of spawning occurring downstream of the Thermalito
2 Complex.

3 Modeling results indicate that, in general, there would be greater amounts of
4 spawning habitat for steelhead in the Feather River downstream of Thermalito
5 available from December through April under the No Action Alternative as
6 compared to the Second Basis of Comparison. The increases in long-term
7 average steelhead spawning WUA during this time period would generally be less
8 than 4 percent (Appendix 9E, Table C-22-4). Overall, steelhead spawning habitat
9 availability in the Feather River would be similar under the No Action Alternative
10 and the Second Basis of Comparison.

11 *American River*

12 Modeling results indicate that, in general, there would be variable changes in the
13 amount of spawning habitat for steelhead in the American River downstream of
14 Nimbus Dam available from December through April under the No Action
15 Alternative as compared to the Second Basis of Comparison. The increases in
16 long-term average steelhead spawning WUA during December, February and
17 March would generally be less than 3 percent, while the decrease in April would
18 also be less than 3 percent (Appendix 9E, Table C-26-4). Overall, steelhead
19 spawning habitat availability in the American River would be similar under the
20 No Action Alternative and the Second Basis of Comparison.

21 *Changes in Delta Hydrodynamics*

22 Sacramento River-origin steelhead generally move through the Delta during
23 spring; however, there is less information on their timing than there is for
24 Chinook Salmon. Thus, hydrodynamics in the entire January through June period
25 have the potential to affect juvenile steelhead. For a description of potential
26 hydrodynamic effects on steelhead, see the descriptions for winter-run and fall-
27 run Chinook Salmon above.

28 *Changes in Entrainment at Junctions*

29 Entrainment at Georgiana Slough was similar under both scenarios in most
30 months, but was slightly lower under the No Action Alternative in the month of
31 June (Appendix 9L). At the Head of Old River, entrainment under the No Action
32 Alternative was slightly lower during January and February. Entrainment
33 probabilities were much greater under the No Action Alternative during April and
34 May. Entrainment probabilities were similar under both alternatives in the month
35 of June. At the Turner Cut junction, entrainment probabilities under the No
36 Action Alternative were slightly lower than the Second Basis of Comparison in
37 January, February, March, and June. During April and May, entrainment
38 probabilities were more divergent with lower values for the No Action Alternative
39 relative to the Second Basis of Comparison. Overall, entrainment was lower at
40 the Columbia Cut junction relative to Turner Cut, but patterns of entrainment
41 between these two alternatives were similar. Entrainment was slightly lower for
42 the No Action Alternative relative to the Second Basis of Comparison during
43 January, February, March, and June. In April and May, entrainment was lower
44 for the No Action Alternative relative to the Second Basis of Comparison.

1 Patterns at the Middle River and Old River junctions were similar to those
2 observed at the Columbia and Turner Cut junctions.

3 *Summary of Effects on Steelhead*

4 The multiple model and analysis outputs described above characterize the
5 anticipated conditions for steelhead and their response to change under the No
6 Action Alternative as compared to the Second Basis of Comparison. The analysis
7 of the effects of the No Action Alternative and Second Basis of Comparison for
8 steelhead relied on the WUA analysis for habitat and water temperature model
9 output for the rivers at various locations downstream of the CVP and SWP
10 facilities. The WUA analysis indicated that the availability of steelhead spawning
11 and rearing habitat in Clear Creek and steelhead spawning habitat in the
12 Sacramento, Feather and American rivers would be similar under the No Action
13 Alternative and the Second Basis of Comparison. The temperature model outputs
14 for each of the steelhead life stages suggest that thermal conditions and effects on
15 steelhead in all of these streams generally would be similar under both scenarios.
16 This conclusion is supported by the water temperature threshold exceedance
17 analysis that indicated that the water temperature thresholds for steelhead
18 spawning and egg incubation would be exceeded more frequently in the Feather
19 River. The water temperature threshold for steelhead rearing would also be
20 exceeded more frequently in the Feather River. Given the inherent uncertainty
21 associated with the resolution of the temperature model (average monthly
22 outputs), the increased frequency of exceedance of temperature thresholds under
23 the No Action Alternative could increase the potential for adverse effects on the
24 steelhead population in the Feather River.

25 These model results suggest that overall, effects on steelhead could be slightly
26 more adverse under the No Action Alternative than under the Second Basis of
27 Comparison, particularly in the Feather River. Implementation of the fish passage
28 program under the No Action Alternative intended to address the limited
29 availability of suitable habitat for steelhead in the Sacramento River reaches
30 downstream of Keswick Dam and in the American River could provide a benefit
31 to Central Valley steelhead in the Sacramento and American rivers.

32 *Green Sturgeon*

33 Potential effects on Green Sturgeon were evaluated based on anticipated water
34 temperature conditions and exceedances of established temperature thresholds in
35 the Sacramento and Feather rivers as described below.

36 *Changes in Water Temperature*

37 Long-term average monthly water temperatures in the Sacramento River at
38 Keswick Dam under the No Action Alternative would generally be similar (less
39 than 0.5°F difference) to water temperatures under the Second Basis of
40 Comparison. An exception is during September and October of critical years
41 when water temperatures could be up to 1.1°F and 0.8°F higher, respectively,
42 under the No Action Alternative as compared to the Second Basis of Comparison
43 and up to 1°F cooler in September of wetter years under the No Action
44 Alternative. Water temperatures below Keswick Dam are slightly higher from

1 October to December under the No Action Alternative than under the Second
2 Basis of Comparison in most water year types, but by less than 0.5°F on average
3 (Appendix 6B). A similar pattern in temperature differences generally would be
4 exhibited at downstream locations along the Sacramento River (i.e., Ball's Ferry
5 Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights Landing), with
6 differences in average monthly temperatures in June at Knights Landing
7 progressively increasing (up to 0.9°F) under the No Action Alternative relative to
8 the Second Basis of Comparison and progressively decreasing (up to 4.6°F) in
9 September during the wetter years.

10 Overall, the temperature differences between the No Action Alternative and
11 Second Basis of Comparison would be relatively minor (less than 0.5°F) and
12 likely would have little effect on Green Sturgeon in the Sacramento River. The
13 lower water temperatures from January through May under the No Action
14 Alternative may decrease the likelihood of adverse effects on migrating adult
15 Green Sturgeon and spawning and egg incubation compared to the Second Basis
16 of Comparison.

17 *Feather River*

18 Long-term average monthly water temperatures in the Feather River in the low
19 flow channel under the No Action Alternative relative to the Second Basis of
20 Comparison generally are predicted to be similar (less than 0.5°F differences), but
21 slightly higher from October through December when average monthly water
22 temperatures would be up to 1.4°F higher in some water year types. Modeled
23 water temperatures during May and June under the No Action Alternative were
24 also slightly higher, up to a maximum of 0.7°F higher in June of below normal
25 water years. Average monthly water temperatures in July through September
26 under the No Action Alternative generally were predicted to be higher (up to
27 0.6°F) in drier water year types and lower (up to 1.3°F) in the wetter years.
28 Although temperatures in the river would become progressively higher in the
29 downstream directions, the differences between the No Action Alternative and
30 Second Basis of Comparison would exhibit a similar pattern at the downstream
31 locations (Robinson Riffle and Gridley Bridge), with temperatures under the No
32 Action Alternative generally decreasing in most water year types relative to the
33 Second Basis of Comparison at the confluence with Sacramento River
34 (Appendix 6B, Table B-23-1).

35 Overall, the temperature differences between the No Action Alternative and
36 Second Basis of Comparison would be relatively minor (less than 0.5°F) and
37 likely would have little effect on Green Sturgeon in the Feather River. The
38 slightly higher water temperatures from January through April under the No
39 Action Alternative may decrease the likelihood of adverse effects on migrating
40 adult Green Sturgeon compared to the Second Basis of Comparison. Higher
41 water temperatures in May and June under the No Action Alternative could
42 increase the likelihood of adverse effects on egg incubation and rearing of Green
43 Sturgeon in the Feather River as compared to the Second Basis of Comparison.

1 *Changes in Exceedances of Water Temperature Thresholds*

2 Changes in water temperature could result in the exceedance of established water
3 temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers.
4 The following describes the exceedances for each of those rivers.

5 *Sacramento River*

6 Average monthly water temperatures in the Sacramento River at Bend Bridge
7 under both the No Action Alternative and Second Basis of Comparison would
8 exceed the water temperature threshold of 63°F established for Green Sturgeon
9 egg incubation in August and September, with exceedances under the No Action
10 Alternative occurring about 7 percent of the time in August and about 12 percent
11 of the time in September. This is 1 to 2 percent more frequently than under the
12 Second Basis of Comparison. Average monthly water temperatures at Bend
13 Bridge could exceed the threshold by up to 10 degrees (reaching 73°F) during this
14 period. Temperature conditions in the Sacramento River under the No Action
15 Alternative could be more likely to affect Green Sturgeon rearing than under the
16 Second Basis of Comparison because of the increased frequency of exceedance of
17 the 63°F threshold in August and September.

18 *Feather River*

19 Average monthly water temperatures in the Feather River at Gridley Bridge under
20 both the No Action Alternative and Second Basis of Comparison would exceed
21 the water temperature threshold of 64°F established for Green Sturgeon spawning,
22 incubation, and rearing in May, June, and September; no exceedances under either
23 condition would occur in July and August. The frequency of exceedances would
24 be high, with both the No Action Alternative and Second Basis of Comparison
25 exceeding the threshold in June nearly 100 percent of the time. The magnitude of
26 the exceedance also would be substantial, with average monthly temperatures
27 higher than 72°F in June, and higher than 75°F in July and August. Average
28 monthly water temperatures under the No Action Alternative would exceed the
29 threshold during May about 9 percent more frequently than the Second Basis of
30 Comparison and about 35 percent less frequently in September. Temperature
31 conditions in the Feather River under the No Action Alternative could be more
32 likely to affect Green Sturgeon rearing than under the Second Basis of
33 Comparison because of the increased frequency of exceedance of the 64°F
34 threshold in May. The reduction in exceedance frequency in September may have
35 little effect on rearing Green Sturgeon as many juvenile sturgeon may have
36 migrated downstream to the lower Sacramento River and Delta by this time.

37 *Summary of Effects on Green Sturgeon*

38 The analysis of the effects of the No Action Alternative and Second Basis of
39 Comparison for Green Sturgeon relied on water temperature model output for the
40 Sacramento and Feather rivers at various locations downstream of Shasta Dam
41 and the Thermalito complex. The temperature model outputs for each of these
42 rivers suggest that thermal conditions and effects on Green Sturgeon in the
43 Sacramento and Feather rivers generally would be slightly more adverse under the
44 No Action Alternative. This conclusion is supported by the water temperature

1 threshold exceedance analysis that indicated that the water temperature thresholds
2 for Green Sturgeon spawning, incubation, and rearing would be exceeded more
3 frequently under the No Action Alternative in the Sacramento River. The water
4 temperature threshold for Green Sturgeon spawning, incubation, and rearing
5 would also be exceeded more frequently during some months in the Feather River
6 but would be exceeded substantially less frequently in September under the No
7 Action Alternative.

8 Overall, the increased frequency of exceedance of temperature thresholds under
9 the No Action Alternative could increase the potential for adverse effects on
10 Green Sturgeon in the Sacramento and Feather rivers relative to the Second Basis
11 of Comparison.

12 *White Sturgeon*

13 Changes in water temperature conditions in the Sacramento River would be the
14 same as those described above for Green Sturgeon in the Sacramento River.
15 Overall, the temperature differences between the No Action Alternative and
16 Second Basis of Comparison would be relatively minor (less than 0.5°F) and
17 likely would have little effect on White Sturgeon in the Sacramento River.

18 The water temperature threshold established for White Sturgeon spawning and
19 egg incubation in the Sacramento River at Hamilton City is 61°F from March
20 through June. Although there would be no exceedances of the threshold in March
21 and April, water temperatures under both the No Action Alternative and Second
22 Basis of Comparison would exceed this threshold in May and June. The average
23 monthly water temperatures in May under the No Action Alternative would
24 exceed this threshold about 55 percent of the time (about 6 percent more
25 frequently than the Second Basis of Comparison). In June, average monthly
26 water temperatures under the No Action Alternative would exceed the threshold
27 about 86 percent of the time (about 13 percent more frequently than the Second
28 Basis of Comparison). Average monthly water temperatures during May and
29 June under the No Action Alternative would as high as about 65°F which is below
30 the 68°F threshold considered lethal for White Sturgeon eggs. Temperature
31 conditions in the Sacramento River under the No Action Alternative could be
32 more likely to affect White Sturgeon rearing than under the Second Basis of
33 Comparison because of the increased frequency of exceedance of the 61°F
34 threshold in May and June.

35 The analysis of the effects of the No Action Alternative and Second Basis of
36 Comparison for White Sturgeon relied on water temperature model output for the
37 Sacramento River at various locations downstream of Shasta Dam. The
38 temperature model outputs suggest that thermal conditions and effects on White
39 Sturgeon in the Sacramento River generally would be slightly more adverse under
40 the No Action Alternative. This conclusion is supported by the water temperature
41 threshold exceedance analysis that indicated that the water temperature thresholds
42 for White Sturgeon spawning, incubation, and rearing would be exceeded more
43 frequently under the No Action Alternative in the Sacramento River.

1 Overall, the increased frequency of exceedance of temperature thresholds under
2 the No Action Alternative could increase the potential for adverse effects on
3 White Sturgeon in the Sacramento River relative to the Second Basis of
4 Comparison.

5 *Delta Smelt*

6 The potential effects of the No Action Alternative as compared to the Second
7 Basis of Comparison were analyzed based on differences in proportional
8 entrainment and the fall abiotic index as described below.

9 As described in Appendix 9G, a proportional entrainment regression model
10 (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt
11 entrainment, as influenced by OMR flow in December through March. Results
12 indicate that the percentage of entrainment of migrating and spawning adult Delta
13 Smelt under the No Action Alternative would be 7 to 8.3 percent, depending on
14 the water year type, with a long-term average percent entrainment of 7.6 percent.
15 Percent entrainment of adult Delta Smelt under the No Action Alternative would
16 be similar to results under the Second Basis of Comparison (but slightly lower, by
17 1 to 2 percent). Under the Second Basis of Comparison, the long-term average
18 percent entrainment would be 9 percent.

19 A proportional entrainment regression model (based on Kimmerer 2008) was also
20 used to simulate larval and early juvenile Delta Smelt entrainment, as influenced
21 by OMR flow and location of X2 in March through June (Appendix 9G). Results
22 indicate that the percentage of entrainment of larval and early juvenile Delta
23 Smelt under the No Action Alternative would be 1.3 to 19.3 percent, depending
24 on the water year type, with a long term average percent entrainment of
25 8.6 percent, and highest entrainment under critical water year conditions. Percent
26 entrainment of larval and early juvenile Delta Smelt under the No Action
27 Alternative would be lower than projected entrainment under the Second Basis of
28 Comparison by 4.3 to 9.4 percent. Under the Second Basis of Comparison, the
29 long-term average percent entrainment would be 15.5 percent, and highest
30 entrainment would occur under critical water year conditions, at 23.6 percent.

31 The predicted position of Fall X2 (in September through December) is used as an
32 indicator of fall abiotic habitat index for Delta Smelt. Feyrer et al. (2011) used
33 X2 location as an indicator of the extent of habitat available with suitable salinity
34 for the rearing of older juvenile delta smelt. Feyrer et al. (2011) concluded that
35 when X2 is located downstream (west) of the confluence of the Sacramento and
36 San Joaquin Rivers, at a distance of 70 to 80 km from the Golden Gate Bridge,
37 there is a larger area of suitable habitat. The overlap of the low salinity zone (or
38 X2) with the Suisun Bay/Marsh is believed to lead to more favorable growth and
39 survival conditions for Delta Smelt in fall. The average September through
40 December X2 position in km was used to evaluate the fall abiotic habitat
41 availability for Delta Smelt under the Alternatives. X2 values simulated in the
42 CalSim II model for each Alternative were averaged over September through
43 December, and compared.

1 The average September through December X2 position in km was used to
 2 evaluate the fall abiotic habitat availability for Delta Smelt under the Alternatives.
 3 X2 values simulated in the CalSim II model for each Alternative were averaged
 4 over September through December, and compared. Results indicate that under
 5 the No Action Alternative, the X2 position would range from 75.9 km to 92.4 km,
 6 depending on the water year type, with a long term average X2 position of 84 km.
 7 The most eastward location of X2 is predicted under Critical water year
 8 conditions. The X2 positions predicted under the No Action Alternative would be
 9 similar to results under the Second Basis of Comparison in drier water year types.
 10 In wetter years, the X2 location would be further west under the No Action
 11 Alternative than under the Second Basis of Comparison, by 6.1 to 9.8 km. This
 12 difference is largely due to implementation of 2008 USFWS BO RPA Component
 13 3 (Action 4), under the No Action Alternative, which requires Reclamation and
 14 DWR to provide sufficient Delta outflow to maintain a monthly average X2 no
 15 more eastward than 74 km in above normal and wet year types. Under the Second
 16 Basis of Comparison, the long-term average X2 position would be 88.1 km, a
 17 location that does not provide for the advantageous overlap of the low salinity
 18 zone with Suisun Bay/Marsh.

19 Overall, the No Action Alternative likely would result in better conditions for
 20 Delta Smelt than would the Second Basis of Comparison, primarily due to lower
 21 percentage entrainment for larval and juvenile life stages, and more favorable
 22 location of Fall X2 in wetter years, and on average.

23 *Longfin Smelt*

24 The effects of the No Action Alternative as compared to the Second Basis of
 25 Comparison were analyzed based on the direction and magnitude of OMR flows
 26 during the period (December through June) when adult, larvae, and young
 27 juvenile Longfin Smelt are present in the Delta in the vicinity of the export
 28 facilities (Appendix 5A). The analysis was augmented with calculated Longfin
 29 Smelt abundance index values (Appendix 9G) per Kimmerer et al. (2009), which
 30 is based on the assumptions that lower X2 values reflect higher flows and that
 31 transporting Longfin Smelt farther downstream leads to greater Longfin Smelt
 32 survival. The index value indicates the relative abundance of Longfin Smelt and
 33 not the calculated population.

34 As described in Appendix 5A, OMR flows would generally be negative in all
 35 months under the Second Basis of Comparison, with the long-term average
 36 ranging from -3,700 to -7,400 cfs from December through June; whereas the
 37 OMR flows would generally be less negative during this time period under the No
 38 Action Alternative. The greatest differences between alternatives would be in
 39 April and May, where long-term average OMR flows would be positive under the
 40 No Action Alternative (Appendix 5A, Table C-17-4). The decrease in the
 41 magnitude of negative flows, with positive flows in April and May, under the No
 42 Action Alternative as compared to the Second Basis of Comparison suggests that
 43 it could reduce the potential for entrainment of Delta Smelt at the export facilities.

44 Under the No Action Alternative, Longfin Smelt abundance index values range
 45 from 1,147, under critical water year conditions, to a high of 16,635 under wet

1 water year conditions, with a long-term average value of 7,951. Under the
2 Second Basis of Comparison, Longfin Smelt abundance index values range from
3 947 during critical water year conditions to a high of 15,822 under wet water year
4 conditions, with a long-term average value of 7,257. These results suggest that
5 the Longfin Smelt abundance index values would be higher in every water year
6 type under the No Action Alternative as compared to the Second Basis of
7 Comparison, with a long-term average index for the No Action Alternative that is
8 almost 10 percent higher than the long-term average index for the Second Basis of
9 Comparison. For below normal, dry, and critical water years, the Longfin Smelt
10 abundance index values would be over 20 percent higher under the No Action
11 Alternative than under the Second Basis of Comparison, with the greatest
12 difference (26.2 percent) predicted under dry conditions.

13 Overall, based on the decrease in frequency and magnitude of negative OMR
14 flows and the higher Longfin Smelt abundance index values, especially in dry and
15 critical years, potential adverse effects on the Longfin Smelt population under the
16 No Action Alternative likely would be less than under the Second Basis of
17 Comparison.

18 *Sacramento Splittail*

19 Sacramento Splittail could benefit from the increase in inundated floodplain
20 resulting from implementation of 2009 NMFS BO RPA Action I.6.1, Restoration
21 of Floodplain Rearing Habitat, which would restore 17,000 to 20,000 acres for the
22 primary purpose of enhancing rearing habitat for juvenile salmonids. The efforts
23 currently underway in the Yolo Bypass to comply with this action apply to all
24 alternatives under consideration and it is assumed that a notch in the Fremont
25 Weir (6,000 cfs capacity) will be constructed and that the inundation objectives
26 will be met by 2030. It is not currently known if and how the notch would be
27 operated and how flows entering the bypass would be managed to accommodate
28 floodplain rearing.

29 While this action is common to all alternatives, changes in operations that
30 influence the hydrology in the Sacramento River could affect the frequency and
31 duration of flows available to provide inundation on the bypass. To generally
32 evaluate the potential influence of these changes in hydrology, the flows entering
33 the Yolo Bypass during December through April were examined to determine the
34 differences among alternatives. It was assumed that changes in flow, particularly
35 those in the range of the 6,000 cfs capacity of the notch and during drier years,
36 would be more likely to influence the acreage of inundated floodplain or the
37 frequency and duration of inundation. It also was assumed that the magnitude of
38 flow (and flow change) roughly corresponds to the amount of inundated
39 floodplain created.

40 Under the No Action Alternative, flows entering the Yolo Bypass generally would
41 be lower than under the Second Basis of Comparison, especially during below
42 normal years when flows entering the bypass under the No Action Alternative
43 would be lower in December through March (Appendix 5A, Table C-26-4).
44 These decreases would occur during periods of relatively low flow in the bypass,
45 and could slightly decrease the frequency of potential inundation.

1 Overall, the slight decreases under the No Action Alternative could result in less
 2 spawning habitat for Sacramento Splittail than under the Second Basis of
 3 Comparison because of the decreased area of potential habitat (inundation) and
 4 the potential for a slight decrease in the frequency of inundation.

5 *Reservoir Fishes*

6 The analysis of effects associated with changes in operation on reservoir fishes
 7 relied on evaluation of changes in available habitat (reservoir storage) and
 8 anticipated changes in black bass nesting success.

9 *Changes in Available Habitat (Storage)*

10 As described in Chapter 5, Surface Water Resources and Water Supplies, changes
 11 in CVP and SWP water supplies and operations under the No Action Alternative
 12 as compared to the Second Basis of Comparison generally would result in lower
 13 reservoir storage in CVP and SWP reservoirs in the Central Valley Region.
 14 Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be lower
 15 under the No Action Alternative as compared to the Second Basis of Comparison,
 16 as summarized in Tables 5.12 through 5.14, in the fall and winter months due to
 17 the inclusion of Fall X2 criteria under the No Action Alternative.

18 The highest reductions in Shasta Lake and Lake Oroville storage could be in
 19 excess of 20 percent. Storage in Folsom Lake could be reduced up to around
 20 10 percent in some months of some water year types. Additional information
 21 related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and
 22 DSM2 Modeling. It is anticipated that aquatic habitat within the CVP and SWP
 23 water supply reservoirs is not limiting; however, storage volume is an indicator of
 24 how much habitat is available to fish species inhabiting these reservoirs.
 25 Therefore, the amount of habitat for reservoir fishes could be reduced under the
 26 No Action Alternative as compared to the Second Basis of Comparison.

27 *Changes in Black Bass Nesting Success*

28 Black bass nest survival in CVP and SWP reservoirs is anticipated to be near
 29 100 percent in March and April due to increasing reservoir elevations
 30 (Appendix 9F). For May, the likelihood of nest survival for Largemouth Bass in
 31 Shasta Lake being in the 40 to 100 percent range is about 2 percent higher under
 32 the No Action Alternative as compared to the Second Basis of Comparison. For
 33 June, the likelihood of nest survival being greater than 40 percent for Largemouth
 34 Bass is similar (within 1 percent) under the No Action Alternative and Second
 35 Basis of Comparison; however, nest survival of greater than 40 percent is likely
 36 only in about 20 percent of the years evaluated. The likelihood of nest survival
 37 for Smallmouth Bass in Shasta Lake exhibits nearly the same pattern. For Spotted
 38 Bass, the likelihood of nest survival being greater than 40 percent is high
 39 (100 percent) in May under both the No Action Alternative and the Second Basis
 40 of Comparison with the likelihood of greater than 40 percent nest survival being
 41 slightly less under the No Action Alternative as compared to the Second Basis of
 42 Comparison. For June, Spotted Bass nest survival would be less than for May due
 43 to greater daily reductions in water surface elevation as Shasta Lake is drawn
 44 down. The likelihood of survival being greater than 40 percent is somewhat

1 higher (about 10 percent) under the No Action Alternative as compared to the
2 Second Basis of Comparison.

3 For May and June, the likelihood of nest survival for Largemouth Bass in Lake
4 Oroville being in the 40 to 100 percent range is higher under the No Action
5 Alternative as compared to the Second Basis of Comparison, about 10 percent
6 higher in May and 3 percent higher in June. However, June nest survival of
7 greater than 40 percent is likely only in about 40 percent of the years evaluated.
8 The likelihood of nest survival for Smallmouth Bass in Lake Oroville exhibits
9 nearly the same pattern. For Spotted Bass, the likelihood of nest survival being
10 greater than 40 percent is high (>90 percent) in May under both the No Action
11 Alternative and the Second Basis of Comparison with the likelihood of greater
12 than 40 percent survival being slightly (about 4 percent) higher under the No
13 Action Alternative as compared to the Second Basis of Comparison. For June,
14 Spotted Bass survival would be less than for May due to greater daily reductions
15 in water surface elevation as Lake Oroville is drawn down. The likelihood of
16 survival being greater than 40 percent is substantially (about 20 percent) higher
17 under the No Action Alternative as compared to the Second Basis of Comparison.

18 Black bass nest survival in Folsom Lake is near 100 percent in March, April, and
19 May due to increasing reservoir elevations. For June, the likelihood of nest
20 survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the
21 40 to 100 percent range is somewhat (around 5 percent) higher under the No
22 Action Alternative as compared to the Second Basis of Comparison. For Spotted
23 Bass, nest survival for June would be less than for May due to greater daily
24 reductions in water surface elevation. However, the likelihood of survival being
25 greater than 40 percent is somewhat (about 5 percent) higher under the No Action
26 Alternative as compared to the Second Basis of Comparison.

27 *Summary of Effects on Reservoir Fishes*

28 Reservoir storage is anticipated to be reduced under the No Action Alternative
29 relative to the Second Basis of Comparison and this reduction could affect the
30 amount of warm and cold water habitat available within the reservoirs. However,
31 it is unlikely that aquatic habitat within the CVP and SWP water supply reservoirs
32 is limiting and therefore, it is unlikely that habitat for reservoir fish in the CVP
33 and SWP storage reservoirs under the No Action Alternative and the Second
34 Basis of Comparison would differ in a biologically meaningful manner.

35 The analysis of black bass nest survival based on changes in water surface
36 elevation during the spawning period indicated that the likelihood of high
37 (>40 percent) nest survival in most of the reservoirs under the No Action
38 Alternative would be similar to or slightly higher than under the Second Basis of
39 Comparison.

40 Overall, the results of the nest survival analysis suggest that conditions in the
41 reservoirs would be more likely to support self-sustaining populations of black
42 bass under the No Action Alternative than under the Second Basis of Comparison.

1 *Pacific Lamprey*

2 Little information is available on factors that influence populations of Pacific
3 Lamprey in the Sacramento River, but they are likely affected by many of the
4 same factors as salmon and steelhead because of the parallels in their life cycles.

5 *Changes in Water Temperature*

6 The following describes anticipated changes in average monthly water
7 temperature in the Sacramento, Feather, and American rivers and the potential for
8 those changes to affect Pacific Lamprey.

9 *Sacramento River*

10 Long-term average monthly water temperatures in the Sacramento River at
11 Keswick Dam under the No Action Alternative would generally be similar (less
12 than 0.5°F difference) to water temperatures under the Second Basis of
13 Comparison. An exception is during September and October of critical dry years
14 when water temperatures could be up to 1.1°F and 0.8°F higher, respectively,
15 under the No Action Alternative as compared to the Second Basis of Comparison
16 and up to 1°F cooler in September of wetter years under the No Action
17 Alternative. Water temperatures below Keswick Dam are slightly higher from
18 October to December under the No Action Alternative than under the Second
19 Basis of Comparison in most water year types, but by less than 0.5°F on average
20 (Appendix 6B, Table 5-5-4). A similar temperature pattern generally would be
21 exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with
22 average monthly temperatures in June progressively increasing by a small margin
23 under the No Action Alternative relative to the Second Basis of Comparison. Due
24 to the similarity of water temperatures under the No Action Alternative and
25 Second Basis of Comparison from January through the summer, there would be
26 little difference in potential effects on Pacific Lamprey adults during their
27 migration, holding, and spawning periods.

28 *Feather River*

29 Long-term average monthly water temperature in the Feather River in the low
30 flow channel (downstream of the Thermalito Complex) under the No Action
31 Alternative relative to the Second Basis of Comparison generally are predicted to
32 be similar (less than 0.5°F differences), but slightly higher from October through
33 December when average monthly water temperatures would be up to 1.4°F higher
34 in some water year types. Modeled water temperatures during May and June
35 under the No Action Alternative were also slightly higher, up to a maximum of
36 0.7°F higher in June of below normal water years. Average monthly water
37 temperatures in July through September under the No Action Alternative
38 generally were predicted to be higher (up to 0.6°F) in drier water year types and
39 lower (up to 1.3°F) in the wetter years (Appendix 6B, Table B-20-4). Although
40 temperatures in the river would become progressively higher in the downstream
41 directions, the differences in water temperatures between the No Action
42 Alternative and Second Basis of Comparison would exhibit a similar pattern at the
43 downstream locations (Robinson Riffle and Gridley Bridge), with temperatures
44 under the No Action Alternative generally decreasing in most water year types

1 relative to the Second Basis of Comparison at the confluence with Sacramento
2 River (Appendix 6B, Table B-23-4).

3 Due to the similarity of water temperatures under the No Action Alternative and
4 Second Basis of Comparison from January through April, there would be little
5 difference in potential effects on Pacific Lamprey adults during their upstream
6 migration. The slightly higher water temperatures from May through the summer
7 may increase the likelihood of adverse effects on Pacific Lamprey during their
8 holding, and spawning periods.

9 *American River*

10 Average monthly water temperatures in the American River at Nimbus Dam
11 under the No Action Alternative generally would be similar (differences less than
12 0.5°F) to the Second Basis of Comparison, with the exception of during June and
13 August, when differences under the No Action Alternative could be as much as
14 0.9°F higher in below normal years. This pattern generally would persist
15 downstream to Watt Avenue and the mouth, although temperatures under the No
16 Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than
17 under the Second Basis of Comparison in June. In addition, average monthly
18 water temperatures at the mouth generally would be lower under the No Action
19 Alternative than the Second Basis of Comparison in September, especially in
20 wetter water year types when the No Action Alternative could be up to 1.7°F
21 cooler. Due to the similarity of water temperatures under the No Action
22 Alternative and Second Basis of Comparison from January through May, there
23 would be little difference in potential effects on Pacific Lamprey adults during
24 their upstream migration. The higher water temperatures during June and August
25 may increase the likelihood of adverse effects on Pacific Lamprey during their
26 holding, and spawning periods.

27 *Summary of Effects on Pacific Lamprey*

28 In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up
29 to around 72°F during their entire life history. Based on the somewhat reduced
30 flows and increased temperatures during their spawning and incubation period
31 under the No Action Alternative, it is unlikely that conditions for and effects on
32 Pacific Lamprey in the Sacramento, Feather, and American rivers under the No
33 Action Alternative and the Second Basis of Comparison would differ in a
34 biologically meaningful manner. This conclusion likely applies to other species
35 of lamprey that inhabit these rivers (e.g., River Lamprey).

36 *Striped Bass, American Shad, and Hardhead*

37 Changes in operations influence temperature and flow conditions that could affect
38 Striped Bass, American Shad, and Hardhead. The following describes those
39 changes and their potential effects.

40 *Changes in Water Temperature*

41 The following describes temperature conditions in the Sacramento, Feather, and
42 American rivers.

Sacramento River

1
2 Long-term average monthly water temperatures in the Sacramento River at
3 Keswick Dam under the No Action Alternative would generally be similar (less
4 than 0.5°F difference) to water temperatures under the Second Basis of
5 Comparison. An exception is during September and October of critical dry years
6 when water temperatures could be up to 1.1°F and 0.8°F higher, respectively,
7 under the No Action Alternative as compared to the Second Basis of Comparison
8 and up to 1°F cooler in September of wetter years under the No Action
9 Alternative. Water temperatures from October to December would be slightly
10 higher under the No Action Alternative than under the Second Basis of
11 Comparison in most water year types, but by less than 0.5°F on average
12 (Appendix 6B, Table 5-5-4). A similar temperature pattern generally would be
13 exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with
14 average monthly temperatures in June progressively increasing by a small margin
15 under the No Action Alternative relative to the Second Basis of Comparison. In
16 general, Striped Bass, American Shad, and Hardhead can tolerate higher
17 temperatures than salmonids. Therefore, it is unlikely that the slightly increased
18 temperatures during some months under the No Action Alternative would have
19 substantial adverse effects on these species.

Feather River

20
21 Average monthly water temperature in the Feather River in the low flow channel
22 (below the Thermalito Complex) under the No Action Alternative relative to the
23 Second Basis of Comparison generally were predicted to be similar (less than
24 0.5°F differences), but slightly higher from October through December when
25 average monthly water temperatures would be up to 1.4°F higher in some water
26 year types (Appendix 6B, Table B-20-4). Although temperatures in the river
27 would become progressively higher in the downstream directions, the differences
28 between the No Action Alternative and Second Basis of Comparison would
29 exhibit a similar pattern at the downstream locations (Appendix 6B,
30 Table B-23-4). As described above for the Sacramento River, Striped Bass,
31 American Shad, and Hardhead can tolerate higher temperatures than salmonids.
32 Therefore, it is unlikely that the slightly increased temperatures during some
33 months under the No Action Alternative would have substantial adverse effects
34 on these species in the Feather River.

American River

35
36 Average monthly water temperatures in the American River at Nimbus Dam
37 under the No Action Alternative generally would be similar (differences less than
38 0.5°F) to the Second Basis of Comparison, with the exception of during June and
39 August, when differences under the No Action Alternative could be as much as
40 0.9°F higher in below normal years. This pattern generally would persist
41 downstream to Watt Avenue and the mouth, although temperatures under the No
42 Action Alternative would be up to 1.6°F and 2.0°F greater, respectively, than
43 under the Second Basis of Comparison in June. As described above for the
44 Sacramento River, Striped Bass, American Shad, and Hardhead can tolerate

1 higher temperatures than salmonids. Therefore, it is unlikely that the slightly
2 increased temperatures during some months under the No Action Alternative
3 would have substantial adverse effects on these species in the American River.

4 *Summary of Effects on Striped Bass, American Shad, and Hardhead*

5 In general, Striped Bass, American Shad, and Hardhead can tolerate higher
6 temperatures than salmonids. Based on the slightly decreased flows and increased
7 temperatures during their spawning and incubation period under the No Action
8 Alternative, it is unlikely that conditions for and effects on Striped Bass,
9 American Shad, and Hardhead in the Sacramento, Feather, and American rivers
10 under the No Action Alternative and the Second Basis of Comparison would
11 differ in a biologically meaningful manner.

12 **9.4.3.1.3 Stanislaus River/Lower San Joaquin River**

13 *Fall-Run Chinook Salmon*

14 Changes in operations influence temperature and flow conditions that could affect
15 fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam
16 and in the San Joaquin River downstream of the Stanislaus River confluence, as
17 measured at Vernalis. The following describes those changes and their potential
18 effects.

19 *Changes in Water Temperature (Stanislaus River)*

20 Average monthly water temperatures in the Stanislaus River at Goodwin Dam
21 under the No Action Alternative and Second Basis of Comparison generally
22 would be similar (differences less than 0.5°F), with small differences in critical
23 dry years when the No Action Alternative would 0.8°F and 1.3°F warmer on
24 average than under the Second Basis of Comparison during June and September,
25 respectively, and 0.7°F cooler in November (Appendix 6B, Table B-17-4).

26 Downstream at Orange Blossom Bridge, average monthly water temperatures in
27 October under the No Action Alternative would be lower in all water year types
28 than the Second Basis of Comparison by as much as 1.9°F. In most other months,
29 water temperatures under the No Action Alternative generally would be similar,
30 although somewhat higher, compared to the Second Basis of Comparison. An
31 exception to this pattern occurs in April and December when average monthly
32 water temperatures in all water year types would be lower under the No Action
33 Alternative by as much as about 1.2°F (April) and 0.4°F (December) in the drier
34 years (Appendix 6B, Table B-18-4).

35 This temperature pattern would continue downstream to the confluence with the
36 San Joaquin River, although temperatures would progressively increase, as would
37 the magnitude of difference between the No Action Alternative and Second Basis
38 of Comparison. Decreases in average monthly water temperatures in October and
39 April would be more pronounced under the No Action Alternative, with average
40 differences as much as 2.7°F in October and 2.0°F in April (Appendix 6B,
41 Table B-19-4) relative to the Second Basis of Comparison. The magnitude of
42 differences in average monthly water temperatures between the No Action

1 Alternative and the Second Basis of Comparison in May and June also would
2 increase relative to the upstream locations.

3 Based on the life history timing for fall-run Chinook Salmon, the lower
4 temperatures in October and December under the No Action Alternative may
5 reduce the likelihood of adverse to fall-run Chinook Salmon spawning and egg
6 incubation as compared to the Second Basis of Comparison.

7 *Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

8 While specific water temperature thresholds for fall-run Chinook Salmon in the
9 Stanislaus River are not established, temperatures generally considered suitable
10 for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and
11 November approximately 30 percent of the time in the Stanislaus River at
12 Goodwin Dam under the No Action Alternative (Appendix 6B, Figures B-17-1
13 and B-17-2). Similar exceedances would occur under the Second Basis of
14 Comparison, although slightly less frequently in November. Water temperatures
15 for rearing from January to May generally would be below 56°F, except in May
16 when average monthly water temperatures would reach about 60°F under both the
17 No Action Alternative and the Second Basis of Comparison (Appendix 6B, Figure
18 B-17-8).

19 Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run
20 Chinook Salmon spawning (56°F) would be exceeded frequently under both the
21 No Action Alternative and Second Basis of Comparison during October and
22 November. Under the No Action Alternative, average monthly water
23 temperatures would exceed 56°F about 57 percent of the time in October
24 (Appendix 6B, Figure B-18-1). This, however, would be about 28 percent less
25 frequently than under the Second Basis of Comparison. In November, average
26 monthly water temperatures would exceed 56°F about 33 percent of the time
27 under the No Action Alternative, which would be about 5 percent more frequent
28 than under the Second Basis of Comparison (Appendix 6B, Figure B-18-2).

29 From January through May, rearing fall-run Chinook Salmon would be subjected
30 to average monthly water temperatures that exceed 56°F in March (less than
31 10 percent of the time) and May (about 30 percent of the time) under the No
32 Action Alternative which is about 10 percent more frequently in May than under
33 the Second Basis of Comparison (Appendix 6B, Figure B-18-8).

34 *Changes in Egg Mortality (Stanislaus River)*

35 For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg
36 mortality rate is predicted to be around 7 percent, with higher mortality rates (in
37 excess of 14 percent) occurring in critical dry years under the No Action
38 Alternative. Overall, egg mortality would be 0.4 percent lower under the No
39 Action Alternative; in most water year types the average egg mortality rate would
40 be lower than under the Second Basis of Comparison by up to 1.5 percent in
41 critical dry years (Appendix 9C, Table B-8). In water year types where there is
42 increased egg mortality under the No Action Alternative (wet and below-normal
43 years), the increases would be 0.1 and 0.3 percent, respectively. Overall, fall-run

1 Chinook Salmon egg mortality in the Stanislaus River under the No Action
2 Alternative and the Second Basis of Comparison would be similar.

3 *Changes in Delta Hydrodynamics*

4 San Joaquin River-origin fall-run Chinook Salmon smolts are most abundant in
5 the Delta during the months of April, May and June. Near the Confluence of the
6 San Joaquin River and the Mokelumne River, the proportion of positive velocities
7 was moderately greater under the No Action Alternative relative to the Second
8 Basis of Comparison in April and May and almost indistinguishable in June
9 (Appendix 9K). On Old River downstream of the facilities, the proportion of
10 positive velocities was substantially greater in April and May, but became more
11 similar in June. In Old River upstream of the facilities, the percent of positive
12 velocities was moderately greater for the No Action Alternative relative to the
13 Second Basis of Comparison in April and May, and moderately lower in June.
14 On the San Joaquin River downstream of the Head of Old River, the percent of
15 positive velocities was moderately lower under the No Action Alternative relative
16 to the Second Basis of Comparison in April and May, whereas the values were
17 similar in June.

18 *Changes in Entrainment at Junctions*

19 Entrainment probabilities at the Head of Old River were much greater under the
20 No Action Alternative relative to the Second Basis of Comparison during April
21 and May. Entrainment probabilities were similar under both alternatives in the
22 month of June (Appendix 9L). At the Turner Cut junction, entrainment
23 probabilities under the No Action Alternative were slightly lower than the Second
24 Basis of Comparison in June. During April and May, entrainment probabilities
25 were more divergent with lower values for the No Action Alternative relative to
26 the Second Basis of Comparison. Overall, entrainment was lower at the
27 Columbia Cut junction relative to Turner Cut, but patterns of entrainment between
28 these two scenarios were similar. Entrainment was slightly lower for the No
29 Action Alternative relative to the Second Basis of Comparison during June. In
30 April and May, entrainment was lower for the No Action Alternative relative to
31 the Second Basis of Comparison. Patterns at the Middle River and Old River
32 junctions were similar to those observed at Columbia and Turner Cut junctions.

33 *Changes in Fish Passage on the Stanislaus River*

34 The No Action Alternative includes the provision of passage at New Melones
35 Dam for spring-run Chinook Salmon and steelhead. The challenges and
36 difficulties associated with providing fish passage upstream of Shasta and Folsom
37 dams were briefly summarized previously, and the same considerations apply to
38 passage upstream of New Melones Dam.

39 If a fish passage program could establish self-sustaining populations of spring-run
40 Chinook Salmon and steelhead upstream of New Melones, it would contribute
41 substantially to satisfaction of the spatial diversity viability standard. The passage
42 program could also contribute to abundance and productivity, if average returns
43 consistently exceeded 500 individuals. However, the passage program could also

1 function as a population sink if fish transported above the reservoir achieved a
2 cohort replacement rate of less than 1.

3 Insufficient information is available currently on the quantity, suitability, and
4 accessibility of habitat upstream of New Melones. Given poor habitat data and
5 the considerable technical uncertainties discussed previously, it is not possible to
6 determine if (or how much) fish passage at New Melones Dam are likely to affect
7 the status of Central Valley spring-run Chinook Salmon and steelhead
8 populations.

9 While the purpose of the fish passage action is not intended to benefit fall-run
10 Chinook Salmon, it could provide benefit if volitional passage by adult fish is
11 successful.

12 *Summary of Effects on Fall-Run Chinook Salmon*

13 The multiple model and analysis outputs described above characterize the
14 anticipated conditions for fall-run Chinook Salmon and their response to change
15 under the No Action Alternative as compared to the Second Basis of Comparison.
16 In the Stanislaus River, the analysis of the effects of the No Action Alternative
17 and Second Basis of Comparison for fall-run Chinook Salmon relied on the water
18 temperature model output for the rivers at various locations downstream of
19 Goodwin Dam. The temperature model outputs for each of the fall-run Chinook
20 Salmon life stages suggest that thermal conditions and effects on fall-run Chinook
21 Salmon in the Stanislaus River generally would be similar under both scenarios,
22 although water temperatures could be somewhat more suitable for fall-run
23 Chinook Salmon spawning/egg incubation under the No Action Alternative. This
24 conclusion is supported by the water temperature threshold exceedance analysis
25 that indicated that suitable water temperatures for fall-run Chinook Salmon
26 spawning and egg incubation would be exceeded slightly more frequently in
27 November, but substantially less frequently in October under the No Action
28 Alternative. Suitable water temperatures for fall-run Chinook Salmon rearing
29 would be exceeded somewhat more frequently under the No Action Alternative.
30 Results of the analysis using Reclamation's salmon mortality model indicate that
31 there would be little difference in fall-run Chinook Salmon egg mortality under
32 the No Action Alternative and the Second Basis of Comparison.

33 Given the inherent uncertainty associated with the resolution of the temperature
34 model (average monthly outputs), the differences in the frequency of exceedance
35 of suitable temperatures for spawning and rearing under the No Action
36 Alternative could affect the potential for adverse effects on the fall-run Chinook
37 Salmon populations in the Stanislaus River. However, the direction and
38 magnitude of this effect is uncertain and it likely that the effects on fall-run
39 Chinook Salmon in the Stanislaus River would be similar under both the No
40 Action Alternative and Second Basis of Comparison. Implementation of a fish
41 passage project, although intended to address the limited availability of suitable
42 habitat for Spring-run Chinook Salmon and steelhead in the Stanislaus River
43 reaches downstream of Goodwin Dam, likely would provide some benefit to fall-
44 run Chinook Salmon if volitional passage were provided and additional habitat
45 could be accessed. Any potential benefit to fall-run Chinook Salmon is uncertain.

1 *Steelhead*

2 Changes in operations that influence temperature and flow conditions in the
3 Stanislaus River downstream of Goodwin Dam and the San Joaquin River
4 downstream of the Stanislaus River confluence, as measured at Vernalis could
5 affect steelhead. The following describes those changes and their potential
6 effects.

7 *Changes in Water Temperature (Stanislaus River)*

8 Average monthly water temperatures in the Stanislaus River at Goodwin Dam
9 under the No Action Alternative and Second Basis of Comparison generally
10 would be similar (differences less than 0.5°F), with small differences in critical
11 dry years when the No Action Alternative would 0.8°F and 1.3°F warmer on
12 average than under the Second Basis of Comparison during June and September,
13 respectively, and 0.7°F cooler in November (Appendix 6B, Table B-17-4).

14 Downstream at Orange Blossom Bridge, average monthly water temperatures in
15 October under the No Action Alternative would be lower than the Second Basis
16 of Comparison in all water year types by as much as 1.9°F. In most other months,
17 water temperatures under the No Action Alternative generally would be similar,
18 although somewhat higher, to the Second Basis of Comparison, except in April
19 when average monthly water temperatures in all water year types would be lower
20 under the No Action Alternative by as much as about 1.2°F in the drier years
21 (Appendix 6B, Table B-18-4).

22 This temperature pattern would continue downstream to the confluence with the
23 San Joaquin River, although temperatures would progressively increase, as would
24 the magnitude of difference between the No Action Alternative and Second Basis
25 of Comparison. Decreases in average monthly water temperatures in October and
26 April would be more pronounced under the No Action Alternative, with average
27 differences as much as 2.7°F (Appendix 6B, Table B-19-4) relative to the Second
28 Basis of Comparison. The magnitude of differences in average monthly water
29 temperatures between the No Action Alternative and the Second Basis of
30 Comparison in May and June also would increase relative to the upstream
31 locations.

32 Overall, the temperature differences between the No Action Alternative and
33 Second Basis of Comparison would be relatively minor (less than 0.5°F) and
34 likely would have little effect on steelhead in the Stanislaus River. Based on the
35 life history timing for steelhead, the slightly higher temperatures under the No
36 Action Alternative may increase the likelihood of adverse effects to steelhead
37 rearing in the Stanislaus River; the lower temperatures in October and December
38 under the No Action Alternative may reduce the likelihood of adverse effects on
39 adult steelhead during their upstream migration.

40 *Changes in Exceedance of Water Temperature Thresholds (Stanislaus River)*

41 Average monthly water temperatures in the Stanislaus River at Orange Blossom
42 Bridge would frequently exceed the temperature threshold (56°F) established for
43 adult steelhead migration under both the No Action Alternative and Second Basis

1 of Comparison during October and November. Under the No Action Alternative,
2 average monthly water temperatures would exceed 56°F about 57 percent of the
3 time in October which is about 28 percent less frequently than under the Second
4 Basis of Comparison (Appendix 6B, Figure B-18-1). In November, average
5 monthly water temperatures would exceed 56°F about 33 percent of the time
6 under the No Action Alternative, which would be about 5 percent more frequently
7 than under the Second Basis of Comparison (Appendix 6B, Figure B-18-2).

8 In January through May, the temperature threshold at Orange Blossom Bridge is
9 55°F, which is intended to support steelhead spawning. This threshold would not
10 be exceeded under either the No Action Alternative or Second Basis of
11 Comparison during January or February. In March through May, however,
12 exceedances would occur under both the No action Alternative and Second Basis
13 of Comparison in each month, with the threshold most frequently exceeded
14 (nearly half the time) under the No Action Alternative in May (Appendix 9N).
15 Average monthly water temperatures under the No Action Alternative would
16 exceed the threshold more frequently in March (5 percent) and May (5 percent),
17 and less frequently (17 percent) in April than under the Second Basis of
18 Comparison.

19 From June through November, the temperature threshold of 65°F established to
20 support steelhead rearing would be exceeded under both the No Action
21 Alternative and Second Basis of Comparison in all months but November, and
22 would exceed the threshold about 16 percent of the time in July under both the No
23 Action Alternative and Second Basis of Comparison. The differences between
24 the No Action Alternative and Second Basis of Comparison, however, could be
25 biologically meaningful, with average monthly water temperatures under the No
26 Action Alternative generally exceeding the threshold up to about 3 percent more
27 frequently than under the Second Basis of Comparison.

28 Average monthly water temperatures also would exceed the threshold (52°F)
29 established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles
30 upstream of Knights Ferry, average monthly water temperatures under the No
31 Action Alternative would exceed 52°F in March, April, and May about 8 percent,
32 33 percent, and 63 percent of the time, respectively. Water temperatures under
33 the No Action Alternative would result in exceedances occurring about 1 to
34 2 percent less frequently during the January through May period. Farther
35 downstream at Orange Blossom Bridge, the temperature threshold for
36 smoltification is higher (57°F) and would be exceeded less frequently. The
37 magnitude of the exceedance also would be less. Average monthly water
38 temperatures under the No Action Alternative and the Second Basis of
39 Comparison would not exceed the threshold during January through March. In
40 April and May, exceedances of 2 percent and 18 percent would occur under the
41 No Action Alternative, which would represent a frequency of about 6 percent less
42 than the Second Basis of Comparison in April and about an 8 percent higher
43 frequency in May.

1 Overall, the differences between the No Action Alternative and Second Basis of
2 Comparison would be relatively small, with the exception of substantial
3 differences in the frequency of exceedances in October when the average monthly
4 water temperatures under the No Action Alternative would exceed the threshold
5 for adult steelhead migration about 28 percent less frequently and in April during
6 the spawning period when the exceedance frequency would be about 17 percent
7 less. Given the frequency of exceedance under both the No Action Alternative
8 and Second Basis of Comparison and the generally stressful temperature
9 conditions in the river, the substantial differences (improvements) in October and
10 April under the No Action Alternative suggest that there would be less potential
11 to adversely affect steelhead under the No Action Alternative than under the
12 Second Basis of Comparison. Even during months when the differences would be
13 relatively small, the lower frequency of exceedances under the No Action
14 Alternative could represent a biologically meaningful and positive difference.

15 *Changes in Delta Hydrodynamics*

16 San Joaquin River-origin steelhead generally move through the Delta during
17 spring; however, there is less information on their timing than there is for
18 Chinook salmon. Thus, hydrodynamics in the entire January through June period
19 have the potential to affect juvenile steelhead. For a description of potential
20 hydrodynamic effects on steelhead, see the descriptions for fall-run Chinook
21 Salmon in the San Joaquin River basin above.

22 *Changes in Entrainment at Junctions*

23 At the Head of Old River, entrainment under the Second Basis of Comparison
24 was slightly higher during January and February relative to the No Action
25 Alternative. Entrainment probabilities were much lower under the Second Basis
26 of Comparison during April and May. Entrainment probabilities were similar
27 under both scenarios in the month of June (Appendix 9L). At the Turner Cut
28 junction, entrainment probabilities under the No Action Alternative were slightly
29 lower than the Second Basis of Comparison in January, February March and June.
30 During April and May, Entrainment probabilities were more divergent with lower
31 values for the No Action Alternative relative to the Second Basis of Comparison.
32 Overall, entrainment was lower at the Columbia Cut junction relative to Turner
33 Cut but patterns of entrainment between these two alternatives were similar.
34 Entrainment was slightly lower for the No Action Alternative relative to the
35 Second Basis of Comparison during January, February, March and June. In April
36 and May, Entrainment was lower for the No Action Alternative relative to the
37 Second Basis of Comparison. Patterns at the Middle River and Old River
38 junctions were similar to those observed at the Columbia and Turner Cut
39 junctions.

40 *Summary of Effects on Steelhead*

41 The analysis of the effects of the No Action Alternative and Second Basis of
42 Comparison for steelhead relied on the water temperature model output for the
43 rivers at various locations downstream of Goodwin Dam. The temperature model
44 outputs for each of the steelhead life stages suggest that thermal conditions and
45 effects on steelhead in all of these streams generally would be similar under both

1 scenarios, although water temperatures could be somewhat more suitable for
2 steelhead rearing under the No Action Alternative. Water temperatures could be
3 somewhat less suitable during the adult upstream migration period under the No
4 Action relative to the Second Basis of Comparison. This conclusion is supported
5 by the water temperature threshold exceedance analysis that indicated that the
6 water temperature threshold for steelhead migration would be exceeded less
7 frequently in October, but more frequently in November under the No Action
8 Alternative. The water temperature threshold for steelhead spawning would also
9 be exceeded less frequently in May, but less frequently in other months under the
10 No Action Alternative. The water temperature threshold for steelhead rearing
11 generally would be exceeded more frequently under the No action Alternative
12 while the temperature thresholds for smoltification would be exceeded less
13 frequently in most months.

14 Given the inherent uncertainty associated with the resolution of the temperature
15 model (average monthly outputs), the differences in the magnitude and frequency
16 of exceedance of suitable temperatures for the various life stages under the No
17 Action Alternative could affect the potential for adverse effects on the steelhead
18 populations in the Stanislaus River. However, the direction and magnitude of this
19 effect is uncertain. Implementation of the fish passage program under the No
20 Action Alternative intended to address the limited availability of suitable habitat
21 for steelhead in the Stanislaus River reaches downstream of Goodwin Dam could
22 provide a benefit to steelhead, however, the extent of benefit is uncertain.

23 *Reservoir Fishes*

24 The analysis of effects associated with changes in operation on reservoir fishes
25 relied on evaluation of changes in available habitat (reservoir storage) and
26 anticipated changes in black bass nesting success.

27 As described in Chapter 5, Surface Water Resources and Water Supplies, changes
28 in CVP and SWP water supplies and operations under the No Action Alternative
29 as compared to the Second Basis of Comparison would result in lower Storage
30 levels in New Melones Reservoir under the No Action Alternative as compared to
31 the Second Basis of Comparison, as summarized in Table 5.16, due to increased
32 instream releases to support fish flows under the 2009 NMFS BO.

33 Storage in New Melones could be reduced up to around 10 percent in some
34 months of some water year types. Additional information related to monthly
35 reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.
36 It is anticipated that aquatic habitat within New Melones is not limiting; however,
37 storage volume is an indicator of how much habitat is available to fish species
38 inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes
39 could be reduced under the No Action Alternative as compared to the Second
40 Basis of Comparison.

41 As shown in Appendix 9F, predicted survival in New Melones is higher than in
42 the other reservoirs during May and June. For March, Largemouth Bass and
43 Smallmouth Bass nest survival is predicted to be above 40 percent in all of the
44 years simulated. For April, the likelihood that nest survival of Largemouth Bass

1 and Smallmouth Bass is between 40 and 100 percent is reasonably high, but is
2 lower (about 13 percent) under the No Action Alternative as compared to the
3 Second Basis of Comparison. For May, this pattern is reversed with the
4 likelihood of high nest survival being slightly (about 3 percent) greater under the
5 No Action Alternative. For June, the likelihood of survival being greater than
6 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is also
7 higher (about 8 percent) under the No Action Alternative as compared to the
8 Second Basis of Comparison. For Spotted Bass, nest survival in March is
9 anticipated to be near 100 percent in every year under both the No Action
10 Alternative and Second Basis of Comparison. The likelihood of survival being
11 greater than 40 percent is high in April under both the No Action Alternative and
12 the Second Basis of Comparison with the likelihood of greater than 40 percent
13 survival being slightly (about 1 percent) lower under the No Action Alternative as
14 compared to the Second Basis of Comparison. For May, this pattern is reversed
15 with the likelihood of high Spotted Bass nest survival being slightly (about
16 2 percent) higher under the No Action Alternative. For June, Spotted Bass nest
17 survival would be greater than 40 percent in approximately 98 percent of the
18 years under the No Action Alternative, compared to every year under the Second
19 Basis of Comparison.

20 Overall, the potential for adverse effects could slightly higher under Alternative 1
21 as compared to the Second Basis of Comparison because of the overall relative
22 reductions in reservoir storage and the slightly improved nest survival in some
23 months.

24 *Other species*

25 Changes in operations that influence temperature and flow conditions in the
26 Stanislaus River downstream of Goodwin Dam and the San Joaquin River at
27 Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

28 As described above, average monthly water temperatures in the Stanislaus River
29 at Goodwin Dam under the No Action Alternative and Second Basis of
30 Comparison generally would be similar. Downstream at Orange Blossom Bridge,
31 average monthly water temperatures in the November to March period under the
32 No Action Alternative generally would be similar to, although somewhat higher
33 than, under the Second Basis of Comparison, except in April when average
34 monthly water temperatures in all water year types would be lower under the No
35 Action Alternative. This temperature pattern would continue downstream to the
36 confluence with the San Joaquin River, although temperatures would
37 progressively increase, as would the magnitude of difference between the No
38 Action Alternative and Second Basis of Comparison (Appendix 6B,
39 Table B-19-1).

40 In general, lamprey species can tolerate higher temperatures than salmonids, up to
41 around 72°F during their entire life history. Because lamprey ammocoetes remain
42 in the river for several years, any substantial flow reductions or temperature
43 increases could adversely affect these larval lamprey. Given the similar flows and
44 temperatures during their spawning and incubation period, it is likely that the

1 potential to affect lamprey species in the Stanislaus and San Joaquin rivers would
2 be similar under the No Action Alternative and the Second Basis of Comparison.

3 In general, Striped Bass and Hardhead also can tolerate higher temperatures than
4 salmonids. Given the similar flows and temperatures during their spawning and
5 incubation period, it is likely that the potential to affect Striped Bass and
6 Hardhead in the Stanislaus and San Joaquin rivers would be similar under the No
7 Action Alternative and the Second Basis of Comparison.

8 **9.4.3.2 Alternative 1**

9 As described in Chapter 3, Description of Alternatives, Alternative 1 is identical
10 to the Second Basis of Comparison. As described in Chapter 4, Approach to
11 Environmental Analysis, Alternative 1 is compared to the No Action Alternative
12 and the Second Basis of Comparison. However, because aquatic resource
13 conditions under Alternative 1 are identical to aquatic resource conditions under
14 the Second Basis of Comparison; Alternative 1 is only compared to the No Action
15 Alternative.

16 **9.4.3.2.1 Alternative 1 Compared to the No Action Alternative**

17 *Trinity River Region*

18 *Coho Salmon*

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

23 Long-term average monthly water temperatures in the Trinity River at Lewiston
24 Dam under Alternative 1 generally would be similar to, although slightly cooler,
25 (up to 0.4°F), than under the No Action Alternative (Appendix 6B, Table B-1-1).
26 Average monthly temperatures generally would be slightly lower (up to 0.4°F)
27 during November through February under Alternative 1, with the exception of
28 critical years when temperatures under Alternative 1 could be as much as 2.4°F
29 warmer (November) and in December when water temperatures could be as much
30 as 1.5°F cooler in below normal years (Appendix 6B, Table B-1-1). Average
31 monthly water temperatures generally would be similar (less than 0.5°F
32 differences) under Alternative 1 and the No Action Alternative during July
33 through September, except in wet years and critical years in September when
34 temperatures would be slightly higher (0.6°F and 0.3°F, respectively) under
35 Alternative 1.

36 The USFWS established a water temperature threshold of 56°F for Coho Salmon
37 spawning in the reach of the Trinity River from Lewiston to the confluence with
38 the North Fork Trinity River from October through December. Although not
39 entirely reflective of water temperatures throughout the reach, the temperature
40 model provides average monthly water temperature outputs for releases from the
41 Lewiston Dam, which may provide perspective on temperature conditions in the
42 reach. In October and November, average monthly water temperatures under

1 both Alternative 1 and the No Action Alternative would exceed 56°F at Lewiston
2 Dam in some years (Appendix 9N). Under Alternative 1, the threshold would be
3 exceeded about 6 percent of the time in October, about 1 percent less frequently
4 than under the No Action Alternative. In November, both conditions would result
5 in an exceedance frequency of about 2 percent. There would be no exceedance of
6 the threshold in December under both the Alternative 1 and the No Action
7 Alternative.

8 Overall, the temperature model outputs for each of the Coho Salmon life stages
9 suggest that the temperature of water released at Lewiston Dam generally would
10 be similar under both scenarios, although the exceedance of water temperature
11 thresholds would be slightly less frequent (1 percent) under Alternative 1. The
12 higher water temperatures in November of critical years (and lower temperatures
13 in December) under Alternative 1 would likely have little effect on Coho Salmon
14 as water temperatures in the Trinity River are typically low during this time
15 period. Given the similarity of the results and the inherent uncertainty associated
16 with the resolution of the temperature model (average monthly outputs),
17 Alternative 1 and the No Action Alternative are likely to have similar effects on
18 the Coho Salmon population in the Trinity River.

19 *Spring-run Chinook Salmon*

20 The analysis of effects associated with changes in operation on spring-run
21 Chinook Salmon was conducted using temperature model outputs for Lewiston
22 Dam to anticipate the likely effects on conditions in the Trinity River downstream
23 of Lewiston Dam.

24 As described above for Coho Salmon, the temperature differences between
25 Alternative 1 and the No Action Alternative would be relatively minor (less than
26 0.5°F) and likely would have little effect on spring-run Chinook Salmon in the
27 Trinity River. The higher average monthly water temperatures (up to 2.4°F) in
28 November of critical years (and lower temperatures in December) under
29 Alternative 1 would likely have little effect on spring-run Chinook Salmon as
30 water temperatures in the Trinity River are typically low during this time period.

31 Under both Alternative 1 and the No Action Alternative, average monthly water
32 temperatures in the Trinity River at Lewiston Dam would infrequently (1 percent
33 to 2 percent of the time) exceed 60°F, the threshold for spring-run Chinook
34 Salmon holding. There would be no difference in the frequency of exceedance of
35 the 60°F threshold under Alternative 1 as compared to the No Action Alternative.
36 In September, however, the threshold for spawning (56°F) would be exceeded
37 11 percent of the time under Alternative 1 which is about 2 percent more
38 frequently than under the No Action Alternative.

39 Overall, the differences in the frequency of threshold exceedance between
40 Alternative 1 and the No Action Alternative would be relatively minor, although,
41 temperature conditions under Alternative 1 could be slightly more likely to
42 adversely affect spring-run Chinook Salmon spawning than under the No Action
43 Alternative because of the slightly increased frequency of exceedance of the 56°F
44 threshold at Lewiston Dam in September.

1 The majority of spring-run Chinook Salmon in the Trinity River are produced in
2 the South Fork Trinity watershed. Although the water temperatures under
3 Alternative 1 could adversely affect spring-run Chinook Salmon in the Trinity
4 River, these effects would not occur in every year and are not anticipated to be
5 substantial based on the relatively small differences water temperatures under
6 Alternative 1 as compared to the No Action Alternative.

7 Overall, Alternative 1 is likely to have similar effects on the spring-run Chinook
8 Salmon population in the Trinity River as compared to the No Action Alternative.

9 *Fall-Run Chinook Salmon*

10 The analysis of effects associated with changes in operation on fall-run Chinook
11 Salmon was conducted using temperature model outputs for Lewiston Dam to
12 anticipate the likely effects on conditions in the Trinity River downstream of
13 Lewiston Dam. In addition, the Reclamation Salmon Mortality Model was used
14 to assess egg mortality.

15 As described above for Coho Salmon, the temperature differences between
16 Alternative 1 and No Action Alternative would be relatively minor (less than
17 0.5°F) and egg incubation likely would have little effect on fall-run Chinook
18 Salmon in the Trinity River. The higher water temperatures (as much as 2.4°F) in
19 November of critical years (and lower temperatures in December) under
20 Alternative 1 would likely have little effect on fall-run Chinook Salmon as water
21 temperatures in the Trinity River are typically low during this time period.

22 The temperature threshold and months during which it applies for fall-run
23 Chinook Salmon are the same as those for Coho Salmon. Under Alternative 1,
24 the threshold would be exceeded about 6 percent of the time in October, about
25 1 percent less frequently than under the No Action Alternative. In November,
26 both conditions would result in an exceedance frequency of about 2 percent.
27 There would be no exceedance of the threshold in December under both
28 Alternative 1 and the No Action Alternative. Overall, the differences in the
29 frequency of threshold exceedance between Alternative 1 and the No Action
30 Alternative would be relatively minor. Temperature conditions under the
31 Alternative 1 could be slightly less likely to adversely affect fall-run Chinook
32 Salmon spawning than under the No Action Alternative because of the slightly
33 reduced frequency of exceedance of the 56°F threshold at Lewiston Dam in
34 October. However, this would occur prior to the peak spawning period for
35 fall-run Chinook Salmon.

36 The temperatures described above for the Trinity River downstream of Lewiston
37 Dam are reflected in the analysis of egg mortality using the Reclamation salmon
38 mortality model (Appendix 9C). For fall-run Chinook Salmon in the Trinity
39 River, the long-term average egg mortality rate is predicted to be relatively low
40 (around 4 percent), with higher mortality rates (nearly 15 percent) occurring in
41 critical dry years under the No Action Alternative. The predicted long-term
42 average egg mortality would be about 0.2 percent lower under Alternative 1 than
43 under the No Action Alternative; in critical dry years the average egg mortality
44 rate would be 1.8 percent lower under Alternative 1 than under the No Action

1 Alternative and in wet years it would be 0.6 percent higher under Alternative 1
2 (Appendix 9C, Table B-1-5). Overall, egg mortality under Alternative 1 and the
3 No Action Alternative would be similar.

4 Based on the water temperature changes described above Alternative 1 would not
5 likely have adverse effects on fall-run Chinook Salmon in the Trinity River
6 compared to the No Action Alternative. Further, these effects would not occur in
7 every year and are not anticipated to be substantial based on the relatively small
8 differences in flows and water temperatures (as well as egg mortality) under
9 Alternative 1 as compared to the No Action Alternative.

10 Overall, Alternative 1 is likely to have similar effects on the fall-run Chinook
11 Salmon population in the Trinity River as compared to the No Action Alternative.

12 *Steelhead*

13 The analysis of effects associated with changes in operation on steelhead relied on
14 temperature model outputs for Lewiston Dam to anticipate the likely effects on
15 conditions in the Trinity River downstream of Lewiston Dam.

16 Temperature differences between Alternative 1 and No Action Alternative would
17 be relatively minor (less than 0.5°F) and likely would have little effect on
18 steelhead in the Trinity River. The higher water temperatures (up to 2.4°F) in
19 November of critical years (and lower temperatures in December) under
20 Alternative 1 would likely have little effect on steelhead as water temperatures in
21 the Trinity River are typically low during this time period.

22 The temperature threshold and months during which it applies for steelhead are
23 the same as those described for Coho Salmon. Thus, the frequency of average
24 monthly water temperatures in the Trinity River at Lewiston Dam exceeding the
25 threshold of 56°F for steelhead would be the same as those described above for
26 Coho Salmon. Overall, the differences in the frequency of threshold exceedance
27 between Alternative 1 and the No Action Alternative would be relatively minor
28 and are unlikely to affect steelhead spawning in the Trinity River.

29 Based on the water temperature changes described above, Alternative 1 would not
30 likely have adverse effects on steelhead in the Trinity River compared to the No
31 Action Alternative. Further, these effects would not occur in every year and are
32 not anticipated to be substantial based on the relatively small differences in flows
33 and water temperatures under Alternative 1 as compared to the No Action
34 Alternative. Overall, Alternative 1 is likely to have similar effects on the
35 steelhead population in the Trinity River as compared to the No Action
36 Alternative.

37 *Green Sturgeon*

38 The analysis of effects associated with changes in operation on Green Sturgeon
39 relied on temperature model outputs for Lewiston Dam to anticipate the likely
40 effects on conditions in the Trinity River downstream of Lewiston Dam.

41 Green Sturgeon spawn in the lower reaches of the Trinity River during April
42 through June, and water temperatures above about 63°F are believed stressful to

1 embryos (Van Eenennaam et al. 2005). Average monthly water temperature
2 conditions during April through June in the Trinity River at Lewiston Dam under
3 Alternative 1 would be similar to the temperatures under the No Action
4 Alternative and would not exceed 58°F during this period. In addition, water
5 temperatures in the reach of the river where Green Sturgeon spawn are likely
6 controlled by other factors (e.g., ambient air temperatures and tributary inflows)
7 more than water operations at Trinity and Lewiston dams.

8 Overall, given the similarities between average monthly water temperatures at
9 Lewiston Dam under Alternative 1 and the No Action Alternative, it is likely that
10 temperature conditions for Green Sturgeon in the Trinity River or lower Klamath
11 River and estuary would be similar under both scenarios.

12 *Reservoir Fishes*

13 The analysis of effects associated with changes in operation on reservoir fishes
14 relied on evaluation of changes in available habitat (reservoir storage) and
15 anticipated changes in black bass nesting success.

16 Changes in CVP water supplies and operations under Alternative 1 as compared
17 to the No Action Alternative would result in higher reservoir storage in Trinity
18 Lake. Storage in Trinity Lake could increase by up to about 10 percent in some
19 months of some water year types. Additional information related to monthly
20 reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

21 Using Trinity Lake storage as an indicator of habitat available to fish species
22 inhabiting the reservoir, the amount of habitat for reservoir fishes would not be
23 reduced under Alternative 1 as compared to the No Action Alternative.

24 As shown in Appendix 9F, nest survival in Trinity Lake is near 100 percent in
25 March and April due to increasing reservoir elevations. For May, the likelihood
26 of survival for Largemouth Bass in Trinity Lake being in the 40 to 100 percent
27 range is slightly (about 2 percent) higher under Alternative 1 as compared to the
28 No Action Alternative. For June, the likelihood of survival being greater than
29 40 percent for Largemouth Bass is somewhat lower than in May and is slightly
30 lower (about 2 percent) under Alternative 1 as compared to the No Action
31 Alternative. For Spotted Bass, the likelihood of survival being greater than
32 40 percent would be 100 percent in May under both Alternative 1 and the No
33 Action Alternative. For June, Spotted Bass survival in Trinity Lake would be less
34 than for May due to greater daily reductions in water surface elevation. The
35 likelihood of survival being greater than 40 percent would be similar (near
36 100 percent) under Alternative 1 and the No Action Alternative.

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

40 *Pacific Lamprey*

41 Little information is available on factors that influence populations of Pacific
42 Lamprey in the Trinity River, but they are likely affected by many of the same
43 factors as salmon and steelhead because of the parallels in their life cycles. On

1 average, the temperature of water released at Lewiston Dam under Alternative 1
2 generally would be similar to (less than 0.5°F differences) to those under the No
3 Action Alternative. Given the similarities in temperature, it is likely that the
4 effects on Pacific Lamprey would be similar under Alternative 1 and the No
5 Action Alternative. This conclusion likely applies to other species of lamprey
6 that inhabit the Trinity and lower Klamath rivers (e.g., River Lamprey).

7 *Eulachon*

8 It is unclear whether this species has been extirpated from the Klamath River.
9 Given that the highest increases in flow under Alternative 1 would be less than
10 10 percent in the Trinity River (Appendix 5A), with a smaller relative change in
11 the lower Klamath River and Klamath River estuary, and that water temperatures
12 in the Klamath River are unlikely to be affected by changes upstream at Lewiston
13 Dam, it is likely that Alternative 1 would have a similar potential to influence
14 Eulachon in the Klamath River as the No Action Alternative.

15 *Sacramento River System*

16 *Winter-run Chinook Salmon*

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

20 *Changes in Water Temperature*

21 Long-term average monthly water temperature in the Sacramento River at
22 Keswick Dam under Alternative 1 would generally be similar to (less than 0.5°F
23 difference) to water temperatures under the No Action Alternative. An exception
24 is during September and October of critical dry years when water temperatures
25 could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as
26 compared to the No Action Alternative and up to 1°F warmer in September of
27 wetter years in some water year types (up to 0.3°F) (Appendix 6B, Table B-5-1).
28 A similar pattern of changes in temperature generally would be exhibited
29 downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge, with average monthly
30 temperatures under Alternative 1 progressively increasing (up to a 2.8°F
31 difference at Bend Bridge) in September during the wetter years under Alternative
32 1 (Appendix 6B, Table B-8-1).

33 Overall, the temperature differences between Alternative 1 and the No Action
34 Alternative would be relatively minor (less than 0.5°F) and likely would have little
35 effect on winter-run Chinook Salmon in the Sacramento River. Spawning for
36 winter-run Chinook Salmon in the Sacramento River takes place from mid-April
37 to mid-August with incubation occurring over the same time period and extending
38 into October. The somewhat lower water temperatures in September and October
39 or critical dry years under the No Action Alternative could reduce the likelihood
40 of adverse effects on winter-run Chinook Salmon egg incubation and fry rearing
41 during this water year type. However, the increased water temperatures during
42 this time period under Alternative 1 in wetter years could increase the likelihood
43 of adverse effects on egg incubation relative to the No Action Alternative.

1 *Changes in Exceedances of Water Temperature Thresholds*

2 With the exception of April, average monthly water temperatures under both
 3 Alternative 1 and the No Action Alternative would show exceedances of the water
 4 temperature threshold of 56°F established in the Sacramento River at Ball's Ferry
 5 from April to September for winter-run Chinook Salmon spawning and egg
 6 incubation, with exceedances under both as high as about 52 percent and
 7 42 percent, respectively, in some months (Appendix 9N). Under Alternative 1,
 8 the temperature threshold generally would be exceeded less frequently than under
 9 the No Action Alternative (by about 1 percent to 3 percent) in the April through
 10 August period, with the temperature threshold in September exceeded about
 11 10 percent more frequently under Alternative 1 than the No Action Alternative.
 12 Farther downstream at Bend Bridge, the frequency of exceedances would
 13 increase, with exceedances under both Alternative 1 and the No Action as
 14 Alternative as high as about 90 percent in some months. Under Alternative 1,
 15 temperature exceedances generally would be less frequent (by up to 8 percent)
 16 than under the No Action Alternative, with the exception of September, when
 17 threshold exceedances under Alternative 1 would be about 29 percent more
 18 frequent.

19 Overall, there would be substantial differences in the frequency of threshold
 20 exceedance between Alternative 1 and the No Action Alternative, particularly in
 21 September. Temperature conditions under Alternative 1 would reduce the
 22 likelihood of adverse effects on winter-run Chinook Salmon egg incubation than
 23 under the No Action Alternative because of the reduced frequency of exceedance
 24 of the 56°F threshold from April through August. However, the substantial
 25 increase in the frequency of exceedance in September under Alternative 1 may
 26 increase the likelihood of adverse effects on winter-run Chinook Salmon egg
 27 incubation during this limited portion of the spawning and egg incubation period.

28 *Changes in Egg Mortality*

29 The temperatures described above for the Sacramento River downstream of
 30 Keswick Dam are reflected in the analysis of egg mortality using the Reclamation
 31 salmon mortality model (Appendix 9C). For winter-run Chinook Salmon in the
 32 Sacramento River, the long-term average egg mortality rate is predicted to be
 33 relatively low (around 4 percent), with higher mortality rates (exceeding
 34 20 percent) occurring in critical dry years under Alternative 1. Overall, egg
 35 mortality would be 0.7 percent lower under Alternative 1 compared to the No
 36 Action Alternative; in critical dry years the average egg mortality rate would be
 37 5.4 percent lower under Alternative 1 than under the No Action Alternative
 38 (Appendix 9C, Table B-4). Overall, winter-run Chinook Salmon egg mortality in
 39 the Sacramento River under Alternative 1 and the No Action Alternative would be
 40 similar, except in critical dry water years.

41 *Changes in Weighted Usable Area*

42 As described above for the assessment methodology, Weighted Usable Area
 43 (WUA) is a function of flow, but the relationship is not linear due to differences
 44 in depths and velocities present in the wetted channel at different flows. Because

1 the combination of depths, velocities, and substrates preferred by species and life
2 stages varies, WUA values at a given flow can differ substantially for the life
3 stages evaluated.

4 As an indicator of the amount of suitable spawning habitat for winter-run Chinook
5 Salmon between Keswick Dam and Battle Creek, modeling results indicate that,
6 in general, there would be lower amounts of spawning habitat available from May
7 through September under Alternative 1 as compared to the No Action Alternative
8 (Appendix 9E). The decrease in long-term average spawning WUA during these
9 months would be relatively small (less than 5 percent), with smaller (less than
10 1 percent) decreases in May and July. There would be increase in the long-term
11 average spawning WUA in April, but this increase is small (less than 1 percent)
12 and would occur prior to the peak spawning period in May and June. Overall,
13 spawning habitat availability would be similar under Alternative 1 and the No
14 Action Alternative.

15 Modeling results indicate that, in general, there would be higher amounts of
16 suitable fry rearing habitat available from June through October under
17 Alternative 1 (Appendix 9E) compared to the No Action Alternative. The
18 increase in long-term average fry rearing WUA during these months would be
19 relatively small (less than 5 percent), with smaller (less than 1 percent) reductions
20 in July and October. There would be a decrease in the long-term average fry
21 rearing WUA in September, but this reduction would be small (less than 5
22 percent) and would occur at a time when most fry have grown into juveniles and
23 moved into habitats with different depth and velocity characteristics as reflected
24 in the analysis of juvenile rearing WUA below. Overall, fry rearing habitat
25 availability would be similar under Alternative 1 and the No Action Alternative.

26 Similar to the results for fry rearing WUA, modeling results indicate that there
27 would be slightly increased amounts of suitable juvenile rearing habitat available
28 during the early juvenile rearing period from September through December under
29 Alternative 1. There would be a decrease in the long-term average juvenile
30 rearing WUA from January through August (Appendix 9E). The increases in
31 long-term average juvenile rearing WUA would be relatively small (less than
32 5 percent), while the decreases would be smaller (less than 1 percent). Overall,
33 juvenile rearing habitat availability would be similar under Alternative 1 and the
34 No Action Alternative.

35 *Changes in SALMOD Output*

36 SALMOD results indicate that flow-related winter-run Chinook Salmon egg
37 mortality would be increased by 61 percent under Alternative 1 compared to the
38 No Action Alternative. Conversely, temperature-related egg mortality would be
39 16 percent lower under Alternative 1 (Appendix 9D, Table B-4-4). Both
40 temperature- and flow (habitat)-related fry mortality would be approximately
41 16 to 17 percent lower under Alternative 1 as compared to the No Action
42 Alternative. Temperature-related juvenile mortality would be approximately
43 15 percent lower under Alternative 1, while flow (habitat)-related mortality would
44 be approximately 21 percent higher under Alternative 1 as compared to the No

1 Action Alternative. Overall, potential juvenile production under Alternative 1
2 would be the similar to the No Action Alternative (Appendix 9D, Table B-4-1).

3 *Changes in Delta Passage Model Output*

4 The Delta Passage Model predicted similar estimates of annual Delta survival
5 across the 81 water year time period for winter-run Chinook Salmon between
6 Alternative 1 and the No Action Alternative (Appendix 9J). Median Delta
7 survival would be 0.352 for Alternative 1 and 0.349 for the No Action
8 Alternative.

9 *Changes in Oncorhynchus Bayesian Analysis Output*

10 Escapement of winter-run Chinook Salmon and Delta survival was modeled by
11 the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook
12 salmon. Escapement was generally lower under Alternative 1 as compared to the
13 No Action Alternative (Appendix 9I). The median abundance under Alternative 1
14 was lower in 19 of the 22 years of simulation (1971 to 2002), and there was
15 typically greater than a 25 percent chance that Alternative 1 values would be
16 lower than under the No Action Alternative. Median delta survival was
17 approximately 12 percent lower under Alternative 1 as compared to the No Action
18 Alternative. The differences in survival, although not consistent across the
19 uncertainty in the parameter values, suggest a high probability of no difference
20 between these two scenarios.

21 *Changes in Interactive Object-Oriented Simulation Output*

22 The IOS model predicted similar adult escapement trajectories for winter-run
23 Chinook Salmon between Alternative 1 and the No Action Alternative across the
24 81 water years (Appendix 9H). Under Alternative 1 median adult escapement
25 was 4,042 and under the No Action Alternative, median escapement was 3,935.

26 Similar to adult escapement, the IOS model predicted similar egg survival time
27 histories for winter-run Chinook Salmon between Alternative 1 and the No Action
28 Alternative across the 81 water years (Appendix 9H). Under Alternative 1
29 median egg survival was 0.987 and under the No Action Alternative median egg
30 survival was 0.990 (.

31 *Changes in Delta Hydrodynamics*

32 Winter-run Chinook Salmon smolts are most abundant in the Delta during
33 January, February and March. On the Sacramento River near the confluence of
34 Georgiana Slough, the percentage of positive velocities under Alternative 1 was
35 indistinguishable from the No Action Alternative (Appendix 9K).

36 *Changes in Junction Entrainment*

37 Entrainment at Georgiana Slough was similar under both Alternative 1 and No
38 Action Alternative during January, February and March when winter-run Chinook
39 Salmon smolts are most abundant in the Delta (Appendix 9L).

40 *Changes in Salvage*

41 Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater
42 under Alternative 1 relative to No Action Alternative in every month

1 (Appendix 9M). Winter-run Chinook Salmon smolts migrating through the Delta
2 would be most susceptible in the months of January, February and March.
3 Predicted values in January and February indicated an increase in the fraction of
4 fish salvaged for Alternative 1 relative to the No Action Alternative.

5 *Summary of Effects on Winter-Run Chinook Salmon*

6 The multiple model and analysis outputs described above characterize the
7 anticipated conditions for winter-run Chinook Salmon and their response to
8 change under Alternative 1 as compared to the No Action Alternative. For the
9 purpose of analyzing effects on winter-run Chinook Salmon and developing
10 conclusions, greater reliance was placed on the outputs from the two life cycle
11 models, IOS and OBAN because they each integrate the available information to
12 produce single estimates of winter-run Chinook Salmon escapement. The output
13 from IOS indicated that winter-run Chinook Salmon escapement would be similar
14 under both scenarios, whereas the OBAN results indicated that escapement under
15 Alternative 1 would be lower than under the No Action Alternative, although
16 there would be some chance (less than a 25 percent) that escapement under the
17 Alternative 1 could be greater than the No Action Alternative.

18 These model results suggest that effects on winter-run Chinook Salmon would be
19 similar under both scenarios, with a small likelihood that winter-run Chinook
20 Salmon escapement would be lower under Alternative 1 than under the No Action
21 Alternative. This potential distinction between the two scenarios, however, may
22 be offset or reversed by the benefits of implementation of fish passage under the
23 No Action Alternative intended to address the limited availability of suitable
24 habitat for winter-run Chinook Salmon in the Sacramento River reaches
25 downstream of Keswick Dam. This potential beneficial effect and its magnitude
26 would depend on the success of the fish passage program.

27 *Spring-run Chinook Salmon*

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

33 *Changes in Water Temperature*

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

37 *Sacramento River*

38 Long-term average monthly water temperature in the Sacramento River at
39 Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F
40 difference) to water temperatures under the No Action Alternative. An exception
41 is during September and October of critical dry years when water temperatures
42 could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as
43 compared to the No Action Alternative and up to 1°F warmer in September of

1 wetter years (Appendix 6B, Table B-5-1). A similar pattern of changes in
2 temperature generally would be exhibited downstream at Ball's Ferry, Jelly's
3 Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences
4 progressively increasing (up to a 3.2°F difference at Red Bluff) in September
5 during the wetter years (Appendix 6B, Table B-9-1).

6 Overall, the temperature differences between Alternative 1 and the No Action
7 Alternative would be relatively minor (less than 0.5°F) and likely would have
8 little effect on spring-run Chinook Salmon in the Sacramento River. The slightly
9 lower water temperatures from October to December under Alternative 1 would
10 likely have little effect on spring-run Chinook Salmon as water temperatures in
11 the Sacramento River below Keswick Dam are typically low during this time
12 period. The somewhat higher water temperatures in September of wetter years
13 may increase the likelihood of adverse effects on spring-run Chinook Salmon
14 spawning, although the decreased temperatures in September of critical dry years
15 under Alternative 1 may reduce the likelihood of adverse effects on spring-run
16 Chinook Salmon spawning in this water year type. There would be little
17 difference in potential effects on spring-run Chinook Salmon holding over the
18 summer due to the similar water temperatures during this time period under
19 Alternative 1 and the No Action Alternative.

20 *Clear Creek*

21 Average monthly water temperatures in Clear Creek at Igo under Alternative 1
22 relative to the No Action Alternative are generally predicted to be similar to or
23 lower (up to about 0.5°F differences) from September through April and June
24 through August from September through April and June through August
25 (Appendix 6B, Table B-3-1). Average monthly water temperatures during May
26 under Alternative 1 would be higher by 0.4°F to 0.8°F than under the No Action
27 Alternative in all water year types. Overall, effects on spring-run Chinook
28 Salmon due to temperature differences between Alternative 1 and the No Action
29 Alternative would be relatively minor.

30 *Feather River*

31 Average monthly water temperature in the Feather River in the low flow channel
32 under Alternative 1 relative to the No Action Alternative generally were predicted
33 to be similar (less than 0.5°F differences), but slightly lower from October
34 through December when average monthly water temperatures would be up to
35 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Modeled
36 water temperatures during May and June under Alternative 1 were also slightly
37 lower, up to a maximum of 0.7°F lower in June of below normal water years.
38 Average monthly water temperatures in July through September under Alternative
39 1 generally were predicted to be lower (up to 0.6°F) in drier water year types and
40 higher (up to 1.3°F) in the wetter years. Although temperatures in the river would
41 become progressively higher in the downstream directions, the differences
42 between Alternative 1 and No Action Alternative would exhibit a similar pattern
43 at the downstream locations (Robinson Riffle and Gridley Bridge), with water
44 temperatures under Alternative 1 generally increasing in most water year types
45 relative to the No Action Alternative. Water temperatures under the No Action

1 Alternative were predicted to be somewhat (0.7°F to 1.6°F) warmer on average
2 and up to 4.0°F warmer at the confluence with the Sacramento River from July to
3 September in wetter years (Appendix 6B, Table B-23-1).

4 Overall, the temperature differences in the Feather River between Alternative 1
5 and the No Action Alternative would be relatively minor (less than 0.5°F) and
6 likely would have little effect on spring-run Chinook Salmon in the Feather River.
7 The slightly lower water temperatures in November and December under
8 Alternative 1 would likely have little effect on spring-run Chinook Salmon as
9 water temperatures in the Feather River are typically low during this time period.
10 The somewhat higher water temperatures in September of wetter years may
11 increase the likelihood of adverse effects on spring-run Chinook Salmon
12 spawning, although the decreased temperatures in September of critical dry years
13 under Alternative 1 may reduce the likelihood of adverse effects on spring-run
14 Chinook Salmon spawning in this water year type. There would be little
15 difference in potential effects on spring-run Chinook Salmon holding over the
16 summer due to the similar water temperatures during this time period under
17 Alternative 1 and the No Action Alternative.

18 *Changes in Exceedances of Water Temperature Thresholds*

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

23 *Sacramento River*

24 Average monthly water temperatures under both Alternative 1 and No Action
25 Alternative would show exceedances of the water temperature threshold of 56°F
26 established in the Sacramento River at Red Bluff for spring-run Chinook Salmon
27 (egg incubation) in October, November, and again in April. The exceedances
28 would occur at the greatest frequency in October (79 percent of the time under
29 Alternative 1); under Alternative 1 the water temperature threshold would be
30 exceeded less frequently in November (7 percent of the time under Alternative 1)
31 and not exceeded at all from December through March (Appendix 9N). As water
32 temperatures warm in the spring, the thresholds would be exceeded in April by
33 15 percent under Alternative 1. In the months when the greatest frequency of
34 exceedances occur (October, November, and April), model results generally
35 indicate less frequent exceedances (by up to 4 percent in October) under
36 Alternative 1 than under the No Action Alternative. Temperature conditions in
37 the Sacramento River under Alternative 1 could be less likely to affect spring-run
38 Chinook Salmon egg incubation than under the No Action Alternative because of
39 the decreased frequency of exceedance of the 56°F threshold in October,
40 November, and April.

41 *Clear Creek*

42 Average monthly water temperatures under both Alternative 1 and No Action
43 Alternative would not exceed the water temperature threshold of 60°F established
44 in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in

1 June through August. However, water temperatures under Alternative 1 and No
2 Action Alternative would exceed the water temperature threshold of 56°F
3 established for spawning in September and October about 10 percent to
4 15 percent of the time (Appendix 9N). The differences between Alternative 1 and
5 the No Action Alternative could be biologically meaningful, with water
6 temperatures under Alternative 1 exceeding thresholds about 3 percent less
7 frequently than under the No Action Alternative in September and about 2 percent
8 less frequently in October, respectively (Appendix 9N). Temperature conditions
9 in Clear Creek under Alternative 1 could be less likely to affect spring-run
10 Chinook Salmon spawning than under the No Action Alternative because of the
11 decreased frequency of exceedance of the 56°F threshold in September and
12 October.

13 *Feather River*

14 Average monthly water temperatures under both Alternative 1 and the No Action
15 Alternative would exceed the water temperature threshold of 56°F established in
16 the Feather River at Robinson Riffle for spring-run Chinook Salmon egg
17 incubation and rearing during some months, particularly in October and
18 November, and March and April, when temperature thresholds could be exceeded
19 frequently (Appendix 9N). The frequency of exceedance was highest in October,
20 a month in which average monthly water could get as high as about 68°F.
21 However, the differences in the frequency of exceedances between Alternative 1
22 and No Action Alternative would be relatively small. Water temperatures under
23 Alternative 1 would exceed the temperature threshold about 1 percent less
24 frequently than under the No Action Alternative in October, November, and
25 December, and about 2 percent more frequently in March.

26 The established water temperature threshold of 63°F for rearing during May
27 through August would be exceeded often under both Alternative 1 and the No
28 Action Alternative in May and June, but not at all in July and August. Water
29 temperatures under Alternative 1 would exceed the rearing temperature threshold
30 about 9 percent less frequently than under the No Action Alternative in May.
31 Temperature conditions in the Feather River under Alternative 1 could be less
32 likely to affect spring-run Chinook Salmon spawning and rearing than under the
33 No Action Alternative because of the decreased frequency of exceedance of the
34 water temperature thresholds.

35 *Changes in Egg Mortality*

36 These temperature differences described above are reflected in the analysis of egg
37 mortality using the Reclamation salmon mortality model (Appendix 9C). For
38 spring-run Chinook Salmon in the Sacramento River, the long-term average egg
39 mortality rate is predicted to be relatively high (exceeding 20 percent), with high
40 mortality rates (exceeding 70 percent) occurring in critical dry years. Overall,
41 spring-run Chinook Salmon egg mortality in the Sacramento River is predicted to
42 be 0.7 percent lower under Alternative 1; in critical dry years the average egg
43 mortality rate is predicted to be 10.4 percent lower than under the No Action
44 Alternative (Appendix 9C, Table B-3). Overall, spring-run Chinook Salmon egg

1 mortality in the Sacramento River under Alternative 1 and the No Action
2 Alternative would be similar, except in critical dry water years.

3 *Changes in Weighted Usable Area*

4 Weighted usable area curves are available for spring-run Chinook Salmon in
5 Clear Creek. As described above, flows in Clear Creek downstream of
6 Whiskeytown Dam are not anticipated to differ under Alternative 1 relative to the
7 No Action Alternative except in May due to the release of spring attraction flows
8 in accordance with the 2009 NMFS BO under the No Action Alternative.
9 Therefore, there would be no change in the amount of potentially suitable
10 spawning and rearing habitat for spring-run Chinook Salmon (as indexed by
11 WUA) available under Alternative 1 as compared to the No Action Alternative.

12 *Changes in SALMOD Output*

13 SALMOD results indicate that pre-spawning mortality of spring-run Chinook
14 Salmon eggs would be approximately 18 percent lower under Alternative 1,
15 primarily due to decreased summer temperatures. Flow-related spring-run
16 Chinook Salmon egg mortality would be increased by 10 percent under
17 Alternative 1 compared to the No Action Alternative. Conversely, temperature-
18 related egg mortality would be 10 percent lower under Alternative 1
19 (Appendix 9D, Table B-3-4). Flow (habitat)-related fry mortality would be
20 approximately 8 percent higher under Alternative 1 as compared to the No Action
21 Alternative. There would be no temperature- or flow (habitat)-related juvenile
22 mortality under either alternative, as most spring-run Chinook Salmon juveniles
23 have migrated downstream as fry and are not found in the mainstem Sacramento
24 River. Overall, potential spring-run juvenile production would be slightly
25 (approximately 2 percent) higher under Alternative 1 as compared to the No
26 Action Alternative (Appendix 9D, Table B-3-1).

27 *Changes in Delta Passage Model Output*

28 The Delta Passage Model predicted similar estimates of annual Delta survival
29 across the 81 water year time period for spring-run Chinook Salmon between
30 Alternative 1 and the No Action Alternative (Appendix 9J). Median Delta
31 survival was 0.286 for Alternative 1 and 0.296 for the No Action Alternative.

32 *Changes in Delta Hydrodynamics*

33 Spring-run Chinook Salmon are most abundant in the Delta from March through
34 May. Near the junction of Georgiana Slough (DSM2 channel 421), the percent of
35 time that velocity was positive was similar in the March for both scenarios. In
36 April and May, percent positive velocity near the junction of Georgiana Slough
37 was slightly higher under Alternative 1 relative to the No Action Alternative. In
38 Old River upstream of the facilities (DSM2 channel 212) percent positive velocity
39 was slightly higher in March and moderately lower in April and May under
40 Alternative 1 relative to the No Action Alternative (Appendix 9K). In Old River
41 downstream of the facilities (channel 94) percent positive velocity was slightly
42 lower in March and increasingly lower in April and May under Alternative 1
43 relative to No Action Alternative.

1 *Changes in Junction Entrainment*

2 Entrainment at Georgiana Slough was similar under both Alternative 1 and No
3 Action Alternative during March, April and May when spring run are most
4 abundant in the Delta (Appendix 9L).

5 *Changes in Salvage*

6 Salvage of Sacramento River-origin Chinook Salmon is predicted to be higher
7 under Alternative 1 relative to No Action Alternative in every month
8 (Appendix 9M). Spring-run smolts migrating through the Delta would be most
9 susceptible in the months of March April and May. Predicted values in April and
10 May indicated a larger fraction of fish salvaged for Alternative 1. Predicted
11 salvage was more similar in March but still higher under Alternative 1.

12 *Summary of Effects on Spring-Run Chinook Salmon*

13 The multiple model and analysis outputs described above characterize the
14 anticipated conditions for spring-run Chinook Salmon and their response to
15 change under Alternative 1 and the No Action Alternative. For the purpose of
16 analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater
17 reliance was placed on the outputs from the SALMOD model because it integrates
18 the available information on temperature and flows to produce estimates of
19 mortality for each life stage and an overall, integrated estimate of potential spring-
20 run Chinook Salmon juvenile production. The output from SALMOD indicated
21 that spring-run Chinook Salmon production in the Sacramento River would be
22 slightly higher under Alternative 1 than under the No Action Alternative, although
23 production under Alternative 1 could be over 10 percent greater than under the No
24 Action Alternative in critical dry years. The analyses attempting to assess the
25 effects on routing, entrainment, and salvage of juvenile salmonids in the Delta
26 suggest that salvage (as an indicator of potential losses of juvenile salmon at the
27 export facilities) of Sacramento River-origin Chinook Salmon is predicted to be
28 higher under Alternative 1 relative to No Action Alternative in every month.

29 In Clear Creek and the Feather River, the analysis of the effects of Alternative 1
30 and the No Action Alternative for spring-run Chinook Salmon relied on output
31 from the WUA analysis and water temperature output for Clear Creek at Igo, and
32 in the Feather River low flow channel and downstream of the Thermalito
33 complex. The WUA analysis suggests that there would be little difference in the
34 availability of spawning and rearing habitat in Clear Creek. The temperature
35 model outputs suggest that thermal conditions and effects on each of the spring-
36 run Chinook Salmon life stages generally would be similar under both scenarios
37 in Clear Creek and the Feather River, although water temperatures could be
38 somewhat more suitable for spring-run Chinook Salmon holding and
39 spawning/egg incubation in the Feather River under Alternative 1. This
40 conclusion is supported by the water temperature threshold exceedance analysis
41 that indicated that water temperature thresholds for spawning and egg incubation
42 would be exceeded slightly less frequently under Alternative 1 than under the No
43 Action Alternative in Clear Creek and the Feather River. The water temperature
44 threshold for rearing spring-run Chinook Salmon would also be exceeded slightly
45 less frequently in the Feather River under Alternative 1. Because of the inherent

1 uncertainty associated with the resolution of the temperature model (average
2 monthly outputs), the slightly greater likelihood of exceeding water temperature
3 thresholds under Alternative 1 could increase the potential for adverse effects on
4 the spring-run Chinook Salmon populations in the Feather River. Given the
5 similarity of the results, Alternative 1 and the No Action Alternative are likely to
6 have similar effects on the spring-run Chinook Salmon population in Clear Creek.
7 These model results suggest that overall, effects on spring-run Chinook Salmon
8 could be slightly more adverse under Alternative 1 than the No Action
9 Alternative, with a small likelihood that spring-run Chinook Salmon production
10 would be lower under the No Action Alternative. This potential distinction
11 between the two scenarios, however, may be partially offset by the benefits of
12 implementation of fish passage under the No Action Alternative intended to
13 address the limited availability of suitable habitat for spring-run Chinook Salmon
14 in the Sacramento River reaches downstream of Keswick Dam. This potential
15 beneficial effect and its magnitude would depend on the success of the fish
16 passage program.

17 *Fall-Run Chinook Salmon*

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

23 *Changes in Water Temperature*

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

27 *Sacramento River*

28 Long-term average monthly water temperature in the Sacramento River at
29 Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F
30 difference) to water temperatures under the No Action Alternative. An exception
31 is during September and October of critical dry years when water temperatures
32 could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as
33 compared to the No Action Alternative and up to 1°F warmer in September of
34 wetter years (Appendix 6B). A similar pattern in temperature differences
35 generally would be exhibited at downstream locations along the Sacramento River
36 (i.e., Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and
37 Knights Landing), with differences in average monthly temperatures in June at
38 Knights Landing progressively decreasing (up to 0.9°F) under Alternative 1
39 relative to the No Action Alternative and progressively increasing (up to 4.6°F) in
40 September during the wetter years.

41 Overall, the temperature differences between Alternative 1 and the No Action
42 Alternative would be relatively minor (less than 0.5°F) and likely would have
43 little effect on fall-run Chinook Salmon in the Sacramento River. The slightly

1 lower water temperatures from October to December under Alternative 1 would
2 likely have little effect on fall-run Chinook Salmon as water temperatures in the
3 Sacramento River below Keswick Dam are typically low during this time period.
4 The somewhat higher water temperatures in September of wetter years may
5 increase the likelihood of adverse effects on early spawning fall-run Chinook
6 Salmon under Alternative 1, although the reduced water temperatures in
7 September of critical dry years under Alternative 1 may decrease the likelihood of
8 adverse effects on fall-run Chinook Salmon spawning in this water year type.

9 *Clear Creek*

10 Average monthly water temperatures in Clear Creek at Igo under Alternative 1
11 relative to the No Action Alternative are generally predicted to be similar to or
12 lower (up to about 0.5°F) from September through April and June through August
13 (Appendix 6B, Table B-3-1). Average monthly water temperatures during May
14 under Alternative 1 would be higher by 0.4°F to 0.8°F than under the No Action
15 Alternative in all water year types. Average monthly temperatures at the
16 confluence with the Sacramento River would exhibit a similar pattern, although
17 temperatures in the creek would be slightly higher in general.

18 Under Alternative 1, temperature conditions at Igo would be slightly cooler than
19 under the No Action Alternative. However, these temperature outputs represent
20 conditions at Igo, a location upstream of most fall-run Chinook Salmon spawning
21 and rearing. Temperatures where fall-run Chinook Salmon inhabit the creek
22 would be somewhat higher as indicated by average monthly temperatures at the
23 confluence with the Sacramento River, although these temperatures would be
24 similar under Alternative 1 and the No Action Alternative. Overall, water
25 temperature effects on fall-run Chinook Salmon in Clear Creek due to
26 temperature differences between Alternative 1 and the No Action Alternative
27 would be relatively minor.

28 *Feather River*

29 Average monthly water temperature in the Feather River in the low flow channel
30 under Alternative 1 relative to the No Action Alternative generally were predicted
31 to be similar (less than 0.5°F differences), but slightly lower from October
32 through December when average monthly water temperatures would be up to
33 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Modeled
34 water temperatures during May and June under Alternative 1 were also slightly
35 lower, up to a maximum of 0.7°F lower in June of below normal water years.
36 Average monthly water temperatures in July through September under Alternative
37 1 generally were predicted to be lower (up to 0.6°F) in drier water year types and
38 higher (up to 1.3°F) in the wetter years. Although temperatures in the river would
39 become progressively higher in the downstream directions, the differences
40 between Alternative 1 and No Action Alternative would exhibit a similar pattern
41 at the downstream locations (Robinson Riffle and Gridley Bridge), with water
42 temperatures under Alternative 1 generally increasing in most water year types
43 relative to the No Action Alternative. Water temperatures under Alternative 1
44 were predicted to be somewhat (0.7°F to 1.6°F) warmer on average and up to

1 4.0°F warmer at the confluence with the Sacramento River from July to
2 September in wetter years (Appendix 6B, Table B-23-1).
3 Overall, the temperature differences in the Feather River between Alternative 1
4 and the No Action Alternative would be relatively minor (less than 0.5°F) and
5 likely would have little effect on fall-run Chinook Salmon in the Feather River.
6 The slightly lower water temperatures in November and December under
7 Alternative 1 would likely have little effect on fall-run Chinook Salmon as water
8 temperatures in the Feather River are typically low during this time period. The
9 somewhat higher water temperatures in September of wetter years may increase
10 the likelihood of adverse effects on early spawning fall-run Chinook Salmon,
11 although the decreased temperatures in September of critical dry years under
12 Alternative 1 may reduce the likelihood of adverse effects on fall-run Chinook
13 Salmon spawning in this water year type.

14 *American River*

15 Long-term average monthly water temperatures in the American River at Nimbus
16 Dam under Alternative 1 generally would be similar (differences less than 0.5°F)
17 to the No Action Alternative, with the exception of during June and August, when
18 temperatures under Alternative 1 could be as much as 0.9°F lower in below
19 normal years (Appendix 6B, Table B-12-1). This pattern generally would persist
20 downstream to Watt Avenue and the mouth, although temperatures under
21 Alternative 1 would be up to 1.6°F and 2.0°F lower, respectively, than under the
22 No Action Alternative in June. In addition, average monthly water temperatures
23 at the mouth generally would be higher under Alternative 1 than the No Action
24 Alternative in September, especially in wetter water year types when Alternative
25 1 could be up to 1.7°F warmer (Appendix 6B, Table B-14-1).

26 Overall, the temperature differences in the American River between Alternative 1
27 and the No Action Alternative would be relatively minor (less than 0.5°F) and
28 likely would have little effect on fall-run Chinook Salmon in the American River.
29 The slightly lower water temperatures in June and August in some water year
30 types under Alternative 1 may decrease the likelihood of adverse effects on
31 fall-run Chinook Salmon rearing in the American River if they are present. The
32 slightly higher water temperatures during September under Alternative 1 would
33 have little effect on fall-run Chinook Salmon spawning in the American River
34 because most spawning occurs later in November.

35 *Changes in Exceedances of Water Temperature Thresholds*

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

40 *Sacramento River*

41 Average monthly water temperatures under both Alternative 1 and the No Action
42 Alternative indicate exceedances of the water temperature threshold of 56°F
43 established in the Sacramento River at Red Bluff for Chinook Salmon spawning
44 and egg incubation in October, November, and again in April. There would be no

1 exceedances of the threshold from December to March under both Alternative 1
2 and the No Action Alternative. In the months when the greatest frequency of
3 exceedances occur (October, November, and April), model results generally
4 indicate less frequent exceedances (by up to 4 percent in October) under
5 Alternative 1 than under the No Action Alternative. Temperature conditions in
6 the Sacramento River under Alternative 1 could be less likely to affect fall-run
7 Chinook Salmon spawning and egg incubation than under the No Action
8 Alternative because of the reduced frequency of exceedance of the 56°F threshold
9 in October, November, and April.

10 *Clear Creek*

11 Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during
12 October through December (USFWS 2015). Average monthly water
13 temperatures at Igo during this period generally fall below 56°F, except in
14 October. Under Alternative 1, the 56°F threshold would be exceeded in October
15 about 10 percent of the time as compared to 12 percent under the No Action
16 Alternative (Appendix 9N). At the confluence with the Sacramento River,
17 average monthly water temperatures in October would be warmer, with the 56°F
18 threshold exceeded slightly less frequently under Alternative 1 compared to the
19 No Action Alternative (Appendix 6B, Figure B-4-1). During November and
20 December, average monthly water temperatures generally would remain below
21 56°F at both locations (Appendix 6B, Figure B-4-2 and B-4-3). Temperature
22 conditions in Clear Creek under Alternative 1 could be less likely to affect
23 fall-run Chinook Salmon spawning and egg incubation than under the No Action
24 Alternative because of the reduced frequency of exceedance of the 56°F threshold
25 in October.

26 For fall-run Chinook Salmon rearing (January through August), the exceedances
27 described previously for spring-run Chinook Salmon would apply, with the
28 average monthly temperatures at Igo remaining below the 60°F rearing threshold
29 in all months. Downstream at the mouth of Clear Creek, average monthly water
30 temperatures would exceed the 60°F threshold often during the summer, but the
31 frequency of exceedance would be similar under Alternative 1 and the No Action
32 Alternative (Appendix 6B). Temperature conditions for fall-run Chinook Salmon
33 rearing in Clear Creek would be similar under Alternative 1 and the No Action
34 Alternative.

35 *Feather River*

36 Average monthly water temperatures under both Alternative 1 and No Action
37 Alternative would exceed the water temperature threshold of 56°F established in
38 the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and
39 egg incubation during some months, particularly in October, November, March,
40 and April, when temperature thresholds would be exceeded frequently (Appendix
41 6B, Table B-22-4). The frequency of exceedance would be greatest in October,
42 when average monthly temperatures under both Alternative 1 and the No Action
43 Alternative would be above the threshold in nearly every year. The magnitude of
44 the exceedances would be high as well, with average monthly temperatures in
45 October reaching about 68°F. Similarly, the threshold would be exceeded under

1 both Alternative 1 and the No Action Alternative about 85 percent of the time in
2 April. The differences between Alternative 1 and the No Action Alternative,
3 however, would be relatively small, with Alternative 1 generally exceeding
4 temperature thresholds about 1-2 percent less frequently than the No Action
5 Alternative during the October through April period. Temperature conditions in
6 the Feather River under Alternative 1 could be less likely to affect fall-run
7 Chinook Salmon spawning and egg incubation than under the No Action
8 Alternative because of the reduced frequency of exceedance of the 56°F threshold
9 from October through April.

10 *Changes in Egg Mortality*

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

14 *Sacramento River*

15 For fall-run Chinook Salmon in the Sacramento River, the long-term average egg
16 mortality rate is predicted to be around 17 percent, with higher mortality rates (in
17 excess of 35 percent) occurring in critical dry years under Alternative 1.
18 Predicted egg mortality would be 0.1 percent higher under Alternative 1 than
19 under the No Action Alternative; in critical dry years the average egg mortality
20 rate would be 2.4 percent lower than under the No Action Alternative (Appendix
21 9C, Table B-1). Overall, fall-run Chinook Salmon egg mortality in the
22 Sacramento River under Alternative 1 and the No Action Alternative would be
23 similar, except in critical dry water years.

24 *Feather River*

25 For fall-run Chinook Salmon in the Feather River, the long-term average egg
26 mortality rate is predicted to be relatively low (around 7 percent), with higher
27 mortality rates (around 17 percent) occurring in critical dry years under
28 Alternative 1. Predicted egg mortality would be 0.2 percent lower under
29 Alternative 1 than under the No Action Alternative; in critical dry years the
30 average egg mortality rate would be 3 percent greater than under the No Action
31 Alternative (Appendix 9C, Table B-7). Overall, fall-run Chinook Salmon egg
32 mortality in the Feather River under Alternative 1 and the No Action Alternative
33 would be similar, except in critical dry water years.

34 *American River*

35 For fall-run Chinook Salmon in the American River, the predicted long-term
36 average egg mortality rate is predicted to range from approximately 22 to
37 25 percent in all water year types under Alternative 1. The predicted egg
38 mortality rate would be 0.2 percent lower under Alternative 1 than under the No
39 Action Alternative; in Below Normal water years the average egg mortality rate
40 would be 2 percent lower than under the No Action Alternative. In other water
41 year types, egg mortality is predicted to be from 0.6 percent lower to 0.6 percent
42 higher under Alternative 1 as compared to the No Action Alternative
43 (Appendix 9C, Table B-6). Overall, fall-run Chinook Salmon egg mortality in the

1 American River under Alternative 1 and the No Action Alternative would be
2 similar.

3 *Changes in Weighted Usable Area*

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

7 *Sacramento River*

8 As an indicator of the amount of suitable spawning habitat for fall-run Chinook
9 Salmon between Keswick Dam and Battle Creek, modeling results indicate that,
10 in general, there would be greater amounts of spawning habitat available from
11 September through November under Alternative 1 as compared to the No Action
12 Alternative; fall-run spawning WUA would be slightly (less than 5 percent)
13 reduced in December, but this is after the peak spawning period for fall-run
14 Chinook Salmon in this reach (Appendix 9E, Table C-11-4). The increase in
15 long-term average spawning WUA during September (prior to the peak spawning
16 period) under Alternative 1 would be relatively large (more than 20 percent), with
17 smaller increases in October (around 2 percent) and November (around 6 percent)
18 which comprise the peak spawning period for fall-run Chinook Salmon. Results
19 for the reach from Battle Creek to Deer Creek show the same pattern in changes
20 in WUA for spawning fall-run Chinook Salmon between Alternative 1 and the No
21 Action Alternative (Appendix 9E, Table C-10-4). Overall, spawning habitat
22 availability would be somewhat higher under Alternative 1 relative to the No
23 Action Alternative.

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

28 Similar to the results for fry rearing WUA, modeling results indicate that, there
29 would be similar amounts of suitable juvenile rearing habitat available during the
30 early juvenile rearing period from February to April under Alternative 1 and the
31 No Action Alternative. There would be a slight decrease (around 3 percent) in the
32 long-term average juvenile rearing WUA during May and June under Alternative
33 as compared to the No Action Alternative (Appendix 9E, Table C-13-4). Overall,
34 the amount of juvenile rearing habitat (WUA) would be similar under Alternative
35 1 and the No Action Alternative.

36 *Clear Creek*

37 As described above, flows in Clear Creek downstream of Whiskeytown Dam are
38 not anticipated to differ under Alternative 1 relative to the No Action Alternative
39 except in May due to the release of spring attraction flows in accordance with the
40 2009 NMFS BO under the No Action Alternative. Therefore, there would be no
41 change in the amount of potentially suitable spawning and rearing habitat for
42 fall-run Chinook Salmon (as indexed by WUA) available under Alternative 1 as
43 compared to the No Action Alternative.

1 *Feather River*

2 As described above, Flows in the low flow channel of the Feather River are not
3 anticipated to differ under Alternative 1 relative to the No Action Alternative.
4 Therefore, there would be no change in the amount of potentially suitable
5 spawning habitat for fall-run Chinook Salmon (as indexed by WUA) available
6 under Alternative 1 as compared to the No Action Alternative. The majority of
7 spawning activity by fall-run Chinook Salmon in the Feather River occurs in this
8 reach with a lesser amount of spawning occurring downstream of the Thermalito
9 Complex.

10 Modeling results indicate that, in general, there would be greater amounts of
11 spawning habitat available in September, November, and December under
12 Alternative 1 as compared to the No Action Alternative; fall-run spawning WUA
13 would be slightly (less than 5 percent) reduced in October (the peak spawning
14 month) for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-24-4).
15 The increase in long-term average spawning WUA during September (prior to the
16 peak spawning period) under Alternative 1 would be relatively large (more than
17 15 percent), with smaller increases in November and December (less than 1
18 percent) which are after the peak spawning period for fall-run Chinook Salmon.
19 Overall, spawning habitat availability would be similar under Alternative 1 and
20 the No Action Alternative.

21 *American River*

22 Modeling results indicate that, in general, there would be lower amounts of
23 spawning habitat available for fall-run Chinook Salmon in the American River
24 from October through December under Alternative 1 as compared to the No
25 Action Alternative; fall-run spawning WUA would be slightly (less than
26 5 percent) decreased in December with less than 1 percent decreases in September
27 and October (prior to the peak spawning period in November) (Appendix 9E,
28 Table C-25-4). Overall, spawning habitat availability would be similar under
29 Alternative 1 and the No Action Alternative.

30 *Changes in SALMOD Output*

31 SALMOD results indicate that pre-spawning mortality of fall-run Chinook
32 Salmon eggs would be approximately 16 percent lower under Alternative 1,
33 primarily due to reduced summer temperatures. Flow-related fall-run Chinook
34 Salmon egg mortality would be increased by 8 percent under Alternative 1
35 compared to the No Action Alternative. Conversely, temperature-related egg
36 mortality would be 11 percent lower under Alternative 1 (Appendix 9D,
37 Table B-1-4). Flow (habitat)-related fry mortality would be approximately 1
38 percent higher under Alternative 1 as compared to the No Action Alternative.
39 Temperature-related juvenile mortality would be approximately 21 percent lower
40 under Alternative 1, while flow (habitat)-related mortality would be similar under
41 Alternative 1 as compared to the No Action Alternative. Overall, potential
42 fall-run juvenile production would be slightly (approximately 1 percent) higher
43 under Alternative 1 as compared to the No Action Alternative (Appendix 9D,
44 Table B-1-1).

1 *Changes in Delta Passage Model Output*

2 The Delta Passage Model predicted similar estimates of annual Delta survival
3 across the 81 water year time period for fall-run between Alternative 1 and the No
4 Action Alternative (Appendix 9J). Median Delta survival was 0.245 for
5 Alternative 1 and 0.248 for the No Action Alternative.

6 *Changes in Delta Hydrodynamics*

7 Fall-run Chinook Salmon smolts are most abundant in the Delta during the
8 months of April, May and June. At the junction of Georgiana Slough and the
9 Sacramento River, percent positive velocity was similar under both Alternative 1
10 and No Action Alternative in the month of April and was moderately higher for
11 Alternative 1 relative to the No Action Alternative during May and June
12 (Appendix 9K). Near the confluence of the San Joaquin River and the
13 Mokelumne River, the proportion of positive velocities was moderately lower
14 under Alternative 1 relative to No Action Alternative in April and May and
15 almost indistinguishable in June. On Old River downstream of the facilities, the
16 proportion of positive velocities was substantially lower in April and May under
17 Alternative 1 relative to No Action Alternative but became more similar in June
18 (Appendix 9K). In Old River upstream of the facilities, the percent of positive
19 velocities was moderately lower for Alternative 1 relative to No Action
20 Alternative in April and May and moderately higher in June (Appendix 9K). On
21 the San Joaquin River downstream of the Head of Old River, the percent of
22 positive velocities was moderately higher under Alternative 1 relative to No
23 Action Alternative in April and May whereas the values were similar in June
24 (Appendix 9K).

25 *Changes in Junction Entrainment*

26 Entrainment at Georgiana Slough was similar under both Alternative 1 and No
27 Action Alternative in most months but was slightly higher under Alternative 1 in
28 the month of June (Appendix 9L). Entrainment probabilities at the Head of Old
29 River were much lower under Alternative 1 relative to the No Action Alternative
30 during April and May. Entrainment probabilities were similar under both
31 Alternatives in the month of June. At the Turner Cut junction, entrainment
32 probabilities under Alternative 1 were slightly higher than No Action Alternative
33 in June. During April and May, entrainment probabilities were more divergent
34 with higher values for Alternative 1 relative to No Action Alternative. Overall,
35 entrainment was lower at the Columbia Cut junction relative to Turner Cut but
36 patterns of entrainment between these two alternatives were similar. Entrainment
37 was slightly greater for Alternative 1 relative to No Action Alternative during
38 June. In April and May, entrainment was higher for Alternative 1 relative to No
39 Action Alternative. Patterns at the Middle River and Old River junctions were
40 similar to those observed at Columbia and Turner Cut junctions.

41 *Changes in Salvage*

42 Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater
43 under Alternative 1 relative to No Action Alternative in every month
44 (Appendix 9M). Fall-run smolts migrating through the Delta would be most

1 susceptible in the months of April, May and June. Predicted values in April and
2 May indicated an increased fraction of fish salvaged under Alternative 1 relative
3 to No Action Alternative. Predicted salvage was more similar in March but still
4 higher under Alternative 1.

5 *Summary of Effects on Fall-Run Chinook Salmon*

6 The multiple model and analysis outputs described above characterize the
7 anticipated conditions for fall-run Chinook Salmon and their response to change
8 under Alternative 1 and the No Action Alternative. For the purpose of analyzing
9 effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was
10 placed on the outputs from the SALMOD model because it integrates the
11 available information on temperature and flows to produce estimates of mortality
12 for each life stage and an overall, integrated estimate of potential fall-run Chinook
13 Salmon juvenile production. The output from SALMOD indicated that fall-run
14 Chinook Salmon production would be slightly higher in most water year types
15 under Alternative 1 than under the No Action Alternative, and up to 12 percent
16 greater than under the No Action Alternative in critical dry years.

17 The analyses attempting to assess the effects on routing, entrainment, and salvage
18 of juvenile salmonids in the Delta suggest that salvage (as an indicator of
19 potential losses of juvenile salmon at the export facilities) of Sacramento River-
20 origin Chinook Salmon is predicted to be higher under Alternative 1 relative to
21 No Action Alternative in every month.

22 In Clear Creek and the Feather and American rivers, the analysis of the effects of
23 Alternative 1 and the No Action Alternative for fall-run Chinook Salmon relied
24 on the WUA analysis for habitat and water temperature model output for the
25 rivers at various locations downstream of the CVP and SWP facilities. The WUA
26 analysis indicated that the availability of spawning and rearing habitat in Clear
27 Creek and spawning habitat in the Feather and American rivers would be similar
28 under Alternative 1 and the No Action Alternative. The temperature model
29 outputs for each of the fall-run Chinook Salmon life stages suggest that thermal
30 conditions and effects on fall-run Chinook Salmon in all of these streams
31 generally would be similar under both scenarios. The water temperature threshold
32 exceedance analysis that indicated that the water temperature thresholds for fall-
33 run Chinook Salmon spawning and egg incubation would be exceeded slightly
34 less frequently in the Feather River and Clear Creek under Alternative 1. Given
35 the inherent uncertainty associated with the resolution of the temperature model
36 (average monthly outputs), the reduced frequency of exceedance of temperature
37 thresholds under Alternative 1 could reduce the potential for adverse effects on
38 the fall-run Chinook Salmon populations in Clear Creek and the Feather River.
39 Results of the analysis using Reclamation's salmon mortality model indicate that
40 there would be little difference in fall-run Chinook Salmon egg mortality under
41 Alternative 1 and the No Action Alternative.

42 These model results suggest that overall, effects on fall-run Chinook Salmon
43 could be slightly less adverse under Alternative 1 than the No Action Alternative,
44 with a small likelihood that fall-run Chinook Salmon production would be higher
45 under Alternative 1. This potential distinction between the two scenarios,

1 however, may be partially offset by the benefits of implementation of fish passage
2 under the No Action Alternative intended to address the limited availability of
3 suitable habitat for winter-run and spring-run Chinook Salmon in the Sacramento
4 River reaches downstream of Keswick Dam. This potential benefit, however,
5 would only apply if volitional passage provides access to additional habitat for
6 fall-run Chinook Salmon.

7 *Late Fall-Run Chinook Salmon*

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

11 *Changes in Water Temperature*

12 Long-term average monthly water temperature in the Sacramento River at
13 Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F
14 difference) to water temperatures under the No Action Alternative. An exception
15 is during September and October of critical dry years when water temperatures
16 could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as
17 compared to the No Action Alternative and up to 1°F warmer in September of
18 wetter years (Appendix 6B, Table 5-5-1). A similar pattern in temperature
19 differences generally would be exhibited at downstream locations along the
20 Sacramento River (i.e., Ball's Ferry, Jelly's Ferry, Bend Bridge, Red Bluff,
21 Hamilton City, and Knights Landing), with differences in average monthly
22 temperatures in June at Knights Landing progressively increasing (up to 0.9°F)
23 under Alternative 1 relative to the No Action Alternative and progressively
24 decreasing (up to 4.6°F) in September during the wetter years.

25 Overall, the temperature differences between Alternative 1 and the No Action
26 Alternative would be relatively minor (less than 0.5°F) and likely would have
27 little effect on late fall-run Chinook Salmon in the Sacramento River. The
28 slightly lower water temperatures from October to December under Alternative 1
29 would likely have little effect on late fall-run Chinook Salmon migration and
30 holding as water temperatures in the Sacramento River below Keswick Dam are
31 typically low during this time period. The likelihood of adverse effects on late
32 fall-run Chinook Salmon spawning and egg incubation would be similar under
33 Alternative 1 and the No Action Alternative due to similar water temperatures
34 during the January to May time period. Because late fall-run Chinook Salmon
35 have an extended rearing period, the similar water temperatures during the
36 summer under Alternative 1 and the No Action Alternative would have similar
37 effects on rearing fry and juvenile late fall-run Chinook Salmon in the Sacramento
38 River. The higher water temperatures under Alternative 1 in September of wetter
39 years may increase the likelihood of adverse effects on fry and juvenile late fall-
40 run Chinook Salmon in the Sacramento River during this limited time period.

41 *Changes in Exceedances of Water Temperature Thresholds*

42 Average monthly water temperatures under both Alternative 1 and the No Action
43 Alternative indicate exceedances of the water temperature threshold of 56°F
44 established in the Sacramento River at Red Bluff for Chinook Salmon spawning

1 and egg incubation in October, November, and again in April. There would be no
2 exceedances of the threshold from December to March under both Alternative 1
3 and the No Action Alternative. In April, model results indicate that water
4 temperatures under Alternative 1 would exceed the threshold about 2 percent less
5 frequently than under the No Action Alternative. Temperature conditions in the
6 Sacramento River under Alternative 1 could be slightly less likely to affect late
7 fall-run Chinook Salmon spawning and egg incubation than under the No Action
8 Alternative because of the reduced frequency of exceedance of the 56°F threshold
9 in April.

10 *Changes in Egg Mortality*

11 For late fall-run Chinook Salmon in the Sacramento River, the long-term average
12 egg mortality rate is predicted to range from approximately 2 to nearly 5 percent
13 in all water year types under Alternative 1. Overall, egg mortality would be
14 0.4 percent lower under Alternative 1; in Below Normal water years the average
15 egg mortality rate would be 0.1 percent higher than under Alternative 1. In other
16 water year types, egg mortality is predicted to be from 0.1 to 0.8 percent lower
17 under Alternative 1 as compared to the No Action Alternative (Appendix 9C,
18 Table B-2). Overall, late fall-run Chinook Salmon egg mortality in the
19 Sacramento River under Alternative 1 and the No Action Alternative would be
20 similar.

21 *Changes in Weighted Usable Area*

22 Modeling results indicate that there would be slightly (less than 5 percent)
23 reduced amounts of spawning habitat available for late fall-run Chinook Salmon
24 in the Sacramento River from January through April under Alternative 1 as
25 compared to the No Action Alternative (Appendix 9E, Table C-14-4). Overall,
26 spawning habitat availability would be similar under Alternative 1 and the No
27 Action Alternative.

28 Modeling results indicate that, in general, there would be reduced amounts of
29 suitable late fall-run Chinook Salmon fry rearing habitat available during April
30 and May under Alternative 1 (Appendix 9E, Table C-15-4). The decrease in
31 long-term average fry rearing WUA during these months would be relatively
32 small (less than 5 percent). Late fall-run Chinook Salmon fry rearing WUA
33 would be increased by about 2 percent in June under Alternative 1 as compared to
34 the No Action Alternative. Overall, late fall-run fry rearing habitat availability
35 would be similar under Alternative 1 and the No Action Alternative.

36 A substantial fraction of late fall run Chinook Salmon juveniles oversummer in
37 the Sacramento River before emigrating, which allows them to avoid predation
38 through both their larger size and greater swimming ability. One implication of
39 this life history strategy is that rearing habitat is most likely the limiting factor for
40 late-fall-run Chinook Salmon, especially if availability of cool water determines
41 the downstream extent of spawning habitat for late-fall-run salmon. Modeling
42 results indicate that, there would be decreased amounts of suitable juvenile
43 rearing habitat available from December through August, but this decrease would
44 be small (generally less than 2 percent) under Alternative 1 as compared to the No

1 Action Alternative. There would an increase in the amount of late fall-run
2 Chinook Salmon juvenile rearing WUA in the other months (September through
3 November) of up to 10 percent (Appendix 9E, Table C-16-4). Overall, late
4 fall-run juvenile rearing habitat availability would be slightly increased under
5 Alternative 1 relative to the No Action Alternative.

6 *Changes in SALMOD Output*

7 SALMOD results indicate that flow-related late fall-run Chinook Salmon egg
8 mortality would be increased by 5 percent under Alternative 1 compared to the
9 No Action Alternative. Conversely, temperature-related egg mortality would be
10 4 percent lower under Alternative 1 (Appendix 9D, Table B-2-4). Flow
11 (habitat)-related fry mortality would be approximately 3 percent higher while
12 temperature-related fry mortality would be about 2 percent lower under
13 Alternative 1 as compared to the No Action Alternative. Temperature-related
14 juvenile mortality would be approximately 16 percent lower under Alternative 1,
15 while flow (habitat)-related mortality would approximately 34 percent lower
16 under Alternative 1 as compared to the No Action Alternative. Overall, potential
17 juvenile production would be the similar under Alternative 1 and the No Action
18 Alternative (Appendix 9D, Table B-2-1).

19 *Changes in Delta Passage Model Output*

20 For late fall-run Chinook Salmon, through-Delta survival was predicted to be
21 slightly lower under Alternative 1 relative to the No Action Alternative for all
22 81 years simulated by the Delta Passage Model (Appendix 9J). Median Delta
23 survival across all years was 0.199 for Alternative 1 and 0.244 for the No Action
24 Alternative.

25 *Changes in Delta Hydrodynamics*

26 The late fall run Chinook migration period overlaps with winter-run. See the
27 section on hydrodynamic analysis for winter run Chinook Salmon for potential
28 effects on late fall-run Chinook Salmon.

29 *Changes in Junction Entrainment*

30 Entrainment probabilities for late fall-run Chinook Salmon are assumed to mimic
31 that of winter-run Chinook Salmon due to the overlap in timing. See the section
32 on winter-run Chinook Salmon entrainment for potential effects on late fall-run
33 Chinook Salmon.

34 *Changes in Salvage*

35 Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run
36 Chinook Salmon due to the overlap in timing. See the section on winter-run
37 Chinook Salmon entrainment for potential effects on late fall-run Chinook
38 Salmon.

39 *Summary of Effects on Late Fall-Run Chinook Salmon*

40 The multiple model and analysis outputs described above characterize the
41 anticipated conditions for late fall-run Chinook Salmon and their response to
42 change under Alternative 1 and the No Action Alternative. For the purpose of
43 analyzing effects on late fall-run Chinook Salmon and developing conclusions,

1 greater reliance was placed on the outputs from the SALMOD model because it
2 integrates the available information on temperature and flows to produce
3 estimates of mortality for each life stage and an overall, integrated estimate of
4 potential fall-run Chinook Salmon juvenile production. The output from
5 SALMOD indicated that late fall-run Chinook Salmon production would be
6 similar under Alternative 1 and the No Action Alternative, although production
7 under Alternative 1 could be slightly lower in some water year types and about
8 4 percent higher in critical dry years than under the No Action Alternative. The
9 analyses attempting to assess the effects on routing, entrainment, and salvage of
10 juvenile salmonids in the Delta suggest that salvage (as an indicator of potential
11 losses of juvenile salmon at the export facilities) of Sacramento River-origin
12 Chinook Salmon is predicted to be higher under Alternative 1 relative to No
13 Action Alternative in every month.

14 Although survival in the Delta may be lower, given the similarity in the
15 SALMOD outputs, it is likely that Alternative 1 and the No Action Alternative
16 would have similar effects on fall-run Chinook Salmon.

17 *Steelhead*

18 Changes in operations that influence temperature and flow conditions that could
19 affect steelhead. The following describes those changes and their potential
20 effects.

21 *Changes in Water Temperature*

22 Changes in water temperature could affect steelhead in the Sacramento, Feather,
23 and American rivers, and Clear Creek. The following describes temperature
24 conditions in those water bodies.

25 *Sacramento River*

26 Long-term average monthly water temperature in the Sacramento River at
27 Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F
28 difference) to water temperatures under the No Action Alternative. An exception
29 is during September and October of critical dry years when water temperatures
30 could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as
31 compared to the No Action Alternative and up to 1°F warmer in September of
32 wetter years (Appendix 6B, Table 5-5-1). A similar pattern of changes in
33 temperature generally would be exhibited downstream at Ball's Ferry, Jelly's
34 Ferry, Bend Bridge and Red Bluff, with average monthly temperature differences
35 progressively increasing (up to a 3.2°F at Red Bluff) in September during the
36 wetter years (Appendix 6B, Table B-9-1).

37 Overall, the temperature differences between Alternative 1 and the No Action
38 Alternative would be relatively minor (less than 0.5°F) and likely would have
39 little effect on steelhead in the Sacramento River. Based on the life history timing
40 for steelhead, the slightly lower water temperatures in September and October of
41 drier years under Alternative 1 may reduce the likelihood of adverse effects on
42 steelhead adults migrating upstream in the Sacramento River. The higher water
43 temperatures in September of wetter years under Alternative 1 may increase the

1 likelihood of adverse effects on steelhead migration compared to the No Action
2 Alternative.

3 *Clear Creek*

4 Average monthly water temperatures in Clear Creek at Igo under Alternative 1 are
5 generally predicted to be similar to (less than 0.5°F differences) water
6 temperatures under the No Action Alternative from September through April and
7 June through August (Appendix 6B, Table B-3-1). Average monthly water
8 temperatures during May under Alternative 1 would be higher by 0.4°F to 0.8°F
9 than under the No Action Alternative in all water year types.

10 Overall, the temperature differences between Alternative 1 and the No Action
11 Alternative would be relatively minor.

12 The lower water temperatures in May associated with the No Action Alternative
13 reflect the effects of the additional water discharged from Whiskeytown Dam to
14 meet the spring attraction flow requirements to promote attraction of spring-run
15 Chinook Salmon into Clear Creek. While the reduction in water temperature
16 indicated by the modeling could improve thermal conditions for steelhead, the
17 duration of the two pulse flows under the No Action Alternative may not be of
18 sufficient duration (3 days each) to provide biologically meaningful temperature
19 benefits. Overall, thermal conditions for steelhead in Clear Creek would be
20 similar under Alternative 1 and the No Action Alternative.

21 *Feather River*

22 Average monthly water temperature in the Feather River in the low flow channel
23 under Alternative 1 relative to the No Action Alternative generally were predicted
24 to be similar (less than 0.5°F differences), but slightly lower from October
25 through December when average monthly water temperatures would be up to
26 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Modeled
27 water temperatures during May and June under Alternative 1 were also slightly
28 lower, up to a maximum of 0.7°F lower in June of below normal water years.
29 Average monthly water temperatures in July through September under Alternative
30 1 generally were predicted to be lower (up to 0.6°F) in drier water year types and
31 higher (up to 1.3°F) in the wetter years. Although temperatures in the river
32 generally become progressively higher in the downstream direction, the
33 differences between Alternative 1 and the No Action Alternative exhibit a similar
34 pattern at the downstream locations (Robinson Riffle and Gridley Bridge), with
35 water temperature differences under Alternative 1 generally decreasing in most
36 water year types relative to the No Action Alternative. Water temperatures under
37 Alternative 1 are predicted to be somewhat (0.7°F to 1.6°F) cooler on average and
38 up to 4.0°F cooler at the confluence with Sacramento River from July to
39 September in wetter years than under the No Action Alternative.

40 Overall, the temperature differences in the Feather River between Alternative 1
41 and the No Action Alternative would be relatively minor (less than 0.5°F) and
42 likely would have little effect on steelhead in the Feather River. The slightly
43 lower water temperatures in November and December under Alternative 1 would
44 likely have little effect on adult steelhead migration as water temperatures in the

1 Feather River are typically low during this time period. The somewhat higher
2 water temperatures in September of wetter years may increase the likelihood of
3 adverse effects on adult steelhead migrating upstream and juveniles rearing in the
4 Feather River, although the decreased temperatures in September of critical dry
5 years under Alternative 1 may decrease the likelihood of adverse effects on
6 migrating and rearing steelhead in this water year type.

7 *American River*

8 Average monthly water temperatures in the American River at Nimbus Dam
9 under Alternative 1 generally would be similar (differences less than 0.5°F) to the
10 No Action Alternative, with the exception of during June and August, when
11 temperatures under Alternative 1 could be as much as 0.9°F lower in below
12 normal years. This pattern generally would persist downstream to Watt Avenue
13 and the mouth, although temperatures under Alternative 1 would be up to 1.6°F
14 and 2.0°F lower, respectively, than under the No Action Alternative in June. In
15 addition, average monthly water temperatures at the mouth generally would be
16 higher under Alternative 1 than the No Action Alternative in September,
17 especially in wetter water year types when Alternative 1 could be up to 1.7°F
18 warmer.

19 Overall, the temperature differences between Alternative 1 and the No Action
20 Alternative would be relatively minor. The (less than 0.5°F) and likely would
21 have little effect on steelhead in the American River. The slightly cooler water
22 temperatures in June and August under Alternative 1 may reduce the likelihood of
23 adverse effects on steelhead rearing in the American River compared to the No
24 Action Alternative.

25 *Changes in Exceedances of Water Temperature Thresholds*

26 Changes in water temperature could result in the exceedance of established water
27 temperature thresholds for steelhead in the Sacramento River, Clear Creek, and
28 Feather River. The following describes the extent of those exceedance for each of
29 those streams.

30 *Sacramento River*

31 Steelhead spawning in the mainstem Sacramento River generally occurs in the
32 upper reaches from Keswick Dam downstream to near Balls Ferry, with most
33 spawning concentrated near Redding. Most steelhead, however, spawn in
34 tributaries to the Sacramento River. Spawning generally takes place in the
35 January through March period when water temperatures in the river generally do
36 not exceed 52°F under either Alternative 1 or the No Action Alternative. While
37 there are no established temperature thresholds for steelhead rearing in the
38 mainstem Sacramento River, average monthly temperatures in during March
39 through June when fry and juvenile steelhead are in the river would be below
40 56°F during March and April at Balls Ferry. In May and June, average monthly
41 water temperatures would be slightly lower under Alternative 1 than they would
42 be under the No Action Alternative in the drier years, although neither condition
43 would exceed about 57°F. Thus, as it relates to temperature conditions for

1 steelhead in the mainstem Sacramento River, it is unlikely that Alternative 1 and
2 the No Action Alternative would differ in a biologically meaningful way.

3 *Clear Creek*

4 While there are no established temperature thresholds for steelhead spawning in
5 Clear Creek, average monthly water temperatures in the river generally would not
6 exceed 48°F during the spawning period (December to April) under Alternative 1
7 and the No Action Alternative. Similarly, while there are no established
8 temperature thresholds for steelhead rearing in Clear Creek, average monthly
9 temperatures in most months of the year would not exceed 56°F at Igo under both
10 alternatives. Thus, as it relates to temperature conditions for steelhead in Clear
11 Creek, it is unlikely that Alternative 1 and the No Action Alternative would differ
12 in a biologically meaningful way.

13 *Feather River*

14 Average monthly water temperatures under both Alternative 1 and the No Action
15 Alternative and would on occasion exceed the water temperature threshold of
16 56°F established in the Feather River at Robinson Riffle for steelhead spawning
17 and incubation during some months, particularly in October and November, and
18 March and April, when temperature thresholds could be exceeded frequently
19 (Appendix 9N). There would be no exceedances of the 56°F threshold from
20 December through February under both Alternative 1 and the No Action
21 Alternative. However, the differences in the frequency of exceedance between
22 Alternative 1 and No Action Alternative during March and April would be
23 relatively small with water temperatures under Alternative 1 exceeding the
24 threshold about 2 percent less frequently in March and the same exceedance
25 frequency (75 percent) as the No Action Alternative in April.

26 The established water temperature threshold of 63°F for rearing from May
27 through August would be exceeded often under both Alternative 1 and the No
28 Action Alternative in May and June, but not at all in July and August. Water
29 temperatures under Alternative 1 would exceed the rearing temperature threshold
30 about 9 percent less frequently than under the No Action Alternative in May, but
31 no more frequently in June. Temperature conditions in the Feather River under
32 Alternative 1 could be less likely to affect steelhead spawning and rearing than
33 under the No Action Alternative because of the reduced frequency of exceedance
34 of the 56°F spawning threshold in March and the increased frequency of
35 exceedance of the 63°F rearing threshold in May.

36 *American River*

37 In the American River, the water temperature threshold for steelhead rearing
38 (May through October) is 65°F at the Watt Avenue Bridge. Average monthly
39 water temperatures would exceed this threshold often under both Alternative 1
40 and No Action Alternative, especially in the July through September period when
41 the threshold is exceeded nearly all of the time. In addition, the magnitude of the
42 exceedance would be high, with average monthly water temperatures sometimes
43 higher than 76°F. The differences between Alternative 1 and No Action
44 Alternative, however, would be relatively small and only occur in June (1 percent

1 more frequently under Alternative 1), and in September, when average monthly
2 water temperatures under Alternative 1 would exceed 65°F about 7 percent more
3 frequently than under the No Action Alternative. Temperature conditions in the
4 American River under Alternative 1 could be more likely to affect steelhead
5 rearing than under the No Action Alternative because of the increased frequency
6 of exceedance of the 65°F rearing threshold.

7 *Changes in Weighted Usable Area*

8 The following describes changes in WUA for steelhead in the Sacramento,
9 Feather, and American rivers and Clear Creek.

10 *Sacramento River*

11 Modeling results indicate that, in general, there would be lower amounts of
12 suitable steelhead spawning habitat available from December through March
13 under Alternative 1 as compared to the No Action Alternative (Appendix 9E,
14 Table C-20-4). The decreases in long-term average steelhead spawning WUA
15 would be relatively small (less than 3 percent). Overall, spawning habitat
16 availability would be similar under Alternative 1 and the No Action Alternative.

17 *Clear Creek*

18 As described above, flows in Clear Creek downstream of Whiskeytown Dam are
19 not anticipated to differ under Alternative 1 relative to the No Action Alternative
20 except in May due to the release of spring attraction flows in accordance with the
21 2009 NMFS BO under the No Action Alternative. Therefore, there would be no
22 change in the amount of potentially suitable spawning and rearing habitat for
23 steelhead (as indexed by WUA) available under Alternative 1 as compared to the
24 No Action Alternative.

25 *Feather River*

26 Flows in the low flow channel of the Feather River are not anticipated to differ
27 under Alternative 1 relative to the No Action Alternative. Therefore, there would
28 be no change in the amount of potentially suitable spawning habitat for steelhead
29 (as indexed by WUA) available under Alternative 1 as compared to the No Action
30 Alternative. The majority of spawning activity by steelhead in the Feather River
31 occurs in this reach with a lesser amount of spawning occurring downstream of
32 the Thermalito Complex.

33 Modeling results indicate that, in general, there would be lower amounts of
34 spawning habitat for steelhead in the Feather River downstream of Thermalito
35 available from December through April under Alternative 1 as compared to the
36 No Action Alternative. The decreases in long-term average steelhead spawning
37 WUA during this time period would generally be less than 3 percent
38 (Appendix 9E, Table C-22-4). Overall, steelhead spawning habitat availability in
39 the Feather River would be similar under Alternative 1 and the No Action
40 Alternative.

41 *American River*

42 Modeling results indicate that, in general, there would be variable changes in the
43 amount of spawning habitat for steelhead in the American River downstream of
44 Nimbus Dam available from December through April under Alternative 1 as

1 compared to the No Action Alternative. The decreases in long-term average
2 steelhead spawning WUA during December, February and March would
3 generally be less than 3 percent, while the increase in April would also be less
4 than 3 percent (Appendix 9E, Table C-26-4). Overall, steelhead spawning habitat
5 availability in the American River would be similar under Alternative 1 and the
6 No Action Alternative.

7 *Summary of Effects on Steelhead*

8 The multiple model and analysis outputs described above characterize the
9 anticipated conditions for steelhead and their response to change under
10 Alternative 1 and the No Action Alternative. The analysis of the effects of
11 Alternative 1 and the No Action Alternative for steelhead relied on the WUA
12 analysis for habitat and water temperature model output for the rivers at various
13 locations downstream of the CVP and SWP facilities.

14 The WUA analysis indicated that the availability of steelhead spawning and
15 rearing habitat in Clear Creek and steelhead spawning habitat in the Sacramento,
16 Feather and American rivers would be similar under Alternative 1 and the No
17 Action Alternative. The temperature model outputs for each of the steelhead life
18 stages suggest that thermal conditions and effects on steelhead in all of these
19 streams generally would be similar under both scenarios. This conclusion is
20 supported by the water temperature threshold exceedance analysis that indicated
21 that the water temperature thresholds for steelhead spawning and egg incubation
22 would be exceeded less frequently in the Feather River under Alternative 1. The
23 water temperature threshold for steelhead rearing would also be exceeded less
24 frequently in the Feather River. Given the inherent uncertainty associated with
25 the resolution of the temperature model (average monthly outputs), the reduced
26 frequency of exceedance of temperature thresholds under Alternative 1 could
27 reduce the potential for adverse effects on the steelhead population in the Feather
28 River.

29 These model results suggest that overall, effects on steelhead could be slightly
30 less adverse under Alternative 1 than the No Action Alternative, particularly in
31 the Feather River. Implementation of the fish passage program under the No
32 Action Alternative intended to address the limited availability of suitable habitat
33 for steelhead in the Sacramento River reaches downstream of Keswick Dam and
34 in the American River could provide a benefit to Central Valley steelhead in the
35 Sacramento and American rivers.

36 *Green Sturgeon*

37 The effects on Green Sturgeon were analyzed by comparing changes in water
38 temperature and the frequency of temperature threshold exceedance between
39 Alternative 1 and the No Action Alternative, as described below.

40 *Changes in Water Temperature*

41 The effects of Alternative 1 compared to the No Action Alternative on Green
42 Sturgeon were analyzed based on water temperature model outputs and
43 comparisons of the frequency of water temperature threshold exceedances in the
44 Sacramento and Feather rivers.

1 *Sacramento River*

2 As described previously, long-term average monthly water temperature in the
3 Sacramento River at Keswick Dam under Alternative 1 would generally be
4 similar (less than 0.5°F difference) to water temperatures under the No Action
5 Alternative. An exception is during September and October of critical dry years
6 when water temperatures could be up to 1.1°F and 0.8°F lower, respectively,
7 under Alternative 1 as compared to the No Action Alternative and up to 1°F
8 warmer in September of wetter years (Appendix 6B). A similar pattern in
9 temperature differences generally would be exhibited at downstream locations
10 along the Sacramento River (i.e., Ball's Ferry, Jelly's Ferry, Bend Bridge, Red
11 Bluff, Hamilton City, and Knights Landing), with differences in average monthly
12 temperatures in June at Knights Landing progressively decreasing (up to 0.9°F)
13 under Alternative 1 relative to the No Action Alternative and progressively
14 increasing (up to 4.6°F) in September during the wetter years.

15 Overall, the temperature differences between Alternative 1 and the No Action
16 Alternative would be relatively minor. Based (less than 0.5°F) and likely would
17 have little effect on the life history timing for Green Sturgeon, the higher water
18 temperatures from January through May under the Alternative 1 may increase the
19 likelihood of adverse effects on migrating adult Green Sturgeon and spawning
20 and egg incubation compared to the No Action Alternative.

21 *Feather River*

22 Average monthly water temperature in the Feather River in the low flow channel
23 under Alternative 1 relative to the No Action Alternative generally were predicted
24 to be similar (less than 0.5°F differences), but slightly lower from October
25 through December when average monthly water temperatures would be up to
26 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Modeled
27 water temperatures during May and June under Alternative 1 were also slightly
28 lower, up to a maximum of 0.7°F lower in June of below normal water years.
29 Average monthly water temperatures in July through September under Alternative
30 1 generally were predicted to be lower (up to 0.6°F) in drier water year types and
31 higher (up to 1.3°F) in the wetter years.

32 Although temperatures in the river would become progressively higher in the
33 downstream directions, the differences between Alternative 1 and the No Action
34 Alternative would exhibit a similar pattern at the downstream locations (Robinson
35 Riffle and Gridley Bridge), with temperatures under Alternative 1 generally
36 increasing in most water year types relative to the No Action Alternative at the
37 confluence with Sacramento River (Appendix 6B, Table B-23-1).

38 Overall, the temperature differences between Alternative 1 and the No Action
39 Alternative would be relatively minor (less than 0.5°F) and likely would have
40 little effect on Green Sturgeon in the Feather River. The higher water
41 temperatures from January through April under Alternative 1 may increase the
42 likelihood of adverse effects on migrating adult Green Sturgeon compared to the
43 No Action Alternative. Lower water temperatures during May and June under
44 Alternative 1 could decrease the likelihood of adverse effects on egg incubation

1 and rearing of Green Sturgeon in the Feather River as compared to the No Action
2 Alternative.

3 *Changes in Exceedances of Water Temperature Thresholds*

4 Changes in water temperature could result in the exceedance of established water
5 temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers.
6 The following describes the extent of those exceedance for each of those rivers.

7 *Sacramento River*

8 Average monthly water temperatures in the Sacramento River at Bend Bridge
9 under both Alternative 1 and the No Action Alternative would exceed the water
10 temperature threshold of 63°F established for Green Sturgeon egg incubation in
11 August and September, with exceedances under Alternative 1 occurring about
12 6 percent of the time in August and about 10 percent of the time in September.
13 This is 1 to 2 percent less often than under the No Action Alternative. Average
14 monthly water temperatures at Bend Bridge could exceed the threshold by up to
15 10 degrees (reaching 73°F) during this period. Temperature conditions in the
16 Sacramento River under Alternative 1 could be less likely to affect Green
17 Sturgeon rearing than under the No Action Alternative because of the reduced
18 frequency of exceedance of the 63°F threshold in August and September.

19 *Feather River*

20 Average monthly water temperatures in the Feather River at Gridley Bridge under
21 both Alternative 1 and No Action Alternative would exceed the water temperature
22 threshold of 64°F established for Green Sturgeon spawning, incubation, and
23 rearing in May, June, and September; no exceedances under either scenarios
24 would occur in July and August. The frequency of exceedances would be high,
25 with water temperatures under both Alternative 1 and No Action Alternative
26 exceeding the threshold in June nearly 100 percent of the time. The magnitude of
27 the exceedance also would be substantial, with average monthly water
28 temperatures higher than 72°F in June, and higher than 75°F in July and August.
29 Water temperatures under Alternative 1 would exceed the threshold during May
30 about 9 percent less frequently than the No Action Alternative and about
31 35 percent more frequently in September. Temperature conditions in the Feather
32 River under Alternative 1 could be less likely to affect Green Sturgeon rearing
33 than under the No Action Alternative because of the reduced frequency of
34 exceedance of the 64°F threshold in May. The increase in exceedance frequency
35 in September under Alternative 1 may have little effect on rearing Green Sturgeon
36 as many juvenile sturgeon may have migrated downstream to the lower
37 Sacramento River and Delta by this time.

38 *Summary of Effects on Green Sturgeon*

39 The temperature model outputs for the Sacramento and Feather rivers suggest that
40 thermal conditions and effects on Green Sturgeon in the Sacramento and Feather
41 rivers generally would be slightly less adverse under Alternative 1. This
42 conclusion is supported by the water temperature threshold exceedance analysis
43 that indicated that the water temperature thresholds for Green Sturgeon spawning,
44 incubation, and rearing would be exceeded less frequently under Alternative 1 in

1 the Sacramento River. The water temperature threshold for Green Sturgeon
2 spawning, incubation, and rearing would also be exceeded less frequently during
3 some months in the Feather River, but would be exceeded more frequently in
4 September under Alternative 1. Given the inherent uncertainty associated with
5 the resolution of the temperature model (average monthly outputs), the reduced
6 frequency of exceedance of temperature thresholds under Alternative 1 could
7 reduce the potential for adverse effects on Green Sturgeon in the Sacramento and
8 Feather rivers relative to the No Action Alternative.

9 *White Sturgeon*

10 Changes in water temperature conditions in the Sacramento River would be the
11 same as those described above for Green Sturgeon in the Sacramento River.
12 Overall, the temperature differences between Alternative 1 and the No Action
13 Alternative would be relatively minor (less than 0.5°F) and likely would have
14 little effect on White Sturgeon in the Sacramento River.

15 The water temperature threshold established for White Sturgeon spawning and
16 egg incubation in the Sacramento River at Hamilton City is 61°F from March
17 through June. Although there would be no exceedances of the threshold in March
18 and April, water temperatures under both Alternative 1 and No Action Alternative
19 would exceed this threshold in May and June. The average monthly water
20 temperatures in May under Alternative 1 would exceed this threshold about
21 49 percent of the time (about 6 percent less frequently than the No Action
22 Alternative). In June, the average monthly water temperature under Alternative 1
23 would exceed the threshold about 73 percent of the time (about 13 percent less
24 frequently than under the No Action Alternative). Average monthly water
25 temperatures during May and June under Alternative 1 would as high as about
26 64°F, which is below the 68°F threshold considered lethal for White Sturgeon
27 eggs. Temperature conditions in the Sacramento River under Alternative 1 could
28 be less likely to affect White Sturgeon rearing than under the No Action
29 Alternative because of the reduced frequency of exceedance of the 61°F threshold
30 in May and June.

31 Overall, the temperature model outputs suggest that thermal conditions and
32 effects on White Sturgeon in the Sacramento River generally would be slightly
33 less adverse under Alternative 1. This conclusion is supported by the water
34 temperature threshold exceedance analysis that indicated that the water
35 temperature thresholds for White Sturgeon spawning, incubation, and rearing
36 would be exceeded less frequently under Alternative 1 in the Sacramento River.
37 Given the inherent uncertainty associated with the resolution of the temperature
38 model (average monthly outputs), the reduced frequency of exceedance of
39 temperature thresholds under Alternative 1 could reduce the potential for adverse
40 effects on White Sturgeon in the Sacramento River relative to the No Action
41 Alternative.

1 *Delta Smelt*

2 The potential for effects on Delta Smelt resulting from Alternative 1 as compared
3 to the No Action Alternative were analyzed using changes in proportional
4 entrainment and fall abiotic habitat index values.

5 As described in Appendix 9G, a proportional entrainment regression model
6 (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt
7 entrainment, as influenced by OMR flow in December through March. Results
8 indicate that the percentage of entrainment of migrating and spawning adult Delta
9 Smelt under Alternative 1 would be 9 percent (long term average percent
10 entrainment). Percent entrainment of adult Delta Smelt under Alternative 1 would
11 be similar to results under the No Action Alternative (but slightly higher, by 1 to
12 2 percent). Under the No Action Alternative, the long term average percent
13 entrainment would be 7.6 percent.

14 As described in Appendix 9G, a proportional entrainment regression model
15 (based on Kimmerer 2008) was used to simulate larval and early juvenile Delta
16 Smelt entrainment, as influenced by OMR flow and location of X2 in March
17 through June. Results indicate that the percentage of entrainment of larval and
18 early juvenile Delta Smelt under Alternative 1 would be 15.5 percent, long-term
19 average, and highest entrainment of 23.6 percent under Critical water year
20 conditions. Percent entrainment of larval and early juvenile Delta Smelt under
21 Alternative 1 would be higher than results under the No Action Alternative, by
22 4.3 to 9.4 percent. Under the No Action Alternative, the long term average
23 percent entrainment would be 8.6 percent, and highest entrainment would occur
24 under Critical water year conditions, at 19.3 percent.

25 The predicted location of Fall X2 position (in September through December) is
26 used as an indicator of fall abiotic habitat index for Delta Smelt. Feyrer et al.
27 used X2 location as an indicator of the extent of habitat available with suitable
28 salinity for the rearing of older juvenile delta smelt. Feyrer et al. concluded that
29 when X2 is located downstream (west) of the confluence of the Sacramento and
30 San Joaquin Rivers, at a distance of 70 to 80 km from the Golden Gate Bridge,
31 there is a larger area of suitable habitat. The overlap of the low salinity zone (or
32 X2) with the Suisun Bay/Marsh is believed to lead to more favorable growth and
33 survival conditions for Delta Smelt in fall. The average September through
34 December X2 position in km was used to evaluate the fall abiotic habitat
35 availability for delta smelt under the Alternatives. X2 values simulated in the
36 CalSim II model for each Alternative were averaged over September through
37 December, and compared.

38 Alternative 1 does not include the operations related to the 2008 USFWS BO
39 RPA Component 3 (Action 4), Fall X2 requirement while the No Action
40 Alternative includes it. Therefore, the average September through December X2
41 position under Alternative 1 would be eastward by over 6 km compared to the No
42 Action Alternative during the wetter years. In the drier years September through
43 December average X2 position is similar under both scenarios.

1 Overall, Alternative 1 likely would have adverse effects on Delta Smelt, as
2 compared to the No Action Alternative, primarily due to the potential for
3 increased percentage entrainment during larval and juvenile life stages, and less
4 favorable location of Fall X2 in wetter years, and on average.

5 *Longfin Smelt*

6 The effects of the Alternative 1 as compared to the No Action Alternative were
7 analyzed based on the direction and magnitude of OMR flows during the period
8 (December through June) when adult, larvae, and young juvenile Longfin Smelt
9 are present in the Delta in the vicinity of the export facilities (Appendix 5A). The
10 analysis was augmented with calculated Longfin Smelt abundance index values
11 (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions
12 that lower X2 values reflect higher flows and that transporting Longfin Smelt
13 farther downstream leads to greater Longfin Smelt survival. The index value
14 indicates the relative abundance of Longfin Smelt and not the calculated
15 population.

16 The OMR flows would generally be negative in all months under Alternative 1,
17 with the long-term average ranging from -3,700 to -7,400 cfs from December
18 through June (Appendix 5A). The OMR flows generally would be more negative
19 during this time period under Alternative 1 as compared to the No Action
20 Alternative. The greatest differences between alternatives would be in April and
21 May, where long-term average OMR flows would be negative under Alternative 1
22 and positive under the No Action Alternative (Appendix 5A, Table C-17-4). The
23 increase in the magnitude of negative flows, with negative flows in April and
24 May, under Alternative 1 as compared to the No Action Alternative could
25 increase the potential for entrainment of Longfin Smelt at the export facilities.

26 Under Alternative 1, Longfin Smelt abundance index values range from 947
27 under critical water year conditions to a high of 15,822 under wet water year
28 conditions, with a long-term average value of 7,257. Under the No Action
29 Alternative, Longfin Smelt abundance index values range from 1,147 under
30 critical water year conditions to a high of 16,635 under wet water year conditions,
31 with a long-term average value of 7,951.

32 Results indicate that the Longfin Smelt abundance index values would be lower in
33 every water year type under Alternative 1 than they would be under the No Action
34 Alternative, with a long-term average index for Alternative 1 that is almost
35 10 percent lower than the long-term average index for the No Action Alternative.
36 For below normal, dry, and critical water years, the Longfin Smelt abundance
37 index values would be over 20 percent lower under Alternative 1 than they would
38 be under the No Action Alternative, with the greatest difference (26.2 percent)
39 predicted under dry conditions. Based on the Longfin Smelt abundance indices,
40 Alternative 1 likely would have adverse effects on Longfin Smelt, as compared to
41 the No Action Alternative.

42 Overall, based on the increase in frequency and magnitude of negative OMR
43 flows and the lower Longfin Smelt abundance index values, especially in dry and

1 critical years, potential adverse effects on the Longfin Smelt population under
2 Alternative 1 likely would be greater than under the No Action Alternative.

3 *Sacramento Splittail*

4 Under Alternative 1, flows entering the Yolo Bypass generally would be higher
5 than under the No Action Alternative, especially during below normal years when
6 flows entering the bypass under Alternative 1 would be higher (up to 2,264 cfs)
7 than the No Action Alternative in December through March (Appendix 5A,
8 Table C-26-1). These increases would occur during periods of relatively low flow
9 in the bypass, and could slightly increase the frequency of potential inundation.
10 Thus, Alternative 1 could result in a slight increase relative to the No Action
11 Alternative in spawning habitat for Sacramento Splittail as a result of the
12 increased area of potential habitat (inundation) and the potential for a slight
13 increase in the frequency of inundation.

14 *Reservoir Fishes*

15 The analysis of effects associated with changes in operation on reservoir fishes
16 relied on evaluation of changes in available habitat (reservoir storage) and
17 anticipated changes in black bass nesting success.

18 *Changes in Available Habitat (Storage)*

19 Changes in CVP and SWP water supplies and operations under Alternative 1 as
20 compared to the No Action Alternative generally would result in higher reservoir
21 storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels
22 in Shasta Lake, Lake Oroville, and Folsom Lake would be higher under
23 Alternative 1 as compared to the No Action Alternative, as summarized in Tables
24 5.12 through 5.14, in the fall and winter months due to the inclusion of Fall X2
25 criteria under the No Action Alternative.

26 The highest increases in Shasta Lake and Lake Oroville storage could be in excess
27 of 20 percent. Storage in Folsom Lake and New Melones could be increased by
28 up to around 10 percent in some months of some water year types. Additional
29 information related to monthly reservoir elevations is provided in Appendix 5A,
30 CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within the
31 CVP and SWP water supply reservoirs is not limiting; however, storage volume is
32 an indicator of how much habitat is available to fish species inhabiting these
33 reservoirs. Therefore, the amount of habitat for reservoir fishes could increase
34 under Alternative 1 as compared to the No Action Alternative.

35 *Changes in Black Bass Nesting Success*

36 As shown in Appendix 9F, black bass nest survival in CVP and SWP reservoirs is
37 anticipated to be near 100 percent in March and April due to increasing reservoir
38 elevations. For May, the likelihood of nest survival for Largemouth Bass in
39 Shasta Lake being in the 40 to 100 percent range is slightly (less than 2
40 percent) lower under Alternative 1 as compared to the No Action Alternative. For
41 June, the likelihood of nest survival being greater than 40 percent for Largemouth
42 Bass is the same under Alternative 1 and No Action Alternative; however, nest
43 survival of greater than 40 percent is likely only in about 20 percent of the years

1 evaluated. The likelihood of high nest survival for Smallmouth Bass in Shasta
2 Lake exhibits nearly the same pattern. For Spotted Bass, the likelihood of nest
3 survival being greater than 40 percent is high (nearly 100 percent) in May under
4 both Alternative 1 and the No Action Alternative. For June, Spotted Bass nest
5 survival would be less than for May due to greater daily reductions in water
6 surface elevation as Shasta Lake is drawn down. The likelihood of nest survival
7 being greater than 40 percent is about 10 percent less under Alternative 1 as
8 compared to the No Action Alternative.

9 For May and June, the likelihood of nest survival for Largemouth Bass in Lake
10 Oroville being in the 40 to 100 percent range is substantially (4 to 10 percent)
11 lower under Alternative 1 than under the No Action Alternative. However, in
12 June, nest survival of greater than 40 percent is likely only in about 35 percent of
13 the years evaluated under Alternative 1. The likelihood of high nest survival for
14 Smallmouth Bass in Lake Oroville exhibits nearly the same pattern. For Spotted
15 Bass, the likelihood of nest survival being greater than 40 percent is high (over
16 90 percent) in May under both Alternative 1 and the No Action Alternative with
17 the likelihood of greater than 40 percent survival being about 4 percent lower
18 under Alternative 1 than the No Action Alternative. For June, Spotted Bass nest
19 survival would be less than for May due to greater daily reductions in water
20 surface elevation as Lake Oroville is drawn down. The likelihood of survival
21 being greater than 40 percent is substantially lower (nearly 20 percent) under
22 Alternative 1 as compared to the No Action Alternative.

23 Black bass nest survival in Folsom Lake is near 100 percent in March, April, and
24 May due to increasing reservoir elevations. For June, the likelihood of nest
25 survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the
26 40 to 100 percent range is about 5 percent lower under Alternative 1 than the No
27 Action Alternative. For Spotted Bass, nest survival for June would be less than
28 for May due to greater daily reductions in water surface elevation. However, the
29 likelihood of survival being greater than 40 percent is somewhat (around
30 5 percent) lower under Alternative 1 as compared to the No Action Alternative.

31 *Summary of Effects on Reservoir Fishes*

32 The analysis of the effects of Alternative 1 and the No Action Alternative for
33 reservoir fish relied on CalSim II output for reservoir storage levels and water
34 surface elevation changes as described in Appendix 9F. As described above,
35 reservoir storage is anticipated to be increased under Alternative 1 relative to the
36 No Action Alternative and this increase could affect the amount of warm and cold
37 water habitat available within the reservoirs. However, it is unlikely that aquatic
38 habitat within the CVP and SWP water supply reservoirs is limiting and therefore,
39 it is unlikely that habitat for reservoir fish in the CVP and SWP storage reservoirs
40 under Alternative 1 and the No Action Alternative would differ in a biologically
41 meaningful manner.

42 The analysis of black bass nest survival based on changes in water surface
43 elevation during the spawning period indicated that the likelihood of high
44 (>40 percent) nest survival in most of the reservoirs under Alternative 1 would be
45 similar to or slightly lower than under the No Action Alternative. This suggests

1 that conditions in the reservoirs would be less likely to support self-sustaining
2 populations of black bass under Alternative 1 than under the No Action
3 Alternative.

4 *Pacific Lamprey*

5 Little information is available on factors that influence populations of Pacific
6 Lamprey in the Sacramento River, but they are likely affected by many of the
7 same factors as salmon and steelhead because of the parallels in their life cycles.

8 *Changes in Water Temperature*

9 The following describes anticipated changes in average monthly water
10 temperature in the Sacramento, Feather, and American rivers and the potential for
11 those changes to affect Pacific Lamprey.

12 *Sacramento River*

13 Long-term average monthly water temperature in the Sacramento River at
14 Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F
15 difference) to water temperatures under the No Action Alternative. An exception
16 is during September and October of critical dry years when water temperatures
17 could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as
18 compared to the No Action Alternative and up to 1°F warmer in September of
19 wetter years (Appendix 6B, Table 5-5-1). A similar temperature pattern generally
20 would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge,
21 with average monthly temperature differences in June progressively decreasing
22 under Alternative 1 relative to the No Action Alternative. Due to the similarity of
23 water temperatures under Alternative 1 and the No Action Alternative from
24 January through the summer, there would be little difference in potential effects
25 on Pacific Lamprey adults during their migration, holding, and spawning periods.

26 *Feather River*

27 Long-term average monthly water temperature in the Feather River in the low
28 flow channel under Alternative relative to the No Action Alternative generally
29 were predicted to be similar (less than 0.5°F differences), but slightly lower from
30 October through December when average monthly water temperatures would be
31 up to 1.4°F lower in some water year types (Appendix 6B, Table B-20-1).
32 Modeled water temperatures during May and June under Alternative 1 were also
33 slightly lower, up to a maximum of 0.7°F lower in June of below normal water
34 years. Average monthly water temperatures in July through September under
35 Alternative 1 generally were predicted to be lower (up to 0.6°F) in drier water
36 year types and higher (up to 1.3°F) in the wetter years. Although temperatures in
37 the river would become progressively higher in the downstream directions, the
38 differences in water temperatures between Alternative 1 and the No Action
39 Alternative would exhibit a similar pattern at the downstream locations (Robinson
40 Riffle and Gridley Bridge), with temperatures under Alternative 1 generally
41 increasing in most water year types relative to the No Action Alternative at the
42 confluence with Sacramento River.

1 Due to the similarity of water temperatures under Alternative 1 and the No Action
2 Alternative from January through April, there would be little difference in
3 potential effects on Pacific Lamprey adults during their upstream migration. The
4 slightly lower water temperatures from May through the summer may decrease
5 the likelihood of adverse effects on Pacific Lamprey during their holding, and
6 spawning periods.

7 *American River*

8 Average monthly water temperatures in the American River at Nimbus Dam
9 under Alternative 1 generally would be similar (differences less than 0.5°F) to the
10 No Action Alternative, with the exception of during June and August, when
11 differences under Alternative 1 could be as much as 0.9°F lower in below normal
12 years. This pattern generally would persist downstream to Watt Avenue and the
13 mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F
14 lower, respectively, than under the No Action Alternative in June. In addition,
15 average monthly water temperatures at the mouth generally would be lower under
16 Alternative 1 than the No Action Alternative in September, especially in wetter
17 water year types when the No Action Alternative could be up to 1.7°F cooler.
18 Due to the similarity of water temperatures under Alternative 1 and the No Action
19 Alternative from January through May, there would be little difference in
20 potential effects on Pacific Lamprey adults during their upstream migration. The
21 lower water temperatures during June and August may decrease the likelihood of
22 adverse effects on Pacific Lamprey during their holding, and spawning periods.

23 *Summary of Effects on Pacific Lamprey*

24 In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up
25 to around 72°F during their entire life history. Based on the somewhat increased
26 flows and reduced temperatures during their spawning and incubation period
27 under Alternative 1, it is unlikely that conditions for and effects on Pacific
28 Lamprey in the Sacramento, Feather, and American rivers under Alternative 1 and
29 the No Action Alternative differ in a biologically meaningful manner. This
30 conclusion likely applies to other species of lamprey that inhabit these rivers (e.g.,
31 River Lamprey).

32 *Striped Bass, American Shad, and Hardhead*

33 Changes in operations influence temperature and flow conditions that could affect
34 Striped Bass, American Shad, and Hardhead. The following describes those
35 changes and their potential effects.

36 *Changes in Water Temperature*

37 Changes in water temperature that affect Striped Bass, American Shad, and
38 Hardhead could occur in the Sacramento, Feather, and American rivers. The
39 following describes temperature conditions in those water bodies.

40 *Sacramento River*

41 Long-term average monthly water temperatures in the Sacramento River at
42 Keswick Dam under Alternative 1 would generally be similar (less than 0.5°F
43 difference) to water temperatures under the No Action Alternative. An exception

1 is during September and October of critical dry years when water temperatures
2 could be up to 1.1°F and 0.8°F lower, respectively, under Alternative 1 as
3 compared to the No Action Alternative and up to 1°F warmer in September of
4 wetter years (Appendix 6B, Table 5-5-1). A similar temperature pattern generally
5 would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge,
6 with average monthly temperatures in June progressively decreasing by a small
7 margin under Alternative 1 relative to the No Action Alternative. In general,
8 Striped Bass, American Shad, and Hardhead can tolerate higher temperatures than
9 salmonids. Therefore, it is unlikely that the slightly reduced temperatures during
10 some months would have adverse effects on these species.

11 *Feather River*

12 Average monthly water temperature in the Feather River in the low flow channel
13 under Alternative relative to the No Action Alternative generally were predicted
14 to be similar (less than 0.5°F differences), but slightly lower from October
15 through December when average monthly water temperatures would be up to
16 1.4°F lower in some water year types (Appendix 6B, Table B-20-1). Modeled
17 water temperatures during May and June under Alternative 1 were also slightly
18 lower, up to a maximum of 0.7°F lower in June of below normal water years.
19 Average monthly water temperatures in July through September under Alternative
20 1 generally were predicted to be lower (up to 0.6°F) in drier water year types and
21 higher (up to 1.3°F) in the wetter years. Although temperatures in the river would
22 become progressively lower in the downstream directions, the differences
23 between Alternative 1 and No Action Alternative would exhibit a similar pattern
24 at the downstream locations (Appendix 6B, Table B-23-1). As described above
25 for the Sacramento River, Striped Bass, American Shad, and Hardhead can
26 tolerate higher temperatures than salmonids. Therefore, it is unlikely that the
27 slightly reduced temperatures during some months would have adverse effects on
28 these species in the Feather River.

29 *American River*

30 Average monthly water temperatures in the American River at Nimbus Dam
31 under Alternative 1 generally would be similar (differences less than 0.5°F) to the
32 No Action Alternative, with the exception of during June and August, when
33 differences under Alternative 1 could be as much as 0.9°F lower in below normal
34 years. This pattern generally would persist downstream to Watt Avenue and the
35 mouth, although temperatures under Alternative 1 would be up to 1.6°F and 2.0°F
36 lower, respectively, than under the No Action Alternative in June. As described
37 above for the Sacramento River, Striped Bass, American Shad, and Hardhead can
38 tolerate higher temperatures than salmonids. Therefore, it is unlikely that the
39 slightly reduced temperatures during some months would have adverse effects on
40 these species in the American River.

41 *Summary of Effects on Striped Bass, American Shad, and Hardhead*

42 In general, Striped Bass, American Shad, and Hardhead can tolerate higher
43 temperatures than salmonids. Based on the slightly increased flows and decreased
44 temperatures during their spawning and incubation period under Alternative 1, it

1 is unlikely that conditions for and effects on Striped Bass, American Shad, and
2 Hardhead in the Sacramento, Feather, and American rivers under Alternative 1
3 and the No Action Alternative would differ in a biologically meaningful manner.

4 *Stanislaus River/Lower San Joaquin River*

5 *Fall-Run Chinook Salmon*

6 Changes in operations influence temperature and flow conditions that could affect
7 fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam
8 and in the San Joaquin River below Vernalis. The following describes those
9 changes and their potential effects.

10 *Changes in Water Temperature (Stanislaus River)*

11 Average monthly water temperatures in the Stanislaus River at Goodwin Dam
12 under Alternative 1 and the No Action Alternative generally would be similar
13 (differences less than 0.5°F), with small differences in critical dry years when
14 Alternative 1 would 0.8°F and 1.3°F cooler on average than under the No Action
15 Alternative during June and September, respectively, and 0.7°F warmer in
16 November (Appendix 6B, Table B-1-1).

17 Downstream at Orange Blossom Bridge, average monthly water temperatures in
18 October under Alternative 1 would be higher in all water year types than the No
19 Action Alternative by as much as 1.9°F. In most other months, water
20 temperatures under Alternative 1 generally would be similar, although somewhat
21 lower, compared to the No Action Alternative. An exception to this pattern
22 occurs in April and December when average monthly water temperatures in all
23 water year types would be higher under Alternative 1 by as much as about 1.2°F
24 (April) in the drier years (Appendix 6B, Table B-18-1).

25 This temperature pattern would continue downstream to the confluence with the
26 San Joaquin River, although temperatures would progressively increase, as would
27 the magnitude of difference between Alternative 1 and No Action Alternative.
28 Increases in average monthly water temperatures in October and April would be
29 more pronounced under Alternative 1, with average differences as much as 2.7°F
30 in October and 2.0 F in April (Appendix 6B, Table B-19-1) relative to the No
31 Action Alternative. The magnitude of differences in average monthly water
32 temperatures between Alternative 1 and the No Action Alternative in May and
33 June also would increase relative to the upstream locations.

34 Based on the life history timing for fall-run Chinook Salmon, the higher water
35 temperatures in October and December under Alternative 1 may increase the
36 likelihood of adverse effects on fall-run Chinook Salmon spawning and egg
37 incubation as compared to the No action Alternative.

38 *Changes in Exceedance of Water Temperature Thresholds (Stanislaus*
39 *River)*

40 While specific water temperature thresholds for fall-run Chinook Salmon in the
41 Stanislaus River are not established, temperatures generally considered suitable
42 for fall-run Chinook Salmon spawning (56°F) would be exceeded in October and
43 November about 30 and 25 percent of the time, respectively at Goodwin Dam

1 under Alternative 1 (Appendix 6B, Figures B-17-1 and B-17-2). Similar
 2 exceedances would occur under the No Action Alternative, although slightly more
 3 frequently in November. Water temperatures for rearing generally would be
 4 below 56°F, except in May when average monthly water temperatures would
 5 reach about 60°F under both Alternative 1 and the No action Alternative
 6 (Appendix 6B, Figure B-17-8).

7 Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run
 8 Chinook Salmon spawning (56°F) would be exceeded frequently under both
 9 Alternative 1 and the No Action Alternative during October and November.
 10 Under Alternative 1, average monthly water temperatures would exceed 56°F
 11 about 85 percent of the time in October. This, would be about 28 percent more
 12 frequently than under the No Action Alternative. In November, average monthly
 13 water temperatures would exceed 56°F about 28 percent of the time under
 14 Alternative 1, which would be about 5 percent more frequent than under the No
 15 Action Alternative (Appendix 6B, Figure B-18-2).

16 From January through May, rearing fall-run Chinook Salmon would be subjected
 17 to average monthly water temperatures that exceed 56° in March (less than
 18 10 percent of the time) and May (about 10 percent of the time) under
 19 Alternative 1, less frequently than under the No Action Alternative (about
 20 30 percent in May) (Appendix 6B, Figure B-18-8).

21 *Changes in Egg Mortality (Stanislaus River)*

22 For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg
 23 mortality rate is predicted to be around 7 percent, with higher mortality rates (in
 24 excess of 15 percent) occurring in critical dry years under Alternative 1. Overall,
 25 egg mortality would be 0.4 percent higher under Alternative 1; in most water year
 26 types the average egg mortality rate would be higher than under the No Action
 27 Alternative by up to 1.5 percent in critical dry years (Appendix 9C, Table B-1).
 28 In water year types where there is reduced egg mortality under Alternative 1 (wet
 29 and below-normal years), the reduction would be 0.1 and 0.3 percent,
 30 respectively. Overall, the difference in egg mortality between Alternative 1 and
 31 the No Action Alternative would be relatively minor and likely would have little
 32 effect on fall-run Chinook Salmon in the Stanislaus River.

33 *Changes in Delta Hydrodynamics*

34 San Joaquin River-origin fall-run Chinook Salmon smolts are most abundant in
 35 the Delta during the months of April, May and June. Near the confluence of the
 36 San Joaquin River and the Mokelumne River, the proportion of positive velocities
 37 was moderately lower under Alternative 1 relative to No Action Alternative in
 38 April and May and almost indistinguishable in June (Appendix 9K). On Old
 39 River downstream of the facilities, the proportion of positive velocities was
 40 substantially lower in April and May under Alternative 1 relative to No Action
 41 Alternative but became more similar in June. In Old River upstream of the
 42 facilities, the percent of positive velocities was moderately lower for Alternative 1
 43 relative to No Action Alternative in April and May and moderately lower in June.
 44 On the San Joaquin River downstream of the Head of Old River, the percent of

1 positive velocities was moderately higher under Alternative 1 relative to No
2 Action Alternative in April and May whereas values were similar in June.

3 *Changes in Entrainment at Junctions*

4 Entrainment probabilities at the Head of Old River were much greater under
5 Alternative 1 relative to the No Action Alternative during April and May.
6 Entrainment probabilities were similar under both alternatives in the month of
7 June (Appendix 9L). At the Turner Cut junction, entrainment probabilities under
8 Alternative 1 were slightly higher than No Action Alternative in June. During
9 April and May, entrainment probabilities were more divergent with higher values
10 for Alternative 1 relative to No Action Alternative. Overall, entrainment was
11 lower at the Columbia Cut junction relative to Turner Cut but patterns of
12 entrainment between these two alternatives were similar). Entrainment was
13 slightly lower for Alternative 1 relative to No Action Alternative during June. In
14 April and May, entrainment was higher for Alternative 1 relative to No Action
15 Alternative. Patterns at the Middle River and Old River junctions were similar to
16 those observed at Columbia and Turner Cut junctions.

17 *Summary of Effects on Fall-Run Chinook Salmon*

18 In the Stanislaus River, the analysis of the effects of Alternative 1 and the No
19 Action Alternative for fall-run Chinook Salmon relied on the water temperature
20 model output for the rivers at various locations downstream of Goodwin Dam.
21 The temperature model outputs for each of the fall-run Chinook Salmon life
22 stages suggest that thermal conditions and effects on fall-run Chinook Salmon in
23 the Stanislaus River generally would be similar under both scenarios, although
24 water temperatures could be somewhat less suitable for fall-run Chinook Salmon
25 spawning/egg incubation under the Second Basis of Comparison. This conclusion
26 is supported by the water temperature threshold exceedance analysis that
27 indicated that suitable water temperatures for fall-run Chinook Salmon spawning
28 and egg incubation would be exceeded slightly less frequently in November, but
29 substantially more frequently in October under Alternative 1. Suitable water
30 temperatures for fall-run Chinook Salmon rearing would be exceeded somewhat
31 less frequently under Alternative 1. Results of the analysis using Reclamation's
32 salmon mortality model indicate that there would be little difference in fall-run
33 Chinook Salmon egg mortality under Alternative 1 and the No Action Alternative.

34 Given the inherent uncertainty associated with the resolution of the temperature
35 model (average monthly outputs), the differences in the frequency of exceedance
36 of suitable temperatures for spawning and rearing under Alternative 1 could affect
37 the potential for adverse effects on the fall-run Chinook Salmon populations in the
38 Stanislaus River. However, the direction and magnitude of this effect is
39 uncertain. This potential distinction between the two scenarios, however, may be
40 offset by the benefits of implementation of fish passage under the No Action
41 Alternative intended to address the limited availability of suitable habitat for
42 steelhead in the Sacramento River reaches downstream of Goodwin Dam.
43 Depending on the type of passage implemented, fall-run Chinook Salmon could
44 be benefited by implementation of the fish passage program under the No Action
45 Alternative.

1 *Steelhead*

2 Changes in operations that influence temperature and flow conditions in the
3 Stanislaus River downstream of Goodwin Dam and the San Joaquin River below
4 Vernalis could affect steelhead. The following describes those changes and their
5 potential effects.

6 *Changes in Water Temperature (Stanislaus River)*

7 Average monthly water temperatures in the Stanislaus River at Goodwin Dam
8 under Alternative 1 and the No Action Alternative generally would be similar
9 (differences less than 0.5°F), with small differences in critical dry years when
10 Alternative 1 would 0.8°F and 1.3°F cooler on average than under the No Action
11 Alternative during June and September, respectively, and 0.7°F warmer in
12 November (Appendix 6B, Table B-17-1).

13 Downstream at Orange Blossom Bridge, average monthly water temperatures in
14 October under Alternative 1 would be higher in all water year types than the No
15 Action Alternative by as much as 1.9°F. In most other months, water
16 temperatures under Alternative 1 generally would be similar (less than 0.5°F
17 differences), although lower, than the No Action Alternative, except in April
18 when average monthly water temperatures in all water year types would be higher
19 under Alternative 1 by as much as about 1.2°F in the drier years (Appendix 6B,
20 Table B-18-1).

21 This temperature pattern would continue downstream to the confluence with the
22 San Joaquin River, although temperatures would progressively increase, as would
23 the magnitude of difference between Alternative 1 and the No Action Alternative.
24 Increases in average monthly water temperatures in October and April would be
25 more pronounced under Alternative 1, with average differences as much as 2.7°F
26 (Appendix 6B, Table B-19-1) relative to the No Action Alternative. The
27 magnitude of differences in average monthly water temperatures between
28 Alternative 1 and the No Action Alternative in May and June also would increase
29 relative to the upstream locations.

30 *Changes in Exceedance of Water Temperature Thresholds (Stanislaus*
31 *River)*

32 Average monthly water temperatures in the Stanislaus River at Orange Blossom
33 Bridge would frequently exceed the temperature threshold (56°F) established for
34 adult steelhead migration under both Alternative 1 and No Action Alternative
35 during October and November. Under Alternative 1, average monthly water
36 temperatures would exceed 56°F about 85 percent of the time in October and
37 about 57 percent of the time under the No Action Alternative (Appendix 6B,
38 Figure B-18-1). In November, average monthly water temperatures would exceed
39 56°F about 28 percent of the time under Alternative 1, which would be about
40 5 percent less frequent than under the No Action Alternative (Appendix 6B,
41 Figure B-18-2).

42 In January through May, the temperature threshold at Orange Blossom Bridge is
43 55°F, which is intended to support steelhead spawning. This threshold would not

1 be exceeded under either Alternative 1 or No Action Alternative during January
2 or February. In March through May, however, exceedances would occur under
3 both Alternative 1 and the No Action Alternative in each month, with the
4 threshold most frequently exceeded (43 percent) under Alternative 1 in May
5 (Appendix 9N). Water temperatures under Alternative 1 would exceed the
6 threshold less frequently in March (5 percent) and May (5 percent), and more
7 frequently (17 percent) in April than under the No Action Alternative.

8 From June through November, the temperature threshold of 65°F established to
9 support steelhead rearing would be exceeded by both Alternative 1 and No Action
10 Alternative in all months but November, and would exceed the threshold by
11 16 percent of the time in July under both Alternative 1 and the No Action
12 Alternative. The differences between Alternative 1 and the No Action
13 Alternative, however, would be relatively minor, with water temperatures under
14 Alternative 1 generally exceeding the threshold by up to 3 percent less frequently
15 than under the No Action Alternative.

16 Average monthly water temperatures also would exceed the threshold (52°F)
17 established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles
18 upstream of Knights Ferry, average monthly water temperatures under Alternative
19 1 would exceed 52°F in March, April, and May about 9 percent, 31 percent, and
20 66 percent of the time, respectively. Water temperatures under Alternative 1
21 would result in exceedances occurring about 1 to 2 percent more frequently
22 during the January through May period. Farther downstream at Orange Blossom
23 Bridge, the temperature threshold for smoltification is higher (57°F) and would be
24 exceeded less frequently. The magnitude of the exceedance also would be less.
25 Average monthly water temperatures under Alternative 1 and the No Action
26 Alternative would not exceed the threshold during January through March. In
27 April and May, exceedances of 8 percent and 10 percent would occur under
28 Alternative 1, which would represent a frequency of about 6 percent more than
29 the No Action Alternative in April and about an 8 percent lower frequency in
30 May.

31 Overall, the differences between Alternative 1 and No Action Alternative would
32 be relatively small, with the exception of substantial differences in the frequency
33 of exceedances in October when the average monthly water temperatures under
34 Alternative 1 would exceed the threshold for adult steelhead migration about
35 28 percent more frequently and in April during the spawning period when the
36 exceedance frequency would be about 17 percent more. Given the frequency of
37 exceedance under both Alternative 1 and No Action Alternative and the generally
38 stressful temperature conditions in the river, the substantial differences in October
39 and April under Alternative 1 suggest that there would be more potential to
40 adversely affect steelhead under Alternative 1 than under the No Action
41 Alternative. Even during months when the differences would be relatively small,
42 the slightly higher frequency of exceedances under Alternative 1 could represent a
43 biologically meaningful and negative difference.

1 *Changes in Delta Hydrodynamics*

2 San Joaquin River-origin steelhead generally move through the Delta during
3 spring; however, there is less information on their timing relative to Chinook
4 Salmon. Thus, hydrodynamics in the entire January through June period have the
5 potential to affect juvenile steelhead. For a description of potential hydrodynamic
6 effects on steelhead, see the descriptions for winter-run Chinook Salmon in the
7 Sacramento Basin and fall-run Chinook Salmon in the San Joaquin River basin
8 above.

9 *Changes in Entrainment at Junctions*

10 At the Head of Old River, entrainment under Alternative 1 was slightly higher
11 during January and February relative to the No Action Alternative. Entrainment
12 probabilities were much lower under Alternative 1 relative to the No Action
13 Alternative during April and May. Entrainment probabilities were similar under
14 both alternatives in the month of June (Appendix 9L). At the Turner Cut junction,
15 entrainment probabilities under Alternative 1 were slightly higher than No Action
16 Alternative in January, February March and June. During April and May,
17 entrainment probabilities were more divergent with higher values for Alternative
18 1 relative to No Action Alternative. Overall, entrainment was lower at the
19 Columbia Cut junction relative to Turner Cut but patterns of entrainment between
20 these two alternatives were similar. Entrainment was slightly higher for
21 Alternative 1 relative to No Action Alternative during January, February, March
22 and June. In April and May, entrainment was greater for Alternative 1 relative to
23 No Action Alternative. Patterns at the Middle River and Old River junctions were
24 similar to those observed at the Columbia and Turner Cut junctions.

25 *Summary of Effects on Steelhead*

26 The analysis of the effects of Alternative 1 and the No Action Alternative for
27 steelhead relied on the water temperature model output for the rivers at various
28 locations downstream of Goodwin Dam. The temperature model outputs for each
29 of the steelhead life stages suggest that thermal conditions and effects on
30 steelhead in all of these streams generally would be similar under both scenarios,
31 although water temperatures could be somewhat less suitable for steelhead rearing
32 under Alternative 1. Water temperatures could be somewhat more suitable during
33 the adult upstream migration period under Alternative 1 than the No Action
34 Alternative. This conclusion is supported by the water temperature threshold
35 exceedance analysis that indicated that the water temperature threshold for
36 steelhead migration would be exceeded substantially more frequently on October,
37 but somewhat more frequently in November under Alternative 1. The water
38 temperature threshold for steelhead spawning would also be exceeded
39 substantially more frequently in May, but somewhat less frequently in other
40 months under Alternative 1. The water temperature threshold for steelhead
41 rearing generally would be exceeded less frequently under Alternative 1 while the
42 temperature thresholds for smoltification would be exceeded more frequently in
43 most months.

44 Given the inherent uncertainty associated with the resolution of the temperature
45 model (average monthly outputs), the differences in the magnitude and frequency

1 of exceedance of suitable temperatures for the various lifestages under Alternative
2 1 could affect the potential for adverse effects on the steelhead populations in the
3 Stanislaus River. However, the direction and magnitude of this effect is
4 uncertain. Implementation of the fish passage program under the No Action
5 Alternative intended to address the limited availability of suitable habitat for
6 steelhead in the Stanislaus River reaches downstream of Goodwin Dam could
7 provide a benefit to Central Valley steelhead in the Sacramento and American
8 rivers.

9 *White Sturgeon*

10 Evidence of White Sturgeon spawning has been recorded in the San Joaquin River
11 upstream of the confluence with the Stanislaus River. While flows in the San
12 Joaquin River upstream of the Stanislaus River are expected be similar under all
13 alternatives, flow contributions from the Stanislaus River could influence water
14 temperatures in the San Joaquin River where White Sturgeon eggs or larvae may
15 occur during the spring and early summer. The magnitude of influence on water
16 temperature would depend on the proportional flow contribution of the Stanislaus
17 River and the temperatures in both the Stanislaus and San Joaquin rivers. The
18 potential for an effect on White Sturgeon eggs and larvae would be influenced by
19 the proportion of the population occurring in the San Joaquin River. In
20 consideration of this uncertainty, it is not possible to distinguish potential effects
21 on White Sturgeon between alternatives.

22 *Reservoir Fishes*

23 The analysis of effects associated with changes in operation on reservoir fishes
24 relied on evaluation of changes in available habitat (reservoir storage) and
25 anticipated changes in black bass nesting success.

26 Changes in CVP and SWP water supplies and operations under Alternative 1 as
27 compared to the No Action Alternative would result in higher storage levels in
28 New Melones Reservoir under Alternative 1 as compared to the No Action
29 Alternative, as summarized in Table 5.16, due to lower instream releases to
30 support fish flows under Alternative 1.

31 Storage in New Melones could be increased by up to around 10 percent in some
32 months of some water year types under Alternative 1 compared to the No Action
33 Alternative. Additional information related to monthly reservoir elevations is
34 provided in Appendix 5A, CalSim II and DSM2 Modeling. Assuming that
35 storage volume is an indicator of how much habitat is available to fish species
36 inhabiting the reservoir, the amount of habitat for reservoir fishes could be
37 increased under Alternative 1 as compared to the No Action Alternative.

38 As shown in Appendix 9F, the likelihood of Largemouth Bass and Smallmouth
39 Bass nest survival being above 40 percent is 100 percent under both Alternative 1
40 and the No Action Alternative in March. For April, the likelihood that nest
41 survival of Largemouth Bass and Smallmouth Bass is between 40 and 100 percent
42 is reasonably high (nearly 80 percent), although substantially (about 13 percent)
43 higher under Alternative 1 as compared to the No Action Alternative. For May,
44 this pattern is reversed with the likelihood of high nest survival being slightly

1 (about 3 percent) lower under Alternative 1. For June, the likelihood of survival
2 being greater than 40 percent for Largemouth Bass and Smallmouth Bass in New
3 Melones Reservoir is also somewhat (about 8 percent) lower under Alternative 1
4 as compared to the No Action Alternative.

5 For Spotted Bass, nest survival in March is anticipated to be near 100 percent in
6 every year under both Alternative 1 and No Action Alternative. The likelihood of
7 survival being greater than 40 percent in April is 100 percent under both
8 Alternative 1 and the No Action Alternative. For May, the likelihood of Spotted
9 Bass nest survival being greater than 40 percent is slightly (about 2 percent) lower
10 under Alternative 1. For June, Spotted Bass nest survival would be greater than
11 40 percent in every year under Alternative 1 as compared to approximately
12 98 percent of the years under the No Action Alternative.

13 Overall, predicted nest survival is generally above 40 percent in all months
14 evaluated, although survival under Alternative 1 would vary among months.
15 Given the relatively high survival in general and the uncertainty caused by the
16 inconsistency in changes in survival, it is likely that effects would be similar
17 under both alternatives.

18 *Other species*

19 Changes in operations that influence temperature and flow conditions in the
20 Stanislaus River downstream of Keswick Dam and the San Joaquin River at
21 Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

22 As described above, average monthly water temperatures in the Stanislaus River
23 at Goodwin Dam under Alternative 1 and No Action Alternative generally would
24 be similar. Downstream at Orange Blossom Bridge, average monthly water
25 temperatures in the November to March period under Alternative 1 generally
26 would be similar to, although somewhat lower than, under the No Action
27 Alternative. In April and October, average monthly water temperatures in all
28 water year types would be higher under Alternative 1 and in September, water
29 temperatures would be lower under Alternative 1 compared to the No Action
30 Alternative. This temperature pattern would continue downstream to the
31 confluence with the San Joaquin River, although temperatures would
32 progressively increase, as would the magnitude of difference between
33 Alternative 1 and No Action Alternative (Appendix 6B, Table B-19-1).

34 In general, lamprey species can tolerate higher temperatures than salmonids, up to
35 around 72°F during their entire life history. Because lamprey ammocoetes remain
36 in the river for several years, any substantial flow reductions or temperature
37 increases could adversely affect these larval lamprey. Given the similar flows and
38 temperatures during their spawning and incubation period, it is likely that the
39 potential to affect lamprey species in the Stanislaus and San Joaquin rivers would
40 be similar under Alternative 1 and the No Action Alternative.

41 In general, Striped Bass and Hardhead also can tolerate higher temperatures than
42 salmonids. Given the similar flows and temperatures during their spawning and
43 incubation period, it is likely that the potential to affect Striped Bass and

1 Hardhead in the Stanislaus and San Joaquin rivers would be similar under
2 Alternative 1 and the No Action Alternative.

3 *San Francisco Bay Area Region*

4 *Killer Whale*

5 Southern Resident killer whales (Southern Residents) are thought to rely heavily
6 upon salmon as their main source of prey (about 96 percent of their diet)
7 throughout the areas and times for which reliable data on prey consumption are
8 available (Ford and Ellis 2006). Studies have indicated that Chinook Salmon
9 generally constitute a large percentage of the Southern Resident salmon diet, with
10 some indications that Chinook Salmon are strongly preferred at certain times in
11 comparison to other salmonids (Ford and Ellis 2006; Hanson et al. 2007). Results
12 have also suggested that Chinook Salmon from ESUs from California to British
13 Columbia are being consumed by Southern Residents (Hanson et al. 2007).

14 Best available data on the abundance and composition of Central Valley Chinook
15 Salmon indicates that approximately 75 percent of all Central Valley-origin
16 Chinook Salmon available for consumption by Southern Residents are produced
17 by Central Valley fall-run Chinook Salmon hatcheries (Palmer-Zwhalen and
18 Kormos 2012; Table 9). Most Central Valley hatchery fall-run Chinook Salmon
19 production is released directly into San Francisco Bay, and thus bypass potential
20 impacts from water project operations. Even where there might be a nexus with
21 water project operations, the purpose of Central Valley fall-run Chinook Salmon
22 hatchery programs is to produce large numbers of fish independent of freshwater
23 conditions. Since fall-run Chinook Salmon hatcheries came on-line more than
24 forty years ago, the only period of exceptionally low returns was principally
25 attributed to unusual ocean conditions (Lindley et al. 2007).

26 Ocean commercial and recreational fisheries annually harvest hundreds of
27 thousands of Chinook salmon. The Northwest Region of NMFS (NMFS 2009c)
28 used a model that estimates prey reduction associated with the salmon fishery and
29 which considers the metabolic requirements of Southern Residents and the
30 remaining levels of prey availability. Their analysis concluded that the salmon
31 fishery was not likely to result in jeopardy for Southern Residents. Given
32 conclusions from NMFS (2009c), and the fact that at least 75 percent of fall-run
33 Chinook Salmon available for Southern Residents are produced by Central Valley
34 hatcheries, it is likely that Central Valley fall-run Chinook Salmon as a prey base
35 for killer whales would not be appreciably affected by any of the alternatives.

36 **9.4.3.2.2 Alternative 1 Compared to the Second Basis of Comparison**

37 As described in Chapter 3, Description of Alternatives, Alternative 1 is identical
38 to the Second Basis of Comparison.

39 **9.4.3.3 Alternative 2**

40 The CVP and SWP operations under Alternative 2 are identical to the CVP and
41 SWP operations under the No Action Alternative, as described in Chapter 3,
42 Description of Alternatives. Alternative 2 would not include implementation of
43 fish passage actions under the 2009 NMFS BO. As described in Chapter 4,

1 Approach to Environmental Analysis, Alternative 2 is compared to the No Action
2 Alternative and the Second Basis of Comparison.

3 **9.4.3.3.1 Alternative 2 Compared to the No Action Alternative**

4 *Trinity River Region*

5 The CVP and SWP operations under Alternative 2 are identical to the CVP and
6 SWP operations under the No Action Alternative. Therefore, fish and aquatic
7 resources conditions at Trinity Lake and along the Trinity River and lower
8 Klamath River under Alternative 2 would be the same as under the No Action
9 Alternative.

10 *Central Valley Region*

11 The CVP and SWP operations under Alternative 2 are identical to the CVP and
12 SWP operations under the No Action Alternative. Therefore, physical conditions
13 that affect aquatic resources under Alternative 2 be the same as under the No
14 Action Alternative. However, salmonid survival could be less under Alternative 2
15 due to the lack of fish passage actions to move fish to portions of the Sacramento,
16 American, and Stanislaus rivers that would provide cooler temperatures for
17 spawning and rearing under the No Action Alternative.

18 *San Francisco Bay Area Region*

19 *Killer Whale*

20 It is unlikely that the Chinook Salmon prey base of killer whales, supported
21 heavily by hatchery production of fall-run Chinook Salmon, would be appreciably
22 affected by any of the alternatives.

23 **9.4.3.3.2 Alternative 2 Compared to the Second Basis of Comparison**

24 *Trinity River Region*

25 The CVP and SWP operations under Alternative 2 are identical to the CVP and
26 SWP operations under the No Action Alternative. Therefore, changes in aquatic
27 resources at Trinity Lake and along the Trinity River and lower Klamath River
28 under Alternative 2 as compared to the Second Basis of Comparison would be the
29 same as the impacts described in Section 10.4.4.1, No Action Alternative
30 Compared to the Second Basis of Comparison.

31 *Central Valley Region*

32 The CVP and SWP operations under Alternative 2 are identical to the CVP and
33 SWP operations under the No Action Alternative. Therefore, changes in physical
34 conditions that affect aquatic resources in the Central Valley Region under
35 Alternative 2 as compared to the Second Basis of Comparison would be the same
36 as the impacts described for the No Action Alternative Compared to the Second
37 Basis of Comparison. Actions to provide fish passage to portions of the
38 Sacramento, American, and Stanislaus rivers upstream of their dams would not be
39 undertaken under Alternative 2 or the Second Basis of Comparison.

1 *San Francisco Bay Area Region*

2 *Killer Whale*

3 As described above for the comparison of Alternative 1 to the No Action
4 Alternative, it is unlikely that the Chinook Salmon prey base of killer whales,
5 supported heavily by hatchery production of fall-run Chinook Salmon, would be
6 appreciably affected by any of the alternatives.

7 **9.4.3.4 Alternative 3**

8 As described in Chapter 3, Description of Alternatives, CVP and SWP operations
9 under Alternative 3 are similar to the Second Basis of Comparison with modified
10 OMR flow criteria and New Melones Reservoir operations. Alternative 3 also
11 includes the following items that are not included in the No Action Alternative or
12 the Second Basis of Comparison and would affect fish and aquatic resources.

- 13 • Implement predator control programs for black bass, Striped Bass, and
14 Sacramento Pikeminnow to protect salmonids and Delta Smelt as follows:
 - 15 – Black bass catch limit changed to allow catch of 12-inch fish with a bag
16 limit of 10
 - 17 – Striped Bass catch limit changed to allow catch of 12-inch fish with a bag
18 limit of 5
 - 19 – Establish a Sacramento Pikeminnow sport-fishing reward program with a
20 8-inch limit at \$2/fish
- 21 • Establish a trap and haul program for juvenile salmonids entering the Delta
22 from the San Joaquin River in March through June as follows:
 - 23 – Begin operation of downstream migrant fish traps upstream of the Head of
24 Old River on the San Joaquin River
 - 25 – “Barge” all captured juvenile salmonids through the Delta, release at
26 Chipps Island.
 - 27 – Tag subset of fish in order to quantify effectiveness of the program
 - 28 – Attempt to capture 10 percent to 20 percent of out-migrating juvenile
29 salmonids
- 30 • Work with Pacific Fisheries Management Council, CDFW, and NMFS to
31 minimize harvest mortality of natural origin Central Valley Chinook Salmon,
32 including fall-run Chinook Salmon, by evaluating and modifying ocean
33 harvest for consistency with Viable Salmonid Population Standards; including
34 harvest management plan to show that abundance, productivity, and diversity
35 (age-composition) are not appreciably reduced.

36 As described in Chapter 4, Approach to Environmental Analysis, Alternative 3 is
37 compared to the No Action Alternative and the Second Basis of Comparison.

1 **9.4.3.4.1 Alternative 3 Compared to the No Action Alternative**

2 *Trinity River Region*

3 *Coho Salmon*

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

8 Long-term average monthly water temperatures in the Trinity River at Lewiston
9 Dam under Alternative 3 generally would be similar to, although slightly cooler
10 (up to 0.4°F), than under the No Action Alternative (Appendix 6B, Table B-1-2).
11 An exception occurs during November when long-term average water
12 temperatures are increased by 0.3°F under Alternative 3 relative to the No Action
13 Alternative, and up to 3.3°F in critical years. Overall, the temperature differences
14 between Alternative 3 and the No Action Alternative would be relatively minor
15 and likely would have little effect on Coho Salmon in the Trinity River. The
16 higher water temperatures in November of critical years under Alternative 3
17 would likely have little effect on Coho Salmon as water temperatures in the
18 Trinity River are typically low during this time period.

19 The USFWS established a water temperature threshold of 56°F for Coho Salmon
20 spawning in the reach of the Trinity River from Lewiston to the confluence with
21 the North Fork Trinity River from October through December. Although not
22 entirely reflective of water temperatures throughout the reach, the temperature
23 model provides average monthly water temperature outputs for Lewiston Dam,
24 which may provide perspective on temperature conditions in the reach. In
25 October, average monthly water temperatures under both Alternative 3 and the No
26 Action Alternative would exceed 56°F at Lewiston Dam in October of some years
27 (Appendix 6B, Table B-1-2). Under Alternative 3, the threshold would be
28 exceeded about 6 percent of the time in October, about 2 percent less frequently
29 than under the No Action Alternative. In November, average water temperatures
30 under Alternative 3 would not exceed the threshold, whereas average monthly
31 water temperatures the No Action Alternative would exceed the threshold about
32 2 percent of the time.

33 Overall, the temperature model outputs for each of the Coho Salmon life stages
34 suggest that the temperature of water released at Lewiston Dam generally would
35 be similar under both scenarios, although the exceedance of water temperature
36 thresholds would be less frequent under Alternative 3. While average monthly
37 temperatures would be similar overall, the slight reduction in the frequency of
38 threshold exceedance provided by Alternative 3 in October and November might
39 be biologically meaningful. Thus, temperature conditions under Alternative 3
40 could be slightly less likely to affect Coho Salmon spawning than those under the
41 No Action Alternative.

1 *Spring-run Chinook Salmon*

2 The analysis of effects associated with changes in operation on spring-run
3 Chinook Salmon was conducted using temperature model outputs for Lewiston
4 Dam to anticipate the likely effects on conditions in the Trinity River downstream
5 of Lewiston Dam.

6 As described above for Coho Salmon, the differences in long-term average
7 monthly water temperatures between Alternative 3 and the No Action Alternative
8 would be relatively small (less than 0.5°F) and likely would have little effect on
9 spring-run Chinook Salmon in the Trinity River. The substantially higher water
10 temperatures in November of critical dry years under Alternative 3 would likely
11 have little effect on spring-run Chinook Salmon as water temperatures in the
12 Trinity River are typically low during this time period.

13 In July, water temperatures in the Trinity River at Lewiston Dam would not
14 exceed the 60°F threshold for spring-run Chinook Salmon holding under
15 Alternative 3, although this threshold would be exceeded 1 percent of the time
16 under the No Action Alternative. Under both Alternative 3 and the No Action
17 Alternative, average monthly water temperatures in the Trinity River at Lewiston
18 Dam would exceed 60°F two percent of the time in August. In September, the
19 threshold for spawning (56°F) would be exceeded under both scenarios about 9
20 percent of the time. Overall, the differences in the frequency of threshold
21 exceedance between Alternative 3 and the No Action Alternative would be
22 relatively minor. However, temperature conditions under Alternative 3 could be
23 slightly less likely to affect spring-run Chinook Salmon holding than under the No
24 Action Alternative because of the slightly reduced frequency of exceedance of the
25 60°F threshold at Lewiston Dam in July.

26 The majority of spring-run Chinook Salmon in the Trinity River are produced in
27 the South Fork Trinity watershed. Although the water temperature and flow
28 changes could have slight beneficial effects on spring-run Chinook Salmon in the
29 Trinity River, these effects would not occur in every year and are not anticipated
30 to be substantial based on the relatively small differences in flows and water
31 temperatures under Alternative 3 as compared to the No Action Alternative.

32 Overall, Alternative 3 is likely to have similar effects on the spring-run Chinook
33 Salmon population in the Trinity River as compared to the No Action Alternative.

34 *Fall-Run Chinook Salmon*

35 The analysis of effects associated with changes in operation on fall-run Chinook
36 Salmon was conducted using temperature model outputs for Lewiston Dam to
37 anticipate the likely effects on conditions in the Trinity River downstream of
38 Lewiston Dam. The Reclamation Salmon Survival Model also was applied to
39 assess changes in egg mortality.

40 *Changes in Water Temperature*

41 As described above for Coho Salmon, the temperature differences between
42 Alternative 3 and No Action Alternative would be relatively minor (less than
43 0.5°F) and likely would have little effect on fall-run Chinook Salmon in the

1 Trinity River. In critical dry years, increased water temperatures in November
2 under Alternative 3 could increase the likelihood of adverse effects on spawning
3 fall-run Chinook Salmon, although water temperatures are relatively low at this
4 time of year.

5 The temperature threshold and months during which it applies for fall-run
6 Chinook Salmon are the same as those for Coho Salmon. Under Alternative 3,
7 the 56°F threshold for fall-run Chinook Salmon would be exceeded about
8 6 percent of the time in October, about 2 percent less frequently than under the No
9 Action Alternative. In November and December, average water temperatures
10 under Alternative 3 would not exceed the threshold, whereas average monthly
11 water temperatures the No Action Alternative would exceed the threshold about
12 2 percent of the time in November. Overall, the differences in the frequency of
13 threshold exceedance between Alternative 3 and the No Action Alternative would
14 be relatively minor. Temperature conditions under the Alternative 3 could be
15 slightly less likely to affect fall-run Chinook Salmon spawning than under the No
16 Action Alternative because of the slightly reduced frequency of exceedance of the
17 56°F threshold at Lewiston Dam in October. However, this would occur prior to
18 the peak spawning period (November-December) for fall-run Chinook Salmon.

19 The temperatures described above for the Trinity River downstream of Lewiston
20 Dam are reflected in the analysis of egg mortality using the Reclamation model
21 (Appendix 9C). For fall-run Chinook Salmon in the Trinity River, the long-term
22 average egg mortality rate is predicted to be relatively low (around 5 percent),
23 with higher mortality rates (nearly 15 percent) occurring in critical dry years
24 under the No Action Alternative. Overall, egg mortality would be about
25 0.2 percent lower under Alternative 3; in critical dry years the average egg
26 mortality rate would be 1.5 percent less than under the No Action Alternative and
27 in wet years it would be 0.5 percent higher under Alternative 3 (Appendix 9C,
28 Table B-5). Overall, egg mortality under Alternative 3 and the No Action
29 Alternative would be similar.

30 Although the water temperature and flow changes suggest a lower potential for
31 adverse effects on fall-run Chinook Salmon in the Trinity River, these effects
32 would not occur in every year and are not anticipated to be substantial based on
33 the relatively small differences in flows and water temperatures (as well as egg
34 mortality) under Alternative 3 as compared to the No Action Alternative.

35 Overall, Alternative 3 is likely to have similar effects on the fall-run Chinook
36 Salmon population in the Trinity River as compared to the No Action Alternative.

37 *Steelhead*

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

41 As described above for Coho Salmon, the temperature differences between
42 Alternative 3 and No Action Alternative would be relatively minor (less than
43 0.5°F) and likely would have little effect on steelhead in the Trinity River. In

1 critical dry years, increased water temperatures in November under Alternative 3
2 could increase the likelihood of adverse effects on migrating adult steelhead,
3 although water temperatures are relatively low at this time of year. The slightly
4 lower water temperatures in most months under Alternative 3 may decrease the
5 likelihood of adverse effects on steelhead rearing in the Trinity River.

6 The temperature threshold and months during which it applies for steelhead are
7 the same as those for Coho Salmon. Overall, the differences in the frequency of
8 threshold exceedance between Alternative 3 and the No Action Alternative would
9 be relatively minor and are unlikely to affect steelhead spawning in the Trinity
10 River. While average monthly temperatures would be similar overall, the slight
11 reduction in the frequency of threshold exceedance provided by Alternative 3
12 during warm periods in October and November might be biologically meaningful.
13 Thus, temperature conditions under Alternative 3 could be slightly less likely to
14 affect steelhead than under the No Action Alternative.

15 Although water temperatures under Alternative 3 suggest a slightly lower
16 potential for adverse effects on steelhead in the Trinity River, the relatively small
17 differences in flows and water temperatures under Alternative 3 as compared to
18 the No Action Alternative would likely have similar effects on the steelhead
19 population in the Trinity River as compared to the No Action Alternative.

20 *Green Sturgeon*

21 Changes in operations that influence temperature and flow conditions in the
22 Trinity River downstream of Lewiston Dam could influence Green Sturgeon. The
23 following describes those changes and their potential effects.

24 As described in the Affected Environment, Green Sturgeon spawn in the lower
25 reaches of the Trinity River during April through June, and water temperatures
26 above about 63°F are believed stressful to embryos (Van Eenennaam et al. 2005).
27 Average monthly water temperature conditions during April through June in the
28 Trinity River at Lewiston Dam under Alternative 3 are similar and do not exceed
29 58°F during this period. Water temperatures in the downstream reaches where
30 Green Sturgeon spawn would be higher, although temperature conditions likely
31 would be controlled by other factors (e.g., ambient air temperatures and tributary
32 inflows) rather than water operations at Trinity and Lewiston dams. Therefore,
33 given the similarities between average monthly water temperatures at Lewiston
34 Dam under Alternative 3 and the No Action Alternative, it is likely that
35 temperature conditions for Green Sturgeon in the Trinity River or lower Klamath
36 River and estuary would be similar under both scenarios.

37 *Reservoir Fishes*

38 The analysis of effects associated with changes in operation on reservoir fishes
39 relied on evaluation of changes in available habitat (reservoir storage) and
40 anticipated changes in black bass nesting success.

41 Changes in CVP water supplies and operations under Alternative 3 as compared
42 to the No Action Alternative would result in higher reservoir storage in Trinity
43 Lake. Storage in Trinity Lake could be increased up to around 10 percent in some

1 months of some water year types. Additional information related to monthly
2 reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

3 Aquatic habitat in Trinity Lake may not be limiting; however, storage volume is
4 an indicator of how much habitat is available to fish species inhabiting these
5 reservoirs. Therefore, the amount of habitat for reservoir fishes could be
6 increased somewhat under Alternative 3 as compared to the No Action
7 Alternative.

8 Results of the bass nesting success analysis are presented in Appendix 9F,
9 Reservoir Fish Analysis Documentation. Bass nest survival in Trinity Lake is
10 predicted to be near 100 percent in March and April due to increasing reservoir
11 elevations. For May, the likelihood of survival for Largemouth and Smallmouth
12 Bass in Trinity Lake being in the 40 to 100 percent range would be slightly (about
13 2 percent) higher under Alternative 3 as compared to the No Action Alternative.
14 For June, the likelihood of survival being greater than 40 percent for Largemouth
15 and Smallmouth Bass would be somewhat lower than in May and would be
16 similar (less than 1 percent difference) under Alternative 3 and the No Action
17 Alternative. For Spotted Bass, the likelihood of survival being greater than 40
18 percent would be 100 percent in May under both Alternative 3 and the No Action
19 Alternative. For June, Spotted Bass survival in Trinity Lake would be less than
20 for May due to greater daily reductions in water surface elevation. The likelihood
21 of survival being greater than 40 percent would be similar (near 100 percent)
22 under Alternative 3 and the No Action Alternative.

23 Overall, while reservoir storage and nest survival would be slightly higher under
24 Alternative 3, it is uncertain whether these differences would be biologically
25 meaningful. Thus, it is likely that effects on black bass would be similar under
26 both Alternative 3 and the No Action Alternative.

27 *Pacific Lamprey*

28 Little information is available on factors that influence populations of Pacific
29 Lamprey in the Trinity River, but they are likely affected by many of the same
30 factors as salmon and steelhead because of the parallels in their life cycles. On
31 average, the temperature of water released at Lewiston Dam under Alternative 3
32 would be similar to (within 0.5°F) (Appendix 6B). The highest increases in flow
33 would be less than 10 percent in the Trinity River, with a smaller relative increase
34 in the lower Klamath River and Klamath River estuary (Appendix 5A).

35 Overall, it is likely that effects on Pacific Lamprey would be similar under both
36 Alternative 3 and the No Action Alternative. This conclusion likely also applies
37 to other species of lamprey that inhabit the Trinity and lower Klamath rivers (e.g.,
38 River Lamprey).

39 *Eulachon*

40 It is uncertain whether Eulachon has been extirpated from the Klamath River.
41 Given that the highest increases in flow would be less than 10 percent in the
42 Trinity River (Appendix 5A), with a smaller relative increase in the lower
43 Klamath River and Klamath River estuary, and that water temperatures in the

1 Klamath River (Appendix 6B) would be unlikely to be affected by changes
2 upstream at Lewiston Dam, it is likely that Alternative 3 would have a similar
3 potential to influence Eulachon in the Klamath River as the No Action
4 Alternative.

5 *Sacramento River System*

6 *Winter-run Chinook Salmon*

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

10 Average monthly water temperature in the Sacramento River at Keswick Dam
11 under Alternative 3 generally would be similar to or cooler than (less than 0.5°F
12 difference) water temperatures under the No Action Alternative during most
13 months of the year (Appendix 6B, Table B-5-2). In September, average water
14 temperatures would be similar except in wetter years when water temperatures
15 would be increased by up to 0.8°F. Water temperatures under Alternative 3 could
16 be decreased by up to 0.8°F in October and November of drier years. A similar
17 temperature pattern generally would be exhibited downstream at Ball's Ferry,
18 Jelly's Ferry, and Bend Bridge, with average monthly temperatures progressively
19 increasing in the downstream direction (e.g., average difference of about 2°F
20 between Keswick Dam and Bend Bridge) (Appendix 6B, Table B-8-2). The
21 differences between Alternative 3 and the No Action Alternative in September of
22 wetter years would increase, while the differences in water temperatures during
23 October and November associated with Alternative 3 during drier years would
24 remain similar to upstream locations.

25 Overall, the temperature differences between Alternative 3 and the No Action
26 Alternative would be relatively minor and likely would have little effect on
27 winter-run Chinook Salmon in the Sacramento River. The increased water
28 temperatures in September of wetter years under Alternative 3 could increase the
29 likelihood of adverse effects on winter-run Chinook Salmon egg incubation and
30 fry rearing during this water year type. The slightly lower water temperatures in
31 October and November under Alternative 3 could reduce the likelihood of adverse
32 effects on winter-run Chinook Salmon fry rearing in or outmigrating from the
33 Sacramento River. There would be little difference in potential effects on
34 spawning of winter-run Chinook Salmon due to the similar water temperatures
35 during the April to June time period under Alternative 3 as compared to the No
36 Action Alternative.

37 With the exception of April, average monthly water temperatures under both
38 Alternative 3 and the No Action Alternative would show exceedances of the water
39 temperature threshold of 56°F established in the Sacramento River at Ball's Ferry
40 for winter-run Chinook Salmon spawning and egg incubation in every month,
41 with exceedances under both as high as about 49 percent and 42 percent,
42 respectively, in some months. Under Alternative 3, the temperature threshold
43 generally would be exceeded less frequently than it would under the No Action
44 Alternative (by about 2 percent to 4 percent) in June through August, with the

1 temperature threshold in September exceeded about 6 percent more frequently
2 under Alternative 3 than the No Action Alternative. Farther downstream at Bend
3 Bridge, the frequency of exceedances would increase, with exceedances under
4 both Alternative 3 and the No Action Alternative as high as nearly 90 percent in
5 some months. Under Alternative 3, temperature exceedances generally would be
6 less frequent (by up to 8 percent) than under the No Action Alternative, with the
7 exception of September, when exceedances under Alternative 3 would be about
8 26 percent more frequent.

9 Overall, there would be substantial differences in the frequency of threshold
10 exceedance between Alternative 3 and the No Action Alternative, particularly in
11 September. While temperature conditions under Alternative 3 could be less likely
12 to affect winter-run Chinook Salmon egg incubation than under the No Action
13 Alternative because of the reduced frequency of exceedance of the 56°F threshold
14 from April through August, the substantial increase in the frequency of
15 exceedance in September under Alternative 3 may increase the likelihood of
16 adverse effects on winter-run Chinook Salmon egg incubation during this limited
17 portion of the spawning and egg incubation period.

18 *Changes in Egg Mortality*

19 The temperatures described above for the Sacramento River downstream of
20 Keswick Dam are reflected in the analysis of egg mortality using Reclamation's
21 salmon mortality model (Appendix 9C). For winter-run Chinook Salmon in the
22 Sacramento River, the long-term average egg mortality rate is predicted to be
23 relatively low (around 5 percent), with higher mortality rates (exceeding
24 20 percent) occurring in critical dry years under the No Action Alternative.
25 Overall, egg mortality would be 0.8 percent lower under Alternative 3; in critical
26 dry years the average egg mortality rate would be 6 percent less than under the No
27 Action Alternative. In other water year types, the differences in egg mortality
28 would range from 0.1 percent less (dry) to 0.7 percent greater (Below Normal)
29 under Alternative 3 as compared to the No Action Alternative (Appendix 9C,
30 Table B-4). Overall, the difference in egg mortality between Alternative 3 and
31 the No Action Alternative would be relatively minor and likely would have little
32 effect on winter-run Chinook Salmon in the Sacramento River, except in critical
33 water years.

34 *Changes in Weighted Usable Area*

35 As an indicator of the amount of suitable spawning habitat for winter-run Chinook
36 Salmon between Keswick Dam and Battle Creek, modeling results indicate that,
37 in general, there would be lower amounts of spawning habitat available from May
38 through August under Alternative 3 as compared to the No Action Alternative
39 (Appendix 9E, Weighted Usable Area Analysis). The decrease in long-term
40 average spawning WUA during these months would be relatively small (less than
41 5 percent), with smaller (less than 1 percent) decreases in May and July. There
42 would be an increase in the long-term average spawning WUA in April, but this
43 reduction is small (less than 1 percent) and would occur prior to the peak
44 spawning period in May and June. Overall, spawning habitat availability would
45 be similar under Alternative 3 and the No Action Alternative.

1 Modeling results also indicate that, in general, there would be greater amounts of
2 suitable fry rearing habitat available from June through October under Alternative
3 3. The increase in long-term average fry rearing WUA during June would be
4 relatively small (less than 5 percent), with smaller (less than 1 percent) increases
5 in July, August, and October. There would be a decrease in the long-term average
6 fry rearing WUA in September, but this reduction would also be small (less than
7 5 percent) and would occur at a time when most fry have grown into juveniles and
8 moved into habitats with different depth and velocity characteristics as reflected
9 in the analysis of juvenile rearing WUA below. Overall, fry rearing habitat
10 availability would be similar under Alternative 3 and the No Action Alternative.

11 Similar to the results for fry rearing WUA, modeling results indicate that there
12 would be increased amounts of suitable juvenile rearing habitat available during
13 the early juvenile rearing period from September through December under
14 Alternative 3. There would be decrease in the long-term average juvenile rearing
15 WUA from January through August. The decreases in long-term average juvenile
16 rearing WUA would be relatively small (less than 1 percent), while the increases
17 would be somewhat higher (up to 3 percent). Overall, juvenile rearing habitat
18 availability would be similar under Alternative 3 and the No Action Alternative.

19 *Changes in SALMOD Output*

20 SALMOD results indicate that flow-related winter-run Chinook Salmon egg
21 mortality would be increased by 44 percent under Alternative 3 compared to the
22 No Action Alternative. Conversely, temperature-related egg mortality would be
23 reduced by 20 percent under Alternative 3 (Appendix 9D, Table B-4-9). Both
24 temperature- and flow (habitat)-related fry mortality would be reduced under
25 Alternative 3 as compared to the No Action Alternative, by 19 and 15 percent,
26 respectively. Temperature-related juvenile mortality would be approximately
27 21 percent lower under Alternative 3, while flow (habitat)-related mortality would
28 be approximately 30 percent higher under Alternative 3 as compared to the No
29 Action Alternative. Overall, potential juvenile production would be similar
30 (about 1 percent difference) under Alternative 3 as compared to the No Action
31 Alternative (Appendix 9D, Table B-4-6).

32 *Changes in Delta Passage Model Output*

33 The Delta Passage Model predicted similar estimates of annual Delta survival
34 across the 81-year time period for winter-run Chinook Salmon between
35 Alternative 3 and the No Action Alternative (Appendix 9J). Median Delta
36 survival would be 0.354 for Alternative 3 and 0.349 for the No Action
37 Alternative.

38 *Changes in Delta Hydrodynamics*

39 Winter-run Chinook Salmon smolts are most abundant in the Delta during
40 January, February, and March. On the Sacramento River near the confluence of
41 Georgiana Slough, the percentage of positive velocities under Alternative 3 would
42 be slightly lower than the No Action Alternative in January and indistinguishable
43 in February and March (Appendix 9K). On the San Joaquin River near the
44 Mokelumne River confluence, the percent of positive velocities would be

1 indistinguishable between these two scenarios. In Old River downstream of the
2 facilities, the percent of positive velocities would be slightly lower under
3 Alternative 3 during February and March, and indistinguishable in January
4 relative to the No Action Alternative. On Old River upstream of the facilities,
5 percent positive velocities would be slightly higher under Alternative 3 relative to
6 the No Action Alternative in January, but similar in February and March. On the
7 San Joaquin River downstream of Head of Old River, the percent of positive
8 velocities would be similar for both scenarios in January, February and slightly
9 lower for Alternative 3 relative to the No Action Alternative in March.

10 *Changes in Junction Entrainment*

11 For all junctions examined, entrainment probabilities for both scenarios would be
12 almost indistinguishable (Appendix 9L).

13 *Changes in Salvage*

14 Salvage of Sacramento River-origin Chinook Salmon is predicted to be slightly
15 greater under Alternative 3 relative to No Action Alternative in the three months
16 when winter-run Chinook Salmon are most abundant in the Delta (January,
17 February, March; (Appendix 9M).

18 *Changes in Oncorhynchus Bayesian Analysis Output*

19 Escapement of winter-run Chinook Salmon and Delta survival was modeled by
20 the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook
21 salmon. Escapement was generally lower under Alternative 3 as compared to the
22 No Action Alternative (Appendix 9I). The median abundance under Alternative 3
23 was higher in only 5 of the 22 years of simulation (1971 to 2002), and there was
24 typically greater than a 25 percent chance that Alternative 3 values would be
25 lower than under the No Action Alternative. Median delta survival was
26 consistently lower (by approximately 7 percent) under Alternative 3 as compared
27 to the No Action Alternative. The differences in survival were not consistent
28 across the uncertainty in the parameter values, however, and there was a high
29 probability of no difference between Alternative 3 and the No Action Alternative.
30 Thus delta survival was not responsible for the temporal patterns in relative
31 escapement. Since the ocean conditions were equivalent across scenarios, the
32 differences under Alternative 3 were likely due to differences in survival in the
33 life stages upstream of the delta (i.e., due to differences in temperature and flow at
34 Bend Bridge).

35 *Changes in Interactive Object-Oriented Simulation Output*

36 The IOS model predicted similar adult escapement trajectories for winter-run
37 Chinook Salmon between Alternative 3 and the No Action Alternative across the
38 81 years (Appendix 9H). Under Alternative 3 median adult escapement was
39 4,025 and under the No Action Alternative, median escapement was 3,935.

40 Similar to adult escapement, the IOS model predicted similar egg survival time
41 histories for winter-run Chinook Salmon between Alternative 3 and No Action
42 Alternative across the 81 water years. Under Alternative 3 median egg survival
43 was 0.987 and under the No Action Alternative median egg survival was 0.990.

1 *Changes in Predator Management*

2 The fish predator assemblage of the Delta is dominated by invasive predators,
3 with the exception of the Sacramento Pikeminnow (Brown and Michniuk 2007;
4 Nobriga and Feyrer 2007, National Research Council 2010; Cavallo et al. 2012,
5 National Research Council 2012, Brown 2013). With the exception of Striped
6 Bass, there is little population-level information for fish predators including
7 Largemouth Bass and Sacramento Pikeminnow and there is even less information
8 for Smallmouth Bass and White and Channel Catfish (Grossman et al. 2013). It is
9 important to note that, in addition to predation by native and non-native fishes,
10 there has been extensive modification of the hydrology, loss of tidal freshwater
11 wetlands, increases in non-native submerged aquatic vegetation such as *Egeria*
12 *densa*, and other effects of human population growth within the Delta, which also
13 undoubtedly influence the survival of salmonids in the Delta (Brown and
14 Michniuk 2007; National Research Council 2010, 2012).

15 Although it is well documented that Striped Bass can feed heavily on juvenile
16 salmon and steelhead in the rivers, as they migrate seaward, many of the salmon
17 eaten are likely to be hatchery-reared fish; juveniles from natural spawning may
18 be more wary and encounter lower predation rates. It is thought that predation on
19 hatchery-reared juveniles may buffer wild fish from such predation (Moyle and
20 Bennett 2010). Much of the predation on juvenile salmon seems to take in place
21 in conjunction with artificial structures and release practices. These include
22 releases of fish from hatcheries and those trucked to the estuary from the export
23 facilities in the south Delta (DWR 2010).

24 In general, Striped Bass are opportunistic predators that tend to forage on
25 whatever prey are most abundant, from benthic invertebrates to their own young
26 to juvenile salmon and American Shad (Stevens 1966, Moyle 2002, Nobriga and
27 Feyrer 2008). Striped Bass are unlikely to be a major predator of Delta Smelt
28 because Delta Smelt are semi-transparent (making them hard to see in turbid
29 water) and do not school, unlike more favored prey such as Threadfin Shad,
30 juvenile Striped Bass, and Mississippi Silverside. Delta Smelt were a minor item
31 in Striped Bass diets when they were highly abundant in the early 1960s
32 (Stevens 1966), as well as in recent years at record low abundance (Nobriga and
33 Feyrer 2008).

34 Predator control measures are included in Alternative 3, including an increased
35 bag limit (10/day) with a minimum size limit of 12 inches on Striped Bass and
36 black bass. In addition, a sport reward program for Sacramento Pikeminnow
37 (\$2/fish > 8 inches) would be implemented to encourage fishing for and removal
38 of this native predatory fish.

39 A number of studies have been conducted on predation effects in the Delta, and a
40 recent (2013) workshop was held to assess the status of information and
41 potentially establish conclusions regarding the importance of fish predation on
42 salmonid populations in the Delta (Grossman et al. 2013). The workshop
43 concluded that:

1 “Available data and analyses have generated valuable information
2 regarding aspects of the predation process in the Delta but do not provide
3 unambiguous and comprehensive estimates of fish predation rates on
4 juvenile salmon or steelhead nor on population-level effects for these
5 species in the Delta.”

6 And:

7 “Juvenile salmon are clearly consumed by fish predators and several
8 studies indicate that the population of predators is large enough to
9 effectively consume all juvenile salmon production. However, given
10 extensive flow modification, altered habitat conditions, native and non-
11 native fish and avian predators, temperature and dissolved oxygen
12 limitations, and overall reduction in historical salmon population size, it is
13 not clear what proportion of juvenile mortality can be directly attributed to
14 fish predation. Fish predation may serve as the proximate mechanism of
15 mortality in a large proportion of the population but the ultimate causes of
16 mortality and declines in productivity are less clear.”

17 The proposed bag and size limits are intended and expected to encourage more
18 fishing effort for and greater harvest of Striped Bass and black bass species,
19 resulting in a reduction in the Striped Bass and black bass populations throughout
20 the Delta. It is reasonable to assume that removing or relaxing restrictions on the
21 harvest of these predatory species would lead to a substantial reduction in their
22 number. However, whether or not this reduction would lead to a substantial
23 benefit or population-level effect on salmonid populations is unknown
24 (Moyle and Bennett 2010). For the proposed (under Alternative 3) predator
25 reduction program to be effective, it must be true that predation by Striped Bass
26 and black bass regulates populations of salmon, steelhead, and smelt, with
27 predation by other species (other fish, birds, marine mammals, etc.) playing a
28 minor role. The program may not be effective, or the effectiveness would be
29 reduced if other predators exhibit compensatory increases in predation if Striped
30 Bass and black bass are removed.

31 As noted above, the modification of the hydrology, loss of tidal freshwater
32 wetlands, increases in non-native submerged aquatic vegetation, and other effects
33 of human population growth within the Delta play a role in the survival of
34 salmonids in the Delta and contribute to the uncertainty that any predator
35 reduction program will have the desired results. It is unknown whether reducing
36 Striped bass and black bass populations can measurably compensate for the large
37 changes to the estuary and watershed, which also contribute to reduced
38 populations of salmon, steelhead and smelt.

39 In addition to the proposed bag and size limits, Alternative 3 includes a proposal
40 to implement a sport reward program for Sacramento Pikeminnow to encourage
41 fishing for and removal of predatory Sacramento Pikeminnow. It is unknown
42 whether a Sacramento Pikeminnow bounty would be feasible under California
43 regulations. Currently, the Sacramento Pikeminnow is regulated under CCR
44 Title 14, section 5.95 (no limit or season), sections 2.25 and 2.30 (bow and arrow

1 and spear fishing) and section 1.87 (no wastage of fish). Therefore, any fishing
2 practice, derby or bounty program in which the Sacramento Pikeminnow is
3 wasted would be in violation of the regulations. In addition, Sacramento
4 Pikeminnow is listed as a "game fish" in commission regulations (CCR Title 14,
5 section 230) and a permit is required before any prizes can be offered to take
6 them.

7 Regardless of whether a Sacramento Pikeminnow reward system is feasible to
8 implement, the effectiveness of such a program is not assured. This same
9 approach to predator reduction is ongoing in the Columbia River through the
10 Northern Pikeminnow (*Ptychocheilus oregonensis*) Sport-Reward Program
11 sponsored by Bonneville Power Administration that began in 1991. The program
12 seeks to maintain 10 to 20 percent exploitation rate on Northern Pikeminnow
13 throughout the Columbia River by paying anglers \$4 to \$8 to harvest fish >
14 228 mm (>9 inches) in total length. In 2012, a total of 158,159 fish were
15 harvested in the sport-reward fishery. Vouchers for 156,837 untagged fish were
16 submitted for payment totaling rewards of \$1,016,672. System-wide pikeminnow
17 exploitation efforts suggest that the desired 10 to 20 percent exploitation rate has
18 been achieved for a number of years (Porter 2012). The program has removed
19 over 2.2 million fish from 1998-2009 and is believed to have reduced predation
20 on juvenile salmonids; however, predation estimates have varied widely and
21 positive effects on salmonid populations have been difficult to detect (Carey et al.
22 2012).

23 Control of undesired and invasive fishes is a common fishery management
24 strategy (Kolar et al. 2010). However, changes in predator abundance produced
25 via removal, augmentation, or invasion can produce unintended consequences
26 (Polis and Strong 1996). It is possible that other species on which Striped Bass
27 prey, such as Mississippi Silverside, would increase in abundance, causing harm
28 by competing with and preying on desired species, particularly Delta Smelt.
29 Mississippi Silversides are important in the diets of 1 to 3 year old Striped Bass;
30 predation by Striped Bass could be regulating the silverside population. Reducing
31 Striped Bass predation pressure on Mississippi Silversides may increase their
32 numbers, which could have negative effects on Delta Smelt through predation on
33 eggs and larvae (Bennett and Moyle 2006).

34 The predator reduction program under Alternative 3 is intended to improve the
35 survival of listed species (e.g., salmonids and Delta Smelt) by reducing predation
36 on these species. As described above, the program may be difficult to implement,
37 may not be effective, and may cause unintended harm to other native Delta fish
38 species. Consequently, the outcome of the predator management program is
39 highly uncertain. Compared to the No Action Alternative, which does not include
40 a predator reduction program, Alternative 3 may or may not provide a benefit to
41 salmonids and may result in an adverse effect on Delta smelt.

42 *Changes in Ocean Salmon Harvest*

43 Alternative 3 includes an action to change ocean salmon harvest for the purpose
44 of increasing escapement of adult winter-run Chinook Salmon as well as other

1 runs. The following outlines the benefits and challenges associated with such a
2 program.

3 Central Valley origin Chinook Salmon of all races are harvested in commercial
4 and recreational fisheries off the coast of California. Central Valley origin fall-
5 run Chinook Salmon are the primary target of this harvest. Harvested Chinook
6 Salmon between Point Conception and Bodega Bay were found to be composed
7 of 89-95 percent Central Valley fall-run Chinook Salmon (Winans et al. 2001).
8 More recent studies have shown most Central Valley fall-run Chinook Salmon are
9 produced by hatcheries, and are not of natural origin. Barnett-Johnson et al.
10 (2007) analyzed otolith microstructure from harvested Chinook Salmon and
11 estimated 90 percent were of hatchery origin. Palmer-Zwhalen and Kormos
12 (2012; Table 9) reported data indicating spawning-escapement for Central Valley
13 fall-run Chinook Salmon was composed of 75 percent hatchery origin fish.

14 Despite the relatively high abundance of hatchery-produced fall-run Chinook
15 Salmon, ocean fisheries are often constrained to protect ESA-listed Chinook
16 Salmon stocks (including Sacramento winter-run and spring-run Chinook Salmon,
17 and Coastal Chinook Salmon), which constitute less than 10 percent of available
18 Chinook Salmon (Winans et al. 2001). This “mixed-stock” fishery is managed by
19 using stock-specific differences in ocean distribution, age at maturity, size-at-date,
20 and/or timing of river entry to help minimize harvest of sensitive stocks.
21 However, such management strategies are only partially effective.

22 For example, spring-run Chinook Salmon return to freshwater in the spring and
23 thus avoid most ocean harvest during the year in which they mature. However,
24 spring-run Chinook Salmon that mature at age 4 (or older) are subjected to a full
25 season of harvest at “impact levels” comparable to those directed at Central
26 Valley fall-run Chinook Salmon. Harvest managers define “impact rate” as the
27 proportion of a particular stock that will suffer mortality associated with the ocean
28 fishery. Fall-run Chinook Salmon often experience impact rates between 40 and
29 70 percent.

30 Thus, the impact of ocean harvest varies considerably by stock, but all stocks are
31 impacted by harvest directed at the most abundant Chinook Salmon population
32 (typically hatchery origin fall-run Chinook Salmon). Several analyses are
33 available that provide a basis for assessing how harvest management identified in
34 Alternative 3 would affect Central Valley Chinook Salmon populations. Though
35 there are political and societal considerations for changes in ocean harvest
36 management, there are no technical or scientific constraints. We have the tools,
37 the knowledge and the ability to manage Chinook ocean harvest in whatever way
38 is needed. As such, Alternative 3 is, from a technical and scientific level, entirely
39 feasible.

40 Alternative 3 calls for ocean harvest to be managed with the standard of causing
41 no appreciable reduction in viability criteria for natural origin Chinook Salmon.
42 This alternative is addressed separately for Central Valley spring-run, winter-run,
43 and fall-run Chinook Salmon.

1 *Spring-Run Chinook Salmon.*
2 Fifteen years have elapsed since NMFS last updated its spring-run Chinook
3 Salmon ocean harvest Biological Opinion (NMFS 2000). The 2000 BO did not
4 report an estimated “impact rate” for the ocean harvest impact on spring-run
5 Chinook Salmon. The BO reached a non-jeopardy opinion for the impacts of
6 ocean harvest primarily by referring to the growth in Central Valley spring-run
7 Chinook Salmon population which was occurring at that time. Though NMFS
8 (2010) did not provide a quantitative analysis of spring-run Chinook Salmon
9 harvest, Grover et al. (2004) estimated that two thirds of spring-run Chinook
10 Salmon matured at age 4, indicating that a large fraction of the spring-run
11 Chinook Salmon population is annually subject to high impact rates (40 to
12 70 percent), which would greatly influence population productivity and
13 abundance. Harvest of age-3 spring-run Chinook Salmon is likely to be
14 comparable to that experienced by winter-run Chinook Salmon (which also
15 mature and return to fresh water, missing most of the ocean fishing season).
16 Though a comparable analysis for spring-run Chinook Salmon is not available,
17 Winship et al. (2013) applied a simulation model that showed a 25 percent impact
18 rate (much less than that likely experienced by age 4 spring-run Chinook Salmon)
19 on winter-run Chinook Salmon substantially decreased population abundance and
20 population resiliency relative to alternatives with less harvest.

21 Harvest pressure of this intensity can also alter diversity in age at-maturity, a
22 critical factor for population viability (NMFS 2010). The ocean fishery is thought
23 to select against fish that mature later because fish that would do so are vulnerable
24 to harvest for more years (Ricker 1981; Hankin and Healey 1986; Sierra and
25 Lackey 2015), and age at maturity has moderate heritability (Hankin et al. 1993).
26 As such, reduced ocean harvest would contribute substantially to age at-maturity
27 diversity (certainly demographically, if not genetically) and thereby enhance
28 population viability. A downward shift in size and age at maturity also affect
29 fitness by reducing fecundity and reproductive rates (Calduch-Verdiell et al.
30 2014). Larger females generally have larger and more numerous eggs
31 (Wertheimer et al. 2004), both of which provide reproductive advantages. Larger
32 eggs produce larger juveniles, which tend to have higher survival rates
33 (Quinn 2005) and are more resistance to temperature extremes. Since size and
34 age-at-maturity are heritable, selection for earlier adult maturity leads to a
35 feedback loop in which younger and smaller adults produce offspring that mature
36 earlier at smaller sizes. Change in body size may also influence spawning habitat
37 use where larger fish occupy areas with coarser substrate that smaller fish may not
38 be able to use. Thus, advantages of diversity in age at-maturity could be
39 especially important in degraded and thermally stressful habitats typical of
40 Central Valley tributaries.

41 *Winter-Run Chinook Salmon*
42 NMFS updated their winter-run Chinook Salmon ocean harvest BO in 2010
43 (NMFS 2010) and concluded:

44 *The effect of harvest and indirect mortality associated with the salmon*
45 *ocean fishery reduces the reproductive capability of this population, and*

1 *subsequently the entire ESU, by 10-25 percent per brood, when ocean*
 2 *fisheries occur at a level similar to what has been observed for most of the*
 3 *last decade south of Point Arena, California.*

4 *There is concern about the relatively high impact rate for age-4 fish and*
 5 *the consequences of this relative to the genetic diversity of winter-run. If*
 6 *age at maturity is strongly related to a genetic component, the removal of*
 7 *older fish at a high rate before they can return to spawn, however few of*
 8 *these individuals in the population there might be, could theoretically*
 9 *reduce the potential for that trait to pass on to successive generation. The*
 10 *change in an average life history trait over time, such as age at maturity,*
 11 *has been suggested as evidence for fisheries induced evolution in some*
 12 *situations (Law 2000; Kuparinen and Merilä 2007; Hard et al. 2008).*

13 NMFS has since implemented changes in ocean harvest regulations intended to
 14 reduce impacts, but the effectiveness of those programs is unclear. Winship et al.
 15 (2013) applied a simulation model and showed that all current winter-run
 16 Chinook Salmon harvest alternatives substantially decreased population
 17 abundance and population extinction risk relative to closing recreational and
 18 commercial fisheries south of Point Arena. While closing these fisheries may not
 19 be a realistic management alternative, Winship et al. (2013) did not consider
 20 intermediate harvest management strategies such as a mark-selective fishery
 21 (Pyper et al. 2012) or quota based fishing seasons. Currently, about 90 percent of
 22 winter-run Chinook Salmon mature at age-3. As identified in the winter-run
 23 Chinook Salmon harvest BO (NMFS 2010), diversity in age at maturity is an
 24 important viability criterion likely to be adversely impacted by current harvest
 25 management; winter-run Chinook Salmon currently maturing at age-4 are
 26 subjected to impact rates comparable to those targeting fall-run Chinook Salmon
 27 (40 to 70 percent). Given information presented in the spring-run Chinook
 28 Salmon section, it seems likely that in the absence of this harvest, winter-run
 29 Chinook Salmon would have a larger fraction of their population maturing at
 30 age-4 or possibly older. Age-4 and older winter-run Chinook Salmon would
 31 enhance demographic population viability, but also benefit the population by
 32 more effectively spawning in coarse substrates, and producing more, larger, and
 33 more thermally tolerant eggs.

34 *Fall-Run Chinook Salmon.*

35 As indicated previously, fall-run Chinook Salmon produced by Central Valley
 36 hatcheries are the most abundant stock harvested off the coast of California. The
 37 current management of Central Valley fall-run Chinook Salmon makes no
 38 distinction between natural and hatchery fish, and, as such, harvest of natural
 39 origin fall-run Chinook Salmon appears to occur at a much higher rate than
 40 population productivity can sustain. The recently convened California HSRG
 41 concluded:

42 *“Fishery harvests that are sustained at high levels by targeting abundant*
 43 *hatchery-origin fish may over-exploit naturally reproducing salmonids*
 44 *and may also induce selection on maturation schedule and other traits...*
 45 *fishery exploitation rates must be in alignment with the productivity of*

1 *naturally reproducing salmon stocks for the recommendations in this*
2 *report to be successful at conserving natural salmonid populations.”*
3 *(p. 19)*

4 *“The California HSRG also believes that an aggregate escapement target*
5 *for [the Central Valley natural stocks] that includes returns to hatcheries*
6 *lacks biological support. The target could theoretically be met if all fish*
7 *returned to hatcheries and none returned to natural spawning areas, or if*
8 *all fish in natural spawning areas were of hatchery origin.” (p. 21)*

9 Quantitative analyses of current ocean harvest impacts to natural origin fall-run
10 Chinook Salmon are not currently available. However, impact rates combined
11 with relatively low abundances of natural origin fall-run Chinook Salmon indicate
12 adverse impacts to population viability are likely severe. Changes in harvest
13 strategies which could more effectively target hatchery origin fall Chinook while
14 better protecting natural origin fish would yield substantial benefits. Pyper et al.
15 (2012) analyzed one alternative, a mark-selective fishery, and found that natural
16 origin spawning escapement would increase from 24 to 48 percent.

17 Managing ocean salmon harvest as described in Alternative 3 would contribute to
18 the abundance, productivity and diversity viability criteria for natural origin
19 spring-run, winter-run, and fall-run Chinook Salmon.

20 *Summary of Effects on Winter-Run Chinook Salmon*

21 The multiple model and analysis outputs described above characterize the
22 anticipated conditions for winter-run Chinook Salmon and their response to
23 change under Alternative 3 as compared to the No Action Alternative. For the
24 purpose of analyzing effects on winter-run Chinook Salmon and developing
25 conclusions, greater reliance was placed on the outputs from the two life cycle
26 models, IOS and OBAN because they each integrate the available information to
27 produce single estimates of winter-run Chinook Salmon escapement. The output
28 from IOS indicated that winter-run Chinook Salmon escapement would be similar
29 under both scenarios, whereas the OBAN results indicated that escapement under
30 Alternative 3 would be lower than under the No Action Alternative.

31 These model results suggest that effects on winter-run Chinook Salmon would be
32 similar under both scenarios, with a small likelihood that winter-run Chinook
33 Salmon escapement would be lower under Alternative 3 than under the No Action
34 Alternative. This potential distinction between the two scenarios, however, could
35 be increased because Alternative 3 does not include passage at Shasta Dam. By
36 comparison the No Action Alternative, Alternative 3 would not include the
37 potential for providing access to better quality (temperature) habitat upstream of
38 the dam.

39 The ocean harvest restriction component of Alternative could increase winter-run
40 Chinook Salmon numbers by reducing ocean harvest and the predator control
41 measures under Alternative 3 could reduce predation on juvenile winter-run
42 Chinook Salmon and thereby increase survival.

1 Overall, given the small differences between alternatives and the uncertainty
 2 regarding the non-operational components, distinguishing a clear difference
 3 between alternatives is not possible. However, if fish passage is successful in
 4 providing access to higher quality habitat, Alternative 3 would do less than the No
 5 Action Alternative to address long-term temperature issues in the river
 6 downstream of the dam.

7 *Spring-run Chinook Salmon*

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

11 *Changes in Water Temperature*

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

15 *Sacramento River*

16 Average monthly water temperature in the Sacramento River at Keswick Dam
 17 under Alternative 3 relative to the No Action Alternative generally would be
 18 similar to or cooler (less than 0.5°F differences) water temperatures under the No
 19 Action Alternative during most months of the year (Appendix 6B, Table B-5-2).
 20 In September, average water temperatures also would be similar except in wetter
 21 years when water temperatures would be increased by up to 0.8°F. Water
 22 temperatures under Alternative 3 could be decreased by up to 0.8°F in October
 23 and November of drier years. A similar temperature pattern generally would be
 24 exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, and Red Bluff,
 25 with average monthly temperatures progressively increasing in the downstream
 26 direction (e.g., average difference of about 3°F between Keswick Dam and Red
 27 Bluff). The differences between Alternative 3 and the No Action Alternative in
 28 September of wetter years would increase, while the differences in water
 29 temperatures during October and November associated with Alternative 3 during
 30 drier years would remain similar to upstream locations.

31 Overall, the temperature differences between Alternative 3 and the No Action
 32 Alternative would be relatively minor and likely would have little effect on
 33 spring-run Chinook Salmon in the Sacramento River. The increased water
 34 temperatures in September of wetter years under Alternative 3 could increase the
 35 likelihood of adverse effects on spring-run Chinook Salmon spawning and egg
 36 incubation during this water year type. The slightly lower water temperatures in
 37 October and November under Alternative 3 would reduce the likelihood of
 38 adverse effects on spring-run Chinook Salmon spawning and egg incubation in
 39 the Sacramento River as compared to the No Action Alternative. There would be
 40 little difference in potential effects on spring-run Chinook Salmon holding in
 41 other summer months due to the similar water temperatures during this time
 42 period under Alternative 3 and the No Action Alternative.

1 *Clear Creek*

2 Average monthly water temperatures in Clear Creek at Igo under Alternative 3
3 would be similar to (less than 0.5°F differences) water temperatures under the No
4 Action Alternative with the exception of May when average monthly
5 temperatures under Alternative 3 would be somewhat higher (up to about 0.8°F)
6 than the No Action Alternative (Appendix 6B, Table B-3-2). The lower water
7 temperatures in May associated with the No Action Alternative reflect the effects
8 of the additional water that would be discharged from Whiskeytown Dam to meet
9 the spring attraction flow requirements to promote attraction of spring-run
10 Chinook Salmon into the creek. Overall, water temperature conditions for
11 spring-run Chinook Salmon in Clear Creek would be similar under Alternative 3
12 and the No Action Alternative.

13 *Feather River*

14 Average monthly water temperatures in the Feather River low flow channel under
15 Alternative 3 generally would be similar (within 0.5°F) to water temperatures
16 under the No Action Alternative in November and December (differences as
17 much as 1.6°F lower in December in below normal water years) (Appendix 6B,
18 Table B-20-2). In September average monthly water temperatures under
19 Alternative 3 would be somewhat higher (up to about 1.5°F) and during May and
20 June water temperatures would be slightly (up to 0.4°F) lower in wetter years than
21 under the No Action Alternative. Although temperatures in the river would
22 become progressively higher in the downstream direction, the differences between
23 Alternative 3 and the No Action Alternative would exhibit a similar pattern at the
24 downstream locations (Robinson Riffle and Gridley Bridge), with temperatures
25 under Alternative 3 and the No Action Alternative generally becoming more
26 similar at the confluence with the Sacramento River, except in September when
27 the differences between Alternative 3 and the No Action Alternative would be up
28 to 4.4 °F higher than under the No Action Alternative (Appendix 6B,
29 Table B-23-2).

30 Overall, the temperature differences in the Feather River between Alternative 3
31 and the No Action Alternative would be relatively minor (less than 0.5°F) and
32 likely would have little effect on spring-run Chinook Salmon in the Feather River.
33 The slightly lower water temperatures from October to in November and
34 December under the No Action Alternative 3 would likely have little effect on
35 spring-run Chinook Salmon as water temperatures in the Feather River are
36 typically low during this time period. The somewhat higher water temperatures in
37 September of wetter years may increase the likelihood of adverse effects on
38 spring-run Chinook Salmon egg incubation and fry rearing in the Feather River.
39 There would be little difference in potential for adverse effects on spring-run
40 Chinook Salmon holding over the summer due to the similar water temperatures
41 during this time period under Alternative 3 and the No Action Alternative.

1 *Changes in Exceedances of Water Temperature Thresholds*

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

6 *Sacramento River*

7 Average monthly water temperatures under both Alternative 3 and the No Action
8 Alternative would show exceedances of the water temperature threshold of 56°F
9 established in the Sacramento River at Red Bluff for spring-run Chinook Salmon
10 (spawning and egg incubation) in October, November, and again in April. The
11 exceedances would occur at the greatest frequency in October, with 78 percent of
12 the time under Alternative 3). The water temperature threshold would be
13 exceeded less frequently in November (8 percent of the time) and not exceeded at
14 all during December through March. As water temperatures warm in the spring,
15 the threshold would be exceeded in April by 14 percent under Alternative 3. In
16 the months when the greatest frequency of exceedances occur (October,
17 November, and April), model results generally indicate that the threshold would
18 be exceeded less frequently (by up to 4 percent in October) under Alternative 3
19 than under the No Action Alternative. Temperature conditions in the Sacramento
20 River under Alternative 3 could be less likely to affect spring-run Chinook
21 Salmon egg incubation than under the No Action Alternative because of the
22 decreased frequency of exceedance of the 56°F threshold in October, November,
23 and April.

24 *Clear Creek*

25 Average monthly water temperatures under both Alternative 3 and the No Action
26 Alternative would not exceed the water temperature threshold of 60°F established
27 in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning and rearing in
28 June through August. However, water temperatures under Alternative 3 would
29 exceed the water temperature threshold of 56°F established for spawning in
30 September and October about 12 percent to 11 percent of the time, respectively.
31 The differences between Alternative 3 and the No Action Alternative could be
32 biologically meaningful, with water temperatures under Alternative 3 exceeding
33 thresholds about 4 percent less frequently than under the No Action Alternative in
34 September and about 2 percent less frequently in October. Temperature
35 conditions in Clear Creek under Alternative 3 could be less likely to affect spring-
36 run Chinook Salmon spawning than under the No Action Alternative because of
37 the decreased frequency of exceedance of the 56°F threshold in September and
38 October.

39 *Feather River*

40 Average monthly water temperatures under both Alternative 3 and the No Action
41 Alternative would exceed the water temperature threshold of 56°F established in
42 the Feather River at Robinson Riffle for spring-run Chinook Salmon egg
43 incubation and rearing) during some months, particularly in October and
44 November, and March and April, when temperature thresholds could be exceeded
45 frequently (Appendix 9N). The frequency of exceedance would be highest

1 (about 57 percent) in October, a month in which average monthly water could get
2 as high as about 68°F. However, the differences in the frequency of exceedances
3 between Alternative 3 and the No Action Alternative would be relatively small.
4 Water temperatures under Alternative 3 would exceed the temperature threshold
5 about 2 percent less frequently than the No Action Alternative in October,
6 5 percent less frequently in November, 2 percent less frequently in December, and
7 1 percent less frequently in March.

8 The established water temperature threshold of 63°F for rearing during May
9 through August would be exceeded often under both Alternative 3 and the No
10 Action Alternative in June, July and August. Water temperatures under
11 Alternative 3 would exceed the rearing temperature threshold about 1 percent less
12 frequently than under the No Action Alternative in June, with the same likelihood
13 of exceedance in July and August. Temperature conditions in the Feather River
14 under Alternative 3 could be less likely to affect spring-run Chinook Salmon
15 spawning and rearing than under the No Action Alternative because of the
16 decreased frequency of exceedance of the water temperature thresholds.

17 *Changes in Egg Mortality*

18 The temperature differences described above are reflected in the analysis of egg
19 mortality using the Reclamation model (Appendix 9C). For spring-run Chinook
20 Salmon in the Sacramento River, the long-term average egg mortality rate is
21 predicted to be relatively high (exceeding 20 percent), with high mortality rates
22 (exceeding 80 percent) occurring in critical dry years under the No Action
23 Alternative. Overall, egg mortality would be 0.7 percent lower under Alternative
24 3; in critical dry years the average egg mortality rate would be 6.6 percent less
25 than under the No Action Alternative. In other water year types, the differences
26 in egg mortality would range from 2.5 percent less (Below Normal) to over
27 2 percent greater (wet and above normal) under Alternative 3 as compared to the
28 No Action Alternative (Appendix 9C, Table B-3). Overall, the difference in egg
29 mortality between Alternative 3 and the No Action Alternative would be
30 relatively minor and likely would have little effect on spring-run Chinook Salmon
31 in the Sacramento River, except in critical dry water years.

32 *Changes in Weighted Usable Area*

33 Weighted usable area curves are available for spring-run Chinook Salmon in
34 Clear Creek. As described above, flows in Clear Creek downstream of
35 Whiskeytown Dam are not anticipated to differ under Alternative 3 relative to the
36 No Action Alternative except in May due to the release of spring attraction flows
37 in accordance with the 2009 NMFS BO under the No Action Alternative.
38 Therefore, there would be no change in the amount of potentially suitable
39 spawning and rearing habitat for spring-run Chinook Salmon (as indexed by
40 WUA) available under Alternative 3 as compared to the No Action Alternative.

41 *Changes in SALMOD Output*

42 SALMOD results indicate that pre-spawning mortality of spring-run Chinook
43 Salmon eggs would be approximately 21 percent less under Alternative 3,
44 primarily due to decreased summer temperatures. Flow-related spring-run

1 Chinook Salmon egg mortality would be similar (less than 1 percent increase)
2 under Alternative 3 compared to the No Action Alternative. Conversely,
3 temperature-related egg mortality would be 7 percent less under Alternative 3
4 (Appendix 9D, Table B-3-9). Flow (habitat)-related fry mortality would be
5 approximately 7 percent higher under Alternative 3 as compared to the No Action
6 Alternative. There would be no temperature-related fry and juvenile mortality or
7 flow (habitat)-related juvenile mortality under either alternative, as most
8 spring-run Chinook Salmon juveniles migrate downstream as fry and are not
9 found in the mainstem Sacramento River. Overall, potential juvenile production
10 would be about 2 percent greater under Alternative 3 as compared to the No
11 Action Alternative (Appendix 9D, Table B-3-6).

12 *Changes in Delta Passage Model Output*

13 The Delta Passage Model predicted similar estimates of annual Delta survival
14 across the 81-year time period for spring-run Chinook Salmon between Alternative
15 3 and the No Action Alternative (Appendix 9J). Median Delta survival was
16 0.286 for Alternative 3 and 0.296 for the No Action Alternative.

17 *Changes in Delta Hydrodynamics*

18 Spring-run Chinook Salmon are most abundant in the Delta from March through
19 May. Near the junction of Georgiana Slough (channel 421), the percent of time
20 that velocity would be positive was similar in the March for both scenarios
21 (Appendix 9K). In April and May, percent positive velocity would be slightly
22 lower under Alternative 3 relative to the No Action Alternative. Near the
23 confluence of the San Joaquin River and the Mokelumne River (channel 45),
24 percent positive velocity would be almost identical in March and slightly, to
25 moderately, lower under Alternative 3 relative to the No Action Alternative in
26 April and May. A similar pattern was observed in the San Joaquin River
27 downstream of the Head of Old River (channel 21); however, the difference
28 between alternatives would be even smaller (Appendix 9K, Figure V6). In Old
29 River upstream of the facilities (channel 212), percent positive velocity would be
30 slightly higher in May under Alternative 3 relative to No Action Alternative and
31 similar magnitude in April and May. In Old River downstream of the facilities,
32 (channel 94) percent positive velocity would be slightly lower in March and
33 increasingly lower in April and May under Alternative 3 relative to the No Action
34 Alternative.

35 *Changes in Junction Entrainment*

36 Entrainment at Georgiana Slough would be similar under both scenarios during
37 March, April and May when spring-run Chinook Salmon are most abundant in the
38 Delta (Appendix 9L. At the Head of Old River, entrainment probabilities would
39 be moderately greater under Alternative 3 during April and May, whereas
40 probabilities would be similar in March. At the Turner Cut junction, entrainment
41 probabilities under Alternative 3 and the No Action Alternative would be similar
42 in March. During April and May, entrainment probabilities would be more
43 divergent with higher values for Alternative 3 relative to the No Action
44 Alternative. Overall, entrainment was lower at the Columbia Cut junction relative
45 to Turner Cut, but patterns of entrainment between these two alternatives would

1 be similar. Patterns at the Middle River and Old River junctions would be similar
2 to those observed at Columbia and Turner Cut junctions.

3 *Changes in Salvage*

4 Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater
5 under Alternative 3 relative to the No Action Alternative in every month
6 (Appendix 9). Spring-run Chinook Salmon smolts migrating through the Delta
7 would be most susceptible in the months of March, April, and May. Predicted
8 values in April and May indicated a substantially larger fraction of fish salvaged
9 for Alternative 3 relative to the No Action Alternative. Predicted salvage was
10 more similar in March, but still higher under Alternative 3

11 *Summary of Effects on Spring-Run Chinook Salmon*

12 The multiple model and analysis outputs described above characterize the
13 anticipated conditions for spring-run Chinook Salmon and their response to
14 change under Alternative 3 and the No Action Alternative. For the purpose of
15 analyzing effects on spring-run Chinook Salmon in the Sacramento River, greater
16 reliance was placed on the outputs from the SALMOD model because it integrates
17 the available information on temperature and flows to produce estimates of
18 mortality for each life stage and an overall, integrated estimate of potential
19 spring-run Chinook Salmon juvenile production. The output from SALMOD
20 indicated that spring-run Chinook Salmon production in the Sacramento River
21 would be slightly higher under Alternative 3 than under the No Action
22 Alternative.

23 The analyses attempting to assess the effects on routing, entrainment, and salvage
24 of juvenile salmonids in the Delta suggest that salvage (as an indicator of
25 potential losses of juvenile salmon at the export facilities) of Sacramento River-
26 origin Chinook Salmon is predicted to be greater under Alternative 3 relative to
27 the No Action Alternative in every month.

28 In Clear Creek and the Feather River, the analysis of the effects of Alternative 3
29 and the No Action Alternative for spring-run Chinook Salmon relied on output
30 from the WUA analysis and water temperature output for Clear Creek at Igo, and
31 in the Feather River low flow channel and downstream of the Thermalito
32 complex. The WUA analysis suggests that there would be little difference in the
33 availability of spawning and rearing habitat in Clear Creek. The temperature
34 model outputs suggest that thermal conditions and effects on each of the
35 spring-run Chinook Salmon life stages generally would be similar under both
36 scenarios in Clear Creek and the Feather River, although water temperatures
37 could be somewhat less suitable for spring-run Chinook Salmon holding and
38 spawning/egg incubation in the Feather River under Alternative 3. This
39 conclusion is supported by the water temperature threshold exceedance analysis
40 that indicated that water temperature thresholds for spawning and egg incubation
41 would be exceeded slightly more frequently under Alternative 3 than under the
42 No Action Alternative in Clear Creek and the Feather River. Because of the
43 inherent uncertainty associated with the resolution of the temperature model
44 (average monthly outputs), the slightly greater likelihood of exceeding water

1 temperature thresholds under Alternative 3 could increase the potential for
 2 adverse effects on the spring-run Chinook Salmon populations in the Feather
 3 River. Given the similarity of the results, Alternative 3 and the No Action
 4 Alternative are likely to have similar effects on the spring-run Chinook Salmon
 5 population in Clear Creek.

6 These model results suggest that overall, effects on spring-run Chinook Salmon
 7 could be slightly less adverse under Alternative 3 than under the No Action
 8 Alternative, with a small likelihood that spring-run Chinook Salmon production
 9 would be lower under the No Action Alternative. The potential differences
 10 between the two scenarios, however, may be offset by the benefits of
 11 implementation of fish passage under the No Action Alternative intended to
 12 address the limited availability of suitable habitat for spring-run Chinook Salmon
 13 in the Sacramento River reaches downstream of Shasta Dam. This potential
 14 beneficial effect and its magnitude would depend on the success of the fish
 15 passage program.

16 The ocean harvest restriction component of Alternative 3 could reduce winter-run
 17 Chinook Salmon mortality by reducing ocean harvest and implementing the
 18 predator control measures to reduce predation on juvenile Chinook Salmon.

19 Overall, given the small differences between alternatives and the uncertainty
 20 regarding the non-operational components, distinguishing a clear difference
 21 between alternatives is not possible. However, if fish passage is successful in
 22 providing access to higher quality habitat, Alternative 3 would do less than the No
 23 Action Alternative to address long-term temperature issues in the Sacramento
 24 River downstream of the Keswick Dam.

25 *Fall-Run Chinook Salmon*

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

31 *Changes in Water Temperature*

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

35 *Sacramento River*

36 Average monthly water temperature in the Sacramento River at Keswick Dam
 37 under Alternative 3 relative to the No Action Alternative generally would be
 38 similar to or cooler (less than 0.5°F differences) water temperatures under the No
 39 Action Alternative during most months of the year (Appendix 6B, Table B-5-2).
 40 In September, average water temperatures also would be similar except in wetter
 41 years when water temperatures would be increased by up to 0.8°F. Water
 42 temperatures under Alternative 3 could be decreased by up to 0.8°F in October
 43 and November of drier years. A similar temperature pattern generally would be

1 exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, Red Bluff,
2 Hamilton City, and Knights Landing, with average monthly temperatures
3 progressively increasing in the downstream direction (e.g., average difference in
4 September of about 9°F between Keswick Dam and Knights Landing). The
5 differences between Alternative 3 and the No Action Alternative in September of
6 wetter years would increase, while the differences in water temperatures during
7 October and November associated with Alternative 3 during drier years would
8 remain similar to upstream locations.

9 Overall, the temperature differences between Alternative 3 and the No Action
10 Alternative would be relatively minor and likely would have little effect on fall-
11 run Chinook Salmon in the Sacramento River. The increased water temperatures
12 in September of wetter years under Alternative 3 could increase the likelihood of
13 adverse effects on early spawning fall-run Chinook Salmon during this water year
14 type. The slightly lower water temperatures in October and November under
15 Alternative 3 would reduce the likelihood of adverse effects on fall-run Chinook
16 Salmon spawning and egg incubation in the Sacramento River as compared to the
17 No Action Alternative.

18 *Clear Creek*

19 Average monthly water temperatures in Clear Creek at Igo under Alternative 3
20 would be similar to (less than 0.5°F differences) water temperatures under the No
21 Action Alternative with the exception of May when average monthly
22 temperatures under Alternative 3 would be somewhat higher (up to about 0.8°F)
23 than the No Action Alternative (Appendix 6B, Table B-3-2). Alternative 32). As
24 described above for spring-run Chinook Salmon, the lower water temperatures in
25 May associated with the No Action Alternative reflect the effects of the additional
26 water that would be discharged from Whiskeytown Dam to meet the 2009 NMFS
27 BO RPA spring attraction flow requirements.

28 Fall-run Chinook Salmon spawn and rear in the lower portion of Clear Creek,
29 generally downstream of Igo. Average monthly temperatures at the confluence
30 with the Sacramento River would exhibit a similar pattern, although temperatures
31 in the creek would be slightly higher in general.

32 Under Alternative 3, temperature conditions at Igo would be slightly cooler than
33 under the No Action Alternative. However, these temperature outputs are at a
34 location upstream of most fall-run Chinook Salmon spawning and rearing in Clear
35 Creek. Temperatures where fall-run Chinook Salmon inhabit the creek would be
36 somewhat higher as indicated by average monthly temperatures at the confluence
37 with the Sacramento River, although these temperatures would be similar under
38 Alternative 3 as and the No Action Alternative. Overall, effects on fall-run
39 Chinook Salmon in Clear Creek due to temperature differences between
40 Alternative 3 and the No Action Alternative would be relatively minor.

41 *Feather River*

42 Average monthly water temperatures in the Feather River at the low flow channel
43 under the Alternative 3 relative generally would be similar (within 0.5°F) to water
44 temperatures under the No Action Alternative generally would be, but somewhat

1 lower in November and December (differences as much as 1.6°F in December in
2 below normal water years) (Appendix 6B, Table B-20-2). Water temperatures
3 generally would be similar for the other months, except in September when
4 average monthly water temperatures under Alternative 3 would be somewhat
5 higher (up to about 1.5°F) and during May and June when water temperatures
6 would be slightly (up to 0.4°F) lower in wetter years than under the No Action
7 Alternative. Although temperatures in the river would become progressively
8 higher in the downstream direction, the differences between Alternative 3 and the
9 No Action Alternative would exhibit a similar pattern at the downstream locations
10 (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and
11 the No Action Alternative generally becoming more similar at the confluence
12 with the Sacramento River, except in September when the differences between
13 Alternative 3 and the No Action Alternative would be up to 4.4 °F higher than
14 under the No Action Alternative.

15 Overall, the temperature differences in the Feather River between Alternative 3
16 and the No Action Alternative would be relatively minor (less than 0.5°F) and
17 likely would have little effect on fall-run Chinook Salmon in the Feather River.
18 The slightly lower water temperatures in November and December under
19 Alternative 3 would likely have little effect on fall-run Chinook Salmon as water
20 temperatures in the Feather River are typically low during this time period. The
21 somewhat higher water temperatures in September of wetter years may increase
22 the likelihood of adverse effects on early spawning fall-run Chinook Salmon in
23 these water year types.

24 *American River*

25 Long term average monthly water temperatures in the American River at Nimbus
26 Dam under Alternative 3 generally would be similar (differences less than 0.25°F)
27 to those under the No Action Alternative (Appendix 6B, Table B-12-2). In
28 September of wetter years, water temperatures under Alternative 3 would be
29 increased relative to under the No Action Alternative by up to 0.4°F in some
30 water year types. This pattern generally would persist downstream to Watt
31 Avenue and the mouth (Appendix 6B, Tables b-13-2 and B-13-2 and B-14-2).
32 In June water temperatures would be up to 0.7°F lower under Alternative 3 than
33 under the No Action Alternative. In September, average monthly water
34 temperatures at the mouth generally would be higher under Alternative 3 than
35 under the No Action Alternative, especially in wetter water year types when the
36 water temperatures under Alternative 3 could be up to 1.6°F warmer.

37 Overall, the temperature differences in the American River between Alternative 3
38 and the No Action Alternative would be relatively minor and likely would have
39 little effect on fall-run Chinook Salmon in the American River. The lower water
40 temperatures in June under Alternative 3 may reduce the likelihood of adverse
41 effects on fall-run Chinook Salmon rearing in the American River if they were
42 present. Higher water temperatures during September under Alternative 3 would
43 have little effect on fall-run Chinook Salmon spawning in the American River
44 because most spawning occurs later in November.

1 *Changes in Exceedances of Water Temperature Thresholds*

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

6 *Sacramento River*

7 Average monthly water temperatures under both Alternative and the No Action
8 Alternative would show exceedances of the water temperature threshold of 56°F
9 established in the Sacramento River at Red Bluff for fall-run Chinook Salmon
10 (spawning and egg incubation) in October, November, and again in April. The
11 exceedances would occur at the greatest frequency in October, with 78 percent of
12 the time under Alternative 3). The water temperature threshold would be
13 exceeded less frequently in November (8 percent of the time) and not exceeded at
14 all during December through March. As water temperatures warm in the spring,
15 the threshold would be exceeded in April by 14 percent under Alternative 3. In
16 the months when the greatest frequency of exceedances occur (October,
17 November, and April), model results generally indicate that the threshold would
18 be exceeded less frequently (by up to 4 percent in October) under Alternative 3
19 than under the No Action Alternative. Temperature conditions in the Sacramento
20 River under Alternative 3 could be less likely to affect fall-run Chinook Salmon
21 spawning and egg incubation than under the No Action Alternative because of the
22 decreased frequency of exceedance of the 56°F threshold in October, November,
23 and April.

24 *Clear Creek*

25 Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during
26 October through December (USFWS 2015). Average monthly water
27 temperatures at Igo during this period generally remain below 56°F, except in
28 October. Under Alternative 3, 56°F would be exceeded in October about
29 10 percent of the time as compared to 12 percent under the No Action Alternative.
30 At the confluence with the Sacramento River, average monthly water
31 temperatures would be warmer, with 56°F exceeded about 15 percent of the time
32 under Alternative 3 and slightly more frequently under the No Action Alternative
33 (Appendix 6B, Figure B-4-1). During November and December, average
34 monthly water temperatures generally would remain below 56°F at both locations.
35 Temperature conditions in Clear Creek under Alternative 3 could be less likely to
36 affect fall-run Chinook Salmon spawning and egg incubation than under the No
37 Action Alternative because of the reduced frequency of exceedance of the 56°F
38 threshold in October.

39 For fall-run Chinook Salmon rearing (January through August), the exceedances
40 described previously for spring-run Chinook Salmon would apply, with the
41 average monthly temperatures remaining below the 60°F threshold in all months
42 Downstream at the mouth of Clear Creek, average monthly water temperatures
43 would exceed the 60°F threshold often during the summer, but the frequency of
44 exceedance would be similar under Alternative 3 and the No Action Alternative

1 (Appendix 6B Figures). Temperature conditions for fall-run Chinook Salmon
2 rearing in Clear Creek would be similar under Alternative 3 and the No Action
3 Alternative.

4 *Feather River*

5 Average monthly water temperatures under both Alternative 3 and the No Action
6 Alternative would exceed the water temperature threshold of 56°F established in
7 the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and
8 rearing during some months, particularly in October, November, March, and
9 April, when temperature thresholds would be exceeded frequently (Appendix 6B,
10 Table B-22-2). The frequency of exceedance would be greatest in October, when
11 average monthly temperatures under both Alternative 3 and the No Action
12 Alternative would be above the threshold in nearly every year. The magnitude of
13 the exceedances would be high as well, with average monthly temperatures in
14 October reaching about 68°F. Similarly, the threshold would be exceeded under
15 both alternatives about 85 percent of the time in April. The differences between
16 Alternative 3 and the No Action Alternative, however, would be relatively small,
17 with Alternative 3 generally exceeding temperature thresholds about 1-4 percent
18 less frequently than the No Action Alternative. Temperature conditions in the
19 Feather River under Alternative 3 could be less likely to affect fall-run Chinook
20 Salmon spawning and egg incubation than under the No Action Alternative
21 because of the reduced frequency of exceedance of the 56°F threshold from
22 October through April.

23 *Changes in Egg Mortality*

24 The analysis of fall-run Chinook Salmon included the application of the
25 Reclamation Salmon Survival Model. The following describes the differences in
26 egg mortality for the Sacramento, Feather, and American rivers based on the
27 model output.

28 *Sacramento River*

29 For fall-run Chinook Salmon in the Sacramento River, the long-term average egg
30 mortality rate is predicted to be around 17 percent, with higher mortality rates (in
31 excess of 35 percent) occurring in critical dry years under Alternative 3. Overall,
32 egg mortality would be 0.2 percent lower under Alternative 3; in critical dry years
33 the average egg mortality rate would be 2.3 percent lower than under the No
34 Action Alternative. In other water year types, egg mortality would be reduced (up
35 to 0.7 percent less) in drier years and increased up to 1 percent in wetter years
36 under Alternative 3 as compared to the No Action Alternative (Appendix 9C,
37 Table B-1). Overall, the difference in egg mortality between Alternative 3 and
38 the No Action Alternative would be relatively minor and likely would have little
39 effect on fall-run Chinook Salmon in the Sacramento River, except in critical dry
40 water years.

41 *Feather River*

42 For fall-run Chinook Salmon in the Feather River, the long-term average egg
43 mortality rate is predicted to be relatively low (around 6 percent), with higher

1 mortality rates (around 14.6 percent) occurring in critical dry years under
2 Alternative 3. Overall, egg mortality would be 1.1 percent less under Alternative
3 3; in critical dry years the average egg mortality rate would be 0.2 percent greater
4 than under the No Action Alternative. In other water year types, egg mortality
5 would be reduced (up to 2.7 percent less) in wetter years under Alternative 3 as
6 compared to the No Action Alternative (Appendix 9C, Table B-7). Overall, the
7 difference in egg mortality between Alternative 3 and the No Action Alternative
8 could be biologically meaningful and reduce the likelihood of adverse effects on
9 fall-run Chinook Salmon spawning in the Feather River, particularly in wetter
10 years.

11 *American River*

12 For fall-run Chinook Salmon in the American River, the long-term average egg
13 mortality rate is predicted to range from approximately 22 to 25 percent in all
14 water year types under Alternative 3. Overall, egg mortality would be 0.1 percent
15 lower under Alternative 3; in Below Normal water years the average egg
16 mortality rate would be 1.7 percent less than under the No Action Alternative. In
17 other water year types, egg mortality is predicted to be from 0.6 percent lower to
18 0.6 percent higher under Alternative 3 as compared to the No Action Alternative
19 (Appendix 9C, Table B-6). Overall, the difference in egg mortality between
20 Alternative 3 and the No Action Alternative would be relatively minor and likely
21 would have little effect on fall-run Chinook Salmon in the American River.

22 *Changes in Weighted Usable Area*

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

26 *Sacramento River*

27 As an indicator of the amount of suitable spawning habitat for fall-run Chinook
28 Salmon between Keswick Dam and Battle Creek, modeling results indicate that,
29 in general, there would be greater amounts of spawning habitat available from
30 September through November under Alternative 3 as compared to the No Action
31 Alternative; fall-run spawning WUA would be slightly (less than 5 percent)
32 decreased in December, but this is after the peak spawning period for fall-run
33 Chinook Salmon in this reach (Appendix 9E, Table C-11-2). The increase in
34 long-term average spawning WUA during September (prior to the peak spawning
35 period) would be relatively large (more than 10 percent), with smaller increases in
36 October (less than 1 percent) and November (around 10 percent) which comprise
37 the peak spawning period for fall-run Chinook Salmon. Results for the reach
38 from Battle Creek to Deer Creek show the same pattern in changes in WUA for
39 spawning fall-run Chinook Salmon between Alternative 3 and the No Action
40 Alternative (Appendix 9E, Table C-10-2). Overall, spawning habitat availability
41 could be increased under Alternative 3 relative to the No Action Alternative.

42 Modeling results indicate that, in general, there would be decreased amounts of
43 suitable fry rearing habitat available from December to March under Alternative 3
44 (Appendix 9E, Table C-12-2). The decrease in long-term average fry rearing
45 WUA during these months would be relatively small (less than 1 percent).

1 Overall, fry rearing habitat availability would be similar under Alternative 3 and
2 the No Action Alternative.

3 Similar to the results for fry rearing WUA, modeling results indicate that, there
4 would be decreased amounts of suitable juvenile rearing habitat available during
5 the juvenile rearing period from February to June, but this increase would be
6 relatively small (less than 5 percent) under Alternative 3 (Appendix 9E,
7 Table C-13-2). Overall, the amount of juvenile rearing habitat (WUA) would be
8 similar under Alternative 3 and the No Action Alternative.

9 *Clear Creek*

10 Flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under
11 Alternative 3 relative to the No Action Alternative except in May due to the
12 release of spring attraction flows in accordance with the 2009 NMFS BO under
13 the No Action Alternative. Therefore, there would be no change in the amount of
14 potentially suitable spawning and rearing habitat for fall-run Chinook Salmon (as
15 indexed by WUA) available under Alternative 3 as compared to the No Action
16 Alternative.

17 *Feather River*

18 Flows in the low flow channel of the Feather River are not anticipated to differ
19 under Alternative 3 relative to the No Action Alternative. Therefore, there would
20 be no change in the amount of potentially suitable spawning habitat for fall-run
21 Chinook Salmon (as indexed by WUA) available under Alternative 3 as compared
22 to the No Action Alternative. The majority of spawning activity by fall-run
23 Chinook Salmon in the Feather River occurs in this reach with a lesser amount of
24 spawning occurring downstream of the Thermalito Complex.

25 Modeling results indicate that, in general, there would be greater amounts of
26 spawning habitat available from September to December under Alternative 3 as
27 compared to the No Action Alternative; fall-run Chinook Salmon spawning WUA
28 would be slightly (around 2 percent) increased in October (the peak spawning
29 month) for fall-run Chinook Salmon in this reach (Appendix 9E, Table C-24-2).
30 The increase in long-term average spawning WUA during September (prior to the
31 peak spawning period) would be relatively large (around 20 percent), with smaller
32 increases in November and December (around 2 percent) which are after the peak
33 spawning period for fall-run Chinook Salmon. Overall, spawning habitat
34 availability would be somewhat higher under Alternative 3 relative to the No
35 Action Alternative.

36 *American River*

37 Modeling results indicate that, in general, there would be greater amounts of
38 spawning habitat available for fall-run Chinook Salmon in the American River
39 during October and November under Alternative 3 as compared to the No Action
40 Alternative; fall-run Chinook Salmon spawning WUA would be slightly (less than
41 2 percent) decreased in December with less than 1 percent increases in September
42 (prior to the peak spawning period) and October (the peak spawning month)
43 (Appendix 9E, Table C-25-2). Overall, spawning habitat availability would be
44 slightly higher under Alternative 3 relative to the No Action Alternative.

1 *Changes in SALMOD Output*

2 SALMOD results indicate that pre-spawning mortality of fall-run Chinook
3 Salmon eggs would be approximately 24 percent less under Alternative 3,
4 primarily due to reduced summer temperatures. Flow-related fall-run Chinook
5 Salmon egg mortality would be increased by about 9 percent under Alternative 3
6 compared to the No Action Alternative, and temperature-related egg mortality
7 would be 8 percent higher under Alternative 3 (Appendix 9D. Flow (habitat)-
8 related fry mortality would be approximately 1 percent greater under
9 Alternative 3 as compared to the No Action Alternative. Temperature-related
10 juvenile mortality would be approximately 16 percent lower under Alternative 3,
11 while flow (habitat)-related mortality would be around 4 percent lower under
12 Alternative 3 as compared to the No Action Alternative. Overall, potential
13 juvenile production would be about 2 percent higher under Alternative 3 as
14 compared to the No Action Alternative.

15 *Changes in Delta Passage Model Output*

16 The Delta Passage Model predicted similar estimates of annual Delta survival
17 across the 81-year time period for fall-run Chinook Salmon between Alternative 3
18 and the No Action Alternative (Appendix 9J). Median Delta survival was
19 0.246 for Alternative 3 and 0.245 for the No Action Alternative.

20 *Changes in Delta Hydrodynamics*

21 Fall-run Chinook Salmon smolts are most abundant in the Delta during the
22 months of April, May and June. At the junction of Georgiana Slough and the
23 Sacramento River, percent positive velocity would be slightly lower in April and
24 May under Alternative 3 relative to the No Action Alternative. In June, values
25 would be moderately lower for Alternative 3 relative to the No Action Alternative
26 (Appendix 9K). Near the confluence of the San Joaquin River and the
27 Mokelumne River, the proportion of positive velocities would be moderately
28 lower under Alternative 3 relative to the No Action Alternative in April and May
29 and slightly lower in June. On Old River downstream of the facilities, the
30 proportion of positive velocities would be substantially lower in April and May
31 under Alternative 3 relative to the No Action Alternative, but would become more
32 similar in June. In Old River upstream of the facilities, the percent of positive
33 velocities would be similar for Alternative 3 relative to the No Action Alternative
34 in April. In May, values for Alternative 3 would be moderately higher in May
35 and similar in June relative to the No Action Alternative. On the San Joaquin
36 River downstream of the Head of Old River, the percent of positive velocities
37 would be similar under Alternative 3 relative to the No Action Alternative in
38 April, May, and June.

39 *Changes in Junction Entrainment*

40 Entrainment at Georgiana Slough under Alternative 3 would be slightly greater in
41 June relative to the No Action Alternative (Appendix 9L). In all other months,
42 entrainment would be almost identical under both alternatives. At the Head of
43 Old River junction, entrainment under Alternative 3 would be similar in all
44 months except in April and May. In these two months, entrainment would be

1 slightly higher under Alternative 3 relative to the No Action Alternative.
2 Entrainment into Turner Cut would be slightly greater under Alternative 3 during
3 April, and May and similar in June. At the Columbia Cut junction, entrainment
4 would be higher under Alternative 3 during April and May, whereas there would
5 be only minor differences in. Entrainment probabilities at the Middle River
6 junction from April through June would be greater for Alternative 3 relative to the
7 No Action Alternative. A similar pattern would be observed at the Old River
8 junction.

9 *Changes in Salvage*

10 Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater
11 under Alternative 3 relative to No Action Alternative in every month (Appendix
12 9M). Fall-run Chinook Salmon smolts migrating through the Delta would be
13 most susceptible in the months of April, May, and June. Predicted values in April
14 and May indicated a substantially increased fraction of fish salvaged under
15 Alternative 3 relative to the No Action Alternative.

16 *Summary of Effects on Fall-Run Chinook Salmon*

17 The multiple model and analysis outputs described above characterize the
18 anticipated conditions for fall-run Chinook Salmon and their response to change
19 under Alternative 3 and the No Action Alternative. For the purpose of analyzing
20 effects on fall-run Chinook Salmon in the Sacramento River, greater reliance was
21 placed on the outputs from the SALMOD model because it integrates the
22 available information on temperature and flows to produce estimates of mortality
23 for each life stage and an overall, integrated estimate of potential fall-run Chinook
24 Salmon juvenile production. The output from SALMOD indicated that fall-run
25 Chinook Salmon production would be slightly higher in most water year types
26 under Alternative 3 than under the No Action Alternative, and up to 5 percent
27 greater than under the No Action Alternative in critical dry years.

28 The analyses attempting to assess the effects on routing, entrainment, and salvage
29 of juvenile salmonids in the Delta suggest that salvage (as an indicator of
30 potential losses of juvenile salmon at the export facilities) of Sacramento
31 River-origin Chinook Salmon is predicted to be greater under Alternative 3
32 relative to the No Action Alternative in every month.

33 In Clear Creek and the Feather and American rivers, the analysis of the effects of
34 Alternative 3 and the No Action Alternative for fall-run Chinook Salmon relied
35 on the WUA analysis for habitat and water temperature model output for the
36 rivers at various locations downstream of the CVP and SWP facilities. The WUA
37 analysis indicated that the availability of spawning and rearing habitat in Clear
38 Creek and spawning habitat in the Feather and American rivers would be similar
39 under Alternative 3 and the No Action Alternative. The temperature model
40 outputs for each of the fall-run Chinook Salmon life stages suggest that thermal
41 conditions and effects on fall-run Chinook Salmon in all of these streams
42 generally would be similar under both scenarios. The water temperature threshold
43 exceedance analysis that indicated that the water temperature thresholds for
44 fall-run Chinook Salmon spawning and egg incubation would be exceeded

1 slightly less frequently in the Feather River and Clear Creek under Alternative 3.
2 Given the inherent uncertainty associated with the resolution of the temperature
3 model (average monthly outputs), the reduced frequency of exceedance of
4 temperature thresholds under Alternative 3 could reduce the potential for adverse
5 effects on the fall-run Chinook Salmon populations in Clear Creek and the
6 Feather River. Results of the analysis using Reclamation's salmon mortality
7 model indicate that there would be slightly reduced fall-run Chinook Salmon egg
8 mortality in the Feather River under Alternative 3 compared to the No Action
9 Alternative.

10 These model results suggest that overall, effects on fall-run Chinook Salmon
11 could be slightly less adverse under Alternative 3 than the No Action Alternative,
12 with a small likelihood that fall-run Chinook Salmon production would be higher
13 under Alternative 3.

14 Implementation of fish passage under the No Action Alternative could benefit
15 fall-run Chinook Salmon if volitional passage for adult fish is provided; whereas
16 the ocean harvest restriction component of Alternative 3 could increase fall-run
17 Chinook Salmon numbers by reducing ocean harvest and the predator control
18 measures under Alternative 3 could reduce predation on juvenile fall-run Chinook
19 Salmon and thereby increase survival.

20 Overall, given the small differences between alternatives and the uncertainty
21 regarding the non-operational components, distinguishing a clear difference
22 between alternatives is not possible.

23 *Late Fall-Run Chinook Salmon*

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

27 *Changes in Water Temperature*

28 Average monthly water temperature in the Sacramento River at Keswick Dam
29 under Alternative 3 relative to the No Action Alternative generally would be
30 similar to or cooler (less than 0.5°F differences) water temperatures under the No
31 Action Alternative during most months of the year (Appendix 6B, Table B-5-2).
32 In September, average water temperatures also would be similar except in wetter
33 years when water temperatures would be increased by up to 0.8°F. Water
34 temperatures under Alternative 3 could be decreased by up to 0.8°F in October
35 and November of drier years. A similar temperature pattern generally would be
36 exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, Red Bluff,
37 Hamilton City, and Knights Landing, with average monthly temperatures
38 progressively increasing in the downstream direction (e.g., average difference in
39 September of about 9°F between Keswick Dam and Knights Landing). The
40 differences between Alternative 3 and the No Action Alternative in September of
41 wetter years would increase, while the differences in water temperatures during
42 October and November associated with Alternative 3 during drier years would
43 remain similar to upstream locations.

1 Overall, the temperature differences between Alternative 3 and the No Action
2 Alternative would be relatively minor (less than 0.5°F) and likely would have
3 little effect on late fall-run Chinook Salmon in the Sacramento River. The
4 slightly lower water temperatures from October to December under Alternative 3
5 would likely have little effect on late fall-run Chinook Salmon migration and
6 holding as water temperatures in the Sacramento River below Keswick Dam are
7 typically low during this time period. The likelihood of adverse effects on late
8 fall-run Chinook Salmon spawning and egg incubation would be similar under
9 Alternative 3 and the No Action Alternative due to similar water temperatures
10 during the January to May time period. Because late fall-run Chinook Salmon
11 have an extended rearing period, the similar water temperatures during the
12 summer under Alternative 3 and the No Action Alternative would have similar
13 effects on rearing fry and juvenile late fall-run Chinook Salmon in the Sacramento
14 River. The slightly higher water temperatures under Alternative 3 in September
15 of wetter years may increase the likelihood of adverse effects on fry and juvenile
16 late fall-run Chinook Salmon rearing in the Sacramento River during this limited
17 time period.

18 *Changes in Exceedances of Water Temperature Thresholds*

19 Average monthly water temperatures under both Alternative and the No Action
20 Alternative would show exceedances of the water temperature threshold of 56°F
21 established in the Sacramento River at Red Bluff for Chinook Salmon (spawning
22 and egg incubation) in October, November, and again in April. The exceedances
23 would occur at the greatest frequency in October, with 78 percent of the time
24 under Alternative 3). The water temperature threshold would be exceeded less
25 frequently in November (8 percent of the time) and not exceeded at all during
26 December through March. As water temperatures warm in the spring, the
27 threshold would be exceeded in April by 14 percent under Alternative 3. In the
28 months when the greatest frequency of exceedances occur (October, November,
29 and April), model results generally indicate that the threshold would be exceeded
30 less frequently (by up to 4 percent in October) under Alternative 3 than under the
31 No Action Alternative. Temperature conditions in the Sacramento River under
32 Alternative 3 could be less likely to affect late fall-run Chinook Salmon spawning
33 and egg incubation than under the No Action Alternative because of the decreased
34 frequency of exceedance of the 56°F threshold in October, November, and April.

35 *Changes in Egg Mortality*

36 For late fall-run Chinook Salmon in the Sacramento River, the long-term average
37 egg mortality rate is predicted to range from approximately 1.8 to nearly 5 percent
38 in all water year types under Alternative 3. Overall, egg mortality would be
39 0.4 percent lower under Alternative 3; in Below Normal water years the average
40 egg mortality rate would be 0.1 percent higher than under the No Action
41 Alternative. In other water year types, egg mortality is predicted to be from 0.1 to
42 0.8 percent less under Alternative 3 as compared to the No Action Alternative
43 (Appendix 9C, Table B-2). Overall, late fall-run Chinook Salmon egg mortality
44 in the Sacramento River under Alternative 3 and the No Action Alternative would
45 be similar.

1 *Changes in Weighted Usable Area*

2 Modeling results indicate that there would be slightly lower amounts of spawning
3 habitat available for late fall-run Chinook Salmon in the Sacramento River from
4 January through April under Alternative 3 as compared to the No Action
5 Alternative; late fall-run Chinook Salmon spawning WUA would be slightly (less
6 than 5 percent) decreased during this time period (Appendix 9E, Table C-14-4).
7 Overall, spawning habitat availability would be similar under Alternative 3 and
8 the No Action Alternative.

9 Modeling results indicate that, in general, there would be decreased amounts of
10 suitable late fall-run Chinook Salmon fry rearing habitat available during April
11 and May under Alternative 3 (Appendix 9E, Table C-15-4). The decrease in
12 long-term average fry rearing WUA during these months would be relatively
13 small (less than 5 percent). Late fall-run Chinook Salmon fry rearing WUA
14 would be increased by about 1 percent in June under Alternative 3 as compared to
15 the No Action Alternative. Overall, late fall-run fry rearing habitat availability
16 would be similar under Alternative 3 and the No Action Alternative.

17 A substantial fraction of late fall run Chinook Salmon juveniles oversummer in
18 the Sacramento River before emigrating, which allows them to avoid predation
19 through both their larger size and greater swimming ability. One implication of
20 this life history strategy is that rearing habitat is most likely the limiting factor for
21 late-fall-run Chinook Salmon, especially if availability of cool water determines
22 the downstream extent of spawning habitat for late-fall-run salmon. Modeling
23 results indicate that, there would be decreased amounts of suitable juvenile
24 rearing habitat available from December through August, but this increase would
25 be small (generally less than 3 percent) under Alternative 3 as compared to the No
26 Action Alternative. There would an increase in the amount of late fall-run
27 Chinook Salmon juvenile rearing WUA in the other months (September through
28 November) of up to nearly 10 percent (Appendix 9E, Table C-16-4). Overall, late
29 fall-run juvenile rearing habitat availability would be slightly increased under
30 Alternative 3 relative to the No Action Alternative.

31 *Changes in SALMOD Output*

32 SALMOD results indicate that flow-related late fall-run Chinook Salmon egg
33 mortality would be increased by 5 percent under Alternative 3 compared to the
34 No Action Alternative. Conversely, temperature-related egg mortality would be
35 9 percent lower under Alternative 3 (Appendix 9D, Table B-2-9). Flow
36 (habitat)-related fry mortality would be approximately 2 percent higher while
37 temperature-related fry mortality would be about 17 percent lower under
38 Alternative 3 as compared to the No Action Alternative. Temperature-related
39 juvenile mortality would be approximately 18 percent lower under Alternative 3,
40 while flow (habitat)-related mortality would approximately 35 percent lower
41 under Alternative 3 as compared to the No Action Alternative. Overall, potential
42 juvenile production would be the same under Alternative 3 and the No Action
43 Alternative (Appendix 9D, Table B-2-6).

1 *Changes in Delta Passage Model Output*

2 For late fall-run Chinook Salmon, Delta survival was predicted to be slightly
3 lower for Alternative 3 versus the No Action Alternative for all 81 years
4 simulated by the Delta Passage Model (Appendix 9J). Median Delta survival
5 across all years was 0.199 for Alternative 3 and 0.244 for the No Action
6 Alternative.

7 *Changes in Delta Hydrodynamics*

8 The late fall-run Chinook Salmon migration period overlaps with the winter-run.
9 See the section on hydrodynamic analysis for winter-run Chinook Salmon for
10 potential effects on late fall-run Chinook Salmon.

11 *Changes in Junction Entrainment*

12 Entrainment probabilities for late fall-run Chinook Salmon are assumed to mimic
13 that of winter-run Chinook Salmon due to the overlap in timing. See the section
14 on winter-run Chinook Salmon entrainment for potential effects on late fall-run
15 Chinook Salmon.

16 *Changes in Salvage*

17 Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run
18 Chinook Salmon due to the overlap in timing. See the section on winter-run
19 Chinook Salmon entrainment for potential effects on late fall-run Chinook
20 Salmon.

21 *Summary of Effects on Late Fall-Run Chinook Salmon*

22 The multiple model and analysis outputs described above characterize the
23 anticipated conditions for late fall-run Chinook Salmon and their response to
24 change under Alternative 3 and the No Action Alternative. For the purpose of
25 analyzing effects on late fall-run Chinook Salmon and developing conclusions,
26 greater reliance was placed on the outputs from the SALMOD model because it
27 integrates the available information on temperature and flows to produce
28 estimates of mortality for each life stage and an overall, integrated estimate of
29 potential fall-run Chinook Salmon juvenile production. The output from
30 SALMOD indicated that late fall-run Chinook Salmon production would be
31 similar under Alternative 3 and the No Action Alternative, although production
32 under Alternative 3 could be slightly lower in some water year types and about
33 3 percent higher in critical years than under the No Action Alternative.

34 The analyses attempting to assess the effects on routing, entrainment, and salvage
35 of juvenile salmonids in the Delta suggest that salvage (as an indicator of
36 potential losses of juvenile salmon at the export facilities) of Sacramento
37 River-origin Chinook Salmon is predicted to be greater under Alternative 3
38 relative to the No Action Alternative in every month.

39 Overall, it is likely that the effects on late fall-run Chinook Salmon would be
40 similar for Alternative 3 and the No Action Alternative. The potential benefits of
41 ocean harvest restrictions and predator management under Alternative 3 and fish
42 passage under the No Action Alternative are uncertain. Given the small

1 differences between alternatives and the uncertainty regarding the non-operational
2 components, distinguishing a clear difference between alternatives is not possible.

3 *Steelhead*

4 Changes in operations that influence temperature and flow conditions that could
5 affect steelhead. The following describes those changes and their potential
6 effects.

7 *Changes in Water Temperature*

8 Changes in water temperature could affect steelhead in the Sacramento, Feather,
9 and American rivers, and Clear Creek. The following describes temperature
10 conditions in those water bodies.

11 *Sacramento River*

12 Average monthly water temperature in the Sacramento River at Keswick Dam
13 under Alternative 3 relative to the No Action Alternative generally would be
14 similar to or cooler (less than 0.5°F differences) water temperatures under the No
15 Action Alternative during most months of the year (Appendix 6B, Table B-5-2).
16 In September, average water temperatures also would be similar except in wetter
17 years when water temperatures would be increased by up to 0.8°F. Water
18 temperatures under Alternative 3 could be decreased by up to 0.8°F in October
19 and November of drier years. A similar temperature pattern generally would be
20 exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, and Red Bluff,
21 with average monthly temperatures progressively increasing in the downstream
22 direction (e.g., average difference of about 3°F between Keswick Dam and Red
23 Bluff). The differences between Alternative 3 and the No Action Alternative in
24 September of wetter years would increase, while the differences in water
25 temperatures during October and November associated with Alternative 3 during
26 drier years would remain similar to upstream locations.

27 Overall, the temperature differences between Alternative 3 and the No Action
28 Alternative would be relatively minor and likely would have little effect on the
29 life history timing for steelhead, the in the Sacramento River. The increased
30 water temperatures in September of wetter years under Alternative 3 could
31 increase the likelihood of adverse effects on migrating adult steelhead during this
32 water year type. The slightly lower water temperatures in December and
33 November under Alternative 3 could reduce the likelihood of adverse effects on
34 steelhead adults migrating upstream and juveniles migrating downstream in the
35 Sacramento River as compared to the No Action Alternative.

36 *Clear Creek*

37 Average monthly water temperatures in Clear Creek at Igo under Alternative 3
38 would be similar to (less than 0.5°F differences) water temperatures under the No
39 Action Alternative with the exception of May when average monthly
40 temperatures under Alternative 3 would be somewhat higher (up to about 0.8°F)
41 than the No Action Alternative. As described above for spring-run Chinook
42 Salmon, the lower water temperatures in May associated with the No Action
43 Alternative reflect the effects of the additional water that would be discharged

1 from Whiskeytown Dam to meet the 2009 NMFS BO RPA spring attraction flow
2 requirements. While the reduction in water temperature indicated by the
3 modeling could improve thermal conditions for steelhead, the duration of the two
4 pulse flows under the No Action Alternative may not be of sufficient duration
5 (3 days each) to provide biologically meaningful temperature benefits. Overall,
6 thermal conditions for steelhead in Clear Creek would be similar under
7 Alternative 3 and the No Action Alternative. Overall, the temperature differences
8 between Alternative 3 and the No Action Alternative would be relatively minor.
9 There would be little difference in potential effects on steelhead in Clear Creek
10 due to the similar water temperatures under Alternative 3 as compared to the No
11 Action Alternative

12 *Feather River*

13 Average monthly water temperatures in the Feather River at the low flow channel
14 under the Alternative 3 relative generally would be similar (within 0.5°F) to water
15 temperatures under the No Action Alternative generally would be, but somewhat
16 lower in November and December (differences as much as 1.6°F in December in
17 below normal water years) (Appendix 6B, Table B-20-2). Water temperatures
18 generally would be similar for the other months, except in). In September when
19 average monthly water temperatures under Alternative 3 would be somewhat
20 higher (up to about 1.5°F) and during May and June when water temperatures
21 would be slightly (up to 0.4°F) lower in wetter years than under the No Action
22 Alternative. Although temperatures in the river would become progressively
23 higher in the downstream direction, the differences between Alternative 3 and the
24 No Action Alternative would exhibit a similar pattern at the downstream locations
25 (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and
26 the No Action Alternative generally becoming more similar among months at the
27 confluence with the Sacramento River, except in September when the differences
28 between Alternative 3 and the No Action Alternative would be up to 4.4 °F higher
29 than under the No Action Alternative.

30 Overall, the temperature differences in the Feather River between Alternative 3
31 and the No Action Alternative would be relatively minor (less than 0.5°F) and
32 likely would have little effect on steelhead in the Feather River. The somewhat
33 higher water temperatures in September of wetter years may increase the
34 likelihood of adverse effects on migrating adult steelhead during this water year
35 type. The slightly lower water temperatures in October and November under
36 Alternative 3 also could reduce the likelihood of adverse effects on steelhead
37 adults migrating upstream and juveniles migrating downstream in the Sacramento
38 River as compared to the No Action Alternative.

39 *American River*

40 Long term average monthly water temperatures in the American River at Nimbus
41 Dam under Alternative 3 generally would be similar (differences less than 0.25°F)
42 to those under the No Action Alternative (Appendix 6B, Table B-12-2). In
43 September of wetter years, water temperatures under Alternative 3 would be
44 increased relative to under the No Action Alternative by up to 0.4°F in some
45 water year types. This pattern generally would persist downstream to Watt

1 Avenue and the mouth, although temperature differences under Alternative 3
2 would be greater than under the No Action Alternative (Appendix 6B,
3 Tables B-13-2 and B-13-2 and B-14-2). In June water temperatures would be up
4 to 0.7°F lower under Alternative 3 than under the No Action Alternative. In
5 September, average monthly water temperatures at the mouth generally would be
6 higher under Alternative 3 than under the No Action Alternative, especially in
7 wetter water year types when the water temperatures under Alternative 3 could be
8 up to 1.6°F warmer.

9 Overall, the temperature differences between Alternative 3 and the No Action
10 Alternative would be relatively minor (less than 0.5°F) and likely would have
11 little effect on steelhead in the American River. The somewhat higher water
12 temperatures in September of wetter years may increase the likelihood of adverse
13 effects on migrating adult steelhead during this water year type. The cooler water
14 temperatures in June under Alternative 3 may reduce the likelihood of adverse
15 effects on steelhead rearing in the American River compared to the No Action
16 Alternative.

17 *Changes in Exceedances of Water Temperature Thresholds*

18 Changes in water temperature could result in the exceedance of established water
19 temperature thresholds for steelhead in the Sacramento River, Clear Creek, and
20 Feather River. The following describes the extent of those exceedance for each of
21 those streams.

22 *Sacramento River*

23 As described in the life history accounts, steelhead spawning in the mainstem
24 Sacramento River generally occurs in the upper reaches from Keswick Dam
25 downstream to near Balls Ferry, with most spawning concentrated near Redding.
26 Most steelhead, however, spawn in tributaries to the Sacramento River.
27 Spawning generally takes place in the January through March period when water
28 temperatures in the river generally do not exceed 52°F under either Alternative 3
29 or the No Action Alternative. While there are no established temperature
30 thresholds for steelhead rearing in the mainstem Sacramento River, average
31 monthly temperatures during March through June when fry and juvenile steelhead
32 are in the river would be below 56°F during March and April at Balls Ferry. In
33 June, average monthly water temperatures would be slightly lower under
34 Alternative 3 than they would be under the No Action Alternative in the drier
35 years, although conditions would not exceed about 57°F. Thus, as it relates to
36 temperature conditions for steelhead in the mainstem Sacramento River, it is
37 unlikely that Alternative 3 and the No Action Alternative would differ in a
38 biologically meaningful way.

39 *Clear Creek*

40 While there are no established temperature thresholds for steelhead spawning in
41 Clear Creek, average monthly water temperatures in the river generally would not
42 exceed 49°F during the spawning period (December to April) under Alternative 3
43 and the No Action Alternative. Similarly, while there are no established
44 temperature thresholds for steelhead rearing in Clear Creek, average monthly

1 temperatures in most months of the year would not exceed 56°F at Igo under both
2 alternatives. Thus, as it relates to temperature conditions for steelhead in Clear
3 Creek, it is unlikely that Alternative 3 and the No Action Alternative would differ
4 in a biologically meaningful way.

5 *Feather River*

6 Average monthly water temperatures in the Feather River at Robinson Riffle
7 would on occasion exceed the water temperature threshold of 56°F established for
8 steelhead spawning and incubation during September through April and the
9 threshold of 63°F established for rearing during May through August. The
10 frequency of exceedance would be highest (about 98 percent) in October, a month
11 in which average monthly water could get as high as about 68°F. However, the
12 differences in the frequency of exceedances between Alternative 3 and the No
13 Action Alternative would be relatively small. Alternative 3 would exceed
14 temperature thresholds about 1 percent less frequently than the No Action
15 Alternative in October, November, December, and March. The established water
16 temperature threshold of 63°F for rearing during May through August would be
17 exceeded often under both Alternative 3 and the No Action Alternative in May
18 and June, but not at all in July and August. Water temperatures under Alternative
19 3 would exceed the rearing temperature threshold about 5 percent less frequently
20 than under the No Action Alternative in May, but no more frequently in June.
21 Temperature conditions in the Feather River under Alternative 3 could be less
22 likely to affect steelhead spawning and rearing than under the No Action
23 Alternative because of the reduced frequency of exceedance of the spawning and
24 rearing thresholds.

25 *American River*

26 In the American River, the water temperature threshold for steelhead rearing
27 (May through October) is 65°F at the Watt Avenue Bridge. Average monthly
28 water temperatures would exceed this threshold often under both Alternative 3
29 and the No Action Alternative, especially in the July when the threshold is
30 exceeded nearly all of the time. In addition, the magnitude of the exceedance
31 would be high, with average monthly water temperatures sometimes higher than
32 76°F. The differences between Alternative 3 and No Action Alternative,
33 however, would be relatively small (differences within 2 percent), except in
34 September, when water temperatures under Alternative 3 would exceed 65°F
35 about 7 percent more frequent than under the No Action Alternative.
36 Temperature conditions in the American River under Alternative 3 could be more
37 likely to affect steelhead rearing than under the No Action Alternative because of
38 the increased frequency of exceedance of the 65°F rearing threshold.

39 *Changes in Weighted Usable Area*

40 The following describes changes in WUA for steelhead in the Sacramento,
41 Feather, and American rivers and Clear Creek.

42 *Sacramento River*

43 Modeling results indicate that, in general, there would be lower amounts of
44 suitable steelhead spawning habitat available from December through March

1 under Alternative 3 as compared to the No Action Alternative (Appendix 9E,
2 Table C-20-2). The decreases in long-term average steelhead spawning WUA
3 would be relatively small (less than 3 percent). Overall, spawning habitat
4 availability would be similar under Alternative 3 and the No Action Alternative.

5 *Clear Creek*

6 Flows in Clear Creek below Whiskeytown Dam are not anticipated to differ under
7 Alternative 3 relative to the No Action Alternative except in May due to the
8 release of spring attraction flows in accordance with the 2009 NMFS BO under
9 the No Action Alternative. Therefore, there would be no change in the amount of
10 potentially suitable spawning and rearing habitat for steelhead (as indexed by
11 WUA) available under Alternative 3 as compared to the No Action Alternative.

12 *Feather River*

13 Flows in the low flow channel of the Feather River are not anticipated to differ
14 under Alternative 3 relative to the No Action Alternative. Therefore, there would
15 be no change in the amount of potentially suitable spawning habitat for steelhead
16 (as indexed by WUA) available under Alternative 3 as compared to the No Action
17 Alternative. The majority of spawning activity by steelhead in the Feather River
18 occurs in this reach with a lesser amount of spawning occurring downstream of
19 the Thermalito Complex.

20 Modeling results indicate that, in general, there would be slightly greater amounts
21 of spawning habitat for steelhead in the Feather River below Thermalito available
22 from January through April under Alternative 3 as compared to the No Action
23 Alternative. The increases in long-term average steelhead spawning WUA during
24 this time period would generally be less than 3 percent (Appendix 9E,
25 Table C-22-2). Steelhead spawning WUA would be slightly increased (less than
26 2 percent) in December. Overall, steelhead spawning habitat availability would
27 be similar under Alternative 3 and the No Action Alternative.

28 *American River*

29 Modeling results indicate that, in general, there would be variable changes in the
30 amount of spawning habitat for steelhead in the American River downstream of
31 Nimbus Dam available from December through April under Alternative 3 as
32 compared to the No Action Alternative. The decreases in long-term average
33 steelhead spawning WUA during December, February and March would
34 generally be less than 3 percent, while the increase in April would also be less
35 than 3 percent (Appendix 9E, Table C-26-2). Overall, steelhead spawning habitat
36 availability would be similar under Alternative 3 and the No Action Alternative.

37 *Summary of Effects on Steelhead*

38 The multiple model and analysis outputs described above characterize the
39 anticipated conditions for steelhead and their response to change under
40 Alternative 3 and the No Action Alternative. The analysis of the effects of
41 Alternative 3 and the No Action Alternative for steelhead relied on the WUA
42 analysis for habitat and water temperature model output for the rivers at various
43 locations downstream of the CVP and SWP facilities. The WUA analysis
44 indicated that the availability of steelhead spawning and rearing habitat in Clear

1 Creek and steelhead spawning habitat in the Sacramento, Feather and American
2 rivers would be similar under Alternative 3 and the No Action Alternative. The
3 temperature model outputs for each of the steelhead life stages suggest that
4 thermal conditions and effects on steelhead could be slightly less adverse for
5 some life stages in various rivers under Alternative 3. This conclusion is
6 supported by the water temperature threshold exceedance analysis that indicated
7 that the water temperature thresholds for steelhead spawning and egg incubation
8 would be exceeded less frequently in the Feather River under Alternative 3. The
9 water temperature threshold for steelhead rearing would also be exceeded less
10 frequently in the Feather River. However, the water temperature threshold for
11 steelhead rearing in the American River would be exceeded more frequently
12 under Alternative 3 than under the No Action Alternative. Given the inherent
13 uncertainty associated with the resolution of the temperature model (average
14 monthly outputs), the reduced frequency of exceedance of temperature thresholds
15 under Alternative 3 could reduce the potential for adverse effects on the steelhead
16 population in the Feather River while the increased frequency of exceedance
17 could increase the likelihood of adverse effects on steelhead rearing in the
18 American River.

19 These model results suggest that overall, effects on steelhead could be slightly
20 less adverse under Alternative 3 than the No Action Alternative, particularly in
21 the Feather River. Implementation of the fish passage program under the No
22 Action Alternative intended to address the limited availability of suitable habitat
23 for steelhead in the Sacramento River and in the American River could provide a
24 benefit to Central Valley steelhead in the Sacramento and American rivers,
25 although the success of a passage program is uncertain. Similarly, the ocean
26 harvest restrictions and predator management actions under Alternative 3 are
27 uncertain. However, if fish passage is successful in providing access to higher
28 quality habitat, Alternative 3 would do less than the No Action Alternative to
29 address long-term temperature issues in the Sacramento and American rivers
30 downstream of the dams.

31 *Green Sturgeon*

32 Changes in operations that influence temperature and flow conditions could affect
33 Green Sturgeon. The following describes those changes and their potential
34 effects.

35 *Changes in Water Temperature*

36 Changes in water temperature could affect Green Sturgeon in the Sacramento and
37 Feather rivers. The following describes temperature conditions in those water
38 bodies.

39 *Sacramento River*

40 Average monthly water temperature in the Sacramento River at Keswick Dam
41 under Alternative 3 relative to the No Action Alternative generally would be
42 similar to or cooler (less than 0.5°F differences) water temperatures under the No
43 Action Alternative during most months of the year (Appendix 6B, Table B-5-2).
44 In September, average water temperatures also would be similar except in wetter

1 years when water temperatures would be increased by up to 0.8°F. Water
2 temperatures under Alternative 3 could be decreased by up to 0.8°F in October
3 and November of drier years. A similar temperature pattern generally would be
4 exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge, and Red Bluff,
5 with average monthly temperatures progressively increasing in the downstream
6 direction (e.g., average difference of about 3°F between Keswick Dam and Red
7 Bluff). The differences between Alternative 3 and the No Action Alternative in
8 September of wetter years would increase, while the differences in water
9 temperatures during October and November associated with Alternative 3 during
10 drier years would remain similar to upstream locations.

11 Overall, the temperature differences between Alternative 3 and the No Action
12 Alternative would be relatively minor. The similar water temperatures during
13 most months suggest that temperature-related effects on Green Sturgeon would
14 likely be similar under Alternative 3 and the No Action Alternative.

15 *Feather River*

16 Average monthly water temperatures in the Feather River at the low flow channel
17 under the Alternative 3 relative generally would be similar (within 0.5°F) to water
18 temperatures under the No Action Alternative generally would be, but somewhat
19 lower in November and December (differences as much as 1.6°F in December in
20 below normal water years) (Appendix 6B, Table B-20-2). In September when
21 average monthly water temperatures under Alternative 3 would be somewhat
22 higher (up to about 1.5°F) and during May and June when water temperatures
23 would be slightly (up to 0.4°F) lower in wetter years than under the No Action
24 Alternative. Although temperatures in the river would become progressively
25 higher in the downstream direction, the differences between Alternative 3 and the
26 No Action Alternative would exhibit a similar pattern at the downstream locations
27 (Robinson Riffle and Gridley Bridge), with temperatures under Alternative 3 and
28 the No Action Alternative generally becoming more similar among months at the
29 confluence with the Sacramento River, except in September when the differences
30 between Alternative 3 and the No Action Alternative would be up to 4.4 °F higher
31 than under the No Action Alternative.

32 Overall, the temperature differences between Alternative 3 and the No Action
33 Alternative would be relatively minor. The similar water temperatures during
34 most months suggest that temperature-related effects on Green Sturgeon would
35 likely be similar under Alternative 3 and the No Action Alternative. The
36 somewhat higher water temperatures in September under Alternative 3 could
37 affect spawning by Green Sturgeon in the Feather River.

38 *Changes in Exceedances of Water Temperature Thresholds*

39 Changes in water temperature could result in the exceedance of established water
40 temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers.
41 The following describes the extent of those exceedance for each of those rivers.

42 *Sacramento River*

43 Average monthly water temperatures in the Sacramento River at Bend Bridge
44 under both Alternative 3 and the No Action Alternative would exceed the water

1 temperature threshold of 63°F established for Green Sturgeon egg incubation in
2 August and September, with exceedances under Alternative 3 occurring about
3 6 percent of the time in August relative the No Action Alternative (7 percent), and
4 about 9 percent of the time in September relative to 12 percent under the No
5 Action Alternative. Average monthly water temperatures at Bend Bridge could
6 be as high as about 73°F during this period. Temperature conditions in the
7 Sacramento River under Alternative 3 could be less likely to affect Green
8 Sturgeon rearing than under the No Action Alternative because of the reduced
9 frequency of exceedance of the 63°F threshold in August and September.

10 *Feather River*

11 Average monthly water temperatures in the Feather River at Gridley Bridge under
12 both Alternative 3 and the No Action Alternative would exceed the water
13 temperature threshold of 64°F established for Green Sturgeon spawning,
14 incubation, and rearing in May, June, and September; no exceedances under either
15 condition would occur in July and August. The frequency of exceedances would
16 be high, with both Alternative 3 and the No Action Alternative exceeding the
17 threshold in June nearly 100 percent of the time. The magnitude of the
18 exceedance also would be substantial, with average monthly temperatures higher
19 than 72°F in June, and higher than 75°F in July and August. Water temperatures
20 under Alternative 3 would exceed the threshold for May about 7 percent less
21 frequently than the No Action Alternative and about 35 percent more frequently
22 in September. Temperature conditions in the Feather River under Alternative 3
23 could be less likely to affect Green Sturgeon rearing than under the No Action
24 Alternative because of the reduced frequency of exceedance of the 64°F threshold
25 in May. The increase in exceedance frequency in September under Alternative 3
26 may have little effect on rearing Green Sturgeon as many juvenile sturgeon may
27 have migrated downstream to the lower Sacramento River and Delta by this time.

28 *Summary of Effects on Green Sturgeon*

29 The analysis of the effects of Alternative 3 and the No Action Alternative for
30 Green Sturgeon relied on water temperature model output for the Sacramento and
31 Feather rivers at various locations downstream of Shasta Dam and the Thermalito
32 complex. The temperature model outputs for each of these rivers suggest that
33 thermal conditions and effects on Green Sturgeon in the Sacramento and Feather
34 rivers generally would be slightly less adverse under Alternative 3. This
35 conclusion is supported by the water temperature threshold exceedance analysis
36 that indicated that the water temperature thresholds for Green Sturgeon spawning,
37 incubation, and rearing would be exceeded less frequently under Alternative 3 in
38 the Sacramento River. The water temperature threshold for Green Sturgeon
39 spawning, incubation, and rearing would also be exceeded less frequently during
40 some months in the Feather River but would be exceeded substantially more
41 frequently in September under Alternative 3.

42 Given the general similarity in results and inherent uncertainty associated with the
43 resolution of the temperature model (average monthly outputs), the effects under
44 Alternative 3 and the No Action Alternative likely would be similar.

1 *White Sturgeon*

2 Changes in water temperature conditions in the Sacramento and Feather rivers
3 would be the same as those described above for Green Sturgeon. Overall, the
4 temperature differences between Alternative 3 and the No Action Alternative
5 would be relatively minor (less than 0.5°F) and likely would have little effect on
6 White Sturgeon in the Sacramento and Feather rivers.

7 The water temperature threshold established for White Sturgeon spawning and
8 egg incubation in the Sacramento River at Hamilton City is 61°F during March
9 through June. Both Alternative 3 and the No Action Alternative would exceed
10 this threshold in May and June. The average monthly water temperatures in May
11 under Alternative 3 would exceed this threshold about 49 percent of the time
12 (about 6 percent less frequently than the No Action Alternative). In June, the
13 temperature under Alternative 3 would exceed the threshold about 74 percent of
14 the time (about 13 percent less frequently than the No Action Alternative).
15 Average monthly water temperatures during May and June under Alternative 3
16 would as high as about 65°F, which is below the 68°F threshold considered lethal
17 for White Sturgeon eggs. Temperature conditions in the Sacramento River under
18 Alternative 3 could be less likely to affect White Sturgeon rearing than under the
19 No Action Alternative because of the reduced frequency of exceedance of the
20 61°F threshold in May and June.

21 The analysis of the effects of Alternative 3 and the No Action Alternative for
22 White Sturgeon relied on water temperature model output for the Sacramento
23 River at various locations downstream of Shasta Dam. The temperature model
24 outputs suggest that thermal conditions and effects on White Sturgeon in the
25 Sacramento River generally would be less adverse under Alternative 3. This
26 conclusion is supported by the water temperature threshold exceedance analysis
27 that indicated that the water temperature thresholds for White Sturgeon spawning,
28 incubation, and rearing would be exceeded less frequently under Alternative 3 in
29 the Sacramento River.

30 Given the general similarity in results and the inherent uncertainty associated with
31 the resolution of the temperature model (average monthly outputs), the effects
32 under Alternative 3 and the No Action Alternative likely would be similar.

33 *Delta Smelt*

34 As described in Appendix 9G, a proportional entrainment regression model
35 (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt
36 entrainment, as influenced by OMR flow in December through March. Results
37 indicate that the percentage of entrainment of migrating and spawning adult Delta
38 Smelt under the No Action Alternative would be 7 to 8.3 percent, depending on
39 the water year type, with a long term average percent entrainment of 7.6 percent.
40 Percent entrainment of adult Delta Smelt under Alternative 3 would be similar to
41 results under the No Action Alternative (differing only by 0.1 to 0.4 percent).
42 Under Alternative 3, the long term average percent entrainment would be
43 7.9 percent.

1 As described in Appendix 9G, a proportional entrainment regression model
2 (based on Kimmerer 2008) was used to simulate larval and early juvenile Delta
3 Smelt entrainment, as influenced by OMR flow and location of X2 in March
4 through June. Results indicate that the percentage of entrainment of larval and
5 early juvenile Delta Smelt under the No Action Alternative would be 1.3 to
6 19.3 percent, depending on the water year type, with a long term average percent
7 entrainment of 8.6 percent, and highest entrainment under Critical water year
8 conditions. Percent entrainment of larval and early juvenile Delta Smelt under
9 Alternative 3 would be higher than results under the No Action Alternative, by
10 1.3 to 6.4 percent. Under Alternative 3, the long term average percent
11 entrainment would be 12.7 percent, and highest entrainment would occur under
12 Critical water year conditions, at 20.5 percent. These values for Alternative 3 are
13 similar to comparable values under the No Action Alternative (estimated to be
14 4.1 and 1.3 percent higher, respectively).

15 The average September through December X2 position in km was used to
16 evaluate the fall abiotic habitat availability for Delta Smelt under the Alternatives.
17 X2 values simulated in the CalSim II model for each alternative were averaged
18 over September through December, and compared. Results indicate that under
19 the No Action Alternative, the X2 position would range from 75.9 km to 92.4 km,
20 depending on the water year type, with a long term average X2 position of 84 km.
21 The most eastward location of X2 is predicted under Critical water year
22 conditions. The X2 positions predicted under Alternative 3 would be similar to
23 results under the No Action Alternative in drier water year types. In wetter years,
24 the X2 location would be further east under Alternative 3 than under the No
25 Action Alternative, by 6.0 to 9.7 km. This difference is largely due to
26 implementation of 2008 USFWS BO RPA Component 3 (Action 4), under the No
27 Action Alternative, which requires Reclamation and DWR to provide sufficient
28 Delta outflow to maintain a monthly average X2 no more eastward than 74 km in
29 Above Normal and Wet years. Under Alternative 3, the long term average X2
30 position would be 88.1 km, a location that does not provide for the advantageous
31 overlap of the low salinity zone with Suisun Bay/Marsh.

32 Overall, Alternative 3 likely would have adverse effects on Delta Smelt, as
33 compared to the No Action Alternative, primarily due to increased percentage
34 entrainment during larval and juvenile life stages, and less favorable location of
35 Fall X2 in wetter years, and on average.

36 *Longfin Smelt*

37 The effects of the Alternative 3 as compared to the No Action Alternative were
38 analyzed based on the direction and magnitude of OMR flows during the period
39 (December through June) when adult, larvae, and young juvenile Longfin Smelt
40 are present in the Delta in the vicinity of the export facilities (Appendix 5A). The
41 analysis was augmented with calculated Longfin Smelt abundance index values
42 (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions
43 that lower X2 values reflect higher flows and that transporting Longfin Smelt
44 farther downstream leads to greater Longfin Smelt survival. The index value

1 indicates the relative abundance of Longfin Smelt and not the calculated
2 population.

3 As described in Appendix 5A, OMR flows would generally be negative in all
4 months, except April and May where OMR flows would be positive, under the No
5 Action Alternative and the long-term average negative flow ranges from -2,700 to
6 -6,200 cfs from December through June. Because there would be no restrictions
7 on export pumping from December 1 to June 15 due to OMR flow criteria under
8 Alternative 3, OMR flows would generally be more negative during this time
9 period under Alternative 3 as compared to the No Action Alternative. The
10 greatest differences between alternatives would be in April and May, where long-
11 term average OMR flows would be negative under Alternative 3 instead of
12 positive as under the No Action Alternative. The increase in the magnitude of
13 negative flows, particularly the negative flows in April and May, under
14 Alternative 3 as compared to the No Action Alternative could increase the
15 potential for entrainment of Longfin Smelt at the export facilities.

16 Under Alternative 3, Longfin Smelt abundance index values range from
17 1,147 under critical water year conditions to a high of 16,635 under wet water
18 year conditions, with a long-term average value of 7951 (Appendix 9G). Under
19 the No Action Alternative, Longfin Smelt abundance index values range from
20 947 under critical water year conditions to a high of 15,822 under wet water year
21 conditions, with a long-term average value of 7,257.

22 Results indicate that the Longfin Smelt abundance index values would be lower in
23 every water year type under Alternative 3 than under the No Action Alternative,
24 with a long-term average index for Alternative 3 that is 7.6 percent lower than the
25 long-term average index under the No Action Alternative. The greatest decrease
26 in the Longfin Smelt abundance index occurs in above normal years where the
27 index value is 12.3 percent less under Alternative 3 than under the No Action
28 Alternative. For below normal, dry, and critical water years, the Longfin Smelt
29 abundance index values would be 4.6 to 9.9 percent lower under Alternative 3
30 than under the No Action Alternative.

31 Overall, based on the increase in frequency and magnitude of negative OMR
32 flows and the lower Longfin Smelt abundance index values, potential adverse
33 effects on the Longfin Smelt population under Alternative 3 likely would be
34 greater than under the No Action Alternative.

35 *Sacramento Splittail*

36 Under Alternative 3, flows entering the Yolo Bypass generally would be
37 somewhat higher than under the No Action Alternative, especially during below
38 normal years when flows entering the bypass under Alternative 3 would be higher
39 than the No Action Alternative in December through March (Appendix 5A,
40 Table C-26-2). These increases would occur during periods of relatively low flow
41 in the bypass, and could slightly increase the frequency of potential inundation.
42 This could provide somewhat greater value to Sacramento Splittail because of the
43 increased area of potential habitat (inundation) and the potential for a slight
44 increase in the frequency of inundation.

1 *Reservoir Fishes*

2 The analysis of effects associated with changes in operation on reservoir fishes
3 relied on evaluation of changes in available habitat (reservoir storage) and
4 anticipated changes in black bass nesting success.

5 Changes in CVP and SWP water supplies and operations under Alternative 3 as
6 compared to the No Action Alternative generally would result in higher reservoir
7 storage in CVP and SWP reservoirs in the Central Valley Region. Storage levels
8 in Shasta Lake, Lake Oroville, and Folsom Lake would be higher under
9 Alternative 3 as compared to the No Action Alternative (Appendix 9F).

10 The greatest increases in Shasta Lake storage could be as high as 15 percent.
11 Storage in Lake Oroville could be increased by up to 30 percent in some months
12 under Alternative 3 as compared to the No Action Alternative. Storage in Folsom
13 Lake could be increased up to around 20 percent in some months of some water
14 year types and could be reduced by up to 10 percent in July, August, and
15 September. Additional information related to monthly reservoir elevations is
16 provided in Appendix 5A, CalSim II and DSM2 Modeling. Although aquatic
17 habitat within the CVP and SWP water supply reservoirs is not limiting, storage
18 volume, as an indicator of how much habitat is available to fish species inhabiting
19 these reservoirs, suggests that the amount of habitat for reservoir fishes could be
20 higher under Alternative 3 as compared to the No Action Alternative.

21 Results of the bass nesting success analysis are presented in Appendix 9F,
22 Reservoir Fish Analysis Documentation. Black bass nest survival in CVP and
23 SWP reservoirs is anticipated to be near 100 percent in March and April due to
24 increasing reservoir elevations. For May, the likelihood of nest survival for
25 Largemouth and Smallmouth Bass in Shasta Lake being in the 40 to 100 percent
26 range is slightly lower (less than 2 percent) under Alternative 3 as compared to
27 the No Action Alternative. For June, the likelihood of nest survival being greater
28 than 40 percent for Largemouth and Smallmouth Bass is the same under
29 Alternative 3 and the No Action Alternative; however, nest survival of greater
30 than 40 percent is likely only in about 20 percent of the years evaluated. For
31 Spotted Bass, the likelihood of nest survival being greater than 40 percent is high
32 (nearly 100 percent) in May under both Alternative 3 and the No Action
33 Alternative. For June, Spotted Bass nest survival would be less than for May due
34 to greater daily reductions in water surface elevation as Shasta Lake is drawn
35 down. The likelihood of survival being greater than 40 percent is about
36 10 percent less under Alternative 3 as compared to the No Action Alternative.

37 For May and June, the likelihood of nest survival for Largemouth Bass in Lake
38 Oroville being in the 40 to 100 percent range is substantially lower percent under
39 Alternative 3 as compared to the No Action Alternative. However, June nest
40 survival of greater than 40 percent is likely only in about 30 percent of the years
41 evaluated under Alternative 3. This is about 10 percent lower likelihood than
42 under the No Action Alternative. The likelihood of nest survival for Smallmouth
43 Bass in Lake Oroville exhibits nearly the same pattern. For Spotted Bass, the
44 likelihood of nest survival being greater than 40 percent is high (over 90 percent)
45 in May under both Alternative 3 and the No Action Alternative with the

1 likelihood of greater than 40 percent survival being similar under Alternative 3 as
2 compared to the No Action Alternative. For June, Spotted Bass survival would be
3 less than for May due to greater daily reductions in water surface elevation as
4 Lake Oroville is drawn down. The likelihood of survival being greater than
5 40 percent is substantially lower (nearly 20 percent) under Alternative 3 as
6 compared to the No Action Alternative.

7 Black bass nest survival in Folsom Lake is anticipated to be near 100 percent in
8 March, April, and May due to increasing reservoir elevations. For June, the
9 likelihood of nest survival for Largemouth Bass and Smallmouth Bass in Folsom
10 Lake being in the 40 to 100 percent range would be about 5 percent lower under
11 Alternative 3 than the No Action Alternative. For Spotted Bass, nest survival for
12 June would be less than for May due to greater daily reductions in water surface
13 elevation. However, the likelihood of survival being greater than 40 percent is
14 somewhat (around 7 percent) lower under Alternative 3 as compared to the No
15 Action Alternative.

16 *Summary of Effects on Reservoir Fishes*

17 The analysis of the effects of Alternative 3 and the No Action Alternative for
18 reservoir fish relied on CalSim II output for reservoir storage levels and water
19 surface elevation changes as described in Appendix 9F. As described above,
20 reservoir storage is anticipated to be increased under Alternative 3 relative to the
21 No Action Alternative and this increase could affect the amount of warm and cold
22 water habitat available within the reservoirs. However, it is unlikely that aquatic
23 habitat within the CVP and SWP water supply reservoirs is limiting and therefore,
24 it is unlikely that habitat for reservoir fish in the CVP and SWP storage reservoirs
25 under Alternative 3 and the No Action Alternative would differ in a biologically
26 meaningful manner.

27 The analysis of black bass nest survival based on changes in water surface
28 elevation during the spawning period indicated that the likelihood of high
29 (>40 percent) nest survival in most of the reservoirs under Alternative 3 would be
30 similar to or slightly lower than under the No Action Alternative. This suggests
31 that conditions in the reservoirs could be less likely to support self-sustaining
32 populations of black bass under Alternative 3 than under the No Action
33 Alternative. However, it is uncertain whether this effect would be biologically
34 meaningful. Thus, it is likely that effects on black bass would be similar under
35 both Alternative 3 and the No Action Alternative.

36 *Other Species*

37 Several other fish species could be affected by changes in operations that
38 influence temperature and flow. The following describes the extent of these
39 changes and the potential effects on these species.

40 *Pacific Lamprey*

41 Little information is available on factors that influence populations of Pacific
42 Lamprey in the Sacramento River, but they are likely affected by many of the
43 same factors as salmon and steelhead because of the parallels in their life cycles.

1 Pacific Lamprey would be subjected to the same temperature conditions described
 2 above for salmonids. The average monthly water temperature differences under
 3 Alternative 3 and the No Action Alternative would be relatively small. In
 4 general, Pacific Lamprey can tolerate higher temperatures than salmonids, up to
 5 around 72°F during their entire life history. Given the somewhat increased flows
 6 and slightly decreased temperatures under Alternative 3 during their spawning
 7 and incubation period, it is likely that Alternative 3 would have a slightly lower
 8 potential to adversely affect Pacific Lamprey in the Sacramento, Feather, and
 9 American rivers than would the No Action Alternative. This conclusion likely
 10 applies to other species of lamprey that inhabit these rivers (e.g., River Lamprey).

11 *Other Species*

12 Changes in average monthly water temperature under Alternative 3 relative to the
 13 No Action Alternative would be small. In general, Striped Bass, American Shad,
 14 and Hardhead can tolerate higher temperatures than salmonids. Given the
 15 somewhat increased flows and decreased water temperatures under Alternative 3
 16 during their spawning and incubation period, it is likely that Alternative 3 would
 17 have a lower potential to adversely affect Striped Bass, American Shad, and
 18 Hardhead in the Sacramento, Feather, and American rivers than would the No
 19 Action Alternative.

20 *Stanislaus River/Lower San Joaquin River*

21 *Fall-Run Chinook Salmon*

22 Changes in operations influence temperature and flow conditions that could affect
 23 fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam
 24 and in the San Joaquin River below Vernalis. The following describes those
 25 changes and their potential effects.

26 *Changes in Water Temperature (Stanislaus River)*

27 Average monthly water temperatures in the Stanislaus River at Goodwin Dam
 28 under Alternative 3 and the No Action Alternative generally would be similar
 29 (differences less than 0.5°F), except in September and October when average
 30 monthly water temperatures would be 0.8°F and 0.5°F cooler, respectively. In
 31 critical dry years, water temperatures under Alternative 3 would be somewhat
 32 (0.7°F to 1.2°F) cooler from May to August and up to 2.9°F and 1.7°F cooler on
 33 average during September and October than under the No Action Alternative
 34 (Appendix 6B, Table B-17-2).

35 Downstream at Orange Blossom Bridge, average monthly water temperatures in
 36 October under Alternative 3 would similar to water temperatures under the No
 37 Action Alternative (less than 0.5°F differences) in most months in most water
 38 year types, but would be lower by up to 2.1°F in September of drier years and up
 39 to 1.5°F warmer in October. Water temperatures in June under Alternative 3
 40 would be substantially higher (2.3°F on average) and up to 3.7°F warmer in
 41 wetter years (Appendix 6B, Table B-18-2).

42 This temperature pattern would continue downstream to the confluence with the
 43 San Joaquin River, although temperatures and magnitude of temperature

1 differences under Alternative 3 compared to the No Action Alternative would
2 progressively increase in a downstream direction (Appendix 6B, Table B-19-1).
3 In addition, the decreases in temperatures under Alternative 3 that would occur in
4 the drier years of some months would diminish at this location.

5 Overall, the temperature differences between Alternative 3 and the No Action
6 Alternative would be relatively minor (less than 0.5°F) and likely would have
7 little effect on fall-run Chinook Salmon in the Stanislaus River. Based on the life
8 history timing for fall-run Chinook Salmon, the lower water temperatures in
9 September and October below Goodwin Dam under Alternative 3 likely would
10 have little effect on fall-run Chinook Salmon spawning as the majority of
11 spawning occurs later, in November. The higher water temperatures in June at
12 Orange Blossom Bridge and the mouth under Alternative 3 may increase the
13 likelihood of adverse effects on fall-run Chinook Salmon rearing in the Stanislaus
14 River, if they are present, as compared to the No action Alternative.

15 *Changes in Exceedance of Water Temperature Thresholds (Stanislaus*
16 *River)*

17 While specific water temperature thresholds for fall-run Chinook Salmon in the
18 Stanislaus River are not established, temperatures generally suitable for fall-run
19 Chinook Salmon spawning (56°F) would be exceeded in October (over 30 percent
20 of the time) and November over 20 percent of the time in the Stanislaus River at
21 Goodwin Dam under Alternative 3 (Appendix 6B, Table B-17-1). Similar
22 exceedances would occur under the No Action Alternative, although average
23 monthly water temperatures under Alternative 3 would remain lower than under
24 the No Action Alternative during the periods when the threshold is exceeded.
25 Water temperatures under Alternative 3 also would exceed the threshold about
26 5 percent less frequently in November than under the No Action Alternative.
27 Conditions for rearing generally would be below 56°F, except in May and June
28 when average monthly water temperatures would reach about 60°F under the No
29 Action Alternative (Appendix 6B, Figure B-17-8).

30 Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run
31 Chinook Salmon spawning would be exceeded frequently under both Alternative
32 3 and the No Action Alternative during October and November. Under
33 Alternative 3, average monthly water temperatures would exceed 56°F about 87
34 percent of the time in October. This would be about 31 percent more frequent
35 than under the No Action Alternative. In November, average monthly water
36 temperatures would exceed 56°F about 24 percent of the time under Alternative 3,
37 which would be about 9 percent less frequent than under the No Action
38 Alternative (Appendix 6B, Figure B-18-1 and B-18-2).

39 During January through May, rearing fall-run Chinook Salmon under
40 Alternative 3 would occasionally encounter average monthly water temperatures
41 that exceed 56°F at Orange Blossom Bridge; however, the differences between
42 Alternative 3 and the No Action Alternative would be less than 0.5°F
43 (Appendix 6B, Table B-18-2).

1 *Changes in Egg Mortality (Stanislaus River)*

2 For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg
3 mortality rate is predicted to be around 6 percent, with higher mortality rates (in
4 excess of 13 percent) occurring in critical dry years under Alternative 3. Overall,
5 egg mortality would be 0.8 percent lower under Alternative 3; in most water year
6 types the average egg mortality rate would be similar to or lower than under the
7 No Action Alternative by up to 1.3 percent (Appendix 9C, Table B-1). Overall,
8 the difference in egg mortality between Alternative 3 and the No Action
9 Alternative would be relatively minor and likely would have little effect on
10 fall-run Chinook Salmon in the Stanislaus River.

11 *Changes in Delta Hydrodynamics*

12 San Joaquin River-origin Chinook Salmon smolts are most abundant in the Delta
13 from April through June. Near the confluence of the San Joaquin River and the
14 Mokelumne River, the proportion of positive velocities would be moderately
15 lower under Alternative 3 relative to the No Action Alternative in April and May,
16 and slightly lower in June (Appendix 9K). On Old River downstream of the
17 facilities, the proportion of positive velocities would be substantially lower in
18 April and May under Alternative 3 relative to the No Action Alternative, but
19 would become more similar in June. In Old River upstream of the facilities, the
20 percent of positive velocities would be similar for Alternative 3 relative to the No
21 Action Alternative in April. In May, values for Alternative 3 would be
22 moderately higher in May and similar in June relative to the No Action
23 Alternative. On the San Joaquin River downstream of the Head of Old River, the
24 percent of positive velocities would be similar under Alternative 3 relative to the
25 No action Alternative in April, May and June.

26 *Changes in Entrainment at Junctions*

27 At the Head of Old River junction, entrainment under Alternative 3 would be
28 similar in all months except in April and May (Appendix 9L). In these two
29 months, entrainment would be slightly higher under Alternative 3 relative to the
30 No Action Alternative. Entrainment into Turner Cut would be slightly greater
31 under Alternative 3 during April and May, and similar in June. At the Columbia
32 Cut junction, entrainment would be higher under Alternative 3 during April and
33 May, whereas there would be only minor differences in June. Entrainment
34 probabilities at the Middle River junction from April through June would be
35 greater for Alternative 3 relative to the No action Alternative. A similar pattern
36 would be observed at the Old River junction.

37 *Changes in Juvenile Salmonid Passage through the Delta (Trap and Haul)*

38 Poor survival of juvenile salmonids in the Sacramento-San Joaquin Delta has
39 been hypothesized as a major contributor to declines in the number of returning
40 adults and may be a significant impediment to the recovery of threatened or
41 endangered populations (NOAA 2009). Under Alternative 3, fish would be
42 trapped in the San Joaquin River between the mouth of the Stanislaus River and
43 the Head of Old River to capture juveniles migrating from natal rearing habitat in
44 the San Joaquin River, Merced River, Tuolumne River and Stanislaus River.

1 Captures fish would be transported by barge through the Delta and released at
2 locations within San Francisco Bay. Although trucks are currently used to
3 transport hatchery reared salmonids and salvaged fishes (including salmonids),
4 barging results in greater survival benefits (Ward et al. 1997) and may reduce
5 straying of returning adults.

6 To assess the potential benefits and risks of a transportation program for
7 salmonids in the San Joaquin River, an analysis of CWT recovery rates for
8 Chinook Salmon reared at the Feather River Hatchery and the Mokelumne River
9 Hatchery was performed. Based on this analysis, Alternative 3 is expected to
10 directly benefit juvenile fall-run Chinook Salmon and steelhead smolts originating
11 from the San Joaquin River basin by comparison to the No Action Alternative.
12 The program would also benefit spring-run Chinook Salmon if these fish become
13 established as part of the San Joaquin River Restoration Program, or as part of the
14 New Melones fish passage project.

15 *Summary of Effects on Fall-Run Chinook Salmon*

16 The analysis of temperatures indicates lower temperatures and a lesser likelihood
17 of exceedance of suitable temperatures for spawning and rearing of fall-run
18 Chinook Salmon under Alternative 3 as compared to the No Action Alternative in
19 the Stanislaus River downstream of Goodwin Dam and in the San Joaquin River
20 at Vernalis. The effect of lower temperatures is reflected in the slightly lower
21 overall mortality of fall-run Chinook Salmon eggs predicted by Reclamation's
22 salmon mortality model for fall-run in the Stanislaus River.

23 Overall, Alternative 3 likely would have slightly beneficial effects on the fall-run
24 Chinook Salmon population in the San Joaquin River watershed as compared to
25 the No Action Alternative. Alternative 3 could also provide beneficial effects to
26 juvenile fall-run Chinook Salmon as a result of trap and haul passage across
27 through the Delta and ocean harvest restrictions. It remains uncertain, however, if
28 predator management actions under Alternative 3 and fish passage under the No
29 Action Alternative would benefit fall-run Chinook Salmon.

30 *Steelhead*

31 Changes in operations that influence temperature and flow conditions in the
32 Stanislaus River downstream of Goodwin Dam and the San Joaquin River
33 downstream of the Stanislaus River confluence, as measured at Vernalis could
34 affect steelhead. The following describes those changes and their potential
35 effects.

36 *Changes in Water Temperature (Stanislaus River)*

37 Average monthly water temperatures in the Stanislaus River at Goodwin Dam
38 under Alternative 3 and the No Action Alternative generally would be similar
39 (differences less than 0.5°F), except in September and October when average
40 monthly water temperatures would be 0.8°F and 0.5°F cooler, respectively. In
41 critical dry years, water temperatures under Alternative 3 would be somewhat
42 (0.7°F to 1.2°F) cooler from May to August and up to 2.9°F and 1.7°F cooler on
43 average during September and October than under the No Action Alternative.

1 Downstream at Orange Blossom Bridge, average monthly water temperatures in
 2 October under Alternative 3 would similar to water temperatures under the No
 3 Action Alternative (less than 0.5°F differences) in most months in most water
 4 year types, but would be lower by up to 2.1°F in September of drier years and up
 5 to 1.5°F warmer in October. Water temperatures in June under Alternative 3
 6 would be substantially higher (2.3°F on average) and up to 3.7°F warmer in
 7 wetter years.

8 This temperature pattern would continue downstream to the confluence with the
 9 San Joaquin River, although temperatures would progressively increase, as would
 10 the magnitude of temperature increase under Alternative 3 (Appendix 6B, Table
 11 B-19-1). In addition, the decreases in temperatures under Alternative 3 that
 12 would occur in the drier years of some months would diminish at this location.

13 Overall, the temperature differences between Alternative 3 and the No Action
 14 Alternative would be relatively minor (less than 0.5°F) and likely would have
 15 little effect on steelhead in the Stanislaus River. The higher water temperatures in
 16 June at Orange Blossom Bridge and the mouth under Alternative 3 may increase
 17 the likelihood of adverse effects on steelhead rearing in the Stanislaus River as
 18 compared to the No action Alternative.

19 *Changes in Exceedance of Water Temperature Thresholds (Stanislaus*
 20 *River)*

21 Average monthly water temperatures in the Stanislaus River at Orange Blossom
 22 Bridge would frequently exceed the temperature threshold (56°F) established for
 23 adult steelhead migration under both Alternative 3 and the No Action Alternative
 24 during October and November. Under Alternative 3, average monthly water
 25 temperatures would exceed 56°F about 87 percent of the time in October and
 26 about 57 percent of the time under the No Action Alternative. In November,
 27 average monthly water temperatures would exceed 56°F about 24 percent of the
 28 time under Alternative 3, which would be about 9 percent less frequent than under
 29 the No Action Alternative.

30 In January through May, the temperature threshold at Orange Blossom Bridge is
 31 55°F, which is intended to support steelhead spawning. This threshold would be
 32 exceeded about 1 percent of the time under Alternative 3 in February. In March
 33 through May, exceedances would occur under both alternatives in each month,
 34 with the threshold most frequently exceeded (nearly half the time) in May.
 35 Compared to the No Action Alternative, water temperatures under Alternative 3
 36 would exceed the threshold more frequently in March (3 percent), April
 37 (1 percent), and May (4 percent). During June through November, the
 38 temperature threshold of 65°F established to support steelhead rearing would be
 39 exceeded by both Alternative 3 and No Action Alternative in all months but
 40 November, with the highest frequency of exceedance in July (19 percent under
 41 Alternative 3). The differences between Alternative 3 and No Action Alternative,
 42 however, would be variable depending on the month, with Alternative 3
 43 exceeding the threshold up to about 6 percent less frequently than under the No
 44 Action Alternative in June and from August through October. Under

1 Alternative 3, water temperatures would exceed the rearing temperature threshold
2 up to 4 percent more frequently in April, May, and July.

3 Average monthly water temperatures also would exceed the threshold (52°F)
4 established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles
5 upstream of Knights Ferry, average monthly water temperatures under
6 Alternative 3 would exceed 52°F in March, April, and May about 12 percent,
7 30 percent, and 63 percent of the time, respectively and 2 percent of the time in
8 January and February. By comparison to the No Action Alternative, Alternative 3
9 would result in exceedances occurring about 2 to 4 percent more frequently
10 during the January through March period. Farther downstream at Orange
11 Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and
12 would be exceeded less frequently. The magnitude of the exceedance also would
13 be less. Average monthly water temperatures under Alternative 3 and the No
14 Action Alternative would not exceed the threshold during January through March.
15 In April and May, exceedances of 3 percent and 17 percent would occur under
16 Alternative 3, which would be nearly the same (within 1 percent) as under the No
17 Action Alternative.

18 Overall, the differences between Alternative 3 and the No Action Alternative
19 would be relatively small, with the exception of substantial differences in the
20 frequency of exceedances in October when the average monthly water
21 temperatures under Alternative 3 would exceed the threshold for adult steelhead
22 migration about 28 percent less frequently and in April during the spawning
23 period when the frequency would be about 17 percent less. Given the frequency
24 of exceedance under both Alternative 3 and the No Action Alternative and the
25 generally stressful temperature conditions in the river, the substantial differences
26 (improvements) in October and April under Alternative 3 suggest that there would
27 be less potential to adversely affect steelhead under Alternative 3 than under the
28 No Action Alternative. Even during months when the differences would be
29 relatively small, the lower frequency of exceedances under Alternative 3 could
30 represent a biologically meaningful and positive difference.

31 *Changes in Delta Hydrodynamics*

32 San Joaquin River-origin steelhead generally move through the Delta during
33 spring; however, there is less information on their timing relative to Chinook
34 Salmon. Thus, hydrodynamics in the entire January through June period have the
35 potential to affect juvenile steelhead. For a description of potential hydrodynamic
36 effects on steelhead, see the descriptions for winter-run Chinook Salmon in the
37 Sacramento Basin and fall-run Chinook Salmon in the San Joaquin River basin
38 above.

39 *Changes in Entrainment at Junctions*

40 At the Head of Old River, entrainment under Alternative 3 would be slightly
41 higher during January and February relative to the No Action Alternative.
42 Entrainment probabilities would be much lower under Alternative 3 relative to the
43 No Action Alternative during April and May. Entrainment probabilities would be
44 similar under both alternatives in the month of June (Appendix 9L).

1 At the Turner Cut junction, entrainment probabilities under Alternative 3 would
2 be slightly higher than under the No Action Alternative in January, February,
3 March, and June. During April and May, entrainment probabilities would be
4 more divergent with higher values for Alternative 3 relative to the No Action
5 Alternative. Overall, entrainment would be lower at the Columbia Cut junction
6 relative to Turner Cut, but patterns of entrainment between the two alternatives
7 would be similar. Entrainment would be slightly higher for Alternative 3 relative
8 to the No Action Alternative during January, February, March, and June. In April
9 and May, entrainment would be greater for Alternative 3 relative to the No Action
10 Alternative. Patterns at the Middle River and Old River junctions would be
11 similar to those observed at the Columbia and Turner Cut junctions.

12 *Summary of Effects on Steelhead*

13 Given the frequency of exceedance under both Alternative 3 and the No Action
14 Alternative, water temperature conditions for steelhead in the Stanislaus River
15 would be generally stressful in the fall, late spring, and summer months. The
16 differences in temperature exceedance (both positive and negative) between
17 Alternative 3 and the No Action Alternative would be relatively small, with no
18 clear benefit associated with either alternative. However, because Alternative 3
19 generally would exceed thresholds less frequently during the warmest months, it
20 may provide slightly less impact than under the No Action Alternative.
21 Alternative 3 could provide additional beneficial effects to juvenile steelhead as a
22 result of trap and haul passage across through the Delta. It remains uncertain,
23 however, if predator management actions under Alternative 3 would benefit
24 steelhead. However, if fish passage above New Melones Dam is successful,
25 Alternative 3 would do less than the No Action Alternative to address long-term
26 temperature issues in the Stanislaus River downstream of the dam.

27 *White Sturgeon*

28 Evidence of White Sturgeon spawning has been recorded in the San Joaquin River
29 upstream of the confluence with the Stanislaus River. While flows in the San
30 Joaquin River upstream of the Stanislaus River are expected to be similar under all
31 alternatives, flow contributions from the Stanislaus River could influence water
32 temperatures in the San Joaquin River where White Sturgeon eggs or larvae may
33 occur during the spring and early summer. The magnitude of influence on water
34 temperature would depend on the proportional flow contribution of the Stanislaus
35 River and the temperatures in both the Stanislaus and San Joaquin rivers. The
36 potential for an effect on White Sturgeon eggs and larvae would be influenced by
37 the proportion of the population occurring in the San Joaquin River. In
38 consideration of this uncertainty, it is not possible to distinguish potential effects
39 on White Sturgeon between alternatives.

40 *Reservoir Fishes*

41 The analysis of effects associated with changes in operation on reservoir fishes
42 relied on evaluation of changes in available habitat (reservoir storage) and
43 anticipated changes in black bass nesting success.

1 Under Alternative 3, storage in New Melones could be increased up to around
2 20 percent in some months of some water year types (Appendix 5A). Additional
3 information related to monthly reservoir elevations is provided in Appendix 5A,
4 CalSim II and DSM2 Modeling. It is anticipated that aquatic habitat within New
5 Melones is not limiting; however, storage volume is an indicator of how much
6 habitat is available to fish species inhabiting these reservoirs. Therefore, the
7 amount of habitat for reservoir fishes could be increased under Alternative 3 as
8 compared to the No Action Alternative.

9 Results of the bass nesting success analysis are presented in Appendix 9F. For
10 March, the likelihood of Largemouth Bass and Smallmouth Bass nest survival in
11 New Melones being above 40 percent is 100 percent under Alternative 3 and the
12 No Action Alternative. For April, the likelihood that nest survival of Largemouth
13 Bass and Smallmouth Bass is between 40 and 100 percent is reasonably high
14 (around 80 percent) but is substantially (about 10 percent) higher under
15 Alternative 3 than under the No Action Alternative. For May, the pattern is
16 similar with the likelihood of high nest survival being about 6 percent greater
17 under Alternative 3. For June, the likelihood of survival being greater than
18 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is about
19 3 percent higher under Alternative 3 as compared to the No Action Alternative.
20 For Spotted Bass, nest survival in March is anticipated to be near 100 percent in
21 every year under both Alternative 3 and the No Action Alternative. The
22 likelihood of survival being greater than 40 percent in April is 100 percent under
23 both Alternative 3 and the No Action Alternative. For May, the likelihood of high
24 Spotted Bass nest survival is near 100 percent under both alternatives with the
25 likelihood under Alternative 3 being about 1 percent higher than under the No
26 Action Alternative. For June, Spotted Bass nest survival would be greater than
27 40 percent in every year under Alternative 3 as compared to approximately
28 98 percent of the years under the No Action Alternative.

29 While the analyses suggest that the effects of operation under Alternative 3 could
30 be less than those under the No Action Alternative, it is uncertain whether these
31 differences would be biologically meaningful. Therefore, it is likely that the effects
32 on black basses in New Melones Reservoir would be similar under both
33 alternatives.

34 *Other Species*

35 Changes in operations that influence temperature and flow conditions in the
36 Stanislaus River downstream of Keswick Dam and the San Joaquin River at
37 Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

38 As described above, average monthly water temperatures in the Stanislaus River
39 at Goodwin Dam under Alternative 3 and the No Action Alternative generally
40 would be similar. Downstream at Orange Blossom Bridge, average monthly
41 water temperatures in the November to March period under Alternative 3
42 generally would be similar to, although somewhat higher than, under the No
43 Action Alternative. In June, July, and October, average monthly water
44 temperatures in most water year types would be higher under Alternative 3 and in
45 September, water temperatures would be lower under Alternative 3 compared to

1 the No Action Alternative. This temperature pattern would continue downstream
 2 to the confluence with the San Joaquin River, although temperatures would
 3 progressively increase, as would the magnitude of difference between
 4 Alternative 3 and the No Action Alternative (Appendix 6B, Table B-19-1).

5 In general, lamprey species can tolerate higher temperatures than salmonids, up to
 6 around 72°F during their entire life history. Because lamprey ammocoetes remain
 7 in the river for several years, any substantial flow reductions or temperature
 8 increases could adversely affect these larval lamprey. Given the slightly lower
 9 flows and temperatures during their spawning and incubation period, it is likely
 10 that the potential to affect lamprey species in the Stanislaus and San Joaquin
 11 rivers would be somewhat greater under Alternative 3 and the No Action
 12 Alternative.

13 In general, Striped Bass and Hardhead also can tolerate higher temperatures than
 14 salmonids. Given the slightly lower flows and temperatures during their
 15 spawning and incubation period, it is likely that the potential to affect Striped
 16 Bass and Hardhead in the Stanislaus and San Joaquin rivers would be somewhat
 17 greater under Alternative 3 and the No Action Alternative.

18 *Killer Whale*

19 As described above for the comparison of Alternative 1 to the No Action
 20 Alternative, it is unlikely that the Chinook Salmon prey base of killer whales,
 21 supported heavily by hatchery production of fall-run Chinook Salmon, would be
 22 appreciably affected by any of the alternatives.

23 **9.4.3.4.1 Alternative 3 Compared to the Second Basis of Comparison**

24 As described in Chapter 3, Description of Alternatives, the CVP and SWP
 25 operations and ongoing operational management policies of the CVP and SWP
 26 under Alternative 3 would be similar to the operational assumptions under the
 27 Second Basis of Comparison except for changes to water demand assumptions,
 28 OMR flow criteria, and operations of New Melones Reservoir to meet SWRCB
 29 D-1641 flow requirements on the San Joaquin River at Vernalis. As a
 30 consequence, conditions for fish and aquatic resources would be relatively
 31 unchanged in most of the system under Alternative 3. The following briefly
 32 summarizes these minor changes, but focuses on portions of the CVP and SWP
 33 where changes would occur under Alternative 3 relative to the Second Basis of
 34 Comparison.

35 *Trinity River Region*

36 *Coho Salmon*

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

41 Long-term average monthly water temperature in the Trinity River at Lewiston
 42 Dam under Alternative 3 would be similar (less than 0.2°F) to long-term average

1 water temperatures under the Second Basis of Comparison in all months. The
2 greatest differences would occur in critical years when average monthly
3 temperatures would be 0.6°F lower in September and October and 0.8°F higher in
4 November under Alternative 3 (Appendix 6B, Table B-1-5). The differences in
5 the frequency with which Alternative 3 and the Second Basis of Comparison
6 would exceed established temperature thresholds also would be small, with water
7 temperatures under Alternative 3 exceeding thresholds about 0-2 percent less
8 frequently than under the Second Basis of Comparison.

9 Overall, the temperature model outputs for each of the Coho Salmon life stages
10 suggest that the temperature of water released at Lewiston Dam generally would
11 be similar under both scenarios.

12 *Spring-run Chinook Salmon*

13 As described above for Coho Salmon, water temperature differences between
14 Alternative 3 and the Second Basis of Comparison generally would be small (less
15 than 0.5°F). Similarly, the differences in the frequency with which water
16 temperatures under Alternative 3 and the Second Basis of Comparison would
17 exceed established temperature thresholds also would be small, with Alternative 3
18 exceeding water temperature thresholds about 1 percent less frequently than the
19 Second Basis of Comparison in July and September.

20 The minor temperature differences suggest that conditions for spring-run Chinook
21 Salmon in the Trinity River generally would be similar under Alternative 3 and
22 the Second Basis of Comparison.

23 *Fall-Run Chinook Salmon*

24 As described above for Coho Salmon, the water temperature differences between
25 Alternative 3 and the Second Basis of Comparison generally would be minor
26 (Appendix 6B, Table B-1-small (less than 0.5°F). These small temperature
27 differences are reflected in the egg mortality results, which indicate minor
28 changes in mortality, with mortality differences less than 0.6 percent
29 (Appendix 9C, Table 5-5). These results suggest that conditions for fall-run
30 Chinook Salmon in the Trinity River generally would be similar under
31 Alternative 3 and the Second Basis of Comparison.

32 *Steelhead*

33 Differences in water temperature conditions for steelhead in the Trinity River
34 between Alternative 3 and the Second Basis of Comparison would be minor as
35 described above for salmon. These minor differences in temperature suggest that
36 conditions for steelhead in the Trinity River generally would be similar under
37 Alternative 3 and the Second Basis of Comparison.

38 *Green Sturgeon*

39 Green Sturgeon would be subjected to the same water temperature conditions
40 described above for salmonids. The minor differences in temperatures flows
41 between Alternative 3 and the Second Basis of Comparison suggest that
42 conditions for Green Sturgeon in the Trinity River generally would be similar
43 under Alternative 3 and the Second Basis of Comparison.

1 *Reservoir Fishes*

2 Reservoir fishes in Trinity Lake would be exposed to relatively minor differences
3 in storage under Alternative 3 as compared to the Second Basis of Comparison
4 and these relatively small differences would have little effect on the amount of
5 habitat available for these species. Black bass nesting survival would be similar
6 under Alternative 3 and the Second Basis of Comparison. These minor
7 differences in nest survival suggest that conditions for black bass species in
8 Trinity Lake would be similar under both Alternative 3 and the Second Basis of
9 Comparison.

10 *Other Species*

11 As described above for Coho Salmon, there would be only minor differences in
12 water temperatures and flows between Alternative 3 and the Second Basis of
13 Comparison. These minor differences suggest that water temperature conditions
14 for Pacific Lamprey, Eulachon, and other aquatic species in the Trinity River and
15 Klamath River downstream of the confluence generally would be similar under
16 Alternative 3 and the Second Basis of Comparison.

17 *Sacramento River System*

18 *Winter-run Chinook Salmon*

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

22 *Changes in Water Temperature*

23 Long-term average monthly water temperature in the Sacramento River at
24 Keswick Dam under Alternative 3 and the Second Basis would be relatively
25 unchanged, with minor differences in some months and water year types of less
26 than 0.3°F (Appendix 6B, Table B-5-5). There would be slight differences in the
27 frequency of exceeding temperature thresholds under Alternative 3 and the
28 Second Basis of Comparison with the frequency of exceedance being up to
29 4 percent less under Alternative 3 at Balls Ferry and up to 4 percent more at Bend
30 Bridge. Egg mortality would be unchanged in all but critical dry years, when
31 Alternative 3 would exhibit 0.7 percent less mortality than the Second Basis of
32 Comparison (Appendix 9C, Table B-4).

33 *Changes in Weighted Usable Area*

34 The WUA results for winter-run Chinook Salmon spawning habitat between
35 Keswick Dam and Battle Creek indicated that the amount of spawning habitat
36 would be similar under Alternative 3 and the Second Basis of Comparison (less
37 than 3 percent difference), except in below normal years in which spawning
38 WUA would be about 6 percent higher as a result of the higher flows during this
39 period (Appendix 9E, Table C-17-5). Results were similar for fry rearing, but
40 higher flows in below normal years during August translated into about 6 percent
41 less WUA under Alternative 3 (Appendix 9E, Table C-18-5). Results for juvenile
42 rearing also were similar (less than 3 percent difference) under both Alternative 3
43 and the Second Basis of Comparison (Appendix 9E, Table C-19-5).

1 *Changes in SALMOD Output*

2 SALMOD results indicated that the long-term annual potential production of
3 winter-run Chinook Salmon under Alternative 3 would be essentially the same as
4 under the Second Basis of Comparison. Differences among water year types
5 would be less than 2 percent (Appendix 9D, Table B-4-1).

6 *Changes in Delta Passage Model Output*

7 The Delta Passage Model predicted similar estimates of annual Delta survival
8 across the 81-year time period for winter-run Chinook Salmon between
9 Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta
10 survival was 0.354 for Alternative 3 and 0.352 for the Second Basis of
11 Comparison.

12 *Changes in Junction Entrainment*

13 Entrainment at the Georgiana Slough Junction under Alternative 3 would be
14 almost indistinguishable from the Second Basis of Comparison (Appendix 9L).
15 At the Head of Old River junction, entrainment would be moderately lower under
16 Alternative 3 in January and February and slightly lower in March. At Turner
17 Cut, entrainment would be moderately lower under Alternative 3 relative to the
18 Second Basis of Comparison in January; however, these differences would be
19 smaller in February and March. Entrainment at Columbia Cut, Middle River, and
20 Old River would be moderately lower in January and February and slightly lower
21 in March relative to the Second Basis of Comparison.

22 *Changes in Salvage*

23 Salvage of Sacramento River-origin Chinook salmon is predicted to be
24 considerably lower under Alternative 3 relative to the Second Basis of
25 Comparison in January (Appendix 9M). In February salvage would be only
26 moderately lower and slightly lower in March.

27 *Changes in Oncorhynchus Bayesian Analysis Output*

28 Escapement of winter-run Chinook Salmon and Delta survival was modeled by
29 the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook
30 salmon. Differences in escapement between Alternative 3 and the Second Basis
31 scenarios were moderately small (Appendix 9I). Escapement was generally
32 greater under Alternative 3 relative to Second Basis of Comparison, and it was
33 consistently greater over the 1986 to 1988 simulation period (dark gray and light
34 gray areas above the dashed line). In most other years the difference in
35 escapement estimates included 0 (i.e., dashed line located in the dark gray, central
36 0.50 probability region) (see Appendix 9I). The median delta survival was
37 slightly higher under Alternative 3 relative to the Second Basis scenario
38 (6 percent), although the probability of no difference between alternatives was
39 generally high throughout the simulation time period.

40 *Changes in Interactive Object-Oriented Simulation Output*

41 The IOS model predicted similar adult escapement trajectories for winter-run
42 Chinook Salmon between Alternative 3 and the Second Basis of Comparison
43 across the 81 years (Appendix 9H). Median adult escapement under Alternative 3

1 was 4,025 and under the Second Basis of Comparison median escapement
2 was 4,042.

3 Similar to adult escapement, the IOS model predicted similar egg survival time
4 histories for winter-run Chinook Salmon between Alternative 3 and the Second
5 Basis of Comparison across the 81 water years. Median egg survival was
6 0.987 for both scenarios.

7 *Summary of Effects on Winter-Run Chinook Salmon*

8 The multiple model and analysis outputs described above characterize the
9 anticipated conditions for winter-run Chinook Salmon and their response to
10 change under Alternative 1 as compared to the Second Basis of Comparison. For
11 the purpose of analyzing effects on winter-run Chinook Salmon and developing
12 conclusions, greater reliance was placed on the outputs from the two life cycle
13 models, IOS and OBAN because they each integrate the available information to
14 produce single estimates of winter-run Chinook Salmon escapement. The output
15 from IOS indicated that winter-run Chinook Salmon escapement would be similar
16 under both scenarios, whereas the OBAN results indicated that escapement under
17 Alternative 3 would be higher than under the Second Basis of Comparison.

18 These model results suggest that effects on winter-run Chinook Salmon would be
19 similar under both scenarios, with a small likelihood that winter-run Chinook
20 Salmon escapement would be higher under Alternative 3 than under the Second
21 Basis of Comparison. The ocean harvest restrictions under Alternative 3 could
22 provide additional benefit, although the effects of the predator management
23 program are uncertain.

24 *Spring-run Chinook Salmon*

25 Operations under Alternative 3 generally would be similar to those for the Second
26 Basis of Comparison. The following describes those changes and their potential
27 effects.

28 *Changes in Water Temperature*

29 Long-term average monthly water temperature in the Sacramento River under
30 Alternative 3 and the Second Basis of Comparison would be relatively
31 unchanged, with minor differences in some months and water year types
32 (Appendix 6B). Differences in the frequency of exceeding temperature thresholds
33 under Alternative 3 and the Second Basis of Comparison also would be similar
34 (differences of about 1 percent), as would egg mortality, which would be similar
35 in all but critical dry years, during which Alternative 3 would exhibit 3.8 percent
36 more mortality than the Second Basis of Comparison (Appendix 9C, Table B-3).

37 In Clear Creek, average monthly water temperature at Igo under Alternative 3
38 relative to the Second Basis of Comparison would be similar (differences less
39 than 0.2°F) (Appendix 6B, Table B-3-5). The frequency of exceeding
40 temperature thresholds for spring-run Chinook Salmon rearing also would be
41 similar (differences of 1 percent).

42 In the Feather River, average monthly water temperature at the low flow channel
43 under Alternative 3 relative to the Second Basis of Comparison also would be

1 similar (differences less than 0.5°F), with a slight reduction in temperature (0.7°F)
2 in August of below normal years (Appendix 6B, Table B-20-5). Water
3 temperatures at the downstream location also would be similar, with temperatures
4 under Alternative 3 at Robinson Riffle up to 2°F percent cooler in August of
5 below normal years (Appendix 6B, Table B-21-5). Changes in the frequency of
6 temperature thresholds would be similar (differences of 1 percent or less), except
7 in May when the temperature threshold for rearing would be exceeded about
8 4 percent more frequently than under the Second Basis of Comparison.

9 *Changes in Weighted Usable Area*

10 Weighted usable area curves are available for spring-run Chinook Salmon in
11 Clear Creek. Flows in Clear Creek downstream of Whiskeytown Dam are not
12 anticipated to differ under Alternative 3 relative to the Second Basis of
13 Comparison. Therefore, there would be no change in the amount of potentially
14 suitable spawning and rearing habitat for spring-run Chinook Salmon (as indexed
15 by WUA) available under the Alternative 3 as compared to the Second Basis of
16 Comparison.

17 *Changes in SALMOD Output*

18 SALMOD results indicate that long-term annual potential production for spring-
19 run Chinook Salmon would be essentially unchanged, with slight improvements
20 (0-2 percent) under Alternative 3 relative to the Second Basis of Comparison,
21 except in critical dry years when potential production under Alternative 3 would
22 be about 8 percent lower (Appendix 9D, Table B-3-21).

23 *Changes in Delta Passage Model Output*

24 The Delta Passage Model predicted similar estimates of annual Delta survival
25 across the 81-year time period for spring-run Chinook Salmon between
26 Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta
27 survival would be 0.286 for both scenarios.

28 *Changes in Delta Hydrodynamics*

29 Spring-run Chinook Salmon are most abundant in the Delta from March through
30 May. Near the junction of Georgiana Slough (channel 421), the percent of time
31 that velocity would be positive was similar for both Alternative 3 and the Second
32 Basis of Comparison in March, April and May (Appendix 9K). Near the
33 confluence of the San Joaquin River and the Mokelumne River (channel 45),
34 percent positive velocity was almost identical in March and April and slightly
35 lower under Alternative 3 relative to the Second Basis of Comparison in May. In
36 the San Joaquin River downstream of the Head of Old River (channel 21), the
37 percent of positive velocities was similar between scenarios in March, whereas
38 values were moderately lower under Alternative 3 relative to the Second Basis of
39 Comparison in April and May. In Old River upstream of the facilities (channel 212),
40 percent positive velocity was similar between scenarios in March and moderately
41 higher in April and May under Alternative 3 relative to the Second Basis of
42 Comparison. In Old River downstream of the facilities (channel 94), percent
43 positive velocity was similar between scenarios in March and slightly higher in
44 April and May under Alternative 3 relative to the Second Basis of Comparison.

1 *Changes in Junction Entrainment*

2 Entrainment at the Georgiana Slough Junction under Alternative 3 would be
3 almost indistinguishable from the Second Basis of Comparison during March
4 April and May (Appendix 9L). At the Head of Old River junction, entrainment
5 would be slightly lower under Alternative 3 in March, whereas entrainment would
6 be much greater under Alternative 3 relative to the Second Basis of Comparison
7 in April and May. At Turner Cut, entrainment would be similar under Alternative
8 3 relative to the Second Basis of Comparison in March and moderately lower in
9 April and May. Entrainment at Columbia Cut, Middle River, and Old River
10 would yield similar patterns as those observed at Turner Cut.

11 *Changes in Salvage*

12 Spring-run Chinook Salmon smolts migrating through the Delta would be most
13 susceptible in the months of March, April, and May. Salvage of Sacramento
14 River-origin Chinook salmon is predicted to be similar under Alternative 3
15 relative to the Second Basis of Comparison in March and April (Appendix 9M).
16 Predicted values in May indicated a moderately greater fraction of fish salvaged
17 for Alternative 3 relative to the Second Basis of Comparison.

18 *Summary of Effects on Spring-Run Chinook Salmon*

19 The multiple model and analysis outputs described above characterize the
20 anticipated conditions for spring-run Chinook Salmon and their response to
21 change under Alternative 3 and the Second Basis of Comparison. For the purpose
22 of analyzing effects on spring-run Chinook Salmon in the Sacramento River,
23 greater reliance was placed on the outputs from the SALMOD model because it
24 integrates the available information on temperature and flows to produce
25 estimates of mortality for each life stage and an overall, integrated estimate of
26 potential spring-run Chinook Salmon juvenile production. The output from
27 SALMOD indicated that spring-run Chinook Salmon production in the
28 Sacramento River would be similar under Alternative 3 and the Second Basis of
29 Comparison, although production under Alternative 3 could be up to 8 percent
30 less than under the Second Basis of Comparison in critical dry years.

31 The analyses attempting to assess the effects on routing, entrainment, and salvage
32 of juvenile salmonids in the Delta suggest that salvage (as an indicator of
33 potential losses of juvenile salmon at the export facilities) of Sacramento
34 River-origin Chinook Salmon generally would be higher under Alternative 3
35 relative to the Second Basis of Comparison.

36 In Clear Creek and the Feather River, the analysis of the effects of Alternative 3
37 and the Second Basis of Comparison for spring-run Chinook Salmon relied on
38 output from the WUA analysis and water temperature output for Clear Creek at
39 Igo, and in the Feather River low flow channel and downstream of the Thermalito
40 complex. The WUA analysis suggests that there would be little difference in the
41 availability of spawning and rearing habitat in Clear Creek. The temperature
42 model outputs suggest that thermal conditions and effects on each of the
43 spring-run Chinook Salmon life stages generally cannot be fully characterized in
44 Clear Creek and the Feather River. This conclusion is supported by the water

1 temperature threshold exceedance analysis that indicated that water temperature
2 thresholds for spawning and egg incubation in Clear Creek and the Feather River
3 would be exceeded less frequently in some months and more frequently in others
4 under Alternative 3 than under the Second Basis of Comparison. The water
5 temperature threshold for rearing spring-run Chinook Salmon in the Feather River
6 would also be exceeded less frequently in some months and more frequently in
7 others under Alternative 3. Because of the inherent uncertainty associated with
8 the resolution of the temperature model (average monthly outputs), and the
9 differences in the magnitude and direction of the temperature exceedances under
10 Alternative 3, the extent of temperature-related effects on spring-run Chinook
11 Salmon in Clear Creek and the Feather River is uncertain.

12 These model results suggest that overall, effects on spring-run Chinook Salmon
13 could be slightly more adverse under Alternative 3 than the Second Basis of
14 Comparison, with a small likelihood that spring-run Chinook Salmon production
15 would be lower under the Second Basis of Comparison. The benefits of ocean
16 harvest restrictions under Alternative 3, however, could offset those effects. The
17 effects of the predator management program under Alternative 3 are uncertain.

18 *Fall-Run Chinook Salmon*

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

24 *Changes in Water Temperature*

25 Water temperature conditions in the Sacramento River, Clear Creek, and Feather
26 River under Alternative 3 and the Second Basis of Comparison would be same as
27 those described above for spring-run Chinook Salmon. Temperature conditions in
28 the Sacramento River, Clear Creek, Feather River, and American River would
29 generally be similar (differences less than 0.5°F) under Alternative 3 and the
30 Second Basis of Comparison (Appendix 6B).

31 The frequency of exceeding established temperature thresholds in the Sacramento
32 and Feather rivers for fall-run Chinook Salmon would be the same or nearly so
33 (differences of up to 2 percent) for both Alternative 3 and the Second Basis of
34 Comparison Exceedances. Similarly, in the American River (Appendix 9C,
35 Table B-6), differences in the frequency of temperature threshold exceedance
36 would be small (up to about 0.6 percent).

37 The results from Reclamation's salmon mortality model reflect the similarities in
38 temperature described above. For fall-run Chinook Salmon in the Sacramento
39 River, egg mortality would be similar (up to 0.6 percent difference) between
40 Alternative 3 and the Second Basis of Comparison (Appendix 9C, Table B-1).
41 Differences in the Feather River would be slightly larger, with about 2.4 percent
42 and 2.8 lower egg mortality under Alternative 3 than under the Second Basis of
43 Comparison in below normal and critical dry years, respectively. Differences in
44 the American River would be similar to those in the Sacramento River, with egg

1 mortality under Alternative 3 ranging from 0.1 percent less to 0.6 percent greater
2 than under the Second Basis of Comparison.

3 *Changes in Weighted Usable Area*

4 Modeling results indicate that, in general, there would be similar amounts (less
5 than 5 percent differences) of fall-run Chinook Salmon spawning habitat available
6 in the Sacramento, Feather, and American rivers under Alternative 3 as compared
7 to the Second Basis of Comparison; fall-run fry and juvenile rearing WUA would
8 be less than 1 percent different under Alternative 3 relative to the Second Basis of
9 Comparison in the Sacramento River. Overall, spawning and rearing habitat
10 availability for fall-run Chinook Salmon would be similar under Alternative 3 and
11 the Second Basis of Comparison.

12 *Changes in SALMOD Output*

13 SALMOD results indicate that long-term annual potential production for fall-run
14 Chinook Salmon would be similar (1 percent difference), with slight increases
15 potential production (0-2 percent) in some water year types under Alternative 3
16 relative to the Second Basis of Comparison, except in critical dry years when
17 potential production under Alternative 3 would be about 2 percent lower
18 (Appendix 9D, Table B-1-21).

19 *Changes in Delta Passage Model Output*

20 The Delta Passage Model predicted similar estimates of annual Delta survival
21 across the 8-year time period for fall-run Chinook Salmon between Alternative 3
22 and the Second Basis of Comparison (Appendix 9J). Median Delta survival was
23 0.246 for Alternative 3 and 0.245 for the Second Basis of Comparison.

24 *Changes in Delta Hydrodynamics*

25 Fall-run Chinook Salmon smolts are most abundant in the Delta during the
26 months of April, May and June. At the junction of Georgiana Slough and the
27 Sacramento River, percent positive velocity would be indistinguishable among
28 scenarios in April, May, and June (Appendix 9K). Near the confluence of the San
29 Joaquin River and the Mokelumne River, the proportion of positive velocities
30 would be slightly lower under Alternative 3 relative to the Second Basis of
31 Comparison in the months when fall-run Chinook Salmon are most abundant. On
32 Old River downstream of the facilities, the proportion of positive velocities would
33 be slightly, to moderately higher in April and May, and moderately lower in June
34 under Alternative 3 relative to the Second Basis of Comparison. In Old River
35 upstream of the facilities, the percent of positive velocities would be considerably
36 higher under Alternative 3 in April and May and moderately lower in June. On
37 the San Joaquin River downstream of the Head of Old River, the percent of
38 positive velocities would be considerably lower under Alternative 3 relative to the
39 Second Basis of Comparison in April and May, and moderately lower in June.

40 *Changes in Junction Entrainment*

41 Entrainment at the Georgiana Slough Junction under Alternative 3 would be
42 almost indistinguishable from the Second Basis of Comparison in April, May, and
43 June (Appendix 9L). At the Head of Old River junction in April and May,

1 entrainment would be much greater under Alternative 3 relative to the Second
2 Basis of Comparison. In June, entrainment would be indistinguishable under each
3 alternative. Patterns of entrainment would be similar at Turner Cut, Columbia
4 Cut, Middle River, and Old River. At these junctions, entrainment under
5 Alternative 3 would be moderately lower in April and May, and slightly lower or
6 almost indistinguishable in June.

7 *Changes in Salvage*

8 Salvage of Sacramento River-origin Chinook Salmon is predicted to be greater
9 under Alternative 3 relative to the Second Basis of Comparison in every month
10 (Appendix 9M). Fall-run Chinook Salmon smolts migrating through the Delta
11 would be most susceptible in the months of April, May, and June. Predicted
12 values in April and May indicated a substantially increased fraction of fish
13 salvaged under Alternative 3 relative to the Second Basis of Comparison.

14 *Summary of Effects on Fall-Run Chinook Salmon*

15 The multiple model and analysis outputs described above characterize the
16 anticipated conditions for fall-run Chinook Salmon and their response to change
17 under Alternative 3 and the Second Basis of Comparison. For the purpose of
18 analyzing effects on fall-run Chinook Salmon in the Sacramento River, greater
19 reliance was placed on the outputs from the SALMOD model because it integrates
20 the available information on temperature and flows to produce estimates of
21 mortality for each life stage and an overall, integrated estimate of potential fall-
22 run Chinook Salmon juvenile production. The output from SALMOD indicated
23 that fall-run Chinook Salmon production would be slightly higher in most water
24 year types under Alternative 3 than under the Second Basis of Comparison, and
25 up to 2 percent less than under the Second Basis of Comparison in critical dry
26 years.

27 The analyses attempting to assess the effects on routing, entrainment, and salvage
28 of juvenile salmonids in the Delta suggest that salvage (as an indicator of
29 potential losses of juvenile salmon at the export facilities) of Sacramento
30 River-origin Chinook Salmon generally would be higher under Alternative 3
31 relative to the Second Basis of Comparison.

32 In Clear Creek and the Feather and American rivers, the analysis of the effects of
33 Alternative 3 and the Second Basis of Comparison for fall-run Chinook Salmon
34 relied on the WUA analysis for habitat and water temperature model output for
35 the rivers at various locations downstream of the CVP and SWP facilities. The
36 WUA analysis indicated that the availability of spawning and rearing habitat in
37 Clear Creek and spawning habitat in the Feather and American rivers would be
38 similar under Alternative 3 and the Second Basis of Comparison. The
39 temperature model outputs for each of the fall-run Chinook Salmon life stages
40 suggest that thermal conditions and effects on fall-run Chinook Salmon in all of
41 these streams generally would be similar under both scenarios. The water
42 temperature threshold exceedance analysis that indicated that the water
43 temperature thresholds for fall-run Chinook Salmon spawning and egg incubation
44 would be exceeded slightly less frequently in the Feather River and Clear Creek

1 under Alternative 3. Given the inherent uncertainty associated with the resolution
2 of the temperature model (average monthly outputs), the reduced frequency of
3 exceedance of temperature thresholds under Alternative 3 could reduce the
4 potential for adverse effects on the fall-run Chinook Salmon populations in Clear
5 Creek and the Feather River. Results of the analysis using Reclamation's salmon
6 mortality model indicate that there would be little difference in fall-run Chinook
7 Salmon egg mortality under Alternative 3 and the Second Basis of Comparison.

8 These model results suggest that overall, effects on fall-run Chinook Salmon
9 could be slightly less adverse under Alternative 3 than the Second Basis of
10 Comparison. Ocean harvest restrictions under Alternative 3 could provide
11 additional benefit; however, the potential effects of the predator management
12 program under Alternative 3 would be uncertain.

13 *Late Fall-Run Chinook Salmon*

14 Differences in temperature conditions in the Sacramento River downstream of
15 Keswick Dam for late fall-run Chinook Salmon between Alternative 3 and the
16 Second Basis of Comparison generally would be similar to those described above
17 for fall-run Chinook Salmon. Results from the SALMOD model, which reflects
18 temperature and flow conditions in the Sacramento River, suggested that
19 long-term annual potential production under Alternative 3 would be slightly lower
20 (up to 2 percent) than under the Second Basis of Comparison, except in critical
21 dry years when production under Alternative 3 would be about 4 percent higher.

22 *Changes in Delta Passage Model Output*

23 The Delta Passage Model predicted similar estimates of annual Delta survival
24 across the 81-year time period for late fall-run Chinook Salmon between
25 Alternative 3 and the Second Basis of Comparison (Appendix 9J). Median Delta
26 survival would be 0.199 for both scenarios.

27 *Changes in Delta Hydrodynamics*

28 The late fall-run Chinook Salmon migration period overlaps with the winter-run.
29 See the section on hydrodynamic analysis for winter-run Chinook Salmon for
30 potential effects on late fall-run Chinook Salmon.

31 *Changes in Junction Entrainment*

32 Entrainment probabilities for late fall-run Chinook Salmon are assumed to mimic
33 that of winter-run Chinook Salmon due to the overlap in timing. See the section
34 on winter-run Chinook Salmon entrainment for potential effects on late fall-run
35 Chinook Salmon.

36 *Changes in Salvage*

37 Salvage of late fall-run Chinook Salmon is assumed to mimic that of winter-run
38 Chinook Salmon due to overlap in timing. See the section on winter-run Chinook
39 Salmon entrainment for potential effects on the late fall-run Chinook Salmon.

1 *Summary of Effects on Late Fall-Run Chinook Salmon*

2 The multiple model and analysis outputs described above characterize the
3 anticipated conditions for late fall-run Chinook Salmon and their response to
4 change under Alternative 3 and the Second Basis of Comparison. For the purpose
5 of analyzing effects on late fall-run Chinook Salmon and developing conclusions,
6 greater reliance was placed on the outputs from the SALMOD model because it
7 integrates the available information on temperature and flows to produce
8 estimates of mortality for each life stage and an overall, integrated estimate of
9 potential fall-run Chinook Salmon juvenile production. The output from
10 SALMOD suggested that late fall-run Chinook Salmon production would be
11 similar under Alternative 3 and the Second Basis of Comparison.

12 Although, potential losses of juvenile salmon at the export facilities could be
13 higher under Alternative 3, as suggested by the analysis of salvage, it is likely that
14 effects on the late fall-run Chinook Salmon population would be similar under
15 Alternative 3 and the Second Basis of Comparison.

16 *Steelhead*

17 The multiple model and analysis outputs described above characterize the
18 anticipated conditions for steelhead and their response to change under
19 Alternative 3 and the Second Basis of Comparison. The analysis of the effects of
20 Alternative 3 and the Second Basis of Comparison for steelhead relied on the
21 WUA analysis for habitat and water temperature model output for the rivers at
22 various locations downstream of the CVP and SWP facilities. The WUA analysis
23 indicated that the availability of steelhead spawning and rearing habitat in Clear
24 Creek and steelhead spawning habitat in the Sacramento, Feather and American
25 rivers would be similar under Alternative 3 and the Second Basis of Comparison.
26 The temperature model outputs for each of the steelhead life stages suggest that
27 thermal conditions and effects on steelhead in all of these streams generally would
28 be similar under Alternative 3 and the Second Basis of Comparison, but cannot be
29 fully characterized in the Feather River. This conclusion is supported by the
30 water temperature threshold exceedance analysis that indicated that the water
31 temperature thresholds for steelhead spawning and egg incubation would be
32 exceeded less frequently in the Feather River under Alternative 3. However, the
33 water temperature threshold for steelhead rearing in the Feather River would be
34 exceeded less frequently in some months and more frequently in others under
35 Alternative 3. The water temperature threshold for steelhead rearing in the
36 American River would also be exceeded more frequently in most months under
37 Alternative 3. Because of the inherent uncertainty associated with the resolution
38 of the temperature model (average monthly outputs), and the differences in the
39 magnitude and direction of the temperature exceedances under Alternative 3, the
40 extent of temperature-related effects on steelhead in the Feather River is
41 uncertain.

42 These model results suggest that overall, effects on steelhead could be slightly
43 more adverse under Alternative 3 than the Second Basis of Comparison,
44 particularly in the Feather and American rivers.

1 *Sturgeon (green and white)*

2 The analysis of the effects of Alternative 3 and Second Basis of Comparison for
3 sturgeon relied on water temperature model output for the Sacramento and
4 Feather rivers at various locations downstream of Shasta Dam and the Thermalito
5 complex. The temperature model outputs for each of these rivers suggest that
6 thermal conditions and effects on sturgeon in the Sacramento and Feather rivers
7 generally would be similar under both scenarios. This conclusion is supported by
8 the water temperature threshold exceedance analysis that indicated that the water
9 temperature thresholds for sturgeon spawning, incubation, and rearing would be
10 exceeded slightly less frequently under Alternative 3 in the Sacramento River.
11 The water temperature threshold for sturgeon spawning, incubation, and rearing
12 also would be exceeded slightly less frequently in the Feather River. Given the
13 inherent uncertainty associated with the resolution of the temperature model
14 (average monthly outputs), the slightly reduced frequency of exceedance of
15 temperature thresholds under Alternative 3 could reduce the potential for adverse
16 effects on sturgeon in the Sacramento and Feather rivers relative to the Second
17 Basis of Comparison.

18 *Delta Smelt*

19 *Changes in Proportional Entrainment*

20 As described in Appendix 9G, a proportional entrainment regression model
21 (based on Kimmerer 2008, 2011) was used to simulate adult Delta Smelt
22 entrainment, as influenced by OMR flow in December through March. Results
23 indicate that the percentage of entrainment of migrating and spawning adult Delta
24 Smelt under the Second Basis of Comparison would be 8.1 to 9.8 percent,
25 depending on the water year type, with a long term average percent entrainment
26 of 9 percent. Percent entrainment of adult Delta Smelt under Alternative 3 would
27 be similar to results under the Second Basis of Comparison (lower by 0.8 to
28 1.6 percent depending on water year type). Under Alternative 3, the long term
29 average percent entrainment would be 7.9 percent.

30 As described in Appendix 9G, a proportional entrainment regression model
31 (based on Kimmerer 2008) was used to simulate larval and early juvenile Delta
32 Smelt entrainment, as influenced by OMR flow and location of X2 in March
33 through June. Results indicate that the percentage of entrainment of larval and
34 early juvenile Delta Smelt under the Second Basis of Comparison would be 6.9 to
35 23.6 percent, depending on the water year type, with a long term average percent
36 entrainment of 15.5 percent, and highest entrainment under Critical water year
37 conditions. Percent entrainment of larval and early juvenile Delta Smelt under
38 Alternative 3 would be similar to results under the Second Basis of Comparison
39 (lower by 1.3 to 4.4 percent). Under Alternative 3, the long term average percent
40 entrainment would be 12.7 percent, and highest entrainment would occur under
41 Critical water year conditions, at 20.5 percent. These Alternative 3 values are
42 similar to comparable values under the Second Basis of Comparison (estimated to
43 be 2.8 and 3.1 percent lower, respectively).

1 *Changes in Fall Abiotic Habitat Index*

2 The average September through December X2 position in km was used to
3 evaluate the fall abiotic habitat availability for delta smelt under the Alternatives.
4 X2 values simulated in the CalSim II model for each alternative were averaged
5 over September through December, and compared. Results indicate that under
6 the Second Basis of Comparison, the X2 position would range from 85.6 km to
7 92.3 km, depending on the water year type, with a long term average X2 position
8 of 88.1 km. The most eastward location of X2 is predicted under Critical water
9 year conditions. The X2 positions predicted under Alternative 3 would be similar
10 to predictions under the Second Basis of Comparison (only 0.1 to 0.3 km
11 difference). Under Alternative 3, the long term average X2 position would be
12 88.1 km, a location that does not provide for the advantageous overlap of the low
13 salinity zone with Suisun Bay/Marsh.

14 *Summary of Effects on Delta Smelt*

15 Overall, Alternative 3 likely would have similar effects on Delta Smelt, as
16 compared to the Second Basis of Comparison with regard to estimated
17 entrainment and predicted location of Fall X2.

18 *Longfin Smelt*

19 The effects of the Alternative 3 as compared to the Second Basis of Comparison
20 were analyzed based on the direction and magnitude of OMR flows during the
21 period (December through June) when adult, larvae, and young juvenile Longfin
22 Smelt are present in the Delta in the vicinity of the export facilities
23 (Appendix 5A). The analysis was augmented with calculated Longfin Smelt
24 abundance index values (Appendix 9G) per Kimmerer et al. (2009), which is
25 based on the assumptions that lower X2 values reflect higher flows and that
26 transporting Longfin Smelt farther downstream leads to greater Longfin Smelt
27 survival. The index value indicates the relative abundance of Longfin Smelt and
28 not the calculated population.

29 As described in Appendix 5A, OMR flows would be negative in all months under
30 both Alternative 3 and the Second Basis of Comparison. Flows under Alternative
31 3 generally would be less negative than under the Second Basis of Comparison,
32 except in June, July, and August, when OMR flows under Alternative 3 would be
33 more negative by greater 25 percent in some months and year types. The increase
34 in the magnitude of negative flows in June, July, and August under Alternative 3
35 could increase the likelihood of entrainment of Longfin Smelt at the export
36 facilities.

37 Under Alternative 3, Longfin Smelt abundance index values calculated for long-
38 term average conditions and for each water year type for the different alternatives
39 (see Appendix 9G) range from 1,094 under critical water year conditions to a high
40 of 15,638 under wet water year conditions, with a long-term average value of
41 7,345. Under the Second Basis of Comparison, Longfin Smelt abundance index
42 values range from 947 under critical water year conditions to a high of
43 15,822 under wet water year conditions, with a long-term average value of 7,257.

1 Results indicate that the Longfin Smelt abundance index values would be higher
2 in most water year types under Alternative 3 than they would be under the Second
3 Basis of Comparison, with a long-term average index for Alternative 3 that is
4 1.2 percent higher than the long-term average index under the Second Basis of
5 Comparison. The greatest increase in the Longfin Smelt abundance index occurs
6 in critical years where it is 15.5 percent greater under Alternative 3 than under the
7 Second Basis of Comparison. For above normal, below normal, and dry water
8 years, the Longfin Smelt abundance index values would be 1.5 to 13.8 percent
9 higher under Alternative 3 than under the Second Basis of Comparison. In wet
10 years, the Longfin Smelt abundance index would be 1.2 percent lower under
11 Alternative 3 as compared to the Second Basis of Comparison. Based on the
12 Longfin Smelt abundance indices, Alternative 3 likely would have beneficial
13 effects on Longfin Smelt, as compared to the Second Basis of Comparison.

14 Overall, based on the relative decrease in frequency and magnitude of negative
15 OMR flows and the higher Longfin Smelt abundance index values, especially in
16 critical years, Alternative 3 would be likely to positively affect the Longfin Smelt
17 population as compared to the Second Basis of Comparison.

18 *Sacramento Splittail*

19 Under Alternative 3, flows entering the Yolo Bypass generally would be slightly
20 less than flows under the Second Basis of Comparison (Appendix 5A,
21 Table C-26-5). These decreases likely would be insufficient to reduce potential
22 Sacramento Splittail spawning habitat in the bypass.

23 *Killer Whale*

24 As described above for the comparison of Alternative 1 to the No Action
25 Alternative, it is unlikely that the Chinook Salmon prey base of killer whales,
26 supported heavily by hatchery production of fall-run Chinook Salmon, would be
27 appreciably affected by any of the alternatives.

28 *Reservoir Fishes*

29 The analysis of effects associated with changes in operation on reservoir fishes
30 relied on evaluation of changes in available habitat (reservoir storage) and
31 anticipated changes in black bass nesting success.

32 Alternative 3 as compared to the Second Basis of Comparison generally would
33 result in similar (differences less than 5 percent) storage levels in CVP and SWP
34 reservoirs during the March through June period (Appendix 5A).

35 In general, black bass nesting success also would be similar under Alternative 3
36 and the Second Basis of Comparison. Nesting success of black bass would be
37 high in March and April due to increasing water surface elevations. During May,
38 the likelihood of high (>40 percent) nesting success would be similar to or
39 slightly higher in most of the reservoirs under Alternative 3 as compared to the
40 Second Basis of Comparison. This pattern is reversed in June, with the likelihood
41 of high nesting success being somewhat lower under Alternative 3 (Appendix 9F).

1 Overall, the changes in nest success would be relatively small, and the decreases
2 in June under Alternative 3 would occur after the peak in spawning. Thus, effects
3 on nest success are expected to be similar between the two alternatives.

4 *Other Species*

5 Several other fish species could be affected by changes in operations that
6 influence temperature and flow. Given the generally small differences in flows
7 and water temperatures between Alternative 3 and the Second Basis of
8 Comparison, it is anticipated that the effect on other species (including Pacific
9 Lamprey, Striped Bass, American Shad, and Hardhead) generally would be the
10 same under both scenarios.

11 *Stanislaus River/Lower San Joaquin River*

12 *Fall-Run Chinook Salmon*

13 Changes in operations influence temperature and flow conditions that could affect
14 fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam
15 and in the San Joaquin River below Vernalis. The following describes those
16 changes and their potential effects.

17 *Changes in Water Temperature (Stanislaus River)*

18 Average monthly water temperatures in the Stanislaus River at Goodwin Dam
19 under Alternative 3 generally would be similar to the Second Basis of Comparison
20 but could be lower (up to 1.5°F) than under the Second Basis of Comparison in
21 September, October, November, and December of drier years (Appendix 6B,
22 Table B-17-5). Downstream at Orange Blossom Bridge, average monthly water
23 temperatures in October through December under Alternative 3 also would be
24 similar (less than 0.5°F difference) to under the Second Basis of Comparison
25 except in June when the average monthly water temperature would be 2.8°F
26 warmer and up to 4.3°F warmer in drier years. Average monthly water
27 temperatures from August to November would be up to 1.6°F cooler in critical
28 dry years under Alternative 3 as compared to the Second Basis of Comparison
29 (Appendix 6B, Table B-18-5). This temperature pattern would continue
30 downstream to the confluence with the San Joaquin River, although the
31 magnitude of temperature decrease under Alternative 3 (Appendix 6B,
32 Table B-19-5) would be smaller. Lower fall water temperatures in drier years
33 would reduce the likelihood of adverse effects on spawning fall-run Chinook
34 Salmon.

35 *Changes in Exceedance of Water Temperature Thresholds (Stanislaus
36 River)*

37 While specific water temperature thresholds for fall-run Chinook Salmon in the
38 Stanislaus River are not established, temperatures generally suitable for fall-run
39 Chinook Salmon spawning (56°F) would be exceeded in October (over 30 percent
40 of the time) and November over 20 percent of the time in the Stanislaus River at
41 Goodwin Dam under Alternative 3 (Appendix 6B, Table B-17-1). Similar
42 exceedances would occur under the Second Basis of Comparison. Water
43 temperatures for rearing generally would be below 56°F, except in May.

1 Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run
2 Chinook Salmon spawning would be exceeded frequently under both Alternative
3 3 and the Second Basis of Comparison during October and November, but the
4 56°F threshold would be exceeded 2 percent more frequently in October and
5 4 percent less frequently in November percent.

6 During January through May, rearing fall-run Chinook Salmon under Alternative
7 3 would be subjected to average monthly water temperatures that exceed 56°F;
8 however, the differences between Alternative 3 and the Second Basis of
9 Comparison could be biologically meaningful, with Alternative 3 exceeding the
10 threshold in April about 4 percent less frequently and about 7 percent more
11 frequently in May (Appendix 6B, Figure B-18-5).

12 *Changes in Egg Mortality (Stanislaus River)*

13 For fall-run Chinook Salmon in the Stanislaus River, egg mortality rates would be
14 similar under both scenarios, with Alternative 3 exhibiting a long-term average
15 egg mortality rate of about 1.2 percent lower than under the Second Basis of
16 Comparison, with predicted egg mortality rates lower (by 2.5 percent) in critical
17 dry years (Appendix 9C, Table B-8).

18 *Changes in Delta Hydrodynamics*

19 San Joaquin River-origin fall-run Chinook Salmon smolts are most abundant in
20 the Delta during the months of April, May and June. Near the confluence of the
21 San Joaquin River and the Mokelumne River, the proportion of positive velocities
22 would be slightly lower under Alternative 3 relative to the Second Basis of
23 Comparison in the months when fall-run would be most abundant (Appendix 9K).
24 On Old River downstream of the facilities, the proportion of positive velocities
25 would be slightly, to moderately higher in April and May, and moderately lower
26 in June under Alternative 3 relative to the Second Basis of Comparison. In Old
27 River upstream of the facilities, the percent of positive velocities would be
28 considerably higher under Alternative 3 in April and May, and moderately lower
29 in June. On the San Joaquin River downstream of the Head of Old River, the
30 percent of positive velocities would be considerably lower under Alternative 3
31 relative to the Second Basis of Comparison in April and May, and moderately
32 lower in June.

33 *Changes in Entrainment at Junctions*

34 Entrainment at the Georgiana Slough Junction under Alternative 3 would be
35 almost indistinguishable from the Second Basis of Comparison in April, May, and
36 June (Appendix 9L). At the Head of Old River junction in April and May,
37 entrainment would be much greater under Alternative 3 relative to the Second
38 Basis of Comparison (Appendix 9L). In June, entrainment would be
39 indistinguishable under each alternative. Patterns of entrainment would be similar
40 at Turner Cut, Columbia Cut, Middle River, and Old River). At these junctions,
41 entrainment under Alternative 3 would be moderately lower in April and May,
42 and slightly lower or almost indistinguishable in June.

1 *Summary of Effects on Fall-Run Chinook Salmon*

2 The analysis of temperatures indicates somewhat similar temperatures and a
3 similar likelihood of exceedance of suitable temperatures for spawning and
4 rearing of fall-run Chinook Salmon under Alternative 3 as compared to the
5 Second Basis of Comparison in the Stanislaus River below Goodwin Dam and in
6 the San Joaquin River at Vernalis. The effect of lower temperatures is reflected in
7 the similar overall mortality of fall-run Chinook Salmon eggs predicted by
8 Reclamation's salmon mortality model for fall-run in the Stanislaus River.
9 Overall, Alternative 3 likely would have similar effects on the fall-run Chinook
10 Salmon population in the San Joaquin River watershed as compared to the Second
11 Basis of Comparison.

12 *Steelhead*

13 Changes in operations that influence temperature and flow conditions in the
14 Stanislaus River downstream of Goodwin Dam and the San Joaquin River below
15 Vernalis could affect steelhead. The following describes those changes and their
16 potential effects.

17 *Changes in Water Temperature (Stanislaus River)*

18 Average monthly water temperatures in the Stanislaus River at Goodwin Dam
19 under Alternative 3 generally would be similar to the Second Basis of Comparison
20 but could be lower (up to 1.5°F) than under the Second Basis of Comparison in
21 September, October, November, and December of drier years. Downstream at
22 Orange Blossom Bridge, average monthly water temperatures in October through
23 December under Alternative 3 also would be similar (less than 0.5°F difference)
24 to under the Second Basis of Comparison except in June when the average
25 monthly water temperature would be 2.8°F warmer and up to 4.3°F warmer in
26 drier years. Average monthly water temperatures from August to November
27 would be up to 1.6°F cooler in critical dry years under Alternative 3 as compared
28 to the Second Basis of Comparison. Second Basis of Comparison. This
29 temperature pattern would continue downstream to the confluence with the San
30 Joaquin River, although the magnitude of temperature decrease under Alternative
31 3 would be smaller.

32 *Changes in Exceedance of Water Temperature Thresholds (Stanislaus*
33 *River)*

34 Average monthly water temperatures in the Stanislaus River at Orange Blossom
35 Bridge would frequently exceed the temperature threshold (56°F) established for
36 adult steelhead migration under both Alternative 3 and the Second Basis of
37 Comparison during October and November, with the threshold being exceeded
38 2 percent more frequently in October and 4 percent less frequently in November
39 percent. In January through May, the temperature threshold at Orange Blossom
40 Bridge is 55°F, which is intended to support steelhead spawning. Under
41 Alternative 3, this threshold would be exceeded under Alternative 3 about
42 8 percent and 10 percent more frequently in March and May, respectively, than
43 under the Second Basis of Comparison. However, the threshold would be
44 exceeded 16 percent less frequently under Alternative 3 in April.

1 During June through November, the temperature threshold of 65°F established to
 2 support steelhead rearing would be exceeded under both Alternative 3 and the
 3 Second Basis of Comparison in all months but November, with the highest
 4 frequency of exceedance in July (19 percent under Alternative 3). The
 5 differences between Alternative 3 and the Second Basis of Comparison, however,
 6 would be variable depending on the month, with water temperatures under
 7 Alternative 3 exceeding the threshold 2 percent to 4 percent more frequently than
 8 under the Second Basis of Comparison in June and July and up to 4 percent less
 9 frequently from August to October.

10 Average monthly water temperatures also would exceed the threshold (52°F)
 11 established for smoltification at Knights Ferry from January through May under
 12 both Alternative 3 and the Second Basis of Comparison. Differences in the
 13 likelihood of threshold exceedance between scenarios could be biologically
 14 meaningful (up to 3 percent) with the threshold being more likely to be exceeded
 15 in March and less likely to be exceeded in April and May. Farther downstream at
 16 Orange Blossom Bridge, the temperature threshold for smoltification is higher
 17 (57°F). Under Alternative 3, water temperatures would exceed the 57°F threshold
 18 about 4 percent less frequently in April and about 7 percent more frequently than
 19 under the Second Basis of Comparison in May.

20 *Changes in Delta Hydrodynamics*

21 San Joaquin River-origin steelhead generally move through the Delta during
 22 spring; however, there is less information on their timing than there is for
 23 Chinook salmon. Thus, hydrodynamics in the entire January through June period
 24 could have the potential to affect juvenile steelhead. For a description of potential
 25 hydrodynamic effects on steelhead, see the descriptions for winter-run Chinook
 26 Salmon in the Sacramento Basin and fall-run Chinook Salmon in the San Joaquin
 27 River basin, above.

28 *Changes in Entrainment at Junctions*

29 At the Head of Old River junction, entrainment would be somewhat lower under
 30 Alternative 3 in January, February, and March (Appendix 9L). In April and May,
 31 entrainment would be much greater under Alternative 3. In June, entrainment
 32 would be indistinguishable relative to the Second Basis of Comparison. At
 33 Turner Cut, entrainment would always be lower under Alternative 3 than under
 34 the Second Basis of Comparison; however, these differences would be greater in
 35 April and May relative to other months. Entrainment at Columbia Cut would be
 36 slightly lower under Alternative 3 during January, February, April, and May. In
 37 March and June, entrainment would be indistinguishable. At the Middle River
 38 junction, entrainment would be lower under Alternative 3 than under the Second
 39 Basis of Comparison during January, February, and April. Entrainment under
 40 these two scenarios would be almost indistinguishable during March, May, and
 41 June. Alternative 3 would result in lower entrainment probabilities at the Old
 42 River junction during January and February, whereas entrainment would be
 43 indistinguishable in other months.

1 *Summary of Effects on Steelhead*

2 Given the frequency of exceedance under both Alternative 3 and the Second Basis
3 of Comparison, water temperature conditions for steelhead in the Stanislaus River
4 would be similar. The differences in temperature exceedance (both positive and
5 negative) between Alternative 3 and the Second Basis of Comparison would be
6 relative small, with no clear benefit associated with either alternative.

7 *White Sturgeon*

8 Evidence of White Sturgeon spawning has been recorded in the San Joaquin River
9 upstream of the confluence with the Stanislaus River. While flows in the San
10 Joaquin River upstream of the Stanislaus River are expected be similar under all
11 alternatives, flow contributions from the Stanislaus River could influence water
12 temperatures in the San Joaquin River where White Sturgeon eggs or larvae may
13 occur during the spring and early summer. The magnitude of influence on water
14 temperature would depend on the proportional flow contribution of the Stanislaus
15 River and the temperatures in both the Stanislaus and San Joaquin rivers. The
16 potential for an effect on White Sturgeon eggs and larvae would be influenced by
17 the proportion of the population occurring in the San Joaquin River. In
18 consideration of this uncertainty, it is not possible to distinguish potential effects
19 on White Sturgeon between alternatives.

20 *Reservoir Fishes*

21 *Changes in Available Habitat (Storage)*

22 As described in Chapter 5, Surface Water Resources and Water Supplies, storage
23 levels in New Melones Reservoir would be higher under Alternative 3 as
24 compared to the Second Basis of Comparison, as summarized in Table 5.38, due
25 to higher allocations of water supplies to CVP water service contractors, less
26 fisheries flows, no water quality releases under SWRCB D-1641, and no
27 Bay-Delta flow releases under SWRCB D-1641.

28 Storage in New Melones could be increased up to around 20 percent in some
29 months of some water year types. Additional information related to monthly
30 reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.
31 It is anticipated that aquatic habitat within New Melones is not limiting; however,
32 storage volume is an indicator of how much habitat is available to fish species
33 inhabiting these reservoirs. Therefore, the amount of habitat for reservoir fishes
34 could be increased under Alternative 3 as compared to the Second Basis of
35 Comparison.

36 *Changes in Black Bass Nesting Success*

37 Results of the bass nesting success analysis are presented in Appendix 9F,
38 Reservoir Fish Analysis Documentation. For March, the likelihood of
39 Largemouth Bass and Smallmouth Bass nest survival in New Melones being
40 above 40 percent is similar under Alternative 3 and the Second Basis of
41 Comparison. For April, the likelihood that nest survival of Largemouth Bass and
42 Smallmouth Bass is between 40 and 100 percent is reasonably high (around
43 80 percent) but is somewhat (about 5 percent) lower 3 under Alternative 3 as
44 compared to the Second Basis of Comparison. For May, the pattern is reversed

1 with the likelihood of high nest survival being about 710 percent greater under
 2 Alternative 3. For June, the likelihood of survival being greater than 40 percent
 3 for Largemouth Bass and Smallmouth Bass in New Melones is about 38 percent
 4 greater under Alternative 3 as compared to the Second Basis of Comparison. For
 5 Spotted Bass, nest survival in March is anticipated to be near 100 percent in every
 6 year under both Alternative 3 and the Second Basis of Comparison. The
 7 likelihood of survival being greater than 40 percent in April is 100 percent under
 8 both Alternative 3 and the Second Basis of Comparison. For May, the likelihood
 9 of Spotted Bass nest survival being greater than 40 percent is slightly (about
 10 2 percent) higher under Alternative 3. For June, Spotted Bass nest survival would
 11 be greater than 40 percent in every year under Alternative 3 and the Second Basis
 12 of Comparison.

13 *Other Species*

14 Changes in operations that influence temperature and flow conditions in the
 15 Stanislaus River downstream of Goodwin Dam and the San Joaquin River at
 16 Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.
 17 As described above, water temperatures would generally be similar under
 18 Alternative 3 and the Second Basis of Comparison. In general, lampreys, Striped
 19 Bass and Hardhead can tolerate higher temperatures than salmonids. Given the
 20 similar flows and temperatures during their spawning and incubation period, it is
 21 likely that the potential to affect these species in the Stanislaus and San Joaquin
 22 rivers would be similar under Alternative 3 and the Second Basis of Comparison.

23 *San Francisco Bay Area Region*

24 *Killer Whale*

25 As described above for the comparison of Alternative 1 to the No Action
 26 Alternative, it is unlikely that the Chinook Salmon prey base of killer whales,
 27 supported heavily by hatchery production of fall-run Chinook Salmon, would be
 28 appreciably affected by any of the alternatives.

29 **9.4.3.5 Alternative 4**

30 The CVP and SWP operations under Alternative 4 are identical to the CVP and
 31 SWP operations under the Second Basis of Comparison and Alternative 1, as
 32 described in Chapter 3, Description of Alternatives. Alternative 4 also includes
 33 the following items that are not included in the No Action Alternative or the
 34 Second Basis of Comparison and would affect fish and aquatic resources.

- 35 • Implement predator control programs for black bass, Striped Bass, and
 36 Pikeminnow to protect salmonids and Delta Smelt as follows:
 - 37 – Black bass catch limit changed to allow catch of 12-inch fish with a bag
 38 limit of 10
 - 39 – Striped Bass catch limit changed to allow catch of 12-inch fish with a bag
 40 limit of 5
 - 41 – Establish a Pikeminnow sport-fishing reward program with a 8-inch limit
 42 at \$2/fish

- 1 • Establish a trap and haul program for juvenile salmonids entering the Delta
2 from the San Joaquin River in March through June as follows:
 - 3 – Begin operation of downstream migrant fish traps upstream of the Head of
4 Old River on the San Joaquin River
 - 5 – “Barge” all captured juvenile salmonids through the Delta, release at
6 Chipps Island.
 - 7 – Tag subset of fish in order to quantify effectiveness of the program
 - 8 – Attempt to capture 10 percent to 20 percent of outmigrating juvenile
9 salmonids
 - 10 • Work with Pacific Fisheries Management Council, CDFW, and NMFS to
11 impose salmon harvest restrictions to reduce by-catch of winter-run and
12 spring-run Chinook Salmon to less than 10 percent of age-3 cohort in all years
- 13 As described in Chapter 4, Approach to Environmental Analysis, Alternative 4 is
14 compared to the No Action Alternative and the Second Basis of Comparison.

15 **9.4.3.5.1 Alternative 4 Compared to the No Action Alternative**

16 *Trinity River Region*

17 The CVP and SWP operations under Alternative 4 are identical to the CVP and
18 SWP operations under the Second Basis of Comparison and Alternative 1.
19 Therefore, changes in aquatic resources at Trinity Lake and along the Trinity
20 River and lower Klamath River under Alternative 4 as compared to the No Action
21 Alternative would be the same as the impacts described in Section 10.4.4.2.1,
22 Alternative 1 Compared to the No Action Alternative.

23 *Central Valley Region*

24 The CVP and SWP operations under Alternative 4 are identical to the CVP and
25 SWP operations under the Second Basis of Comparison and Alternative 1.
26 Therefore, changes in aquatic habitat conditions at CVP and SWP reservoirs, in
27 the rivers downstream of the reservoirs, and in the Delta under Alternative 4 as
28 compared to the No Action Alternative would be the same as the impacts
29 described in Section 10.4.4.2.1, Alternative 1 Compared to the No Action
30 Alternative.

31 Conditions related to salmonid survival could be improved under Alternative 4 as
32 compared to the No Action Alternative due to implementation of: trap and haul
33 program, changes in bag limits, and changes in PMFC/NMFS harvest limits.

34 *San Francisco Bay Area Region*

35 *Killer Whale*

36 As described above the comparison of Alternative 1 to the No Action Alternative,
37 it is unlikely that the Chinook Salmon prey base of killer whales, supported
38 heavily by hatchery production of fall-run Chinook Salmon, would be appreciably
39 affected by any of the alternatives.

1 **9.4.3.5.2 Alternative 4 Compared to the Second Basis of Comparison**

2 *Trinity River Region*

3 The CVP and SWP operations under Alternative 4 are identical to the CVP and
4 SWP operations under the Second Basis of Comparison and Alternative 1.
5 Therefore, aquatic resources conditions at Trinity Lake and along the Trinity
6 River and lower Klamath River under Alternative 4 be the same as under the
7 Second Basis of Comparison.

8 *Central Valley Region*

9 The CVP and SWP operations under Alternative 4 are identical to the CVP and
10 SWP operations under the Second Basis of Comparison and Alternative 1.
11 Therefore, aquatic resources conditions at Trinity Lake and along the Trinity
12 River and lower Klamath River under Alternative 4 be the same as under the
13 Second Basis of Comparison.

14 Conditions related to salmonid survival could be improved under Alternative 4 as
15 compared to the Second Basis of Comparison due to implementation of the Trap
16 and Haul Program, changes in bag limits, and changes in PMFC/NMFS harvest
17 limits.

18 *Killer Whale*

19 As described above for the comparison of Alternative 1 to the No Action
20 Alternative, it is unlikely that the Chinook Salmon prey base of killer whales,
21 supported heavily by hatchery production of fall-run Chinook Salmon, would be
22 appreciably affected by any of the alternatives.

23 **9.4.3.6 Alternative 5**

24 As described in Chapter 3, Description of Alternatives, CVP and SWP operations
25 under Alternative 5 are similar to the No Action Alternative with modified OMR
26 flow criteria and New Melones Reservoir operations. As described in Chapter 4,
27 Approach to Environmental Analysis, Alternative 5 is compared to the No Action
28 Alternative and the Second Basis of Comparison.

29 Alternative 5 also includes the Delta Cross Channel Temporary Closure Multi-
30 year Study. As noted in the Finding of No Significant Impact (FONSI) document
31 from Reclamation (Reclamation, 2012), this study proposes closing the DCC for
32 up to 10 days during the first half of October from 2012 through 2016. The
33 FONSI also notes that the DCC closure would not cause any adverse effects to the
34 native aquatic and fisheries. Therefore, the effects of this study are not
35 considered any further in the impact analyses for Alternative 5 below.

36 **9.4.3.6.1 Alternative 5 Compared to the No Action Alternative**

37 Because of the considerable similarities between Alternative 5 and the No Action
38 Alternative, the analysis below combines species within some regions where to
39 reduce repetition.

1 *Trinity River Region*

2 *Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon,*
3 *Steelhead, and Green Sturgeon*

4 Average monthly water temperature in the Trinity River at Lewiston Dam under
5 Alternative 5 would be similar to the No Action Alternative (less than 0.3°F) in
6 all months (Appendix 6B, Table B-1-3). Similarly, the differences in the
7 frequency with which Alternative 5 and the No Action Alternative would exceed
8 established temperature thresholds also would be small (up to 1 or 2 percent)
9 (Appendix 9N). These temperature results are reflected in the egg mortality
10 results for fall-run Chinook Salmon in the Trinity River, which indicate similar
11 mortality, with differences (generally less than 0.1 percent) even in critical dry
12 years (Appendix 9C, Table B-5).

13 The minor differences in temperature and mortality results suggest that conditions
14 for Coho Salmon, spring-run Chinook Salmon, fall-run Chinook Salmon,
15 steelhead and Green Sturgeon in the Trinity River generally would be similar
16 under Alternative 5 and the No Action Alternative.

17 *Reservoir Fishes*

18 Reservoir fishes in Trinity Lake would be exposed to relatively minor differences
19 in storage (less than 5 percent) under Alternative 5 (Appendix 5A) as compared to
20 the No Action Alternative and these relatively small differences likely would have
21 little effect on the amount of habitat available for these species. Black bass
22 nesting survival would be similar under Alternative 5 and the No Action
23 Alternative (Appendix 9F). The minor differences in nest survival suggest that
24 conditions for black bass species in Trinity Lake would be similar under
25 Alternative 5 and the No Action Alternative.

26 *Other Species*

27 The minor differences in average monthly water temperatures described above for
28 salmonids apply to Pacific Lamprey and Eulachon. These minor differences
29 suggest that conditions for aquatic species in the Trinity River and Klamath River
30 downstream of the confluence generally would be similar under Alternative 5 and
31 the No Action Alternative.

32 *Sacramento River System*

33 *Winter-run Chinook Salmon*

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

37 *Changes in Water Temperature*

38 Monthly water temperature in the Sacramento River at Keswick Dam under
39 Alternative 5 and the No Action Alternative would be relatively unchanged, with
40 minor differences in some months and water year types of less than 0.2°F
41 (Appendix 6B, Table B-5-3). Differences in the frequency of exceeding
42 temperature thresholds under Alternative 5 and the No Action Alternative would
43 be similar (differences less than 3 percent) (Appendix 9N). The differences

1 predicted at locations in the downstream reaches are similar to those predicted at
2 Keswick Dam.

3 Egg mortality is anticipated to be unchanged in all but critical dry years, when
4 Alternative 5 would result in 2.5 percent lower mortality than the No Action
5 Alternative, leading to an overall decrease of 0.4 percent under Alternative 5 as
6 compared to the No Action Alternative (Appendix 9C, Table B-4).

7 *Changes in Weighted Usable Area*

8 The WUA results for winter-run Chinook Salmon spawning habitat between
9 Keswick Dam and Battle Creek indicated that available spawning habitat under
10 Alternative 5 and the No Action Alternative would be similar (less than 2 percent
11 difference), (Appendix 9E, Table C-17-3). The results were similar for fry and
12 juvenile rearing (Appendix 9E, Table C-18-3 and Table C-19-3).

13 *Changes in SALMOD Output*

14 SALMOD results indicated that the long-term annual potential production for
15 winter-run Chinook Salmon under Alternative 5 would be essentially the same as
16 under the No Action Alternative percent(Appendix 9D, Table B-4-11).

17 *Changes in Delta Passage Model Output*

18 The Delta Passage Model predicted similar estimates of annual Delta survival
19 across the 81-year time period for winter-run Chinook Salmon between
20 Alternative 5 and the No Action Alternative (Appendix 9J). Median Delta
21 survival was 0.35 for Alternative 5 and 0.349 for the No Action Alternative.

22 *Changes in Delta Hydrodynamics*

23 Winter-run Chinook Salmon smolts are most abundant in the Delta during
24 January, February and March. On the Sacramento River near the confluence of
25 Georgiana Slough, the percent of positive velocities under Alternative 5 were
26 indistinguishable from the No Action Alternative in January, February and March
27 (Appendix 9K). On the San Joaquin River near the Mokelumne River confluence,
28 the percent of positive velocities was indistinguishable among these two
29 scenarios. In Old River downstream of the facilities, the percent of positive
30 velocities was indistinguishable in the months when winter run are present). On
31 Old River upstream of the facilities, percent positive velocities were
32 indistinguishable). On the San Joaquin River downstream of the Head of Old
33 River, there was no discernable difference in the percent of positive velocities
34 among these two scenarios.

35 *Changes in Junction Entrainment*

36 For all junctions examined, entrainment probabilities for both Alternative 5 and
37 the No Action Alternative were almost indistinguishable (Appendix 9L).

38 *Changes in Salvage*

39 There were no discernable differences in predicted salvage between Alternative 5
40 and No Action Alternative (Appendix 9M).

1 *Changes in Oncorhynchus Bayesian Analysis Output*

2 Escapement and Delta survival was modeled by the OBAN model for winter-run
3 Chinook salmon. Escapement was similar under Alternative 5 as compared to the
4 No Action Alternative (Appendix 9I) as was through-Delta survival.

5 *Changes in Interactive Object-Oriented Simulation Output*

6 The IOS model predicted similar adult escapement trajectories for winter-run
7 Chinook Salmon between Alternative 5 and the No Action Alternative across the
8 81 water years (Appendix 9H). Alternative 5 median adult escapement was
9 3,545 and No Action Alternative median escapement was 3,935.

10 Similar to adult escapement, the IOS model predicted similar egg survival time
11 histories for winter-run Chinook Salmon between Alternative 5 and the No Action
12 Alternative across the 81 water years (Appendix 9H). Median egg survival was
13 0.989 for Alternative 5 and 0.990 for the No Action Alternative.

14 *Summary of Effects on Winter-Run Chinook Salmon*

15 The analysis of temperatures suggested that the frequency of temperature
16 threshold exceedance under Alternative 5 would remain similar to the No Action
17 Alternative. This was reflected in Reclamation's salmon mortality model results,
18 which showed minor reduction in the mortality in critical years. The analysis of
19 flow changes under Alternative 5 suggested that availability of spawning habitat
20 for winter-run Chinook Salmon is similar to the No Action Alternative, as also
21 was indicated by similar potential production results from SALMOD. Through
22 Delta survival of juvenile winter-run Chinook Salmon would be the same under
23 both Alternative 5 and the No Action Alternative as indicated by the DPM results,
24 and the OBAN results suggest that Delta survival would be similar. Median adult
25 escapement to the Sacramento River would be similar under Alternative 5
26 compared to the No Action Alternative as indicated by the IOS and OBAN model
27 results. Additional analyses attempting to assess the effects on routing,
28 entrainment and salvage of juvenile salmonids in the Delta all indicate the effects
29 would remain similar between Alternative 5 and the No Action Alternative.

30 Considering all the above analyses for the winter-run Chinook Salmon
31 population, the changes in overall effects under Alternative 5 compared to No
32 Action Alternative would remain similar.

33 *Spring-run Chinook Salmon, Fall-run Chinook Salmon, Late Fall-run*
34 *Chinook Salmon, Steelhead, Green Sturgeon and White Sturgeon*

35 *Changes in Water Temperature*

36 Average monthly water temperatures in the Sacramento River under Alternative 5
37 and the No Action Alternative would be relatively unchanged, with minor
38 differences in some months and water year types of less than 0.2°F (Appendix 6B,
39 Table B-5-3). Differences in the frequency of exceeding temperature thresholds
40 under Alternative 5 and the No Action Alternative would be relatively small
41 (differences less than 2 percent) for the spring-run, fall-run, and late fall-run
42 Chinook Salmon, steelhead, and sturgeon in the Sacramento River
43 (Appendix 9N).

1 In Clear Creek, average monthly water temperature at Igo under Alternative 5
2 relative to the No Action Alternative would be similar (differences less than
3 0.4°F) (Appendix 6B, Table B-3-3). The frequency of exceeding temperature
4 thresholds for spring-run Chinook Salmon rearing also would be similar
5 (differences of up to 1 percent) (Appendix 9N).

6 In the Feather River, average monthly water temperature at the low flow channel
7 under Alternative 5 relative to the No Action Alternative would be similar
8 (differences less than 0.2°F) (Appendix 6B, Table B-20-3). Water temperatures at
9 the downstream location also would be similar. Changes in the frequency of
10 exceeding temperature thresholds would be relatively small (differences of
11 2 percent or less) between the two scenarios for the fall-run Chinook Salmon,
12 spring-run Chinook Salmon, steelhead, and Green Sturgeon.

13 In the American River at Watt Avenue, average monthly water temperature under
14 Alternative 5 relative to the No Action Alternative would be similar (differences
15 less than 0.5°F) (Appendix 6B, Table B-13-3). Changes in the frequency of
16 exceeding temperature thresholds would be similar (differences of 1 percent or
17 less) between the two scenarios for the fall-run Chinook Salmon and steelhead.

18 Egg mortality for fall-run Chinook Salmon within the Sacramento River system
19 was predicted to be similar (less than 0.5 percent differences in the long-term
20 average) under Alternative 5 compared to No Action Alternative, except in drier
21 years (Appendix 9C, Tables B-1, B-6 and B-7). On the Sacramento River,
22 mortality under Alternative 5 in critical years is predicted to increase by
23 0.6 percent, and in Feather River mortality increases by 2.3 percent in the below
24 normal years, compared to No Action Alternative.

25 *Changes in SALMOD Output*

26 SALMOD results indicate that long-term annual production for fall-run, late
27 fall-run, and spring-run Chinook Salmon would be essentially unchanged under
28 Alternative 5 relative to the No Action Alternative (Appendix 9D).

29 *Changes in Delta Passage Model Output*

30 The Delta Passage Model predicted similar estimates of annual Delta survival
31 across the 81-year time period for spring-run, fall-run and late fall-run Chinook
32 Salmon between Alternative 5 and the No Action Alternative (Appendix 9J).

33 *Changes in Delta Hydrodynamics*

34 As described in Appendix 9K, the percent of time that velocity was positive at
35 various junctions in the Delta were projected to be similar under Alternative 5
36 compared to the No Action Alternative for fall-run, late fall-run, and spring-run
37 Chinook Salmon, and steelhead.

38 *Changes in Junction Entrainment*

39 As described in Appendix 9L, entrainment at various junctions is
40 indistinguishable or lower under Alternative 5 compared to the No Action
41 Alternative for fall-run, late fall-run, spring-run and steelhead.

1 *Changes in Salvage*

2 As described in Appendix 9M, salvage of migrating spring-run, late-fall run and
3 fall-run smolts is similar or better under Alternative 5 compared to the No Action
4 Alternative.

5 *Summary of Effects on Spring-run Chinook Salmon, Fall-run Chinook*
6 *Salmon, Late Fall-run Chinook Salmon, Steelhead, Green Sturgeon and*
7 *White Sturgeon*

8 The analysis of temperatures indicates similar temperatures and likelihood of
9 exceedance of temperature thresholds under Alternative 5 as compared to the No
10 Action Alternative in the Clear Creek, and the Sacramento, Feather, and
11 American rivers. This was reflected in Reclamation’s salmon mortality model
12 results for the fall-run on the Sacramento, Feather and American River which
13 showed similar mortality results except in a small increase in critical dry years in
14 the Sacramento River and in below normal years in the Feather River. There
15 would be no change in flows in Clear Creek and Feather River low flow channel.
16 Flows are expected to be similar in Sacramento River and American River. Flows
17 in May in the Feather River are reduced (Appendix 5A). However, most of the
18 spawning habitat in the Feather River is in the low flow channel; therefore, this
19 reduction in May flow would only have minor effect on the availability of the
20 habitat. SALMOD results indicate that the potential production for the fall-run,
21 late fall-run and spring-run Chinook Salmon on the Sacramento River remain
22 similar. Delta survival is expected to remain similar as indicated by the Delta
23 Passage Model results, and the entrainment risk would be lower based on the
24 expected changes in OMR flows under Alternative 5. Additional analyses
25 attempting to assess the effects on routing, entrainment and salvage of juvenile
26 salmonids in the Delta all indicate the effects would remain similar between
27 Alternative 5 and the No Action Alternative.

28 Considering all the above analyses for the spring-run, fall-run, late-fall run
29 Chinook Salmon, steelhead, Green Sturgeon, and White Sturgeon population, the
30 changes in overall effects under Alternative 5 compared to No Action Alternative
31 would remain similar.

32 *Delta Smelt*

33 A proportional entrainment regression model (based on Kimmerer 2008, 2011)
34 was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow
35 in December through March. Results indicate that the percentage of entrainment
36 of migrating and spawning adult Delta Smelt under Alternative 5 will be nearly
37 identical to the results estimated for the No Action Alternative (less than
38 0.02 percent different) in all water year types.

39 A proportional entrainment regression model (based on Kimmerer 2008) also was
40 used to simulate larval and early juvenile Delta Smelt entrainment, as influenced
41 by OMR flow and location of X2 in March through June. Results indicate that the
42 percentage of entrainment of larval and early juvenile Delta Smelt under
43 Alternative 5 would be similar to that estimated for the No Action Alternative
44 (estimated to be lower by less than 2 percent).

1 The average September through December X2 position in km was used to
2 evaluate the fall abiotic habitat availability for delta smelt under the Alternatives.
3 X2 values simulated in the CalSim II model for each alternative were averaged
4 over September through December, and compared. Results indicate that fall X2
5 values under Alternative 5 would be nearly identical to the No Action Alternative.

6 Overall, Alternative 5 likely would have similar effects on Delta Smelt with
7 regard to estimated entrainment and predicted location of Fall X2, as the No
8 Action Alternative.

9 *Longfin Smelt*

10 The effects of the Alternative 5 as compared to the No Action Alternative were
11 analyzed based on the direction and magnitude of OMR flows during the period
12 (December through June) when adult, larvae, and young juvenile Longfin Smelt
13 are present in the Delta in the vicinity of the export facilities (Appendix 5A). The
14 analysis was augmented with calculated Longfin Smelt abundance index values
15 (Appendix 9G) per Kimmerer et al. (2009), which is based on the assumptions
16 that lower X2 values reflect higher flows and that transporting Longfin Smelt
17 farther downstream leads to greater Longfin Smelt survival. The index value
18 indicates the relative abundance of Longfin Smelt and not the calculated
19 population.

20 OMR flows generally would be negative in all months under both scenarios,
21 except in April and May when the long-term average would positive. Flows
22 under Alternative 5 during these two months would be more positive than under
23 the No Action Alternative, especially in dry and critical years when OMR flows
24 under Alternative 5 would be positive and flows under the No Action Alternative
25 would be negative. Differences in OMR flow during April and May under
26 Alternative 5 would up to about 1,350 cfs more positive than under the No Action
27 Alternative.

28 Longfin Smelt abundance index values were calculated for long-term average
29 conditions and for each water year type for the different alternatives (see
30 Appendix 9G). Under Alternative 5, Longfin Smelt abundance index values are
31 higher compared to the No Action Alternative as shown in Appendix 9G,
32 Table B-4. Under Alternative 5, Longfin Smelt abundance index values range
33 from 1,204 under critical water year conditions to a high of 16,683 under wet
34 water year conditions, with a long-term average value of 8,015 (Appendix 9G).
35 Under the No Action Alternative, Longfin Smelt abundance index values range
36 from 1,147 under critical water year conditions to a high of 16,635 under wet
37 water year conditions, with a long-term average value of 7,951.

38 Results indicate that the Longfin Smelt abundance index values would be slightly
39 higher in every water year type under Alternative 5 than they would be under the
40 No Action Alternative, with a long-term average index for Alternative 5 that is
41 less than 1 percent higher than the long-term average index for the No Action
42 Alternative. For critical water years, the Longfin Smelt abundance index value
43 would be about 5 percent higher under Alternative 5 than they would be under the
44 No Action Alternative.

1 Overall, the slight decrease in magnitude of negative OMR flows and the
2 relatively small differences in Longfin Smelt abundance index values suggest that
3 Alternative 5 could be more likely than the No Action Alternative to positively
4 affect conditions for Longfin Smelt. However, it is uncertain whether these
5 effects would be biologically meaningful.

6 *Sacramento Splittail*

7 Under Alternative 5, flows entering the Yolo Bypass over the Fremont Weir
8 generally would be similar to the No Action Alternative (Appendix 5A,
9 Table C-26-3), thus providing similar value to Sacramento Splittail because of the
10 similar area of potential habitat (inundation) and the similar frequency of
11 inundation.

12 *Reservoir Fishes*

13 The analysis of effects associated with changes in operation on reservoir fishes
14 relied on evaluation of changes in available habitat (reservoir storage) and
15 anticipated changes in black bass nesting success.

16 Changes in CVP and SWP water supplies and operations under Alternative 5 as
17 compared to the No Action Alternative generally would result in similar reservoir
18 storage in CVP and SWP reservoirs in the Central Valley Region (Appendix 5A).
19 Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be similar
20 under Alternative 5 as compared to the No Action Alternative. Additional
21 information related to monthly reservoir elevations is provided in Appendix 5A,
22 CalSim II and DSM2 Modeling.

23 In general, black bass nesting success would be similar under Alternative 5 and
24 the No Action Alternative (Appendix 9F). Nesting success of black bass would
25 be high in March and April due to increasing water surface elevations. During
26 May, the likelihood of high (>40 percent) nesting success would be similar to or
27 slightly higher in most of the reservoirs under Alternative 5 as compared to the
28 No Action Alternative. This pattern is reversed in June, with the likelihood of
29 high nesting success being somewhat lower under Alternative 5 (Appendix 9F).

30 Overall, it is likely that the effects on black bass species would be similar under
31 both Alternative 5 and the No Action Alternative.

32 *Other Species*

33 The minor differences in average monthly water temperatures and flows between
34 Alternative 5 and the No action Alternative described above for salmonids apply
35 to Pacific Lamprey, Striped Bass, American Shad, Hardhead, and other fish
36 species in the Sacramento River system. These minor differences suggest that
37 conditions for these species in the Sacramento River system generally would be
38 similar under Alternative 5 and the No Action Alternative.

1 *Stanislaus River/Lower San Joaquin River*

2 *Fall-Run Chinook Salmon and Steelhead*

3 *Changes in Water Temperature*

4 Monthly average temperatures in the Stanislaus River at Goodwin under
5 Alternative 5 would be similar (less than 0.5°F differences) to the No Action
6 Alternative in most of the months and water years. In June through November
7 months of dry years, temperatures under Alternative 5 could be higher by as much
8 as 4°F compared to the No Action Alternative. This pattern in temperature
9 changes under Alternative 5 were also predicted downstream at Orange Blossom
10 Bridge. However, the differences are smaller at the San Joaquin River
11 confluence.

12 Frequency of exceedance of temperature thresholds for steelhead adult migration
13 in the fall months, steelhead smoltification thresholds in April and May at Knights
14 Ferry, and steelhead rearing in summer and fall months are higher under (by up to
15 8 percent) Alternative 5 compared to the No Action Alternative. Frequency of
16 exceedance of thresholds for steelhead spawning and smoltification at Orange
17 Blossom Bridge in March through May are lower by up to 11 percent under
18 Alternative 5 compared to the No Action Alternative.

19 While specific water temperature thresholds for fall-run Chinook Salmon in the
20 Stanislaus River are not established, temperatures generally suitable for fall-run
21 Chinook Salmon spawning (56°F) would be exceeded in October and November
22 up to 3 percent more frequently under Alternative 5 compared to the No Action
23 Alternative, in the Stanislaus River at Orange Blossom Bridge. During May and
24 June, the 56°F threshold for fall-run rearing is exceeded less frequently (by up to
25 10 percent) under Alternative 5 compared to the No Action Alternative.

26 These changes in temperatures are reflected in Reclamation's salmon mortality
27 model results for the fall-run Chinook Salmon in the Stanislaus River. As shown
28 in Appendix 9C, the long-term average egg mortality rate is predicted to be
29 around 8.5 percent, with higher mortality rates (in excess of 16 percent) occurring
30 in critical dry years under Alternative 5. Overall, egg mortality is predicted to be
31 1.5 percent higher under Alternative 5 compared to the No Action Alternative,
32 and in the drier year egg mortality is predicted to be 2.5 percent higher under
33 Alternative 5. However, these effects could be reduced by fish passage at New
34 Melones Dam.

35 *Changes in Delta Hydrodynamics*

36 San Joaquin River-origin fall run Chinook salmon smolts are most abundant in the
37 Delta during the months of April, May and June. San Joaquin River-origin
38 steelhead generally move through the Delta during spring however there is less
39 information on their timing relative to Chinook salmon. Near the confluence of
40 the San Joaquin River and the Mokelumne River, the proportion of positive
41 velocities was slightly higher under Alternative 5 relative to the No Action
42 Alternative in April and almost indistinguishable in May and June (Appendix
43 9K). On Old River downstream of the facilities, the proportion of positive
44 velocities was slightly higher in April and May and indistinguishable in June

1 under Alternative 5 relative to No Action Alternative). In Old River upstream of
2 the facilities, the percent of positive velocities was similar for Alternative 5
3 relative to No Action Alternative in all months). On the San Joaquin River
4 downstream of the Head of Old River, the percent of positive velocities was
5 similar under Alternative 5 relative to No Action Alternative in April, May and
6 June).

7 *Changes in Entrainment at Junctions*

8 At the Head of Old River junction, entrainment was slightly lower under
9 Alternative 5 during April and May but was indistinguishable from No Action
10 Alternative in June (Appendix 9L). At all other junctions with the San Joaquin
11 River (Turner Cut, Columbia Cut, Middle River and Old River) entrainment
12 under Alternative 5 was indistinguishable from No Action Alternative in all
13 months).

14 *Summary of Effects on Fall-Run Chinook Salmon and Steelhead*

15 The analysis of temperatures indicates somewhat higher temperatures and a
16 higher likelihood of exceedance of suitable temperatures for spawning, and lower
17 likelihood of exceeding suitable temperature for rearing of fall-run Chinook
18 Salmon under Alternative 5 as compared to the No Action Alternative in the
19 Stanislaus River below Goodwin Dam. The effect of higher temperatures is
20 reflected in the slightly higher overall mortality of fall-run Chinook Salmon eggs
21 predicted by Reclamation's salmon mortality model for fall-run Chinook Salmon
22 in the Stanislaus River. The frequency of exceedance of temperature thresholds
23 for steelhead smoltification and rearing would be more stressful under
24 Alternative 5 compared to the No Action Alternative. However, with higher
25 flows in April and May and lower temperatures in April and May under
26 Alternative 5 may benefit steelhead spawning.

27 Overall, Alternative 5 likely would have adverse effects on the fall-run Chinook
28 Salmon and steelhead population in the San Joaquin River watershed as compared
29 to the No Action Alternative primarily because of higher water temperatures.
30 However, these effects would be reduced due to fish passage at New Melones
31 Reservoir.

32 *White Sturgeon*

33 Evidence of White Sturgeon spawning has been recorded in the San Joaquin River
34 upstream of the confluence with the Stanislaus River. While flows in the San
35 Joaquin River upstream of the Stanislaus River are expected to be similar under all
36 alternatives, flow contributions from the Stanislaus River could influence water
37 temperatures in the San Joaquin River where White Sturgeon eggs or larvae may
38 occur during the spring and early summer. The magnitude of influence on water
39 temperature would depend on the proportional flow contribution of the Stanislaus
40 River and the temperatures in both the Stanislaus and San Joaquin rivers. The
41 potential for an effect on White Sturgeon eggs and larvae would be influenced by
42 the proportion of the population occurring in the San Joaquin River. In
43 consideration of this uncertainty, it is not possible to distinguish potential effects
44 on White Sturgeon between alternatives.

1 *Reservoir Fishes*

2 Storage levels in New Melones Reservoir would be similar (within 5 percent) for
3 Alternative 5 as compared to the No Action Alternative (Appendix 5A).

4 Results of the bass nesting success analysis indicate that for March, the likelihood
5 of Largemouth Bass and Smallmouth Bass nest survival in New Melones
6 generally being above 40 percent in most of the years simulated but the likelihood
7 of high survival is 100 percent under both Alternative 5 and the No Action
8 Alternative. For April, the likelihood that nest survival of Largemouth Bass and
9 Smallmouth Bass is between 40 and 100 percent is predicted to be reasonably
10 high but is substantially lower (about 13 percent) lower under Alternative 5 as
11 compared to the No Action Alternative. For May, the difference between
12 alternatives is less with the likelihood of high nest survival being about 5 percent
13 less under Alternative 5. For June, the likelihood of survival being greater than
14 40 percent for Largemouth Bass and Smallmouth Bass in New Melones is about
15 2 percent higher under Alternative 5 than under the No Action Alternative. For
16 Spotted Bass, nest survival in March is anticipated to be near 100 percent in every
17 year under both Alternative 5 and the No Action Alternative. The likelihood of
18 survival being greater than 40 percent is high (greater than 90 percent) in April
19 under both Alternative 5 and the No Action Alternative with the likelihood of
20 greater than 40 percent survival being about 107 percent lower under
21 Alternative 5 as compared to the No Action Alternative. For May and June, the
22 likelihood of high Spotted Bass nest survival is lower (by up to 9 about 5 percent)
23 under Alternative 5 as compared to the No Action Alternative. For June, Spotted
24 Bass nest survival would be greater than 40 percent in every year under
25 Alternative 5 as compared to approximately 98 percent of the years under the No
26 Action Alternative.

27 Overall, the analysis suggests that conditions under Alternative 5 have the
28 potential to adversely influence black bass nesting success, especially in April, by
29 comparison to the No Action Alternative. However, nesting success in April
30 under Alternative 5 would still exceed 40 percent, thus it is uncertain whether this
31 difference would be biologically meaningful.

32 *Other Species*

33 Changes in operations that influence temperature and flow conditions in the
34 Stanislaus River downstream of Goodwin Dam and the San Joaquin River at
35 Vernalis could affect other fishes such as lampreys, Hardhead, and Striped Bass.

36 Monthly average temperatures in the Stanislaus River at Goodwin under
37 Alternative 5 would be similar (less than 0.5°F differences) to the No Action
38 Alternative in most of the months and water years. In June through November
39 months of dry years, temperatures under Alternative 5 could be higher by as much
40 as 4°F compared to the No Action Alternative. This pattern in temperature
41 changes under Alternative 5 were also predicted downstream at Orange Blossom
42 Bridge. However, the differences are smaller at the San Joaquin River
43 confluence.

1 In general, lamprey species can tolerate higher temperatures than salmonids, up to
2 around 72°F during their entire life history. Because lamprey ammocoetes remain
3 in the river for several years, any substantial flow reductions or temperature
4 increases could adversely affect these larval lamprey. Given the similar or higher
5 flows and similar or higher temperatures during their spawning and incubation
6 period, it is likely that the potential to affect lamprey species in the Stanislaus and
7 San Joaquin rivers would be greater under Alternative 5 compared to the No
8 Action Alternative.

9 In general, Striped Bass and Hardhead also can tolerate higher temperatures than
10 salmonids. Given the similar flows and higher temperatures during their
11 spawning and incubation period, it is likely that the potential to affect Striped
12 Bass and Hardhead in the Stanislaus and San Joaquin rivers would be somewhat
13 greater under Alternative 5 compared to the No Action Alternative.

14 *San Francisco Bay Area Region*

15 *Killer Whale*

16 As described above for the comparison of Alternative 1 to the No Action
17 Alternative, it is unlikely that the Chinook Salmon prey base of killer whales,
18 supported heavily by hatchery production of fall-run Chinook Salmon, would be
19 appreciably affected by any of the alternatives.

20 **9.4.3.6.2 Alternative 5 Compared to the Second Basis of Comparison**

21 As described in Chapter 3, Description of Alternatives, CVP and SWP operations
22 under Alternative 5 are similar to the No Action Alternative with modified OMR
23 flow criteria and New Melones Reservoir operations. Therefore, the comparison
24 of Alternative 5 to the Second Basis of Comparison would be similar to the
25 comparison of No Action Alternative to Second Basis of Comparison described
26 above in Section 9.4.4.1, No Action Alternative.

27 *Trinity River Region*

28 *Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon,*
29 *Steelhead, and Green Sturgeon*

30 Monthly water temperature in the Trinity River at Lewiston Dam under
31 Alternative 5 generally would be similar (less than 0.5°F differences) to the
32 temperatures that would occur under the Second Basis of Comparison
33 (Appendix 6B, Table B-1-6), with the exception of drier years when temperatures
34 under Alternative 5 could be as much as 2.2°F cooler in November and 1.5°F in
35 December. Average monthly water temperatures could be slightly (up to 0.6°F)
36 higher under Alternative 5 during July and August and lower (up to 0.7°F) in
37 September. Lower September temperatures under Alternative 5 may result in
38 slightly better conditions than the Second Basis of Comparison for spring-run
39 Chinook Salmon spawning. Similarly, temperature conditions under
40 Alternative 5 could be slightly better than the Second Basis of Comparison for
41 fall-run Chinook Salmon spawning because of the reduced temperatures in
42 November during critical dry years.

1 Under Alternative 5, water temperature thresholds for Coho Salmon, fall-run
2 Chinook Salmon, and steelhead would be exceeded slightly more frequently (less
3 than 1 percent), whereas thresholds for spring-run Chinook Salmon would be
4 exceeded less frequently (up to 4 percent) in August in September
5 (Appendix 9N).

6 These temperature results are reflected in the egg mortality results for fall-run
7 Chinook Salmon, which indicate slightly higher mortality under Alternative 5
8 compared to the Second Basis of Comparison, with differences less than
9 0.3 percent in most year types and 1.9 percent in critical years (Appendix 9C,
10 Table B-5).

11 The minor changes in water temperatures and mortality suggest that conditions
12 for Coho Salmon, fall-run Chinook Salmon, steelhead, and Green Sturgeon in the
13 Trinity River would be similar under both Alternative 5 and the Second Basis of
14 Comparison. However, the reduced threshold exceedances for spring-run
15 Chinook Salmon under Alternative 5, although small, could be biologically
16 meaningful under some conditions.

17 *Reservoir Fishes*

18 The analysis of effects associated with changes in operation on reservoir fishes
19 relied on evaluation of changes in available habitat (reservoir storage) and
20 anticipated changes in black bass nesting success.

21 Storage levels in New Melones Reservoir would be lower under Alternative 5 as
22 compared to the Second Basis of Comparison (Appendix 5A), especially in
23 critical years when the difference could be as much as 23 percent. Using storage
24 volume as an indicator of available availability for fish species inhabiting these
25 reservoirs, these results suggest that the amount of habitat for reservoir fishes
26 could be decreased under Alternative 5 as compared to the Second Basis of
27 Comparison.

28 Black bass species in Trinity Lake would be exposed to minor differences in
29 storage under both Alternative 5 and the Second Basis of Comparison, and these
30 relatively small differences would have negligible effect on nest survival. The
31 nest survival under Alternative 5 would be generally similar to Second Basis of
32 Comparison for Largemouth Bass, Smallmouth Bass, and Spotted Bass
33 (Appendix 9F). These negligible differences in nest survival suggest that
34 conditions for reservoir species in Trinity Lake would be similar under
35 Alternative 5 and the Second Basis of Comparison.

36 *Other Species*

37 The minor differences in average monthly water temperatures described above for
38 salmonids apply to Pacific Lamprey, Eulachon, and other aquatic species in the
39 Trinity River. These minor differences suggest that conditions for aquatic species
40 in the Trinity River and Klamath River downstream of the confluence generally
41 would be similar under Alternative 5 and the Second Basis of Comparison.

1 *Sacramento River System*

2 *Winter-run Chinook Salmon*

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

6 *Changes in Water Temperature*

7 Monthly water temperature in the Sacramento River at Keswick Dam under
8 Alternative 5 and the Second Basis of Comparison generally would be similar
9 (within about 0.5°F). Average monthly water temperatures in September under
10 Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to
11 1.2°F) in drier years (Appendix 6B). A similar temperature pattern generally
12 would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend Bridge,
13 with average monthly temperatures 5 in September progressively decreasing (up
14 to 2.8°F at Bend Bridge) in September during the wetter years (Appendix 6B).

15 *Changes in Exceedances of Water Temperature Thresholds*

16 With the exception of April, average monthly water temperatures under both
17 Alternative 5 and Second Basis of Comparison would show exceedances of the
18 water temperature threshold of 56°F established in the Sacramento River at Ball's
19 Ferry for winter-run Chinook Salmon spawning and egg incubation in every
20 month, with exceedances under both as high as about 41 percent and 54 percent,
21 respectively, in some months (Appendix 9N). Under Alternative 5, the
22 temperature threshold generally would be exceeded more frequently than under
23 the Second Basis of Comparison (by about 1 percent to 3 percent) in the April
24 through August period, with the temperature threshold in September exceeded
25 about 11 percent less frequently under Alternative 5 than under the Second Basis
26 of Comparison. Farther downstream at Bend Bridge, the frequency of
27 exceedances would increase, with exceedances under both Alternative 5 and the
28 Second Basis of Comparison as high as about 90 percent in some months. Under
29 Alternative 5, temperature exceedances generally would be more frequent (by up
30 to 10 percent) than under the Second Basis of Comparison, with the exception of
31 September, when exceedances under Alternative 5 would be about 30 percent less
32 frequent.

33 *Changes in Egg Mortality*

34 The temperatures described above for the Sacramento River below Keswick Dam
35 are reflected in the analysis of egg mortality using the Reclamation Salmon
36 Survival Model (Appendix 9C). For winter-run Chinook Salmon in the
37 Sacramento River, the long-term average egg mortality rate is predicted to be
38 relatively low (around 5 percent), with higher mortality rates (exceeding
39 20 percent) occurring in critical dry years under Alternative 5. Overall, egg
40 mortality would be 0.3 percent higher under Alternative 5; in critical dry years the
41 average egg mortality rate would be about 3 percent greater than under the
42 Second Basis of Comparison (Appendix 9C, Table B-4).

1 *Changes in Weighted Usable Area*

2 As an indicator of the amount of suitable spawning habitat for winter-run Chinook
3 Salmon between Keswick Dam and Battle Creek, modeling results indicate that,
4 in general, there would be greater amounts of spawning habitat available from
5 May through September under Alternative 5 as compared to the Second Basis of
6 Comparison (Appendix 9E, Table C-17-6). The increase in long-term average
7 spawning WUA during these months would be relatively small (less than
8 5 percent), with smaller (less than 1 percent) increases in May and July. There
9 would be a reduction in the long-term average spawning WUA in April, but this
10 reduction is small (less than 1 percent) and would occur prior to the peak
11 spawning period in May and June. Overall, spawning habitat availability would
12 be similar under Alternative 5 and the Second Basis of Comparison.

13 Modeling results indicate that, in general, there would be reduced amounts of
14 suitable fry rearing habitat available from June through October under
15 Alternative 5 (Appendix 9E, Table C-18-6). The decrease in long-term average
16 fry rearing WUA during these months would be relatively small (less than 5
17 percent), with smaller (less than 1 percent) increases in July and September.
18 There would be an increase in the long-term average fry rearing WUA in
19 September, but this reduction would be small (less than 5 percent) and would
20 occur at a time when most fry have grown into juveniles and moved into habitats
21 with different depth and velocity characteristics as reflected in the analysis of
22 juvenile rearing WUA below. Overall, fry rearing habitat availability would be
23 similar under Alternative 5 and the Second Basis of Comparison.

24 Similar to the results for fry rearing WUA, modeling results indicate that there
25 would be reduced amounts of suitable juvenile rearing habitat available during the
26 early juvenile rearing period from September through December under
27 Alternative 5. There would be an increase in the long-term average juvenile
28 rearing WUA from January through August (Appendix 9E, Table C-19-6). The
29 decreases in long-term average juvenile rearing WUA would be relatively small
30 (less than 5 percent), while the increases would be smaller (less than 1 percent).
31 Overall, juvenile rearing habitat availability would be similar under Alternative 5
32 and the Second Basis of Comparison.

33 *Changes in SALMOD Output*

34 SALMOD results indicate that flow-related winter-run Chinook Salmon egg
35 mortality would be reduced by 41 percent under Alternative 5 compared to the
36 Second Basis of Comparison. Conversely, temperature-related egg mortality
37 would be 6 percent higher under Alternative 5 (Appendix 9D, Table B-4-29).
38 Both temperature- and flow (habitat)-related fry mortality would be up to
39 34 percent higher under Alternative 5 as compared to the Second Basis of
40 Comparison. Temperature-related juvenile mortality would be approximately
41 31 percent higher under Alternative 5, while flow (habitat)-related mortality
42 would be approximately 17 percent lower under Alternative 5 as compared to the
43 Second Basis of Comparison. Overall, potential juvenile production would be the
44 same under Alternative 5 and the Second Basis of Comparison (Appendix 9D,
45 Table B-4-26).

1 *Changes in Delta Passage Model Output*

2 The Delta Passage Model predicted similar estimates of annual Delta survival
3 across the 81 water year time period for winter-run Chinook Salmon between
4 Alternative 5 and the Second Basis of Comparison Alternative (Appendix 9J).
5 Median Delta survival was 0.350 for Alternative 5 and 0.352 for the Second Basis
6 of Comparison Alternative. Overall, there would be little change in through-Delta
7 survival for emigrating juvenile winter-run Chinook Salmon under Alternative 5
8 as compared to the Second Basis of Comparison.

9 *Changes in Delta Hydrodynamics*

10 Winter run smolts are most abundant in the Delta during the months of January
11 February and March. On the Sacramento River near the confluence of Georgiana
12 Slough, the percentage of positive velocity under Alternative 5 was moderately
13 lower relative to the Second Basis of Comparison in January and
14 indistinguishable in February and March (Appendix 9K). On the San Joaquin
15 River near the Mokelumne River confluence, the percent of positive velocities
16 was slightly greater under Alternative 5 relative to Second Basis of Comparison in
17 January and February and indistinguishable in March. In Old River downstream
18 of the facilities, the percent of positive velocities was considerably higher under
19 Alternative 5 during January and moderately higher in February. Values in
20 March were almost indistinguishable between scenarios. On Old River upstream
21 of the facilities, percent positive velocities were moderately lower in January and
22 slightly lower in February and March under Alternative 5 relative to Second Basis
23 of Comparison. On the San Joaquin River downstream of Head of Old River, the
24 percent of positive velocities was similar for both scenarios in January, February
25 and March.

26 *Changes in Junction Entrainment*

27 At the junction of Georgiana Slough and the Sacramento River, entrainment under
28 Alternative 5 was slightly lower than Second Basis of Comparison in January but
29 essentially indistinguishable in February and March (Appendix 9L). Entrainment
30 at the Head of Old River junction was moderately lower under Alternative 5
31 relative to Second Basis of Comparison during the period of winter run migration
32 through the Delta (January, February, March). For the Turner Cut junction,
33 entrainment under Alternative 5 was moderately lower in January and February
34 relative to Second Basis of Comparison. In March, the difference in entrainment
35 between scenarios was similar. Similar patterns between Alternative 5 and
36 Second Basis of Comparison were observed at the Columbia Cut, Middle River
37 and Old River junctions. At these junctions, entrainment was moderately lower
38 under Alternative 5 during January and February and values became more similar
39 in March.

40 *Changes in Salvage*

41 Salvage of winter-run Chinook salmon is predicted to be considerably lower
42 under Alternative 5 relative to the Second Basis of Comparison in January and
43 February (Appendix 9M). In March, predicted salvage was only moderately
44 lower under Alternative 5 relative to Second Basis of Comparison.

1 *Changes in Oncorhynchus Bayesian Analysis Output*

2 Escapement of winter-run Chinook Salmon and Delta survival was modeled by
3 the Oncorhynchus Bayesian Analysis (OBAN) model for winter-run Chinook
4 salmon. Escapement was generally higher under Alternative 5 as compared to the
5 Second Basis alternative (Appendix 9I). The median abundance under
6 Alternative 5 was higher the Second Basis of Comparison. Median delta survival
7 was approximately 15 percent higher under Alternative 5 as compared to the
8 Second Basis of Comparison.

9 *Changes in Interactive Object-Oriented Simulation Output*

10 The IOS model predicted similar adult escapement trajectories for Winter-Run
11 Chinook salmon between Alternative 5 and the Second Basis of Comparison
12 Alternative across the 81 water years (Appendix 9H). Alternative 5 median adult
13 escapement was 3,545 and Second Basis of Comparison Alternative median
14 escapement was 4,042).

15 Similar to adult escapement, the IOS model predicted similar egg survival time
16 histories for Winter-Run Chinook salmon between Alternative 5 and the Second
17 Basis of Comparison Alternative across the 81 water years (Appendix 9H).
18 Median egg survival was 0.989 for Alternative 5 and 0.987 for the Second Basis
19 of Comparison Alternative).

20 *Summary of Effects on Winter-Run Chinook Salmon*

21 The analysis of temperatures indicates somewhat higher temperatures and greater
22 likelihood of exceedance of thresholds under Alternative 5 as compared to the
23 Second Basis of Comparison. This is reflected in the slightly lower survival of
24 winter-run Chinook Salmon eggs predicted by Reclamation's salmon mortality
25 model. Flow changes under Alternative 5 would have small effects on the
26 availability of spawning and rearing habitat for winter-run Chinook Salmon as
27 indicated by the decrease in flow (habitat)-related mortality predicted by
28 SALMOD under Alternative 5. Through Delta survival of juvenile winter-run
29 Chinook Salmon would be the same under both Alternative 5 and Second Basis of
30 Comparison as indicated by the DPM results; and the OBAN results suggest that
31 Delta survival could be higher under Alternative 5. Entrainment may also be
32 reduced under Alternative 5 as indicated by the OMR flow analysis. Median
33 adult escapement to the Sacramento River would be reduced slightly under
34 Alternative 5 as indicated by the IOS model results which incorporate
35 temperature, flow, and mortality effects on each life stage over the entire life
36 cycle of winter-run Chinook Salmon. However, the OBAN model results indicate
37 an increase in escapement over a more limited time period (1971 to 2002).
38 Considering all the above analyses for the winter-run Chinook Salmon
39 population, the changes in overall effects under Alternative 5 compared to Second
40 Basis of Comparison are highly uncertain. However, the upstream fish passage
41 included under Alternative 5 could benefit the winter-run Chinook Salmon
42 population in the Sacramento River as compared to the Second Basis of
43 Comparison if successful.

1 *Spring-run Chinook Salmon*

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

7 *Changes in Water Temperature*

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

11 *Sacramento River*

12 Monthly water temperature in the Sacramento River at Keswick Dam under
13 Alternative and the Second Basis of Comparison generally would be similar
14 (within about 0.5°F). Average monthly water temperatures in September under
15 Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to
16 1.2°F) in drier years. Alternative A similar temperature pattern generally would
17 be exhibited downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red
18 Bluff, with average monthly temperature differences in November, June, and
19 September (in drier years) progressively increasing by up to 0.7°F at Red Bluff
20 under Alternative 5 relative to the Second Basis of Comparison and progressively
21 decreasing (up to 3.2°F at Red Bluff) in September during the wetter years
22 (Appendix 6B, Table B-9-6).

23 *Clear Creek*

24 Average monthly water temperatures in Clear Creek at Igo under Alternative
25 relative to the Second Basis of Comparison are generally predicted to be similar
26 (less than 0.5°F differences) from September through April and June through
27 August (Appendix 6B, Table B-3-6). Average monthly water temperatures during
28 May under Alternative 5 would be lower by 0.1°F to 0.8°F than under the Second
29 Basis of Comparison in all water year types. The lower water temperatures in
30 May associated with Alternative 5 reflect the effects of additional water
31 discharged from Whiskeytown Dam to meet the spring attraction flow
32 requirements to promote attraction of spring-run Chinook Salmon into the creek.
33 While the reduction in May water temperatures indicated by the modeling could
34 improve thermal conditions for spring-run Chinook Salmon, the duration of the
35 two pulse flows may not be of sufficient duration (3 days each) to provide
36 biologically meaningful temperature benefits.

37 *Feather River*

38 Long-term average monthly water temperature in the Feather River at the low
39 flow channel under Alternative 5 relative to the Second Basis of Comparison
40 generally would be similar (less than 0.5°F differences), but slightly higher
41 (0.6°F) during December and slightly lower (0.6°F) in September. Water
42 temperatures could be up to 1.5°F warmer in November and December of some
43 water year types and up to 1.2°F cooler in September of wetter years
44 (Appendix 6B, Table B-20-6) under Alternative 5. Although temperatures in the

1 river would become progressively higher in the downstream direction, the
 2 differences between Alternative 5 and Second Basis of Comparison exhibit a
 3 similar pattern at the downstream locations (Robinson Riffle and Gridley Bridge),
 4 with water temperature differences under Alternative 5 generally increasing in
 5 most water year types relative to the Second Basis of Comparison at the
 6 confluence with Sacramento River (Appendix 6B, Table B-23-6). Water
 7 temperatures under Alternative 5 are somewhat (0.5°F to 1.8°F) cooler on average
 8 and up to 3.9°F cooler at the confluence with Sacramento River from July to
 9 September in wetter years.

10 *Changes in Exceedances of Water Temperature Thresholds*

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

15 *Sacramento River*

16 Average monthly water temperatures under both Alternative 5 and Second Basis
 17 of Comparison would show exceedances of the water temperature threshold of
 18 56°F established in the Sacramento River at Red Bluff for spring-run Chinook
 19 Salmon (egg incubation) in October, November, and again in April. The
 20 exceedances would occur at the greatest frequency in October, with 80 percent
 21 and 79 percent for Alternative 5 and Second Basis of Comparison, respectively.
 22 Temperature thresholds would be exceeded less frequently in November
 23 (7 percent) and not exceeded at all during December through March. As water
 24 temperatures warm in the spring, the thresholds would be exceeded in April by
 25 14 percent and 13 percent under Alternative 5 and Second Basis of Comparison.
 26 In the warmer months when exceedances occur (October, November, and April),
 27 temperature thresholds generally would be exceeded more frequently (by up to
 28 2 percent in October) under Alternative 5 than under the Second Basis of
 29 Comparison (Appendix 9N, Table 9N.B.1).

30 *Clear Creek*

31 Average monthly water temperatures under both Alternative 5 and Second Basis
 32 of Comparison would not exceed the water temperature threshold of 60°F
 33 established in Clear Creek at Igo for spring-run Chinook Salmon pre-spawning
 34 and rearing in June through August. However, Alternative 5 and Second Basis of
 35 Comparison would exceed the water temperature threshold of 56°F established
 36 for spawning in September and October about 10 percent to 15 percent of the
 37 time. The differences between Alternative 5 and Second Basis of Comparison
 38 could be biologically meaningful, with Alternative 5 exceeding thresholds about
 39 1 percent more frequently than under the Second Basis of Comparison in
 40 September and about 2 percent more frequently in October (Appendix 9N).

41 *Feather River*

42 Average monthly water temperatures under both Alternative 5 and Second Basis
 43 of Comparison would exceed the water temperature threshold of 56°F established
 44 in the Feather River at Robinson Riffle for spring-run Chinook Salmon egg

1 incubation and rearing (Appendix 9N) during some months, particularly in
2 October and November, and March and April, when temperature thresholds could
3 be exceeded frequently. The frequency of exceedance was highest (about
4 98 percent) in October, a month in which average monthly water could get as high
5 as about 68°F. However, the differences in the frequency of exceedances between
6 Alternative 5 and Second Basis of Comparison could be biologically meaningful.
7 Water temperatures under Alternative 5 would exceed temperature thresholds less
8 than 2 percent more frequently than the Second Basis of Comparison in October,
9 November, and December, and about 1 percent less frequently in March. The
10 established water temperature threshold of 63°F for rearing during May through
11 August would be exceeded often under both Alternative 5 and Second Basis of
12 Comparison in May (57 percent and 51 percent, respectively) and June
13 (97 percent for both), but not at all in July and August.

14 *Changes in Egg Mortality*

15 These temperature differences described above are reflected in the analysis of egg
16 mortality using the Reclamation salmon mortality model (Appendix 9C). For
17 spring-run Chinook Salmon in the Sacramento River, the long-term average egg
18 mortality rate is predicted to be relatively high (exceeding 20 percent), with high
19 mortality rates (exceeding 80 percent) occurring in critical dry years. Overall, egg
20 mortality would be 0.8 percent higher under Alternative 5; in critical dry years the
21 average egg mortality rate would be 13.1 percent greater under Alternative 5 than
22 under the Second Basis of Comparison (Appendix 9C, Table B-3).

23 *Changes in Weighted Usable Area*

24 Weighted usable area curves are available for spring-run Chinook Salmon in
25 Clear Creek. As described above, flows in Clear Creek below Whiskeytown Dam
26 are not anticipated to differ under Alternative 5 relative to the Second Basis of
27 Comparison except in May due to the release of spring attraction flows in
28 accordance with the 2009 NMFS BO. Therefore, there would be no change in the
29 amount of potentially suitable spawning and rearing habitat for spring-run
30 Chinook Salmon (as indexed by WUA) available under Alternative 5 as compared
31 to the Second Basis of Comparison.

32 *Changes in SALMOD Output*

33 SALMOD results indicate that pre-spawning mortality of spring-run Chinook
34 Salmon eggs would be approximately 15 percent greater under Alternative 5,
35 primarily due to increased summer temperatures. Flow-related spring-run
36 Chinook Salmon egg mortality would be reduced by 20 percent under
37 Alternative 5 compared to the Second Basis of Comparison. Conversely,
38 temperature-related egg mortality would be 16 percent higher under Alternative 5
39 (Appendix 9D, Table B-3-29). Flow (habitat)-related fry mortality would be
40 approximately 3 percent lower under Alternative 5 as compared to the Second
41 Basis of Comparison. There would be no temperature- or flow (habitat)-related
42 juvenile mortality under either alternative, as most spring-run Chinook Salmon
43 juveniles have migrated downstream as fry and are not found in the mainstem
44 Sacramento River. Overall, potential spring-run juvenile production would be

1 slightly (approximately 2 percent) lower under Alternative 5 as compared to the
2 Second Basis of Comparison (Appendix 9D).

3 *Changes in Delta Passage Model Output*

4 The Delta Passage Model predicted similar estimates of annual Delta survival
5 across the 81 water year time period for spring-run between Alternative 5 and the
6 Second Basis of Comparison (Appendix 9J). Median Delta survival was 0.296 for
7 Alternative 5 and 0.286 for the Second Basis of Comparison. Overall, there
8 would be little change in through-Delta survival by emigrating juvenile spring-run
9 Chinook Salmon under Alternative 5 as compared to the Second Basis of
10 Comparison.

11 *Changes in Delta Hydrodynamics*

12 Spring run Chinook salmon are most abundant in the Delta from March through
13 May. Near the junction of Georgiana Slough (channel 421), the percent of time
14 that velocity was positive was similar in March, slightly lower in April and
15 moderately lower in May under Alternative 5 relative to the Second Basis of
16 Comparison (Appendix 9K). Near the confluence of the San Joaquin River and
17 the Mokelumne River (channel 45), percent positive velocity was almost identical
18 in March and moderately higher under Alternative 5 relative to Second Basis of
19 Comparison in April and May. In the San Joaquin River downstream of the Head
20 of Old River (channel 21) the percent of positive velocities was considerably
21 higher under Alternative 5 relative to Second Basis of Comparison in April and
22 May whereas there was little variation among scenarios in March. In Old River
23 upstream of the facilities (channel 212) percent positive velocity was moderately
24 lower in April and May under Alternative 5 relative to Second Basis of
25 Comparison and more similar to each other in March. In Old River downstream
26 of the facilities (channel 94), percent positive velocity was substantially higher
27 under Alternative 5 relative to Second Basis of Comparison in April and May and
28 more similar to each other in March.

29 *Changes in Junction Entrainment*

30 At the junction of Georgiana Slough and the Sacramento River, entrainment under
31 Alternative 5 was slightly lower than Second Basis of Comparison in April but
32 essentially indistinguishable in all other months (Appendix 9L). Entrainment at
33 the Head of Old River junction was substantially higher under Alternative 5
34 relative to Second Basis of Comparison during the months of April and May and
35 slightly lower in June. For the Turner Cut junction, entrainment under
36 Alternative 5 was moderately lower in April and May relative to Second Basis of
37 Comparison and more similar in March. At the Columbia Cut, Middle River and
38 Old River junctions, entrainment under Alternative 5 was slightly lower than
39 Second Basis of Comparison in March and became moderately to considerably
40 lower in April and May.

41 *Changes in Salvage*

42 Salvage of spring run Chinook salmon was predicted to be substantially lower
43 under Alternative 5 relative the Second Basis of Comparison during April and
44 May and only slightly lower in the month of March (Appendix 9M).

1 *Summary of Effects on Spring-Run Chinook Salmon*

2 The analysis of temperatures indicates somewhat higher temperatures and greater
3 likelihood of exceedance of thresholds under Alternative 5 as compared to the
4 Second Basis of Comparison in the Sacramento and Feather rivers. There would
5 be little change in flows or temperatures in Clear Creek under Alternative 5
6 relative to the Second Basis of Comparison. The effect of increased temperatures
7 is reflected in the slightly lower overall survival of spring-run Chinook Salmon
8 eggs predicted by Reclamation's salmon mortality model for spring-run in the
9 Sacramento River. In drier years, the likelihood of adverse temperature effects
10 would be increased under Alternative 5 as compared to the Second Basis of
11 Comparison. Flow changes under Alternative 5 would likely have small effects
12 on the availability of spawning and rearing habitat for spring-run Chinook Salmon
13 in the Sacramento River as indicated by the decrease in flow (habitat)-related
14 mortality predicted by SALMOD under Alternative 5. Through Delta survival of
15 juvenile spring-run Chinook Salmon would be the same under both Alternative 5
16 and Second Basis of Comparison as indicated by the DPM results and entrainment
17 could be reduced as indicated by the salvage analysis. Overall, Alternative 5
18 likely would have similar or somewhat greater adverse effects on the spring-run
19 Chinook Salmon population in the Sacramento River watershed as compared to
20 the Second Basis of Comparison, particularly in drier water year types. However,
21 given that most of the spring-run Chinook Salmon are on the tributaries where the
22 effects of changes in Alternative 5 operations are minimal and that Alternative 5
23 includes the fish passage actions, which are not included in the Second Basis of
24 Comparison, it is unlikely that Alternative 5 would result in adverse effects in
25 comparison with the Second Basis of Comparison.

26 *Fall-Run Chinook Salmon*

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

32 *Changes in Water Temperature*

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

36 *Sacramento River*

37 Monthly water temperature in the Sacramento River at Keswick Dam under
38 Alternative and the Second Basis of Comparison generally would be similar
39 (within about 0.5°F). Average monthly water temperatures in September under
40 Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to
41 1.2°F) in drier years. A similar pattern in temperature differences generally
42 would be exhibited at downstream locations along the Sacramento River (i.e.,
43 Ball's Ferry Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and Knights
44 Landing), with differences in average monthly temperatures in June at Knights

1 Landing progressively increasing (up to 0.9°F) under Alternative 5 relative to the
2 Second Basis of Comparison and progressively decreasing (up to 4.6°F) in
3 September during the wetter years.

4 *Clear Creek*

5 Average monthly water temperatures in Clear Creek at Igo under Alternative
6 relative to the Second Basis of Comparison are generally predicted to be similar
7 (less than 0.5°F differences) from September through April and June through
8 August (Appendix 6B, Table B-3-6). Average monthly water temperatures during
9 May under Alternative 5 would be lower by 0.1°F to 0.8°F than under the Second
10 Basis of Comparison in all water year types. The lower water temperatures in
11 May associated with Alternative 5 reflect the effects of additional water
12 discharged from Whiskeytown Dam to meet the spring attraction flow
13 requirements to promote attraction of spring-run Chinook Salmon into the creek.
14 While the reduction in May water temperatures indicated by the modeling could
15 improve thermal conditions for fall-run Chinook Salmon, the duration of the two
16 pulse flows may not be of sufficient duration (3 days each) to provide biologically
17 meaningful temperature benefits.

18 *Feather River*

19 Long-term average monthly water temperature in the Feather River at the low
20 flow channel under Alternative 5 relative to the Second Basis of Comparison
21 generally would be similar (less than 0.5°F differences), but slightly higher
22 (0.6°F) during December and slightly lower (0.6°F) in September. Water
23 temperatures could be up to 1.5°F warmer in November and December of some
24 water year types and up to 1.2°F cooler in September of wetter years. Although
25 temperatures in the river would become progressively higher in the downstream
26 direction, the differences between Alternative 5 and Second Basis of Comparison
27 exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley
28 Bridge), with water temperature differences under Alternative 5 generally
29 increasing in most water year types relative to the Second Basis of Comparison at
30 the confluence with Sacramento River (Appendix 6B, Table B-23-6). Water
31 temperatures under Alternative 5 are somewhat (0.5°F to 1.8°F) cooler on average
32 and up to 3.9°F cooler at the confluence with Sacramento River from July to
33 September in wetter years.

34 *American River*

35 Average monthly water temperatures in the American River at Nimbus Dam
36 under Alternative 5 generally would be similar (differences less than 0.5°F) to the
37 Second Basis of Comparison, with the exception of during June and August, when
38 temperatures under Alternative 5 could be as much as 0.9°F higher. This pattern
39 generally would persist downstream to Watt Avenue and the mouth, although
40 temperatures under Alternative 5 would be up to 1.6°F and 2.1°F greater,
41 respectively, than under the Second Basis of Comparison in June. In addition,
42 average monthly water temperatures at the mouth under Alternative 5 generally
43 would be lower than under the Second Basis of Comparison in September,

1 especially in wetter water year types when water temperatures under Alternative 5
2 could be up to 1.7°F cooler.

3 *Changes in Exceedances of Water Temperature Thresholds*

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

8 *Sacramento River*

9 Average monthly water temperatures under both Alternative 5 and Second Basis
10 of Comparison would exceed the water temperature threshold of 56°F established
11 in the Sacramento River at Red Bluff for fall-run Chinook Salmon spawning and
12 egg incubation (Table temperature targets) during some months, particularly in
13 October, November, and April, when temperature thresholds would be exceeded.
14 The frequency of exceedance would be greatest in October, a month in which
15 average monthly water temperature could get as high as about 64°F. In October,
16 average monthly water temperatures under Alternative 5 and Second Basis of
17 Comparison would exceed the threshold 82 percent and 79 percent of the time,
18 respectively. The differences in the frequency of exceedances between
19 Alternative 5 and Second Basis of Comparison could be biologically meaningful.
20 Water temperatures under Alternative 5 would exceed temperature thresholds
21 about 2 percent more frequently than under the Second Basis of Comparison in
22 October, 1 percent less frequently in November, and 1 percent more frequently in
23 April.

24 *Clear Creek*

25 Fall-run Chinook Salmon spawning in lower Clear Creek typically occurs during
26 October through December (USFWS 2015). Average monthly water
27 temperatures at Igo during this period generally would be below 56°F, except in
28 October. Under Alternative 5, the 56°F threshold would be exceeded in October
29 about 12 percent of the time as compared to 10 percent under the Second Basis of
30 Comparison. At the confluence with the Sacramento River, average monthly
31 water temperatures in October would be warmer, with 56°F exceeded nearly
32 20 percent of the time under Alternative 5 and slightly (about 8 percent) less
33 frequently under the Second Basis of Comparison. During November and
34 December, average monthly water temperatures generally would remain below
35 56°F at both locations.

36 For fall-run Chinook Salmon rearing (January through September), the
37 exceedances described previously for spring-run Chinook Salmon would apply,
38 with the average monthly temperatures remaining below the 60°F threshold
39 except in September when temperatures could increase to over 60°F. During
40 September, water temperatures under Alternative 5 would exceed 56°F about
41 3 percent more frequently than under the Second Basis of Comparison.
42 Downstream at the mouth, the average monthly temperatures would exceed 56°F
43 more frequently, especially in July and August, when it always would be

1 exceeded and average monthly temperatures would approach 64°F under both
2 scenarios in September. Alternative 5

3 Under Alternative 5, temperature conditions at Igo would be slightly warmer than
4 under the Second Basis of Comparison. Average monthly water temperatures
5 likely mask daily temperatures excursions that could exceed important thresholds.
6 Therefore, while the differences in threshold exceedance are relatively minor, the
7 likelihood of adverse effects on fall-run Chinook Salmon under Alternative 5
8 would likely be greater than under the Second Basis of Comparison.

9 *Feather River*

10 Average monthly water temperatures under both Alternative 5 and Second Basis
11 of Comparison would exceed the water temperature threshold of 56°F established
12 in the Feather River at Gridley Bridge for fall-run Chinook Salmon spawning and
13 egg incubation during some months, particularly in October, November, March,
14 and April, when temperature thresholds would be exceeded frequently
15 (Appendix 9N). The frequency of exceedance would be greatest in October,
16 when average monthly temperatures under both Alternative 5 and Second Basis of
17 Comparison would be above the threshold in nearly every year. The magnitude of
18 the exceedances would be high as well, with average monthly temperatures in
19 October reaching about 68°F. Similarly, the threshold would be exceeded under
20 both Alternative 5 and the Second Basis of Comparison about 85 percent of the
21 time in April. The differences between Alternative 5 and Second Basis of
22 Comparison, could be biologically meaningful, with water temperatures under
23 Alternative 5 generally exceeding temperature thresholds about 1-2 percent more
24 frequently than the Second Basis of Comparison during the October through April
25 period.

26 *Changes in Egg Mortality*

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

30 *Sacramento River*

31 For fall-run Chinook Salmon in the Sacramento River, the long-term average egg
32 mortality rate is predicted to be around 17 percent, with higher mortality rates (in
33 excess of 35 percent) occurring in critical dry years under Alternative 5. Overall,
34 egg mortality would be 0.2 percent lower under Alternative 5; in critical dry years
35 the average egg mortality rate would be 3.0 percent greater than under the Second
36 Basis of Comparison (Appendix 9C, Table B-1).

37 *Feather River*

38 For fall-run Chinook Salmon in the Feather River, the long-term average egg
39 mortality rate is predicted to be relatively low (around 7 percent), with higher
40 mortality rates (around 14 percent) occurring in critical dry years under
41 Alternative 5. Overall, egg mortality would be 0.1 percent higher under
42 Alternative 5; in critical dry years the average egg mortality rate would be
43 3.6 percent lower than under the Second Basis of Comparison (Appendix 9C,
44 Table B-7).

1 *American River*

2 For fall-run Chinook Salmon in the American River, the long-term average egg
3 mortality rate is predicted to range from approximately 23 to 25 percent in all
4 water year types under Alternative 5. Overall, egg mortality would be 0.1 percent
5 lower under Alternative 5; in below normal water years the average egg mortality
6 rate would be 1 percent greater than under the Second Basis of Comparison. In
7 other water year types, egg mortality is predicted to be from 0.1 to 0.6 percent
8 lower under Alternative 5 as compared to the Second Basis of Comparison
9 (Appendix 9C, Table B-6).

10 *Changes in Weighted Usable Area*

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

14 *Sacramento River*

15 As an indicator of the amount of suitable spawning habitat for fall-run Chinook
16 Salmon between Keswick Dam and Battle Creek, modeling results indicate that,
17 in general, there would be lesser amounts of spawning habitat available from
18 September through November under Alternative 5 as compared to the Second
19 Basis of Comparison; fall-run spawning WUA would be slightly (less than 5
20 percent) increased in December, but this is after the peak spawning period for
21 fall-run Chinook Salmon in this reach (Appendix 9E, Table C-11-6). The
22 decrease in long-term average spawning WUA during September (prior to the
23 peak spawning period) would be relatively large (more than 20 percent), with
24 smaller decreases in October (around 2 percent) and November (around 6 percent)
25 which comprise the peak spawning period for fall-run Chinook Salmon. Results
26 for the reach from Battle Creek to Deer Creek show the same pattern in changes
27 in WUA for spawning fall-run Chinook Salmon between Alternative 5 and the
28 Second Basis of Comparison (Appendix 9E, Table C-10-6). Overall, spawning
29 habitat availability would be slightly lower under Alternative 5 relative to the
30 Second Basis of Comparison.

31 Modeling results indicate that, in general, there would be increased amounts of
32 suitable fry rearing habitat available from December to March under Alternative 5
33 (Appendix 9E, Table C-12-6). The increase in long-term average fry rearing
34 WUA during these months would be relatively small (less than 1 percent).
35 Overall, fry rearing habitat availability would be similar under Alternative 5 and
36 the Second Basis of Comparison.

37 Similar to the results for fry rearing WUA, modeling results indicate that, there
38 would be increased amounts of suitable juvenile rearing habitat available during
39 the early juvenile rearing period from February to April, but this increase would
40 be small (less than 1 percent) under Alternative 5. There would a somewhat
41 larger increase (around 3 percent) in the long-term average juvenile rearing WUA
42 during May and June (Appendix 9E, Table C-13-6). Overall, juvenile rearing
43 habitat availability would be similar under Alternative 5 and the Second Basis of
44 Comparison.

1 *Clear Creek*

2 As described above, flows in Clear Creek below Whiskeytown Dam are not
3 anticipated to differ under Alternative 5 relative to the Second Basis of
4 Comparison except in May due to the release of spring attraction flows in
5 accordance with the 2009 NMFS BO. Therefore, there would be no change in the
6 amount of potentially suitable spawning and rearing habitat for fall-run Chinook
7 Salmon (as indexed by WUA) available under Alternative 5 as compared to the
8 Second Basis of Comparison.

9 *Feather River*

10 As described above, Flows in the low flow channel of the Feather River are not
11 anticipated to differ under Alternative 5 relative to the Second Basis of
12 Comparison. Therefore, there would be no change in the amount of potentially
13 suitable spawning habitat for fall-run Chinook Salmon (as indexed by WUA)
14 available under Alternative 5 as compared to the Second Basis of Comparison.
15 The majority of spawning activity by fall-run Chinook Salmon in the Feather
16 River occurs in this reach with a lesser amount of spawning occurring
17 downstream of the Thermalito Complex.

18 Modeling results indicate that, in general, there would be lesser amounts of
19 spawning habitat available in September, November, and December under
20 Alternative 5 as compared to the Second Basis of Comparison; fall-run spawning
21 WUA would be slightly (less than 5 percent) increased in October (the peak
22 spawning month) for fall-run Chinook Salmon in this reach (Appendix 9E,
23 Table C-24-6). The decrease in long-term average spawning WUA during
24 September (prior to the peak spawning period) would be relatively large (more
25 than 15 percent), with smaller decreases in November and December (less than
26 1 percent) which are after the peak spawning period for fall-run Chinook Salmon.
27 Overall, spawning habitat availability would be slightly lower under Alternative 5
28 relative to the Second Basis of Comparison.

29 *American River*

30 Modeling results indicate that, in general, there would be greater amounts of
31 spawning habitat available for fall-run Chinook Salmon in the American River
32 from October through December under Alternative 5 as compared to the Second
33 Basis of Comparison; fall-run spawning WUA would be slightly (less than 5
34 percent) increased in December with less than 1 percent increases in September
35 (prior to the peak spawning period) and October (the peak spawning month)
36 (Appendix 9E, Table C-25-6). Overall, spawning habitat availability would be
37 similar under Alternative 5 and the Second Basis of Comparison.

38 *Changes in SALMOD Output*

39 SALMOD results indicate that pre-spawning mortality of fall-run Chinook
40 Salmon eggs would be approximately 12 percent greater under Alternative 5,
41 primarily due to increased summer temperatures. Flow-related fall-run Chinook
42 Salmon egg mortality would be reduced by 7 percent under Alternative 5
43 compared to the Second Basis of Comparison. Conversely, temperature-related
44 egg mortality would be 39 percent higher under Alternative 5 (Appendix 9D,
45 Table B-1-29). Flow (habitat)-related fry mortality would be approximately

1 1 percent lower under Alternative 5 as compared to the Second Basis of
2 Comparison. Temperature-related juvenile mortality would be approximately
3 24 percent higher under Alternative 5, while flow (habitat)-related mortality
4 would be approximately 2 percent lower under Alternative 5 as compared to the
5 Second Basis of Comparison. Overall, potential fall-run juvenile production
6 would be slightly (approximately 1 percent) lower under Alternative 5 as
7 compared to the Second Basis of Comparison (Appendix 9D, Table B-1-26).

8 *Changes in Delta Passage Model Output*

9 The Delta Passage Model predicted similar estimates of annual Delta survival
10 across the 81 water year time period for Fall-run between Alternative 5 and the
11 Second Basis of Comparison Alternative (Appendix 9J). Median Delta survival
12 was 0.248 for Alternative 5 and 0.245 for the Second Basis of Comparison.
13 Overall, there would be little change in through-Delta survival by emigrating
14 juvenile fall-run Chinook Salmon under Alternative 5 as compared to the Second
15 Basis of Comparison.

16 *Changes in Delta Hydrodynamics*

17 Fall run Chinook salmon smolts are most abundant in the Delta during the months
18 of April, May and June. At the junction of Georgiana Slough and the Sacramento
19 River, percent positive velocity was considerably lower under Alternative 5
20 relative to the Second Basis of Comparison in May and June (Appendix 9K).
21 Estimates for Alternative 5 were only slightly lower in April. Near the confluence
22 of the San Joaquin River and the Mokelumne River, the proportion of positive
23 velocities was considerably higher under Alternative 5 relative to Second Basis of
24 Comparison in April and May whereas values in June were similar among the
25 alternatives. On Old River downstream of the facilities, the proportion of positive
26 velocities was considerably higher in April and May and moderately higher in
27 June under Alternative 5 relative to Second Basis of Comparison. In Old River
28 upstream of the facilities, the percent of positive velocities was moderately higher
29 under Alternative 5 April and May and moderately lower in June. On the San
30 Joaquin River downstream of the Head of Old River, the percent of positive
31 velocities was considerably lower under Alternative 5 relative to Second Basis of
32 Comparison in April, May and slightly lower in June.

33 *Changes in Junction Entrainment*

34 At the junction of Georgiana Slough and the Sacramento River, entrainment under
35 Alternative 5 was slightly lower than the Second Basis of Comparison in June but
36 essentially indistinguishable in all other months (Appendix 9L). Entrainment at
37 the Head of Old River junction was considerably higher under Alternative 5
38 relative to Second Basis of Comparison during the months of April and May and
39 essentially the same in June. For the Turner Cut junction, entrainment under
40 Alternative 5 was substantially lower in April and May relative to Second Basis
41 of Comparison. Entrainment was lower in June as well but the magnitude of the
42 difference was smaller. At the Columbia Cut junction, entrainment under
43 Alternative 5 was almost indistinguishable from Second Basis of Comparison in
44 June. Entrainment became considerably lower under Alternative 5 relative to
45 Second Basis of Comparison in April and May. A similar pattern of entrainment

1 under Alternative 5 relative to Second Basis of Comparison was observed at the
2 Middle River and Old River junctions.

3 *Changes in Salvage*

4 Salvage of Sacramento River-origin fall run was predicted to be considerably
5 lower under Alternative 5 relative to the Second Basis of Comparison in April and
6 May (Appendix 9M). During the month of June, salvage was still lower under
7 Alternative 5 but the magnitude of the variation relative to Second Basis of
8 Comparison was less.

9 *Summary of Effects on Fall-Run Chinook Salmon*

10 The analysis of temperatures indicates somewhat higher temperatures and greater
11 likelihood of exceedance of thresholds under Alternative 5 as compared to the
12 Second Basis of Comparison in the Sacramento and Feather rivers. There would
13 be little change in flows or temperatures in Clear Creek under Alternative 5
14 relative to the Second Basis of Comparison, but as described above, these
15 differences might not be biologically meaningful because the temperature outputs
16 represent conditions at Igo, a location upstream of most fall-run Chinook Salmon
17 spawning and rearing. The effect of increased temperatures is reflected in the
18 slightly lower overall survival of fall-run Chinook Salmon eggs predicted by
19 Reclamation's salmon mortality model for fall-run in the Feather and American
20 rivers. In drier years, the likelihood of adverse temperature effects would be
21 increased under Alternative 5 as compared to the Second Basis of Comparison.

22 Flow changes under Alternative 5 would likely have small effects on the
23 availability of spawning and rearing habitat for fall-run Chinook Salmon in the
24 Sacramento River as indicated by the slight decrease in spawning WUA in the
25 Sacramento and Feather Rivers and slight increases in spawning WUA for
26 fall-run Chinook Salmon in the American River. Fry and juvenile rearing WUA
27 would be increased slightly in the Sacramento River and this is reflected in a
28 decrease in flow (habitat)-related mortality predicted by SALMOD under
29 Alternative 5.

30 Through-Delta survival of juvenile fall-run Chinook Salmon would be similar
31 under both Alternative 5 and Second Basis of Comparison as indicated by the
32 DPM results and entrainment could be reduced as indicated by the OMR flow
33 analysis. Overall, Alternative 5 likely would have similar or slightly greater
34 adverse effects on the fall-run Chinook Salmon population in the Sacramento
35 River watershed as compared to the Second Basis of Comparison, particularly in
36 drier water year types. However, given that Alternative 5 includes fish passage
37 actions, which are not included in the Second Basis of Comparison, it is unlikely
38 that Alternative 5 would result in adverse effects in comparison with the Second
39 Basis of Comparison.

40 *Late Fall-Run Chinook Salmon*

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

1 *Changes in Water Temperature*

2 Monthly water temperature in the Sacramento River at Keswick Dam under
3 Alternative and the Second Basis of Comparison generally would be similar
4 (within about 0.5°F). Average monthly water temperatures in September under
5 Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to
6 1.2°F) in drier years. A similar temperature pattern generally would be exhibited
7 downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with
8 average monthly temperatures in November, June, and September (in drier years)
9 progressively increasing by as much as 0.8°F at Red Bluff under Alternative 5
10 relative to the Second Basis of Comparison and progressively decreasing (up to
11 3.2°F at Red Bluff) in September during the wetter years.

12 *Changes in Exceedances of Water Temperature Thresholds*

13 Average monthly water temperatures under both Alternative 5 and Second Basis
14 of Comparison would exceed the water temperature threshold of 56°F established
15 in the Sacramento River at Red Bluff (Table temperature targets) during some
16 months, particularly in October, November, and April, when temperature
17 thresholds would be exceeded. The frequency of exceedance would be greatest in
18 October, a month in which average monthly water could get as high as about
19 64°F. In October, average monthly water temperatures under Alternative 5 and
20 Second Basis of Comparison would exceed the threshold 82 percent and
21 79 percent of the time, respectively. However, the differences in the frequency of
22 exceedances between Alternative 5 and Second Basis of Comparison could be
23 biologically meaningful. Water temperatures under Alternative 5 would exceed
24 temperature thresholds about 2 percent more frequently than under the Second
25 Basis of Comparison in October, 1 percent less frequently in November, and
26 1 percent more frequently in April.

27 *Changes in Egg Mortality*

28 For late fall-run Chinook Salmon in the Sacramento River, the long-term average
29 egg mortality rate is predicted to range from approximately 2.4 to nearly 5 percent
30 in all water year types under Alternative 5. Overall, egg mortality would be
31 0.4 percent higher under Alternative 5; in below normal water years the average
32 egg mortality rate would be 0.1 percent lower than under the Second Basis of
33 Comparison. In other water year types, egg mortality is predicted to be from
34 0.2 to 0.8 percent higher under Alternative 5 as compared to the Second Basis of
35 Comparison (Appendix 9C, Table B-2).

36 *Changes in Weighted Usable Area*

37 Modeling results indicate that there would be slightly (less than 5 percent) greater
38 amounts of spawning habitat available for late fall-run Chinook Salmon in the
39 Sacramento River from January through April under Alternative 5 as compared to
40 the Second Basis of Comparison (Appendix 9E, Table C-14-6). Overall,
41 spawning habitat availability would be similar under Alternative 5 and the Second
42 Basis of Comparison.

1 Modeling results indicate that, in general, there would be increased amounts of
2 suitable late fall-run Chinook Salmon fry rearing habitat available during April
3 and May under Alternative 5 (Appendix 9E, Table C-15-6). The increase in long-
4 term average fry rearing WUA during these months would be relatively small
5 (less than 5 percent). Late fall-run Chinook Salmon fry rearing WUA would be
6 decreased by about 2 percent in June under Alternative 5 as compared to the
7 Second Basis of Comparison. Overall, late fall-run fry rearing habitat availability
8 would be similar under Alternative 5 and the Second Basis of Comparison.

9 A substantial fraction of late fall run Chinook Salmon juveniles oversummer in
10 the Sacramento River before emigrating, which allows them to avoid predation
11 through both their larger size and greater swimming ability. One implication of
12 this life history strategy is that rearing habitat is most likely the limiting factor for
13 late-fall-run Chinook Salmon, especially if availability of cool water determines
14 the downstream extent of spawning habitat for late-fall-run salmon. Modeling
15 results indicate that, there would be increased amounts of suitable juvenile rearing
16 habitat available from December through August, but this increase would be small
17 (generally less than 2 percent) under Alternative 5 as compared to the Second
18 Basis of Comparison. There would be a decrease in the amount of late fall-run
19 Chinook Salmon juvenile rearing WUA in the other months (September through
20 November) of up to 10 percent (Appendix 9E, Table C-16-6). Overall, late fall-
21 run juvenile rearing habitat availability would be similar under Alternative 5 and
22 the Second Basis of Comparison.

23 *Changes in SALMOD Output*

24 SALMOD results indicate that flow-related late fall-run Chinook Salmon egg
25 mortality would be reduced by 6 percent under Alternative 5 compared to the
26 Second Basis of Comparison. Conversely, temperature-related egg mortality
27 would be 6 percent higher under Alternative 5 (Appendix 9D, Table B-2-29).
28 Flow (habitat)-related fry mortality would be approximately 1 percent lower while
29 temperature-related fry mortality would be about 26 percent lower under
30 Alternative 5 as compared to the Second Basis of Comparison.
31 Temperature-related juvenile mortality would be approximately 17 percent higher
32 under Alternative 5, while flow (habitat)-related mortality would approximately
33 26 percent higher under Alternative 5 as compared to the Second Basis of
34 Comparison. Overall, potential juvenile production would be similar under
35 Alternative 5 and the Second Basis of Comparison (Appendix 9D, Table B-2-26).

36 *Changes in Delta Passage Model Output*

37 For Late-Fall-Run, Delta survival was predicted to be slightly higher for
38 Alternative 5 versus the Second Basis of Comparison for all 81 water years
39 simulated by the Delta Passage Model (Appendix 9J). Median Delta survival
40 across all years was 0.243 for Alternative 5 and 0.199 for the Second Basis of
41 Comparison. Overall, there would be a slight increase in through-Delta survival
42 by emigrating juvenile late fall-run Chinook Salmon under Alternative 5 as
43 compared to the Second Basis of Comparison.

1 *Changes in Delta Hydrodynamics*

2 The late fall-run Chinook migration period overlaps with that of winter-run
3 Chinook Salmon and they are most abundant in the Delta during the months of
4 January February and March. On the Sacramento River near the confluence of
5 Georgiana Slough, the percentage of positive velocity under Alternative 5 was
6 moderately lower relative to the Second Basis of Comparison in January and
7 indistinguishable in February and March (Appendix 9K). On the San Joaquin
8 River near the Mokelumne River confluence, the percent of positive velocities
9 was slightly greater under Alternative 5 relative to Second Basis of Comparison in
10 January and February and indistinguishable in March. In Old River downstream
11 of the facilities, the percent of positive velocities was considerably higher under
12 Alternative 5 during January and moderately higher in February. Values in
13 March were almost indistinguishable between scenarios. On Old River upstream
14 of the facilities, percent positive velocities were moderately lower in January and
15 slightly lower in February and March under Alternative 5 relative to Second Basis
16 of Comparison. On the San Joaquin River downstream of Head of Old River, the
17 percent of positive velocities was similar for both scenarios in January, February
18 and March.

19 *Changes in Junction Entrainment*

20 At the junction of Georgiana Slough and the Sacramento River, entrainment under
21 Alternative 5 was slightly lower than Second Basis of Comparison in January but
22 essentially indistinguishable in February and March (Appendix 9L). Entrainment
23 at the Head of Old River junction was moderately lower under Alternative 5
24 relative to Second Basis of Comparison during the period of winter run migration
25 through the Delta (January, February, March). For the Turner Cut junction,
26 entrainment under Alternative 5 was moderately lower in January and February
27 relative to Second Basis of Comparison. In March, the difference in entrainment
28 between scenarios was similar. Similar patterns between Alternative 5 and
29 Second Basis of Comparison were observed at the Columbia Cut, Middle River
30 and Old River junctions. At these junctions, entrainment was moderately lower
31 under Alternative 5 during January and February and values became more similar
32 in March.

33 *Changes in Salvage*

34 Salvage of late fall-run Chinook salmon is predicted to be considerably lower
35 under Alternative 5 relative to the Second Basis of Comparison in January and
36 February (Appendix 9M). In March salvage was only moderately lower under
37 Alternative 5 relative to Second Basis of Comparison.

38 *Summary of Effects on Late Fall-Run Chinook Salmon*

39 The analysis of temperatures indicates somewhat higher temperatures and greater
40 likelihood of exceedance of thresholds under Alternative 5 as compared to the
41 Second Basis of Comparison. This is reflected in the slightly lower survival of
42 late fall-run Chinook Salmon eggs predicted by Reclamation's salmon mortality
43 model. Flow changes under Alternative 5 would have small effects on the
44 availability of spawning habitat for late fall-run Chinook Salmon as indicated by

1 the WUA analysis. Fry rearing habitat would be slightly increased under
 2 Alternative 5 but juvenile rearing WUA would decrease during some months as
 3 compared to the Second Basis of Comparison. These effects are reflected in the
 4 decrease in flow (habitat)-related and the increase in temperature-related egg and
 5 fry mortality predicted by SALMOD under Alternative 5. Juvenile rearing
 6 mortality is also predicted to increase under Alternative 5 as compared to the
 7 Second Basis of Comparison. Through Delta survival of juvenile late fall-run
 8 Chinook Salmon would be increased under Alternative 5 relative to the Second
 9 Basis of Comparison as indicated by the DPM results and entrainment may be
 10 reduced as indicated by the OMR flow analysis.

11 Overall, Alternative 5 is likely to have lesser adverse effects on the late fall-run
 12 Chinook Salmon population in the Sacramento River as compared to the Second
 13 Basis of Comparison. Alternative 5 also includes fish passage actions, which are
 14 not included in the Second Basis of Comparison.

15 *Steelhead*

16 Changes in operations that influence temperature and flow conditions that could
 17 affect steelhead. The following describes those changes and their potential
 18 effects.

19 *Changes in Water Temperature*

20 Changes in water temperature could affect steelhead in the Sacramento, Feather,
 21 and American rivers, and Clear Creek. The following describes temperature
 22 conditions in those water bodies.

23 *Sacramento River*

24 Monthly water temperature in the Sacramento River at Keswick Dam under
 25 Alternative and the Second Basis of Comparison generally would be similar
 26 (within about 0.5°F). Average monthly water temperatures in September under
 27 Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to
 28 1.2°F) in drier years. A similar temperature pattern generally would be exhibited
 29 downstream at Ball's Ferry, Jelly's Ferry, Bend Bridge and Red Bluff, with
 30 average monthly temperatures in November, June, and September (in drier years)
 31 progressively increasing by as much as 0.8°F at Red Bluff under Alternative 5
 32 relative to the Second Basis of Comparison and progressively decreasing (up to
 33 3.2°F at Red Bluff) in September during the wetter years (Appendix 6B,
 34 Table B-9-1).

35 *Clear Creek*

36 Average monthly water temperatures in Clear Creek at Igo under Alternative
 37 relative to the Second Basis of Comparison are generally predicted to be similar
 38 (less than 0.5°F differences) from September through April and June through
 39 August (Appendix 6B, Table B-3-6). Average monthly water temperatures during
 40 May under Alternative 5 would be lower by 0.1°F to 0.8°F than under the Second
 41 Basis of Comparison in all water year types.

1 *Feather River*

2 Long-term average monthly water temperature in the Feather River at the low
3 flow channel under Alternative 5 relative to the Second Basis of Comparison
4 generally would be similar (less than 0.5°F differences), but slightly higher
5 (0.6°F) during December and slightly lower (0.6°F) in September. Water
6 temperatures could be up to 1.5°F warmer in November and December of some
7 water year types and up to 1.2°F cooler in September of wetter years. Although
8 temperatures in the river would become progressively higher in the downstream
9 direction, the differences between Alternative 5 and Second Basis of Comparison
10 exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley
11 Bridge), with water temperature differences under Alternative 5 generally
12 increasing in most water year types relative to the Second Basis of Comparison at
13 the confluence with Sacramento. Water temperatures under Alternative 5 are
14 somewhat (0.5°F to 1.8°F) cooler on average and up to 3.9°F cooler at the
15 confluence with Sacramento River from July to September in wetter years.

16 *American River*

17 Average monthly water temperatures in the American River at Nimbus Dam
18 under Alternative 5 generally would be similar (differences less than 0.5°F) to the
19 Second Basis of Comparison, with the exception of during June and August, when
20 temperatures under Alternative 5 could be as much as 0.9°F higher. This pattern
21 generally would persist downstream to Watt Avenue and the mouth, although
22 temperatures under Alternative 5 would be up to 1.6°F and 2.1°F greater,
23 respectively, than under the Second Basis of Comparison in June. In addition,
24 average monthly water temperatures at the mouth generally would be lower than
25 the Second Basis of Comparison in September, especially in wetter water year
26 types when Alternative 5 could be up to 1.7°F cooler.

27 *Changes in Exceedances of Water Temperature Thresholds*

28 Changes in water temperature could result in the exceedance of established water
29 temperature thresholds for steelhead in the Sacramento River, Clear Creek, and
30 Feather River. The following describes the extent of those exceedance for each of
31 those streams.

32 *Sacramento River*

33 As described in the life history accounts (Appendix), steelhead spawning in the
34 mainstem Sacramento River generally occurs in the upper reaches from Keswick
35 Dam downstream to near Balls Ferry, with most spawning concentrated near
36 Redding. Most steelhead, however, spawn in tributaries to the Sacramento River.
37 Spawning generally takes place in the January through March period when water
38 temperatures in the river generally do not exceed 52°F under either Alternative 5
39 or Second Basis of Comparison. While there are no established temperature
40 thresholds for steelhead rearing in the mainstem Sacramento River, average
41 monthly temperatures in during March through June when fry and juvenile
42 steelhead are in the river would be below 56°F during March and April at Balls
43 Ferry. In May and June, average monthly water temperatures would be slightly
44 higher under Alternative 5 than they would be under the Second Basis of

1 Comparison in the drier years, although neither condition would exceed about
 2 57°F. Thus, as it relates to temperature for steelhead in the mainstem Sacramento
 3 River, it is unlikely that Alternative 5 and Second Basis of Comparison would
 4 differ in a biologically meaningful way.

5 *Clear Creek*

6 While there are no established temperature thresholds for steelhead spawning in
 7 Clear Creek, average monthly water temperatures in the river generally would not
 8 exceed 48°F during the spawning period (December to April) under either
 9 Alternative 5 or Second Basis of Comparison. Similarly, while there are no
 10 established temperature thresholds for steelhead rearing in Clear Creek, average
 11 monthly temperatures in throughout the year would not exceed 56°F at Igo. Thus,
 12 as it relates to temperature for steelhead in Clear Creek, it is unlikely that
 13 Alternative 5 and Second Basis of Comparison would differ in a biologically
 14 meaningful way.

15 *Feather River*

16 Average monthly water temperatures under both Alternative 5 and the Second
 17 Basis of Comparison would on occasion exceed the water temperature threshold
 18 of 56°F established in the Feather River at Robinson Riffle for steelhead
 19 spawning and incubation during some months, particularly in October and
 20 November, and March and April, when temperature thresholds could be exceeded
 21 frequently (Appendix 9N). There would be a 1 percent exceedance of the 56°F
 22 threshold in December and no exceedances of the 56°F threshold in January and
 23 February under both t Alternative 5 and the Second Basis of Comparison.
 24 However, the differences in the frequency of exceedance between Alternative 5
 25 and Second Basis of Comparison during March and April would be relatively
 26 small with water temperatures under Alternative 5 exceeding the threshold about
 27 1 percent more frequently in March and the same exceedance frequency
 28 (75 percent) as the Second Basis of Comparison in April. The established water
 29 temperature threshold of 63°F for rearing from May through August would be
 30 exceeded often under both Alternative 5 and Second Basis of Comparison in May
 31 and June, but not at all in July and August. Water temperatures under Alternative
 32 5 would exceed the rearing temperature threshold about 6 percent more frequently
 33 than under the Second Basis of Comparison in May, but no more frequently in
 34 June. Temperature conditions in the Feather River under Alternative 5 could be
 35 more likely to affect steelhead spawning and rearing than under the Second Basis
 36 of Comparison because of the slightly increased frequency of exceedance of the
 37 56°F spawning threshold in March and the somewhat increased frequency of
 38 exceedance of the 63°F rearing threshold in May.

39 *American River*

40 In the American River, the water temperature threshold for steelhead rearing
 41 (May through October) is 65°F at the Watt Avenue Bridge. Average monthly
 42 water temperatures would exceed this threshold often under both Alternative 5
 43 and Second Basis of Comparison, especially in the July through September period
 44 when the threshold is exceeded nearly all of the time. In addition, the magnitude
 45 of the exceedance would be high, with average monthly water temperatures

1 sometimes higher than 76°F. The differences between Alternative 5 and Second
2 Basis of Comparison, however, would be relatively small (differences within
3 1 percent), except in September, when average monthly water temperatures under
4 Alternative 5 would exceed 65°F about 6 percent less frequently than under the
5 Second Basis of Comparison. This difference may not be as biologically
6 important because it occurs at the lower temperature range for the month.
7 Temperature conditions in the American River under Alternative 5 could increase
8 the likelihood of adverse effects on steelhead rearing than under the Second Basis
9 of Comparison because of the increased frequency of exceedance of the 65°F
10 rearing threshold in some months.

11 *Changes in Weighted Usable Area*

12 The following describes changes in WUA for steelhead in the Sacramento,
13 Feather, and American rivers and Clear Creek.

14 *Sacramento River*

15 Modeling results indicate that, in general, there would be greater amounts of
16 suitable steelhead spawning habitat available from December through March
17 under Alternative 5 as compared to the Second Basis of Comparison (Appendix
18 9E, Table C-20-6). The increases in long-term average steelhead spawning WUA
19 would be relatively small (less than 3 percent). Overall, spawning habitat
20 availability would be similar under Alternative 5 and the Second Basis of
21 Comparison.

22 *Clear Creek*

23 As described above, flows in Clear Creek below Whiskeytown Dam are not
24 anticipated to differ under Alternative 5 relative to the Second Basis of
25 Comparison except in May due to the release of spring attraction flows in
26 accordance with the 2009 NMFS BO. Therefore, there would be no change in the
27 amount of potentially suitable spawning and rearing habitat for steelhead (as
28 indexed by WUA) available under Alternative 5 as compared to the Second Basis
29 of Comparison.

30 *Feather River*

31 As described above, Flows in the low flow channel of the Feather River are not
32 anticipated to differ under Alternative 5 relative to the Second Basis of
33 Comparison. Therefore, there would be no change in the amount of potentially
34 suitable spawning habitat for steelhead (as indexed by WUA) available under
35 Alternative 5 as compared to the Second Basis of Comparison. The majority of
36 spawning activity by steelhead in the Feather River occurs in this reach with a
37 lesser amount of spawning occurring downstream of the Thermalito Complex.

38 Modeling results indicate that, in general, there would be greater amounts of
39 spawning habitat for steelhead in the Feather River below Thermalito available
40 from December through April under Alternative 5 as compared to the Second
41 Basis of Comparison. The increases in long-term average steelhead spawning
42 WUA during this time period would generally be less than 3 percent
43 (Appendix 9E, Table C-22-6). Overall, steelhead spawning habitat availability
44 would be similar under Alternative 5 and the Second Basis of Comparison.

1 *American River*

2 Modeling results indicate that, in general, there would be variable changes in the
3 amount of spawning habitat for steelhead in the American River below Nimbus
4 Dam available from December through April under Alternative 5 as compared to
5 the Second Basis of Comparison. The increases in long-term average steelhead
6 spawning WUA during December, February and March would generally be less
7 than 3 percent, while the decrease in April would also be less than 3 percent
8 (Appendix 9E, Table C-26-4). Overall, steelhead spawning habitat availability
9 would be similar under Alternative 5 and the Second Basis of Comparison.

10 *Changes in Delta Hydrodynamics*

11 Sacramento River-origin steelhead generally move through the Delta during
12 spring however there is less information on their timing relative to Chinook
13 salmon. Thus, hydrodynamics in the entire January through June period have the
14 potential to affect juvenile steelhead.

15 On the Sacramento River near the confluence of Georgiana Slough, the
16 percentage of positive velocity under Alternative 5 was moderately lower relative
17 to the Second Basis of Comparison in January and indistinguishable in February
18 and March (Appendix 9K). On the San Joaquin River near the Mokelumne River
19 confluence, the percent of positive velocities was slightly greater under
20 Alternative 5 relative to Second Basis of Comparison in January and February and
21 indistinguishable in March. In Old River downstream of the facilities, the percent
22 of positive velocities was considerably higher under Alternative 5 during January
23 and moderately higher in February. Values in March were almost
24 indistinguishable between scenarios. On Old River upstream of the facilities,
25 percent positive velocities were moderately lower in January and slightly lower in
26 February and March under Alternative 5 relative to Second Basis of Comparison.
27 On the San Joaquin River downstream of Head of Old River, the percent of
28 positive velocities was similar for both scenarios in January, February and March.

29 At the junction of Georgiana Slough and the Sacramento River, percent positive
30 velocity was considerably lower under Alternative 5 relative to the Second Basis
31 of Comparison in May and June. Estimates for Alternative 5 were only slightly
32 lower in April. Near the confluence of the San Joaquin River and the Mokelumne
33 River, the proportion of positive velocities was considerably higher under
34 Alternative 5 relative to Second Basis of Comparison in April and May whereas
35 values in June were similar among the alternatives. On Old River downstream of
36 the facilities, the proportion of positive velocities was considerably higher in
37 April and May and moderately higher in June under Alternative 5 relative to
38 Second Basis of Comparison. In Old River upstream of the facilities, the percent
39 of positive velocities was moderately higher under Alternative 5 April and May
40 and moderately lower in June. On the San Joaquin River downstream of the Head
41 of Old River, the percent of positive velocities was considerably lower under
42 Alternative 5 relative to Second Basis of Comparison in April, May and slightly
43 lower in June.

1 *Changes in Junction Entrainment*

2 At the junction of Georgiana Slough and the Sacramento River, entrainment under
3 Alternative 5 was slightly lower than Second Basis of Comparison in June but
4 essentially indistinguishable in all other months (Appendix 9L). Entrainment at
5 the Head of Old River junction was considerably higher under Alternative 5
6 relative to Second Basis of Comparison during the months of April and May and
7 slightly lower in January and February. Entrainment in March and June was
8 essentially the same in March and June. For the Turner Cut junction, entrainment
9 under Alternative 5 was much lower in April and May relative to Second Basis of
10 Comparison. Entrainment was lower in the other months as well but the
11 magnitude of the difference was smaller. At the Columbia Cut junction,
12 entrainment under Alternative 5 was almost indistinguishable from Second Basis
13 of Comparison in March and June. Entrainment was slightly lower under
14 Alternative 5 during January and February and became even lower in April and
15 May. A similar pattern of entrainment under Alternative 5 relative to Second
16 Basis of Comparison was observed at the Middle River and Old River junctions.

17 *Summary of Effects on Steelhead*

18 The analysis of temperatures indicates somewhat higher temperatures and greater
19 likelihood of exceedance of thresholds under Alternative 5 as compared to the
20 Second Basis of Comparison in the Sacramento and Feather rivers. In drier years,
21 the likelihood of adverse temperature effects would be increased under
22 Alternative 5 as compared to the Second Basis of Comparison. There would be
23 little change in flows or temperatures in Clear Creek under Alternative 5 relative
24 to the Second Basis of Comparison.

25 Overall, Alternative 5 is likely to have somewhat greater adverse effects on the
26 steelhead population in the Sacramento River watershed as compared to the
27 Second Basis of Comparison, particularly in drier water year types because of the
28 temperature effects. Alternative 5 also includes actions to provide fish passage
29 upstream of Shasta and Folsom dams, which are not included in the Second Basis
30 of Comparison. Depending on the success of these actions, passage could provide
31 additional benefit for steelhead.

32 *Green Sturgeon*

33 Changes in operations that influence temperature and flow conditions could affect
34 Green Sturgeon. The following describes those changes and their potential
35 effects.

36 *Changes in Water Temperature*

37 Changes in water temperature could affect Green Sturgeon in the Sacramento and
38 Feather rivers. The following describes temperature conditions in those water
39 bodies.

40 *Sacramento River*

41 Monthly water temperature in the Sacramento River at Keswick Dam under
42 Alternative and the Second Basis of Comparison generally would be similar
43 (within about 0.5°F). Average monthly water temperatures in September under

1 Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to
 2 1.2°F) in drier years (Appendix 6B). A similar pattern in temperature differences
 3 generally would be exhibited at downstream locations along the Sacramento River
 4 (i.e., Ball's Ferry, Jelly's Ferry, Bend Bridge, Red Bluff, Hamilton City, and
 5 Knights Landing), with differences in average monthly temperatures in June at
 6 Knights Landing progressively increasing (up to 0.9°F) under Alternative 5
 7 relative to the Second Basis of Comparison and progressively decreasing (up to
 8 4.6°F) in September during the wetter years.

9 *Feather River*

10 Long-term average monthly water temperature in the Feather River at the low
 11 flow channel under Alternative 5 relative to the Second Basis of Comparison
 12 generally would be similar (less than 0.5°F differences), but slightly higher
 13 (0.6°F) during December and slightly lower (0.6°F) in September. Water
 14 temperatures could be up to 1.5°F warmer in November and December of some
 15 water year types and up to 1.2°F cooler in September of wetter years. Although
 16 temperatures in the river would become progressively higher in the downstream
 17 direction, the differences between Alternative 5 and Second Basis of Comparison
 18 exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley
 19 Bridge), with water temperature differences under Alternative 5 generally
 20 increasing in most water year types relative to the Second Basis of Comparison at
 21 the confluence with Sacramento. Water temperatures under Alternative 5 are
 22 somewhat (0.5°F to 1.8°F) cooler on average and up to 3.9°F cooler at the
 23 confluence with Sacramento River from July to September in wetter years.

24 *Changes in Exceedances of Water Temperature Thresholds*

25 Changes in water temperature could result in the exceedance of established water
 26 temperature thresholds for Green Sturgeon in the Sacramento and Feather rivers.
 27 The following describes the extent of those exceedance for each of those rivers.

28 *Sacramento River*

29 Average monthly water temperatures in the Sacramento River at Bend Bridge
 30 under both Alternative 5 and Second Basis of Comparison would exceed the
 31 water temperature threshold of 63°F established for Green Sturgeon egg
 32 incubation in August and September, with exceedances under Alternative 5
 33 occurring about 7 percent of the time in August and about 12 percent of the time
 34 in September relative to the Second Basis of Comparison. This is 1 to 2 percent
 35 more frequently than under the Second Basis of Comparison. Average monthly
 36 water temperatures at Bend Bridge could be as high as about 73°F during this
 37 period. Temperature conditions in the Sacramento River under Alternative 5
 38 could be more likely to affect Green Sturgeon rearing than under the Second
 39 Basis of Comparison because of the increased frequency of exceedance of the
 40 63°F threshold in August and September.

41 *Feather River*

42 Average monthly water temperatures in the Feather River at Gridley Bridge under
 43 both Alternative 5 and Second Basis of Comparison would exceed the water
 44 temperature threshold of 64°F established for Green Sturgeon spawning,

1 incubation, and rearing in May, June, and September; no exceedances under either
2 scenarios would occur in July and August. The frequency of exceedances would
3 be high, with both Alternative 5 and Second Basis of Comparison exceeding the
4 threshold in June nearly 100 percent of the time. The magnitude of the
5 exceedance also would be substantial, with average monthly temperatures higher
6 than 72°F in June, and higher than 75°F in July and August. Water temperatures
7 under Alternative 5 would exceed the threshold for May about 7 percent more
8 frequently than the Second Basis of Comparison and about 33 percent less
9 frequently in September. Temperature conditions in the Feather River under
10 Alternative 5 could be more likely to affect Green Sturgeon rearing than under the
11 Second Basis of Comparison because of the increased frequency of exceedance of
12 the 64°F threshold in May. The reduction in exceedance frequency in September
13 may have less effect on rearing Green Sturgeon as many juvenile sturgeon may
14 have migrated downstream to the lower Sacramento River and Delta by this time.

15 *Summary of Effects on Green Sturgeon*

16 The temperature threshold analysis in the Sacramento and Feather rivers both
17 suggest that average monthly water temperatures under Alternative 5 would
18 exceed thresholds for Green Sturgeon more frequently than under the Second
19 Basis of Comparison, although the frequency of exceedance would be relatively
20 small (1-2 percent). However, because the average monthly temperatures may
21 mask higher temperature excursions above the threshold, these differences could
22 be biologically meaningful. Thus, Alternative 5 could be more likely to affect
23 Green Sturgeon than the Second Basis of Comparison.

24 *White Sturgeon*

25 Changes in water temperature conditions in the Sacramento and Feather rivers
26 would be the same as those described above for Green Sturgeon, with relatively
27 minor (less than 0.5°F) differences between Alternative 5 and Second Basis of
28 Comparison.

29 The water temperature threshold established for White Sturgeon spawning and
30 egg incubation in the Sacramento River at Hamilton City is 61°F from March
31 through June. Although there would be no exceedances of the threshold in March
32 and April, water temperatures under both Alternative 5 and Second Basis of
33 Comparison would exceed this threshold in May and June. The average monthly
34 water temperatures in May under Alternative 5 would exceed this threshold about
35 56 percent of the time (about 7 percent more frequently than the Second Basis of
36 Comparison). In June, the temperature under Alternative 5 would exceed the
37 threshold about 87 percent of the time (about 13 percent more frequently than the
38 Second Basis of Comparison). Average monthly water temperatures during May
39 and June under Alternative 5 would as high as about 65°F.

40 *Summary of Effects on White Sturgeon*

41 Overall, based on the frequency and magnitude of temperature threshold
42 exceedances, Alternative 5 is more likely to affect White Sturgeon than the
43 Second Basis of Comparison.

1 *Delta Smelt*

2 A proportional entrainment regression model (based on Kimmerer 2008, 2011)
3 was used to simulate adult Delta Smelt entrainment, as influenced by OMR flow
4 in December through March. Results indicate that the percentage of entrainment
5 of migrating and spawning adult Delta Smelt under Alternative 5 would be 7 to
6 8.3 percent, depending on the water year type, with a long-term average percent
7 entrainment of 7.6 percent. Percent entrainment of adult Delta Smelt under
8 Alternative 5 would be similar to results under Second Basis of Comparison
9 (lower by 1 to 2 percent). Under the Second Basis of Comparison, the long-term
10 average entrainment would be 9 percent.

11 A proportional entrainment regression model (based on Kimmerer 2008) also was
12 used to simulate larval and early juvenile Delta Smelt entrainment, as influenced
13 by OMR flow and location of X2 in March through June. Results indicate that the
14 percentage of entrainment of larval and early juvenile Delta Smelt under
15 Alternative 5 would be 1.3 to 19.3 percent, depending on the water year type, with
16 a long term average percent entrainment of 8.6 percent, and highest entrainment
17 under Critical water year conditions. Percent entrainment of larval and early
18 juvenile Delta Smelt under Alternative 5 would be lower than results under the
19 Second Basis of Comparison by 4.3 to 9.4 percent. Under the Second Basis of
20 Comparison, the long-term average percent entrainment would be 15.5 percent,
21 and highest entrainment would occur under critical dry water year conditions, at
22 23.6 percent.

23 Alternative 5 includes the operations related to the 2008 USFWS BO RPA
24 Component 3 (Action 4), Fall X2 requirement, while the Second Basis of
25 Comparison does not. Therefore, the average September through December X2
26 position under Alternative 5 would be westward by over 6 km compared to the
27 Second Basis of Comparison during the wetter years. In the drier years
28 September through December average X2 position is similar under both
29 scenarios.

30 *Summary of Effects on Delta Smelt*

31 Overall, Alternative 5 likely would have beneficial effects on Delta Smelt, as
32 compared to the Second Basis of Comparison, primarily due to lower percentage
33 entrainment of larval and juvenile life stages, and more favorable location of Fall
34 X2 in wetter years, and on average.

35 *Longfin Smelt*

36 The effects of the Alternative 5 as compared to the Second Basis of Comparison
37 were analyzed based on the direction and magnitude of OMR flows during the
38 period (December through June) when adult, larvae, and young juvenile Longfin
39 Smelt are present in the Delta in the vicinity of the export facilities (Appendix
40 5A). The analysis was augmented with calculated Longfin Smelt abundance
41 index values (Appendix 9G) per Kimmerer et al. (2009), which is based on the
42 assumptions that lower X2 values reflect higher flows and that transporting
43 Longfin Smelt farther downstream leads to greater Longfin Smelt survival. The

1 index value indicates the relative abundance of Longfin Smelt and not the
2 calculated population.

3 Under Alternative 5, Longfin Smelt abundance index values range from
4 1,204 under critical water year conditions to a high of 16,683 under wet water
5 year conditions, with a long-term average value of 8,015. Under the Second Basis
6 of Comparison, Longfin Smelt abundance index values range from 947 under
7 critical water year conditions to a high of 15,822 under wet water year conditions,
8 with a long-term average value of 7,257.

9 Results indicate that the Longfin Smelt abundance index values would be greater
10 in every water year type under Alternative 5 than under the Second Basis of
11 Comparison, with a long-term average index for Alternative 5 that is about
12 10 percent higher than the long term average index for the Second Basis of
13 Comparison. For below normal, dry, and critical water years, the Longfin Smelt
14 abundance index values would be over 20 percent greater under Alternative 5 than
15 under the Second Basis of Comparison, with the greatest difference (30.8 percent)
16 predicted under dry conditions.

17 Overall, based on the lower frequency and magnitude of negative OMR flows and
18 the higher Longfin Smelt abundance index values, especially in dry and critical
19 years, Alternative 5 would be likely to have a positive effect on the Longfin Smelt
20 population as compared to the Second Basis of Comparison.

21 *Sacramento Splittail*

22 Under Alternative 5, flows entering the Yolo Bypass over the Fremont Weir
23 generally would be slightly lower compared to the Second Basis of Comparison
24 (Appendix 5A, Table C-26-6), thus potentially providing lower value to
25 Sacramento Splittail because of the lower area of potential habitat (inundation)
26 and the lower frequency of inundation.

27 *Reservoir Fishes*

28 Changes in CVP and SWP water supplies and operations under Alternative 5 as
29 compared to the Second Basis of Comparison generally would result in lower
30 reservoir storage in CVP and SWP reservoirs in the Central Valley Region.
31 Storage levels in Shasta Lake, Lake Oroville, and Folsom Lake would be lower
32 under Alternative 5 as compared to the Second Basis of Comparison in the fall
33 and winter months due to the inclusion of Fall X2 criteria under Alternative 5.

34 The highest reductions in Shasta Lake and Lake Oroville storage could be in
35 excess of 20 percent. Storage in Folsom Lake could be reduced up to around
36 10 percent in some months of some water year types. Additional information
37 related to monthly reservoir elevations is provided in Appendix 5A, CalSim II and
38 DSM2 Modeling. The reduction in reservoir storage under Alternative 5 may
39 suggest that the amount of habitat for reservoir fishes could be reduced under
40 Alternative 5 as compared to the Second Basis of Comparison.

41 Black bass nest survival in CVP and SWP reservoirs is anticipated to be near
42 100 percent in March and April due to increasing reservoir elevations. For May,
43 the likelihood of nest survival for Largemouth Bass in Lake Shasta being in the

1 40 to 100 percent range is about 2 percent higher under Alternative 5 as compared
2 to the Second Basis of Comparison. For June, the likelihood of nest survival
3 being greater than 40 percent for Largemouth Bass is similar (within 1 percent)
4 under Alternative 5 and Second Basis of Comparison; however, nest survival of
5 greater than 40 percent is likely only in about 20 percent of the years evaluated.
6 The likelihood of nest survival for Smallmouth Bass in Lake Shasta exhibits
7 nearly the same pattern. For Spotted Bass, the likelihood of nest survival being
8 greater than 40 percent is high (100 percent) in May under both Alternative 5 and
9 the Second Basis of Comparison. For June, Spotted Bass nest survival would be
10 less than for May due to greater daily reductions in water surface elevation as
11 Shasta Lake is drawn down. The likelihood of survival being greater than
12 40 percent is higher (about 12 percent) under Alternative 5 as compared to the
13 Second Basis of Comparison.

14 For May and June, the likelihood of nest survival for Largemouth Bass in Lake
15 Oroville being in the 40 to 100 percent range is higher under Alternative 5 as
16 compared to the Second Basis of Comparison, about 13 percent higher in May
17 and about 4 percent higher in June. However, June nest survival of greater than
18 40 percent is likely only in about 40 percent of the years evaluated. The
19 likelihood of nest survival for Smallmouth Bass in Lake Oroville exhibits nearly
20 the same pattern. For Spotted Bass, the likelihood of nest survival being greater
21 than 40 percent is 100 percent in May under Alternative 5 as compared to about
22 94 percent under the Second Basis of Comparison. For June, Spotted Bass
23 survival would be less than for May due to greater daily reductions in water
24 surface elevation as Lake Oroville is drawn down. The likelihood of survival
25 being greater than 40 percent is substantially higher (on the order of 20 percent)
26 under Alternative 5 as compared to the Second Basis of Comparison.

27 Black bass nest survival in Folsom Lake is near 100 percent in March, April, and
28 May due to increasing reservoir elevations. For June, the likelihood of nest
29 survival for Largemouth Bass and Smallmouth Bass in Folsom Lake being in the
30 40 to 100 percent range is somewhat (around 7 percent) higher under Alternative
31 5 than under the Second Basis of Comparison. For Spotted Bass, nest survival for
32 June would be less than for May due to greater daily reductions in water surface
33 elevation. However, the likelihood of survival being greater than 40 percent is
34 slightly (around 3 percent) greater under Alternative 5 as compared to the Second
35 Basis of Comparison.

36 Based on the predicted black bass nest survival in Shasta Lake, Lake Oroville,
37 and Folsom Lake, Alternative 5 is likely to have higher nest survival than the
38 Second Basis of Comparison.

39 *Other Species*

40 Several other fish species could be affected by changes in operations that
41 influence temperature and flow. The following describes the extent of these
42 changes and the potential effects on these species.

1 *Pacific Lamprey*

2 Little information is available on factors that influence populations of Pacific
3 Lamprey in the Sacramento River, but they are likely affected by many of the
4 same factors as salmon and steelhead because of the parallels in their life cycles.

5 *Changes in Water Temperature*

6 The following describes anticipated changes in average monthly water
7 temperature in the Sacramento, Feather, and American rivers and the potential for
8 those changes to affect Pacific Lamprey.

9 *Sacramento River*

10 Monthly water temperature in the Sacramento River at Keswick Dam under
11 Alternative and the Second Basis of Comparison generally would be similar
12 (within about 0.5°F). Average monthly water temperatures in September under
13 Alternative 5 would be lower (up to 0.9°F) in wetter years and higher (up to
14 1.2°F) in drier years (Appendix 6B, Table 5-5-1). A similar temperature pattern
15 generally would be exhibited downstream at Ball's Ferry, Jelly's Ferry, and Bend
16 Bridge, with average monthly temperatures in June progressively increasing by a
17 small margin under Alternative 5 relative to the Second Basis of Comparison.
18 Due to the similarity of water temperatures under Alternative 5 and Second Basis
19 of Comparison from January through the summer, there would be little difference
20 in potential effects on Pacific Lamprey adults during their migration, holding, and
21 spawning periods.

22 *Feather River*

23 Long-term average monthly water temperature in the Feather River at the low
24 flow channel under Alternative 5 relative to the Second Basis of Comparison
25 generally would be similar (less than 0.5°F differences), but slightly higher
26 (0.6°F) during December and slightly lower (0.6°F) in September. Water
27 temperatures could be up to 1.5°F warmer in November and December of some
28 water year types and up to 1.2°F cooler in September of wetter years. Although
29 temperatures in the river would become progressively higher in the downstream
30 direction, the differences between Alternative 5 and Second Basis of Comparison
31 exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley
32 Bridge), with water temperature differences under Alternative 5 generally
33 increasing in most water year types relative to the Second Basis of Comparison at
34 the confluence with Sacramento. Water temperatures under Alternative 5 are
35 somewhat (0.5°F to 1.8°F) cooler on average and up to 3.9°F cooler at the
36 confluence with Sacramento River from July to September in wetter years.

37 Due to the similarity of water temperatures under Alternative 5 and Second Basis
38 of Comparison from January through April, there would be little difference in
39 potential effects on Pacific Lamprey adults during their upstream migration. The
40 slightly higher water temperatures from May through the summer may increase
41 the likelihood of adverse effects on Pacific Lamprey during their holding, and
42 spawning periods.

1 *American River*

2 Average monthly water temperatures in the American River at Nimbus Dam
 3 under Alternative 5 generally would be similar (differences less than 0.5°F) to the
 4 Second Basis of Comparison, with the exception of during June and August, when
 5 differences under Alternative 5 could be as much as 0.9°F higher. This pattern
 6 generally would persist downstream to Watt Avenue and the mouth, although
 7 temperatures under Alternative 5 would be up to 1.6°F and 2.1°F greater,
 8 respectively, than under the Second Basis of Comparison in June. Due to the
 9 similarity of water temperatures under Alternative 5 and Second Basis of
 10 Comparison from January through May, there would be little difference in
 11 potential effects on Pacific Lamprey adults during their upstream migration. The
 12 higher water temperatures during June and August may increase the likelihood of
 13 adverse effects on Pacific Lamprey during their holding, and spawning periods.

14 *Summary of Effects on Pacific Lamprey*

15 In general, Pacific Lamprey can tolerate higher temperatures than salmonids, up
 16 to around 72°F during their entire life history. Because lamprey ammocoetes
 17 remain in the river for several years, any substantial flow reductions or
 18 temperature increases could adversely affect the larvae. Given the reduced flows
 19 and increased temperatures during their spawning and incubation period, it is
 20 likely that Alternative 5 would have a higher potential to adversely influence
 21 Pacific Lamprey in the Sacramento, Feather, and American rivers than would the
 22 Second Basis of Comparison. This conclusion likely applies to other species of
 23 lamprey that inhabit these rivers (e.g., River Lamprey).

24 *Striped Bass, American Shad, and Hardhead*

25 Changes in operations influence temperature and flow conditions that could affect
 26 Striped Bass, American Shad, and Hardhead. The following describes those
 27 changes and their potential effects.

28 *Changes in Water Temperature*

29 Changes in water temperature that affect Striped Bass, American Shad, and
 30 Hardhead could occur in the Sacramento, Feather, and American rivers. The
 31 following describes temperature conditions in those water bodies.

32 *Sacramento River*

33 As described above for lampreys, monthly water temperature in the Sacramento
 34 River at Keswick Dam under Alternative and the Second Basis of Comparison
 35 generally would be similar (within about 0.5°F). Average monthly water
 36 temperatures in September under Alternative 5 would be lower (up to 0.9°F) in
 37 wetter years and higher (up to 1.2°F) in drier years (Appendix 6B, Table 5-5-1).
 38 A similar temperature pattern generally would be exhibited downstream at Ball's
 39 Ferry, Jelly's Ferry, and Bend Bridge, with average monthly temperatures in June
 40 progressively increasing by a small margin under Alternative 5 relative to the
 41 Second Basis of Comparison.

42 *Feather River*

43 Long-term average monthly water temperature in the Feather River at the low
 44 flow channel under Alternative 5 relative to the Second Basis of Comparison

1 generally would be similar (less than 0.5°F differences), but slightly higher
2 (0.6°F) during December and slightly lower (0.6°F) in September. Water
3 temperatures could be up to 1.5°F warmer in November and December of some
4 water year types and up to 1.2°F cooler in September of wetter years. Although
5 temperatures in the river would become progressively higher in the downstream
6 direction, the differences between Alternative 5 and Second Basis of Comparison
7 exhibit a similar pattern at the downstream locations (Robinson Riffle and Gridley
8 Bridge), with water temperature differences under Alternative 5 generally
9 increasing in most water year types relative to the Second Basis of Comparison at
10 the confluence with Sacramento. Water temperatures under Alternative 5 are
11 somewhat (0.5°F to 1.8°F) cooler on average and up to 3.9°F cooler at the
12 confluence with Sacramento River from July to September in wetter years.

13 *American River*

14 Average monthly water temperatures in the American River at Nimbus Dam
15 under Alternative 5 generally would be similar (differences less than 0.5°F) to the
16 Second Basis of Comparison, with the exception of during June and August, when
17 differences under Alternative 5 could be as much as 0.9°F higher. This pattern
18 generally would persist downstream to Watt Avenue and the mouth, although
19 temperatures under Alternative 5 would be up to 1.6°F and 2.1°F greater,
20 respectively, than under the Second Basis of Comparison in June.

21 *Summary of Effects on Striped Bass, American Shad, and Hardhead*

22 Because Striped Bass, American Shad, and Hardhead can tolerate higher
23 temperatures than salmonids, it is unlikely that the slightly increased temperatures
24 during some months under Alternative 5 would have substantial adverse effects
25 on these species in the American River.

26 *Stanislaus River/Lower San Joaquin River*

27 *Fall-Run Chinook Salmon*

28 Changes in operations influence temperature and flow conditions that could affect
29 fall-run Chinook Salmon in the Stanislaus River downstream of Goodwin Dam
30 and in the San Joaquin River below Vernalis. The following describes those
31 changes and their potential effects.

32 *Changes in Water Temperature (Stanislaus River)*

33 Average monthly water temperatures in the Stanislaus River at Goodwin Dam
34 under Alternative 5 and Second Basis of Comparison generally would be similar
35 (differences less than 0.5°F), except in August through October when long-term
36 average monthly temperatures could be up to 1.0°F warmer than under the Second
37 Basis of Comparison. These differences would be of higher magnitude in drier
38 years with average monthly water temperatures in September as much as 1.9°F
39 warmer under Alternative 5 as compared to the Second Basis of Comparison
40 (Appendix 6B, Table B-17-6).

41 Downstream at Orange Blossom Bridge, average monthly water temperatures in
42 October and April under Alternative 5 would be lower in all water year types than
43 the Second Basis of Comparison by as much as 1.4°F in October and 1.6°F in

1 April. In most other months, long-term average monthly water temperatures
 2 under Alternative 5 generally would be similar, although somewhat higher (up to
 3 0.7°F), compared to the Second Basis of Comparison. Water temperatures under
 4 Alternative 5 could be up to 1.3°F warmer in drier years from July to September
 5 than under the Second Basis of Comparison. (Appendix 6B, Table B-18-6).

6 Downstream at the confluence with the San Joaquin River, average monthly water
 7 temperatures in October, April and May would be lower in all water year types
 8 under Alternative 5 than the Second Basis of Comparison by as much as 2.0°F in
 9 October, 1.9°F in April and 0.8°F in May. In most other months, long-term
 10 average monthly water temperatures under Alternative 5 generally would be
 11 similar, although somewhat higher (up to 1.1°F), compared to the Second Basis of
 12 Comparison in June (Appendix 6B, Table B-19-6).

13 *Changes in Exceedance of Water Temperature Thresholds (Stanislaus*
 14 *River)*

15 While specific water temperature thresholds for fall-run Chinook Salmon in the
 16 Stanislaus River are not established, temperatures generally suitable for fall-run
 17 Chinook Salmon spawning (56°F) would be exceeded in October and November
 18 over 30 percent of the time in the Stanislaus River at Goodwin Dam under
 19 Alternative 5 (Appendix 6B, Table B-17-6). Similar exceedances would occur
 20 under the Second Basis of Comparison, although slightly more frequently. Water
 21 temperatures for rearing from January to May generally would be below 56°F,
 22 except in May when average monthly water temperatures would reach about 60°F
 23 under both conditions (Appendix 6B, Figure B-17-8).

24 Downstream at Orange Blossom Bridge, water temperatures suitable for fall-run
 25 Chinook Salmon spawning would be exceeded frequently under both
 26 Alternative 5 and Second Basis of Comparison during October and November.
 27 Under Alternative 5, average monthly water temperatures would exceed 56°F
 28 about 57 percent of the time in October (Appendix 6B, Figure B-18-1). This,
 29 however, would be about 28 percent less frequently than under the Second Basis
 30 of Comparison. In November, average monthly water temperatures would exceed
 31 56°F about 33 percent of the time under Alternative 5, which would be about
 32 5 percent more frequent than under the Second Basis of Comparison
 33 (Appendix 6B, Figure B-18-2).

34 During January through May, rearing fall-run Chinook Salmon under Alternative
 35 5 would be subjected to average monthly water temperatures that exceed 56° in
 36 March (less than 10 percent of the time) and May (about 30 percent of the time)
 37 under Alternative 5 which is about 10 percent more frequently than under the
 38 Second Basis of Comparison (Appendix 6B, Figure B-18-8).

39 *Changes in Egg Mortality (Stanislaus River)*

40 For fall-run Chinook Salmon in the Stanislaus River, the long-term average egg
 41 mortality rate is predicted to be around 8.5 percent, with higher mortality rates (in
 42 excess of 15 percent) occurring in critical dry years under Alternative 5. Overall,
 43 egg mortality would be 1.0 percent higher under Alternative 5; the average egg

1 mortality rate would be higher than under the Second Basis of Comparison by up
2 to 2.0 percent in below normal years (Appendix 9C, Table B-8).

3 *Changes in Delta Hydrodynamics*

4 San Joaquin River-origin fall run Chinook salmon smolts are most abundant in the
5 Delta during the months of April, May and June. Near the confluence of the San
6 Joaquin River and the Mokelumne River, the proportion of positive velocities was
7 considerably higher under Alternative 5 relative to Second Basis of Comparison
8 in April and May whereas values in June were similar among the alternatives
9 (Appendix 9K). On Old River downstream of the facilities, the proportion of
10 positive velocities was considerably higher in April and May and moderately
11 higher in June under Alternative 5 relative to Second Basis of Comparison. In
12 Old River upstream of the facilities, the percent of positive velocities was
13 moderately higher under Alternative 5 April and May and moderately lower in
14 June. On the San Joaquin River downstream of the Head of Old River, the
15 percent of positive velocities was considerably lower under Alternative 5 relative
16 to Second Basis of Comparison in April, May and slightly lower in June.

17 *Changes in Junction Entrainment*

18 Entrainment at the Head of Old River junction was considerably higher under
19 Alternative 5 relative to Second Basis of Comparison during the months of April
20 and May and essentially the same in June (Appendix 9L). For the Turner Cut
21 junction, entrainment under Alternative 5 was substantially lower in April and
22 May relative to Second Basis of Comparison. Entrainment was lower in June as
23 well but the magnitude of the difference was smaller. At the Columbia Cut
24 junction, entrainment under Alternative 5 was almost indistinguishable from
25 Second Basis of Comparison in June. Entrainment became considerably lower
26 under Alternative 5 relative to Second Basis of Comparison in April and May. A
27 similar pattern of entrainment under Alternative 5 relative to Second Basis of
28 Comparison was observed at the Middle River and Old River junctions.

29 *Summary of Effects on Fall-Run Chinook Salmon*

30 The analysis of temperatures indicates lower temperatures and a lesser likelihood
31 of exceedance of suitable temperatures for spawning and rearing of fall-run
32 Chinook Salmon under Alternative 5 as compared to the Second Basis of
33 Comparison in the Stanislaus River below Goodwin Dam and in the San Joaquin
34 River at Vernalis. The effect of lower temperatures is reflected in the slightly
35 lower overall mortality of fall-run Chinook Salmon eggs predicted by
36 Reclamation's salmon survival model for fall-run in the Stanislaus River. As
37 described above, the instream flow patterns under Alternative 5 are anticipated to
38 benefit fall-run Chinook Salmon in the Stanislaus River and downstream in the
39 lower San Joaquin River below Vernalis.

40 Overall, Alternative 5 likely would have less effect on the fall-run Chinook
41 Salmon population in the San Joaquin River watershed as compared to the Second
42 Basis of Comparison.

1 *Steelhead*

2 Changes in operations that influence temperature and flow conditions in the
3 Stanislaus River downstream of Goodwin Dam and the San Joaquin River below
4 Vernalis could affect steelhead. The following describes those changes and their
5 potential effects.

6 *Changes in Water Temperature (Stanislaus River)*

7 Average monthly water temperatures in the Stanislaus River at Goodwin Dam
8 under Alternative 5 and Second Basis of Comparison generally would be similar
9 (differences less than 0.5°F), except in August through October when long-term
10 average monthly temperatures could be up to 1.0°F warmer than under the Second
11 Basis of Comparison. These differences would be of higher magnitude in drier
12 years with average monthly water temperatures in September as much as 1.9°F
13 warmer under Alternative 5 as compared to the Second Basis of Comparison.

14 Downstream at Orange Blossom Bridge, average monthly water temperatures in
15 October and April under Alternative 5 would be lower in all water year types than
16 the Second Basis of Comparison by as much as 1.4°F in October and 1.6°F in
17 April. In most other months, long-term average monthly water temperatures
18 under Alternative 5 generally would be similar, although somewhat higher (up to
19 0.7°F), compared to the Second Basis of Comparison. Water temperatures under
20 Alternative 5 could be up to 1.3°F warmer in drier years from July to September
21 than under the Second Basis of Comparison. (Appendix 6B, Table B-18-6).

22 Downstream at the confluence with the San Joaquin River, average monthly water
23 temperatures in October, April and May would be lower in all water year types
24 under Alternative 5 than the Second Basis of Comparison by as much as 2.0°F in
25 October, 1.9°F in April and 0.8°F in May. In most other months, long-term
26 average monthly water temperatures under Alternative 5 generally would be
27 similar, although somewhat higher (up to 1.1°F), compared to the Second Basis of
28 Comparison in June.

29 *Changes in Exceedance of Water Temperature Thresholds (Stanislaus
30 River)*

31 Average monthly water temperatures in the Stanislaus River at Orange Blossom
32 Bridge would frequently exceed the temperature threshold (56°F) established for
33 adult steelhead migration under both Alternative 5 and Second Basis of
34 Comparison during October and November. Under Alternative 5, average
35 monthly water temperatures would exceed 56°F about 57 percent of the time in
36 October which is about 28 percent less frequently than under the Second Basis of
37 Comparison (Appendix 6B, Figure B-18-1). In November, average monthly
38 water temperatures would exceed 56°F about 33 percent of the time under
39 Alternative 5, which would be about 10 percent more frequently than under the
40 Second Basis of Comparison.

41 In January through May, the temperature threshold at Orange Blossom Bridge is
42 55°F, which is intended to support steelhead spawning. This threshold would not
43 be exceeded under either Alternative 5 or Second Basis of Comparison during

1 January or February. In March through May, however, exceedances would occur
2 under both Alternative 5 and the Second Basis of Comparison in each month, with
3 the threshold most frequently exceeded (40 percent) under Alternative 5 in May
4 (Appendix 9N). Average monthly water temperatures under Alternative 5 would
5 exceed the threshold more frequently in March (4 percent) and less frequently
6 (26 percent) in April and May (5 percent) than under the Second Basis of
7 Comparison.

8 From June through November, the temperature threshold of 65°F established to
9 support steelhead rearing would be exceeded by both Alternative 5 and Second
10 Basis of Comparison in all months but November. The differences between
11 Alternative 5 and Second Basis of Comparison, however, could be biologically
12 meaningful, with average monthly water temperatures under Alternative 5
13 generally exceeding the threshold by 3 percent to 8 percent more frequently than
14 under the Second Basis of Comparison.

15 Average monthly water temperatures also would exceed the threshold (52°F)
16 established for smoltification at Knights Ferry. At Goodwin Dam, about 4 miles
17 upstream of Knights Ferry, average monthly water temperatures under
18 Alternative 5 would exceed 52°F in March, April, and May about 8 percent, 37
19 percent, and 68 percent of the time, respectively. Alternative 5 would result in
20 exceedances of the smoltification threshold occurring up to 6 percent more
21 frequently during the January through May period. Farther downstream at Orange
22 Blossom Bridge, the temperature threshold for smoltification is higher (57°F) and
23 would be exceeded less frequently. The magnitude of the exceedance also would
24 be less. Average monthly water temperatures under Alternative 5 and the Second
25 Basis of Comparison would not exceed the threshold during January through
26 April. In May, the threshold would be exceeded 8 percent of the time under
27 Alternative 5. Compared to the Second Basis of Comparison, the 57°F at Orange
28 Blossom Bridge would be exceeded about 8 percent less frequently in April and 6
29 percent less frequently in May under Alternative 5.

30 Overall, the differences between Alternative 5 and Second Basis of Comparison
31 would be relatively small, with the exception of substantial differences in the
32 frequency of exceedances in October when the average monthly water
33 temperatures under Alternative 5 would exceed the threshold for adult steelhead
34 migration about 28 percent less frequently and in April during the spawning
35 period when the frequency would be about 26 percent less. Given the frequency
36 of exceedance under both Alternative 5 and Second Basis of Comparison and the
37 generally stressful temperature conditions in the river, the substantial differences
38 (improvements) in October and April under Alternative 5 suggest that there would
39 be less potential to adversely affect steelhead under Alternative 5 than under the
40 Second Basis of Comparison. Even during months when the differences would be
41 relatively small, the lower frequency of exceedances under Alternative 5 could
42 represent a biologically meaningful and positive difference.

1 *Changes in Delta Hydrodynamics*

2 Sacramento River-origin steelhead generally move through the Delta during
3 spring however there is less information on their timing relative to Chinook
4 salmon. Thus, hydrodynamics in the entire January through June period have the
5 potential to affect juvenile steelhead.

6 On the Sacramento River near the confluence of Georgiana Slough, the
7 percentage of positive velocity under Alternative 5 was moderately lower relative
8 to the Second Basis of Comparison in January and indistinguishable in February
9 and March (Appendix 9K). On the San Joaquin River near the Mokelumne River
10 confluence, the percent of positive velocities was slightly greater under
11 Alternative 5 relative to Second Basis of Comparison in January and February and
12 indistinguishable in March. In Old River downstream of the facilities, the percent
13 of positive velocities was considerably higher under Alternative 5 during January
14 and moderately higher in February. Values in March were almost
15 indistinguishable between scenarios. On Old River upstream of the facilities,
16 percent positive velocities were moderately lower in January and slightly lower in
17 February and March under Alternative 5 relative to Second Basis of Comparison.
18 On the San Joaquin River downstream of Head of Old River, the percent of
19 positive velocities was similar for both scenarios in January, February and March.

20 At the junction of Georgiana Slough and the Sacramento River, percent positive
21 velocity was considerably lower under Alternative 5 relative to the Second Basis
22 of Comparison in May and June. Estimates for Alternative 5 were only slightly
23 lower in April. Near the confluence of the San Joaquin River and the Mokelumne
24 River, the proportion of positive velocities was considerably higher under
25 Alternative 5 relative to Second Basis of Comparison in April and May whereas
26 values in June were similar among the alternatives. On Old River downstream of
27 the facilities, the proportion of positive velocities was considerably higher in
28 April and May and moderately higher in June under Alternative 5 relative to
29 Second Basis of Comparison. In Old River upstream of the facilities, the percent
30 of positive velocities was moderately higher under Alternative 5 April and May
31 and moderately lower in June. On the San Joaquin River downstream of the Head
32 of Old River, the percent of positive velocities was considerably lower under
33 Alternative 5 relative to Second Basis of Comparison in April, May and slightly
34 lower in June.

35 *Changes in Junction Entrainment*

36 Entrainment at the Head of Old River junction was considerably higher under
37 Alternative 5 relative to Second Basis of Comparison during the months of April
38 and May and slightly lower in January and February (Appendix 9L). Entrainment
39 in March and June was essentially the same in March and June. For the Turner
40 Cut junction, entrainment under Alternative 5 was much lower in April and May
41 relative to Second Basis of Comparison. Entrainment was lower in the other
42 months as well but the magnitude of the difference was smaller. At the Columbia
43 Cut junction, entrainment under Alternative 5 was almost indistinguishable from
44 Second Basis of Comparison in March and June. Entrainment was slightly lower
45 under Alternative 5 during January and February and became even lower in April

1 and May. A similar pattern of entrainment under Alternative 5 relative to Second
2 Basis of Comparison was observed at the Middle River and Old River junctions.

3 *Summary of Effects on Steelhead*

4 Given the frequency of exceedance under both Alternative 5 and Second Basis of
5 Comparison and the generally stressful temperature conditions in the river, the
6 substantial differences (improvements) in October and April under Alternative 5
7 suggest that there would be less potential to adversely affect steelhead under
8 Alternative 5 than under the Second Basis of Comparison.

9 *White Sturgeon*

10 Evidence of White Sturgeon spawning has been recorded in the San Joaquin River
11 upstream of the confluence with the Stanislaus River. While flows in the San
12 Joaquin River upstream of the Stanislaus River are expected to be similar under all
13 alternatives, flow contributions from the Stanislaus River could influence water
14 temperatures in the San Joaquin River where White Sturgeon eggs or larvae may
15 occur during the spring and early summer. The magnitude of influence on water
16 temperature would depend on the proportional flow contribution of the Stanislaus
17 River and the temperatures in both the Stanislaus and San Joaquin rivers. The
18 potential for an effect on White Sturgeon eggs and larvae would be influenced by
19 the proportion of the population occurring in the San Joaquin River. In
20 consideration of this uncertainty, it is not possible to distinguish potential effects
21 on White Sturgeon between alternatives.

22 *Reservoir Fishes*

23 *Changes in Available Habitat (Storage)*

24 As described in Chapter 5, Surface Water Resources and Water Supplies, changes
25 in CVP and SWP water supplies and operations under Alternative 5 as compared
26 to the Second Basis of Comparison would result in lower Storage levels in New
27 Melones Reservoir under Alternative 5 as compared to the Second Basis of
28 Comparison due to increased instream releases to support fish flows under the
29 2009 NMFS BO.

30 Storage in New Melones could be reduced up to around 10 percent in some
31 months of some water year types. Additional information related to monthly
32 reservoir elevations is provided in Appendix 5A, CalSim II and DSM2 Modeling.

33 Nest survival for black bass species in New Melones is higher than in the other
34 reservoirs during May and June. For March, Largemouth Bass and Smallmouth
35 Bass nest survival is predicted to be above 40 percent in all of the years simulated.
36 For April, the likelihood that nest survival of Largemouth Bass and Smallmouth
37 Bass is between 40 and 100 percent is substantially less (about 25 percent) under
38 Alternative 5 as compared to the Second Basis of Comparison. For May, the
39 likelihood of high nest survival is slightly (about 3 percent) less under
40 Alternative 5 than under the Second Basis of Comparison. For June, the
41 likelihood of survival being greater than 40 percent for Largemouth Bass and
42 Smallmouth Bass in New Melones is somewhat (about 10 percent) higher under
43 Alternative 5 as compared to the Second Basis of Comparison. For Spotted Bass,

1 nest survival in March is anticipated to be near 100 percent in every year under
2 both Alternative 5 and Second Basis of Comparison. The likelihood of survival
3 being greater than 40 percent is high (>90 percent) in April under both
4 Alternative 5 and the Second Basis of Comparison with the likelihood of greater
5 than 40 percent survival being (about 6 percent) lower under Alternative 5 as
6 compared to the Second Basis of Comparison (100 percent). For May, the
7 likelihood of high Spotted Bass nest survival is approximately 3 percent lower
8 under Alternative 5 than under the Second Basis of Comparison. For June,
9 Spotted Bass nest survival would be greater than 40 percent in all of the
10 simulation years under both Alternative 5 and the Second Basis of Comparison.

11 Overall, the reductions in nest survival in New Melones Reservoir under
12 Alternative 5 suggest that Alternative 5 could adversely influence black bass
13 species by comparison to the Second Basis of Comparison.

14 *Other species*

15 Changes in operations that influence temperature and flow conditions in the
16 Stanislaus River downstream of Keswick Dam and the San Joaquin River at
17 Vernalis could affect other species such as lampreys, Hardhead, and Striped Bass.

18 As described above, average monthly water temperatures in the Stanislaus River
19 at Goodwin Dam under Alternative 5 and Second Basis of Comparison generally
20 would be similar (differences less than 0.5°F), except in August through October
21 when long-term average monthly temperatures could be up to 1.0°F warmer than
22 under the Second Basis of Comparison. These differences would be of higher
23 magnitude in drier years with average monthly water temperatures in September
24 as much as 1.9°F warmer under Alternative 5 as compared to the Second Basis of
25 Comparison.

26 Downstream at Orange Blossom Bridge, average monthly water temperatures in
27 October and April under Alternative 5 would be lower in all water year types than
28 the Second Basis of Comparison by as much as 1.4°F in October and 1.6°F in
29 April. In most other months, long-term average monthly water temperatures
30 under Alternative 5 generally would be similar, although somewhat higher (up to
31 0.7°F), compared to the Second Basis of Comparison. Water temperatures under
32 Alternative 5 could be up to 1.3°F warmer in drier years from July to September
33 than under the Second Basis of Comparison (Appendix 6B, Table B-18-6).

34 Downstream at the confluence with the San Joaquin River, average monthly water
35 temperatures in October, April and May would be lower in all water year types
36 under Alternative 5 than the Second Basis of Comparison by as much as 2.0°F in
37 October, 1.9°F in April and 0.8°F in May. In most other months, long-term
38 average monthly water temperatures under Alternative 5 generally would be
39 similar, although somewhat higher (up to 1.1°F), compared to the Second Basis of
40 Comparison in June.

41 In general, lamprey species can tolerate higher temperatures than salmonids, up to
42 around 72°F during their entire life history. Because lamprey ammocoetes remain
43 in the river for several years, any substantial flow reductions or temperature

1 increases could adversely affect these larval lamprey. Given the similar flows and
 2 temperatures during their spawning and incubation period, it is likely that the
 3 potential to affect lamprey species in the Stanislaus and San Joaquin rivers would
 4 be similar under Alternative 5 and the Second Basis of Comparison.

5 In general, Striped Bass and Hardhead also can tolerate higher temperatures than
 6 salmonids. Given the similar flows and temperatures during their spawning and
 7 incubation period, it is likely that the potential to affect Striped Bass and
 8 Hardhead in the Stanislaus and San Joaquin rivers would be similar under
 9 Alternative 5 and the Second Basis of Comparison.

10 *San Francisco Bay Area Region*

11 *Killer Whale*

12 As described above for the comparison of Alternative 1 to the No Action
 13 Alternative, it is unlikely that the Chinook Salmon prey base of killer whales,
 14 supported heavily by hatchery production of fall-run Chinook Salmon, would be
 15 appreciably affected by any of the alternatives.

16 **9.4.3.7 Summary of Environmental Consequences**

17 The results of the environmental consequences of implementation of
 18 Alternatives 1 through 5 as compared to the No Action Alternative and the
 19 Second Basis of Comparison are presented in Tables 9.4 and 9.5, respectively.

20 **Table 9.4 Comparison of Alternatives 1 through 5 to No Action Alternative**

Alternative	Potential Change	Consideration for Mitigation Measures
Alternative 1	<p>Trinity River Region</p> <p><u>Coho Salmon</u></p> <p>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.</p> <p><u>Spring-run Chinook Salmon</u></p> <p>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.</p> <p><u>Fall-run Chinook Salmon</u></p> <p>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</p>	<p>Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead.</p> <p>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.</p>

Alternative	Potential Change	Consideration for Mitigation Measures
	<p>temperatures (as well as egg mortality). Overall, likely to have similar effects.</p> <p><u>Steelhead</u></p> <p>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.</p> <p><u>Green Sturgeon</u></p> <p>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.</p> <p><u>Reservoir Fishes</u></p> <p>Overall, the comparison of storage and the analysis of nesting suggest that effects would be similar.</p> <p><u>Pacific Lamprey</u></p> <p>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).</p> <p><u>Eulachon</u></p> <p>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, the changes are likely to have a similar effect to influence Eulachon in the Klamath River.</p> <p>Sacramento River System</p> <p><u>Winter-run Chinook Salmon</u></p> <p>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.</p> <p><u>Spring-run Chinook Salmon</u></p> <p>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.</p> <p><u>Fall-run Chinook Salmon</u></p> <p>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.</p> <p><u>Late Fall-run Chinook Salmon</u></p> <p>The output from SALMOD indicated that late fall-run Chinook Salmon production would be similar, although production could be slightly lower in some</p>	

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Alternative	Potential Change	Consideration for Mitigation Measures
	<p>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.</p> <p>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.</p> <p>Effects may become more adverse due to the lack of without fish passage.</p> <p><u>Steelhead</u></p> <p>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.</p> <p><u>Green Sturgeon</u></p> <p>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.</p> <p><u>White Sturgeon</u></p> <p>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.</p> <p><u>Delta Smelt</u></p> <p>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.</p> <p><u>Longfin Smelt</u></p>	

Alternative	Potential Change	Consideration for Mitigation Measures
	<p>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.</p> <p><u>Sacramento Splittail</u></p> <p>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.</p> <p><u>Reservoir Fishes</u></p> <p>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.</p> <p><u>Pacific Lamprey</u></p> <p>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).</p> <p><u>Striped Bass, American Shad, and Hardhead</u></p> <p>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.</p> <p>Stanislaus River/Lower San Joaquin River</p> <p><u>Fall-run Chinook Salmon</u></p> <p>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.</p> <p><u>Steelhead</u></p> <p>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.</p>	

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Alternative	Potential Change	Consideration for Mitigation Measures
	<p><u>White Sturgeon</u></p> <p>While flows in the San Joaquin River upstream of the Stanislaus River are expected to 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.</p> <p><u>Reservoir Fishes</u></p> <p>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.</p> <p><u>Other Species</u></p> <p>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.</p> <p>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.</p> <p>Pacific Ocean</p> <p><u>Killer Whale</u></p> <p>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.</p>	
Alternative 2	<p>Trinity River Region</p> <p><u>Coho Salmon, spring-run and fall-run Chinook Salmon, steelhead, Green Sturgeon, Reservoir Fishes, Pacific Lamprey, River Lamprey, and Eulachon</u></p> <p>Similar effects.</p> <p>Sacramento River System</p> <p><u>Winter-run, spring-run, fall-run, and late fall-run Chinook Salmon, and steelhead</u></p> <p>The effects may become more adverse due to the lack of fish passage.</p>	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
	<p><u>Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, River Lamprey, Striped Bass, American Shad, and Hardhead</u></p> <p>Similar effects</p> <p>Stanislaus River/Lower San Joaquin River</p> <p><u>Fall-run Chinook Salmon and Steelhead</u></p> <p>The effects may become more adverse due to the lack of fish passage.</p> <p><u>White Sturgeon, Reservoir Fishes, and Other Species</u></p> <p>Similar effects.</p> <p>Pacific Ocean</p> <p><u>Killer Whale</u></p> <p>Similar effects.</p>	
<p>Alternative 3</p>	<p>Trinity River Region</p> <p><u>Coho Salmon and Spring-run Chinook Salmon</u></p> <p>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.</p> <p><u>Fall-run-run Chinook Salmon</u></p> <p>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.</p> <p><u>Steelhead</u></p> <p>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.</p> <p><u>Green Sturgeon</u></p> <p>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.</p> <p><u>Reservoir Fishes</u></p> <p>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.</p> <p><u>Pacific Lamprey</u></p> <p>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).</p> <p><u>Eulachon</u></p>	<p>Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead.</p> <p>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.</p>

Alternative	Potential Change	Consideration for Mitigation Measures
	<p>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.</p> <p>Sacramento River System</p> <p><u>Winter-run Chinook Salmon</u></p> <p>Potentially more adverse due to lack of fish passage. The predator control measures could reduce winter-run Chinook Salmon mortality.</p> <p><u>Spring-run Chinook Salmon</u></p> <p>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.</p> <p>The ocean harvest restriction component and predator control measures could reduce spring-run Chinook Salmon mortality.</p> <p>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.</p> <p><u>Fall-run-run Chinook Salmon</u></p> <p>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.</p> <p>The ocean harvest restriction component and predator control measures could reduce fall-run Chinook Salmon mortality.</p> <p>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.</p> <p><u>Late Fall-run-run Chinook Salmon</u></p> <p>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.</p> <p>The ocean harvest restriction component and predator control measures could reduce late fall-run Chinook Salmon mortality.</p> <p>Overall, given the small differences between Alternative 3 and the No Action Alternative</p>	

Alternative	Potential Change	Consideration for Mitigation Measures
	<p>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.</p> <p><u>Steelhead</u></p> <p>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.</p> <p>The ocean harvest restriction component and predator control measures could reduce steelhead mortality.</p> <p>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.</p> <p><u>Green Sturgeon</u></p> <p>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.</p> <p><u>White Sturgeon</u></p> <p>Given the general similarity in results and the inherent uncertainty associated with the resolution of the temperature model, the effects likely would be similar.</p> <p><u>Delta Smelt</u></p> <p>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.</p> <p><u>Longfin Smelt</u></p> <p>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.</p> <p><u>Sacramento Splittail</u></p> <p>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.</p> <p><u>Reservoir Fishes</u></p> <p>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</p>	

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Alternative	Potential Change	Consideration for Mitigation Measures
	<p>effect would be biologically meaningful. Thus, it is likely that effects on black bass would be similar.</p> <p><u>Pacific Lamprey</u></p> <p>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).</p> <p><u>Other Species</u></p> <p>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.</p> <p>Predation controls related to Striped Bass would result in adverse effects.</p> <p>Stanislaus River/Lower San Joaquin River</p> <p><u>Fall-run-run Chinook Salmon</u></p> <p>Overall, likely would have slightly beneficial effects on the fall-run Chinook Salmon population in the San Joaquin River watershed.</p> <p>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.</p> <p><u>Steelhead</u></p> <p>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.</p> <p>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.</p> <p><u>White Sturgeon</u></p> <p>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</p>	

Alternative	Potential Change	Consideration for Mitigation Measures
	<p>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.</p> <p><u>Reservoir Fishes</u></p> <p>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.</p> <p><u>Other Species</u></p> <p>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.</p> <p>Predation controls related to Striped Bass would result in adverse effects.</p> <p>Pacific Ocean</p> <p><u>Killer Whale</u></p> <p>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.</p> <p>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.</p>	
Alternative 4	<p>Trinity River Region</p> <p><u>Coho Salmon, spring-run and fall-run Chinook Salmon, steelhead, Green Sturgeon, Reservoir Fishes, Pacific Lamprey, River Lamprey, and Eulachon</u></p> <p>The effects are identical as described under Alternative 1 as compared to the No Action Alternative.</p> <p>Sacramento River System</p> <p><u>Winter-run, spring-run, fall-run, and late fall-run Chinook Salmon, and steelhead</u></p> <p>The effects in the Sacramento River system would be similar as described under Alternative 1 as compared to the No Action Alternative.</p> <p>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.</p> <p><u>Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, River Lamprey, American Shad, and Hardhead</u></p> <p>The effects in the Sacramento River system would be similar as described under Alternative 1 as compared to the No Action Alternative.</p> <p><u>Striped Bass</u></p>	<p>Implement fish passage programs at Shasta, Folsom, and New Melones dams to reduce temperature impacts on Chinook Salmon and steelhead.</p> <p>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.</p>

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Alternative	Potential Change	Consideration for Mitigation Measures
	<p>The effects in the Sacramento River system would be similar as described under Alternative 1 as compared to the No Action Alternative.</p> <p>Predation controls related to Striped Bass would result in adverse effects.</p> <p>Stanislaus River/Lower San Joaquin River <u>Fall-run Chinook Salmon and Steelhead</u></p> <p>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.</p> <p>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.</p> <p><u>White Sturgeon, Reservoir Fishes, and Other Species</u></p> <p>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.</p> <p><u>Striped Bass</u></p> <p>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.</p> <p>Predation controls related to Striped Bass would result in adverse effects.</p> <p>Pacific Ocean <u>Killer Whale</u></p> <p>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.</p> <p>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.</p>	
Alternative 5	<p>Trinity River Region <u>Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead, and Green Sturgeon</u></p> <p>Effects would be similar.</p> <p><u>Reservoir Fishes</u></p> <p>Effects would be similar.</p> <p><u>Pacific Lamprey</u></p> <p>Effects would be similar.</p> <p><u>Eulachon</u></p> <p>Effects would be similar.</p> <p>Sacramento River System <u>Winter-run Chinook Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Late Fall-run Chinook Salmon, Steelhead, Green Sturgeon, and White Sturgeon</u></p> <p>Effects would be similar.</p> <p><u>Delta Smelt, Longfin Smelt, and Sacramento Splittail</u></p>	<p>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.</p>

Alternative	Potential Change	Consideration for Mitigation Measures
	<p>Effects would be similar.</p> <p><u>Reservoir Fishes</u></p> <p>Effects would be similar.</p> <p><u>Pacific Lamprey and Other Species</u></p> <p>Effects would be similar.</p> <p>Stanislaus River/Lower San Joaquin River</p> <p><u>Fall-run Chinook Salmon and Steelhead</u></p> <p>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.</p> <p><u>White Sturgeon</u></p> <p>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.</p> <p><u>Reservoir Fishes</u></p> <p>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.</p> <p><u>Other Species</u></p> <p>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.</p> <p>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.</p> <p>Pacific Ocean</p> <p><u>Killer Whale</u></p> <p>It is unlikely that the Chinook Salmon prey base of killer whales, supported heavily by hatchery</p>	

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Alternative	Potential Change	Consideration for Mitigation Measures
	production of fall-run Chinook Salmon, would be appreciably affected.	

1
2

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
No Action Alternative	<p>Trinity River Region</p> <p><u>Coho Salmon</u></p> <p>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.</p> <p><u>Spring-run Chinook Salmon</u></p> <p>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.</p> <p><u>Fall-run Chinook Salmon</u></p> <p>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.</p> <p><u>Steelhead</u></p> <p>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.</p> <p><u>Green Sturgeon</u></p> <p>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.</p>	Not considered for this comparison.

Alternative	Potential Change	Consideration for Mitigation Measures
	<p><u>Reservoir Fishes</u></p> <p>Overall, the comparison of storage and the analysis of nesting suggest that effects would be similar.</p> <p><u>Pacific Lamprey</u></p> <p>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).</p> <p><u>Eulachon</u></p> <p>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.</p> <p>Sacramento River System</p> <p><u>Winter-run Chinook Salmon</u></p> <p>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.</p> <p><u>Spring-run Chinook Salmon</u></p> <p>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.</p> <p><u>Fall-run Chinook Salmon</u></p> <p>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.</p> <p><u>Late Fall-run Chinook Salmon</u></p> <p>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.</p> <p><u>Steelhead</u></p> <p>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.</p> <p><u>Green Sturgeon</u></p> <p>Overall, the increased frequency of exceedance of temperature thresholds could increase the potential</p>	

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Alternative	Potential Change	Consideration for Mitigation Measures
	<p>for adverse effects on Green Sturgeon in the Sacramento and Feather rivers.</p> <p><u>White Sturgeon</u></p> <p>Overall, the increased frequency of exceedance of temperature thresholds could increase the potential for adverse effects on White Sturgeon in the Sacramento River.</p> <p><u>Delta Smelt</u></p> <p>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.</p> <p><u>Longfin Smelt</u></p> <p>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.</p> <p><u>Sacramento Splittail</u></p> <p>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.</p> <p><u>Reservoir Fishes</u></p> <p>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.</p> <p><u>Pacific Lamprey</u></p> <p>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).</p> <p><u>Striped Bass, American Shad, and Hardhead</u></p> <p>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.</p> <p>Stanislaus River/Lower San Joaquin River</p> <p><u>Fall-run Chinook Salmon</u></p> <p>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.</p>	

Alternative	Potential Change	Consideration for Mitigation Measures
	<p>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.</p> <p><u>Steelhead</u></p> <p>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.</p> <p><u>Reservoir Fishes</u></p> <p>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.</p> <p><u>Other Species</u></p> <p>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.</p> <p>Pacific Ocean</p> <p><u>Killer Whale</u></p> <p>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.</p>	
Alternative 1	No effects on aquatic resources.	Not considered for this comparison.
Alternative 2	<p>Trinity River Region</p> <p><u>The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison.</u></p> <p>Sacramento River System</p> <p><u>Winter-run Chinook Salmon</u></p> <p>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.</p> <p><u>Spring-run Chinook Salmon</u></p> <p>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.</p> <p><u>Fall-run Chinook Salmon</u></p> <p>The model results suggest that overall, effects on fall-run Chinook Salmon could be slightly more</p>	Not considered for this comparison.

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Alternative	Potential Change	Consideration for Mitigation Measures
	<p>adverse with a small likelihood that fall-run Chinook Salmon production would be lower.</p> <p><u>Late Fall-run Chinook Salmon</u></p> <p>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.</p> <p><u>Steelhead</u></p> <p>The model results suggest that overall, effects on steelhead could be slightly more adverse, particularly in the Feather River.</p> <p><u>Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, Striped Bass, American Shad, and Hardhead</u></p> <p>The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison.</p> <p>Stanislaus River/Lower San Joaquin River</p> <p><u>Fall-run Chinook Salmon</u></p> <p>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.</p> <p><u>Steelhead</u></p> <p>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.</p> <p><u>Reservoir Fishes and Other Species</u></p> <p>The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison.</p> <p>Pacific Ocean</p> <p><u>Killer Whale</u></p> <p>The effects are identical as described under the No Action Alternative as compared to the Second Basis of Comparison.</p>	
Alternative 3	<p>Trinity River Region</p> <p><u>Coho Salmon and Spring-run Chinook Salmon</u></p> <p>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.</p>	Not considered for this comparison.

	<p><u>Fall-run Chinook Salmon</u></p> <p>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.</p> <p><u>Steelhead</u></p> <p>Water temperatures suggest similar effects on the steelhead population.</p> <p><u>Green Sturgeon</u></p> <p>Water temperatures suggest similar effects on Green Sturgeon in the Trinity River or lower Klamath River and estuary.</p> <p><u>Reservoir Fishes</u></p> <p>Overall, reservoir storage and nest survival suggest similar effects on black bass.</p> <p><u>Pacific Lamprey</u></p> <p>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).</p> <p><u>Eulachon</u></p> <p>It is likely that effects would have a similar potential to influence Eulachon in the Klamath River.</p> <p>Sacramento River System</p> <p><u>Winter-run Chinook Salmon</u></p> <p>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.</p> <p><u>Spring-run Chinook Salmon</u></p> <p>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.</p> <p>The ocean harvest restriction component and predator control measures could reduce spring-run Chinook Salmon mortality.</p> <p><u>Fall-run Chinook Salmon</u></p> <p>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.</p> <p>The ocean harvest restriction component and predator control measures could reduce fall-run Chinook Salmon mortality.</p> <p>Overall, effects on fall-run Chinook Salmon would be slightly less adverse.</p> <p><u>Late Fall-run Chinook Salmon</u></p> <p>Overall, it is likely that the effects on late fall-run Chinook Salmon would be similar.</p> <p>The ocean harvest restriction component and predator control measures could reduce late fall-run Chinook Salmon mortality.</p>	
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	<p><u>Steelhead</u></p> <p>The model results suggest that overall, effects on steelhead could be slightly more adverse, particularly in the Feather and American rivers.</p> <p>The ocean harvest restriction component and predator control measures could reduce steelhead mortality.</p> <p><u>Green Sturgeon</u></p> <p>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.</p> <p><u>White Sturgeon</u></p> <p>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.</p> <p><u>Delta Smelt</u></p> <p>Overall, effects would be similar based on reduced entrainment and more favorable location of Fall X2.</p> <p><u>Longfin Smelt</u></p> <p>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.</p> <p><u>Sacramento Splittail</u></p> <p>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.</p> <p><u>Reservoir Fishes</u></p> <p>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.</p> <p><u>Pacific Lamprey</u></p> <p>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).</p> <p><u>Other Species</u></p> <p>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.</p> <p>Predation controls related to Striped Bass would result in adverse effects.</p>	
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Alternative	Potential Change	Consideration for Mitigation Measures
	<p>Stanislaus River/Lower San Joaquin River</p> <p><u>Fall-run Chinook Salmon</u></p> <p>Overall, likely would have similar effects on the fall-run Chinook Salmon population in the San Joaquin River watershed.</p> <p>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.</p> <p><u>Steelhead</u></p> <p>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.</p> <p>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.</p> <p><u>White Sturgeon</u></p> <p>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.</p> <p><u>Reservoir Fishes</u></p> <p>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.</p> <p><u>Other Species</u></p> <p>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.</p> <p>Predation controls related to Striped Bass would result in adverse effects.</p> <p>Pacific Ocean</p> <p><u>Killer Whale</u></p> <p>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.</p>	
Alternative 4	<p>Trinity River Region</p> <p><u>Coho Salmon, spring-run and fall-run Chinook Salmon, steelhead, Green Sturgeon, Reservoir</u></p>	Not considered for this comparison.

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Alternative	Potential Change	Consideration for Mitigation Measures
	<p><u>Fishes, Pacific Lamprey, River Lamprey, and Eulachon</u></p> <p>The effects would be identical.</p> <p>Sacramento River System</p> <p><u>Winter-run, spring-run, fall-run, and late fall-run Chinook Salmon, and steelhead</u></p> <p>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.</p> <p><u>Green Sturgeon, White Sturgeon, Delta Smelt, Longfin Smelt, Sacramento Splittail, Reservoir Fishes, Pacific Lamprey, River Lamprey, American Shad, and Hardhead</u></p> <p>The effects in the Sacramento River system would be identical.</p> <p><u>Striped Bass</u></p> <p>The effects in the Sacramento River system would be similar. Predation controls related to Striped Bass would result in adverse effects.</p> <p>Stanislaus River/Lower San Joaquin River</p> <p><u>Fall-run Chinook Salmon and Steelhead</u></p> <p>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.</p> <p><u>White Sturgeon, Reservoir Fishes, and Other Species</u></p> <p>The effects in the Stanislaus River/Lower San Joaquin River system would be identical.</p> <p><u>Striped Bass</u></p> <p>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.</p> <p>Pacific Ocean</p> <p><u>Killer Whale</u></p> <p>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.</p> <p>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.</p>	
Alternative 5	<p>Trinity River Region</p> <p><u>Coho Salmon, Spring-run Chinook Salmon, Fall-run Chinook Salmon, Steelhead, and Green Sturgeon</u></p> <p>Monthly water temperature generally would be similar (less than 0.5°F differences), with the exception of drier years when temperatures could be as much as 2.2°F cooler in November and 1.5°F in December. Average monthly water temperatures</p>	Not considered for this comparison.

Alternative	Potential Change	Consideration for Mitigation Measures
	<p>could be slightly (up to 0.6°F) higher during July and August and lower (up to 0.7°F) 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.</p> <p>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.</p> <p>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.</p> <p>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.</p> <p><u>Reservoir Fishes</u></p> <p>Overall, the comparison of storage and the analysis of nesting suggest that effects would be similar.</p> <p><u>Pacific Lamprey</u></p> <p>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).</p> <p><u>Eulachon</u></p> <p>It is likely the conditions would be similar for Eulachon in the Klamath River.</p> <p>Sacramento River System</p> <p><u>Winter-run Chinook Salmon</u></p> <p>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</p>	

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Alternative	Potential Change	Consideration for Mitigation Measures
	<p>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.</p> <p><u>Spring-run Chinook Salmon</u></p> <p>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.</p> <p><u>Fall-run Chinook Salmon</u></p> <p>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.</p> <p>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.</p> <p>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</p>	

Alternative	Potential Change	Consideration for Mitigation Measures
	<p>Sacramento River watershed, particularly in drier water year types. Fish passage actions could result in beneficial effects.</p> <p><u>Late Fall-run Chinook Salmon</u></p> <p>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.</p> <p>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.</p> <p><u>Steelhead</u></p> <p>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.</p> <p>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.</p> <p><u>Green Sturgeon</u></p> <p>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.</p> <p><u>White Sturgeon</u></p> <p>Overall, the increased frequency of exceedance of temperature thresholds could increase the potential for adverse effects on White Sturgeon in the Sacramento River.</p> <p><u>Delta Smelt</u></p> <p>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.</p> <p><u>Longfin Smelt</u></p> <p>Overall, based on the decrease in frequency and magnitude of negative OMR flows and the higher Longfin Smelt abundance index values, especially in</p>	

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Alternative	Potential Change	Consideration for Mitigation Measures
	<p>dry and critical dry years, potential adverse effects on the Longfin Smelt population likely would be less.</p> <p><u>Sacramento Splittail</u></p> <p>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.</p> <p><u>Reservoir Fishes</u></p> <p>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.</p> <p><u>Pacific Lamprey</u></p> <p>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).</p> <p><u>Striped Bass, American Shad, and Hardhead</u></p> <p>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.</p> <p>Stanislaus River/Lower San Joaquin River</p> <p><u>Fall-run Chinook Salmon</u></p> <p>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.</p> <p>Overall, would have less adverse effect on the fall-run Chinook Salmon population in the San Joaquin River watershed.</p> <p><u>Steelhead</u></p> <p>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.</p>	

Alternative	Potential Change	Consideration for Mitigation Measures
	<p><u>Reservoir Fishes</u></p> <p>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.</p> <p><u>Other Species</u></p> <p>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.</p> <p>Pacific Ocean</p> <p><u>Killer Whale</u></p> <p>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.</p>	

- 1 **9.4.3.8 Potential Mitigation Measures**
- 2 Changes in CVP and SWP operations under Alternatives 1 through 5 as compared
- 3 to the No Action Alternative would result in adverse impacts. Potential
- 4 mitigation measures that could be considered to reduce the adverse impacts
- 5 include:
- 6 • Implement fish passage programs at Shasta, Folsom, and New Melones dams
 - 7 to reduce temperature impacts on Chinook Salmon and steelhead under
 - 8 Alternatives 1, 2, 3, and 4.
 - 9 • Coordination of CVP and SWP operations between Reclamation, DWR,
 - 10 USFWS, and NMFS to reduce flow and reservoir storage impacts on late
 - 11 fall-run Chinook Salmon on the Sacramento River system under
 - 12 Alternatives 1, 3, and 4.
 - 13 • Coordination of CVP and SWP operations between Reclamation, DWR,
 - 14 USFWS, and NMFS to reduce entrainment impacts on Delta Smelt and
 - 15 Longfin Smelt, and Reservoir Fishes on the Sacramento River system under
 - 16 Alternatives 1, 3, and 4.
 - 17 • Coordination of CVP and SWP operations between Reclamation, DWR,
 - 18 USFWS, and NMFS to reduce impacts on bass nests at reservoirs on the
 - 19 Sacramento River system under Alternatives 1, 3, and 4.
 - 20 • Coordination of CVP and SWP operations between Reclamation, DWR,
 - 21 USFWS, and NMFS to reduce temperature impacts on Striped Bass and
 - 22 Hardhead on the Stanislaus and San Joaquin rivers system under
 - 23 Alternatives 3 and 5.

1 **9.4.3.9 Cumulative Effects Analysis**

2 As described in Chapter 3, the cumulative effects analysis considers projects,
3 programs, and policies that are not speculative; and are based upon known or
4 reasonably foreseeable long-range plans, regulations, operating agreements, or
5 other information that establishes them as reasonably foreseeable.

6 The No Action Alternative, Alternatives 1 through 5, and Second Basis of
7 Comparison include climate change and sea level rise, implementation of general
8 plans, and completion of ongoing projects and programs (see Chapter 3,
9 Description of Alternatives). The effects of these items were analyzed
10 quantitatively and qualitatively, as described in the Impact Analysis of this
11 chapter. The discussion below focuses on the qualitative effects of the
12 alternatives and other past, present, and reasonably foreseeable future projects
13 identified for consideration of cumulative effects (see Chapter 3, Description of
14 Alternatives).

15 **9.4.3.9.1 No Action Alternative and Alternatives 1 through 5**

16 Continued coordinated long-term operation of the CVP and SWP under the No
17 Action Alternative would result in reduced CVP and SWP water supply
18 availability as compared to recent conditions due to climate change and sea level
19 rise by 2030. These conditions are included in the analysis presented above.

20 There also are several ongoing programs that could result in changes in flow
21 patterns in the Sacramento and San Joaquin rivers watersheds and the Delta that
22 could reduce availability of CVP and SWP water deliveries as well as local and
23 regional water supplies. These projects include renewals of hydroelectric
24 generation permits issued by the Federal Energy Regulatory Commission
25 (FERC 2015) and update of the Water Quality Control Plan for the San Francisco
26 Bay/Sacramento–San Joaquin Delta Estuary by the State Water Resources
27 Control Board (SWRCB 2006, 2013). Based upon the available information
28 related to these projects, the cumulative effects would be to change flow patterns
29 in the rivers and for Delta outflow in a manner that would improve conditions for
30 biological resources.

31 There were be adverse aquatic resources impacts associated with implementation
32 of the alternatives as compared to the No Action Alternative. Therefore,
33 Alternatives 1 through 5 would contribute cumulative impacts to aquatic
34 resources, specifically associated with:

- 35 • Temperature impacts on Chinook Salmon and steelhead under Alternatives 1,
36 2, 3, and 4.
- 37 • Flow and/or reservoir storage impacts on late fall-run Chinook Salmon on the
38 Sacramento River system under Alternatives 1, 3, and 4
- 39 • Entrainment impacts on Delta Smelt and Longfin Smelt under Alternatives 1,
40 3, and 4.
- 41 • Impacts on bass nests at reservoirs on the Sacramento River system under
42 Alternatives 1, 3, and 4.

- 1 • Temperature impacts on Striped Bass and Hardhead on the Stanislaus and San
2 Joaquin rivers system under Alternatives 3 and 5.

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Chapter 9: Fish and Aquatic Resources

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