7.6.2 Aquatic Biological Resources

The proposed Plan amendments were developed to improve flow and water quality conditions over a large geographic area, and particularly for fish and wildlife beneficial uses in the Sacramento River watershed, Delta eastside tributaries, and Delta regions (Sacramento/Delta). Implementation of the proposed Plan amendments is expected to benefit aquatic biological resources that are associated with healthy rivers, healthy estuaries, and a functioning watershed. Because the proposed Plan amendments focus on reasonable protection of fish and wildlife beneficial uses, this topic is discussed throughout this Staff Report. Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, provides detail on the ecosystem functions of flow and various species-specific flow needs. Chapter 4, *Other Aquatic Ecosystem Stressors*, describes non-flow stressors that also can affect ecosystem processes, and how they interact with flow and other stressors, such as physical habitat loss or alteration, water quality constituents, nonnative species, fisheries management, and climate change. Chapter 5, *Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta*, explains the proposed Plan amendments that provide for a more natural hydrograph in the Sacramento/Delta.

Although the primary purpose of the proposed Plan amendments is to improve and reasonably protect fish and wildlife beneficial uses, changes in hydrology and changes in water supply could negatively affect some aquatic species at certain times and in specific locations that must be analyzed under CEQA. This section evaluates the effects on aquatic biological resources from changes in hydrology and changes in water supply. It describes the environmental setting, potential impacts, and mitigation measures that could avoid or reduce any identified potentially significant impacts on aquatic biological resources. The analysis in this section focuses on native fish addressed in the context of their native riverine and estuarine habitat. Other biological resources are discussed in Section 7.6.1, *Terrestrial Biological Resources*. Nonnative sportfish that are important recreational species are discussed in Section 7.18, *Recreation.* The surface water quality analysis (Section 7.12.1, *Surface Water*) focuses on constituents that can impair beneficial uses, including fish and wildlife, that may be affected by implementing the proposed Plan amendments, including salinity, mercury, nutrients, turbidity, harmful algal blooms (HABs), and other contaminants.

Most potential impacts on aquatic biological resources, including fish, would be beneficial or less than significant. Potentially significant impacts on aquatic species could occur below certain reservoirs with limited capacity to maintain storage conditions needed to provide suitable downstream temperatures for native fish. Implementation of the narrative cold water habitat objective and the flexibility provided in the inflow objectives generally would be expected to result in improved water temperature conditions for native cold water fish in the Sacramento/Delta. However, there may be some challenges with meeting suitable temperatures at all times on all tributaries, particularly those with significant water diversions and smaller storage capacity. In addition, this section evaluates potential geomorphic effects on aquatic species and habitat from reductions in the highest flood flows, fish migration in small tributaries or reaches that could be affected by lower groundwater levels, and other water management actions (groundwater storage and recovery, water transfers, water recycling, and water conservation measures) that could reduce instream flows in some streams.

Section 7.1, *Introduction, Project Description, and Approach to Environmental Analysis*, describes reasonably foreseeable methods of compliance and response actions, including actions that would require construction. These actions are analyzed for potential environmental effects in Section 7.21, *Habitat Restoration and Other Ecosystem Projects*, and Section 7.22, *New or Modified Facilities*.

7.6.2.1 Environmental Checklist

The checklist below contains the questions most relevant to the analysis of potential impacts on fisheries. See the Environmental Checklist in Section 7.6.1, *Terrestrial Biological Resources*, for the remainder of Biological Resources impact questions.

IV. Aquatic Biological Resources	Potentially Significant Impact	Less than Significant with Mitigation Incorporated	Less-than-Significant Impact	No Impact
Would the project:				
a. Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game* or U.S. Fish and Wildlife Service?	☒	☐	☐	☐
d. Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?	☒	☐	☐	☐
f. Conflict with the provisions of an adopted habitat conservation plan, natural community conservation plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☒	☐

*California Department of Fish and Game is now California Department of Fish and Wildlife.

7.6.2.2 Environmental Setting

This section describes the aquatic biological resources setting to inform the impact discussion in this section and in Section 7.21, *Habitat Restoration and Other Ecosystem Projects*; Section 7.22, *New or Modified Facilities*; and Chapter 9, *Proposed Voluntary Agreements.*

Water that may be affected by the proposed Plan amendments originates in or is diverted from surface waterbodies in the Sacramento/Delta. Water from the Sacramento/Delta is used within three study area regions (Sacramento River watershed, Delta eastside tributaries, and Delta regions), and additional Sacramento/Delta water is delivered to and used in the other study area regions (San Francisco Bay Area [Bay Area], San Joaquin Valley, Central Coast, and Southern California) (Figures 1-1b and 1-1c). Only a portion of the water supply used in each of the regions is derived from surface water supplied from the Sacramento/Delta. The larger study area is defined to provide context for total water supplies and includes areas beyond the plan area where the proposed Plan amendments may cause environmental impacts.

The Bay-Delta is one of the most important ecosystems in California as well as the hub of California's water supply system. As the largest tidal estuary on the western coast of the Americas, it nurtures a vast array of aquatic, terrestrial, and avian wildlife in the Delta, San Francisco Bay, and near shore ocean, as well as a diverse assemblage of species upstream of the Delta.

Native species in the Bay-Delta ecosystem are experiencing an ecological crisis. In the early 2000s, scientists noted a steep and lasting decline in population abundance of several native estuarine fish species that continued and worsened during the 2012–2016 and 2020–2022 drought periods. For decades, valuable habitat has been converted to farmland and urban uses, the quality of water in the channels has been degraded, there has been a substantial overall reduction in flows and significant changes in the timing and distribution of those flows, and aquatic species have been cut off from natal waters. These conditions have led to severe declines and, in some cases extinctions, of native fish and other aquatic species. Scientific studies also have identified the involvement of other aquatic ecosystem stressors, such as reduced habitat, pollutants, nonnative invasive and predatory species, and abiotic factors, as contributing factors in species declines. Indices of population abundance for multiple native estuarine species are at all-time low levels (see Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*). Longfin smelt were once a common species in the San Francisco estuary, but the population has undergone several significant declines since the late 1980's and is the lowest in the 40-year history of the Fall Midwater Trawl and Bay Study by California Department of Fish and Wildlife (CDFW) (USFWS 2022). Similarly, abundance indices of Delta smelt have declined and the population is now about 1 percent of its historic abundance (Hobbs et al. 2019). Since restoration of the Yolo Bypass and Cosumnes River floodplain, Sacramento splittail catch rates have increased (Moyle et al. 2020), but the strong year classes are highly dependent on artificially maintained flows and unusually wet years to create widespread flooding for spawning habitat (^Moyle et al. 2015). Two resident species have been extirpated: Sacramento perch and thicktail chub, primarily due to loss of suitable habitat (^USFWS 1996).

Flow and water temperature conditions in many Sacramento/Delta tributaries are affected by diversions, hydropower operations, and reservoir water supply and flood control operations. Dams and reservoirs block access to upstream reaches for many native fish, including multiple special-status anadromous fish species that historically migrated into upper watershed streams. The abundance levels of many other native fish species have been reduced by habitat loss and degradation resulting from multiple factors such as mining, grazing and agricultural practices, logging, dam effects, urbanization, and predation and competition from nonnative species.

Changes to the flow regime of Sacramento/Delta tributaries and changes in Delta outflows, cold water habitat, and interior Delta flow conditions contribute to the impairment of the ecosystem and native fish and wildlife beneficial uses. Chapter 2, *Hydrology and Water Supply*, explains the existing hydrology of the Sacramento/Delta tributaries and Delta and describes reductions in Delta outflow over time. The combined effects of water diversions on upstream river systems and exports from the Delta have reduced the average annual net Delta outflow to the ocean by 33 percent and 48 percent during the 1948–1968 and 1986–2005 periods, respectively, compared with unimpaired conditions (^Fleenor et al. 2010). Since the 1990s, there has been a reduction in spring outflow and a reduction in the variability of Delta outflow throughout the year, due largely to the combined effects of exports, diversions, and variable hydrology.

Many tributaries that contain a major flow-regulating reservoir, such as the mainstem Sacramento River below Keswick Reservoir, tend to have reduced flows during winter and spring months and higher flows during summer months compared with unimpaired conditions. On unregulated[1] tributaries with high water demand, such as Mill Creek, flows tend to be unimpaired during winter and early spring months but reduced substantially during the late spring through early fall irrigation season. Changes in the hydrologic regime on many tributaries and the loss of historical upper watershed habitat above dams have negatively affected multiple native fish species.

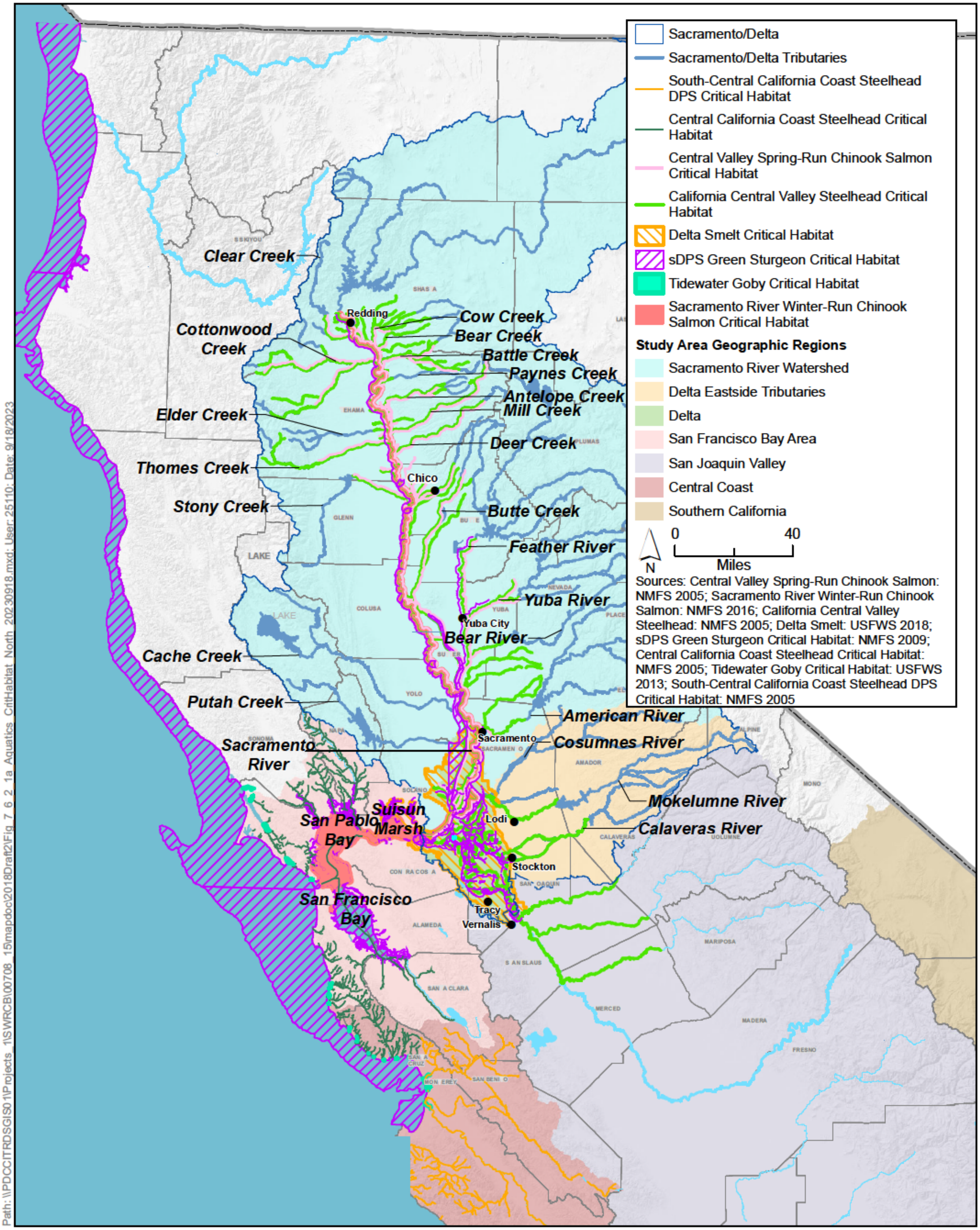
Native species have continued to experience declines in abundance since implementation of Water Right Decision 1641 (D-1641) in 2000, including several species that are protected under the federal Endangered Species Act (ESA) and California Endangered Species Act (CESA). The impaired hydrology of the Bay-Delta watershed has acted through a number of mechanisms to decrease reproductive output and survival of young, including the magnitude and timing of flows needed for adult attraction, transport of larval fish to estuarine rearing habitats, inundation of floodplain spawning and rearing habitat, and maintenance of low-salinity rearing habitat in Suisun Bay and Marsh. Historically, the Delta exhibited higher outflow in winter and spring than in recent years, placing low-salinity habitat (as measured by X2) further downstream under these conditions.[2] Reductions in flows during winter and spring have reduced potential recruitment opportunities and the viability of the estuarine-dependent community.

Anadromous salmonids, which use habitat in the Bay-Delta estuary and upstream tributaries, have also exhibited substantial declines in population abundance in recent decades. Many Sacramento/Delta tributaries provide critical habitat for Chinook salmon and steelhead populations (Figure 7.6.2-1a). Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, presents information that demonstrates significant declines in the natural production of winter-, spring-, fall-, and late fall-run Chinook salmon notwithstanding the population abundance goals, although uncertainties associated with estimation methods can make estimating natural production challenging. It is estimated that the average annual natural production of Sacramento River winter-run Chinook salmon, Sacramento River spring-run Chinook salmon, Sacramento River fall-run Chinook salmon (mainstem), and Sacramento River late fall-run Chinook salmon (mainstem) decreased between 1967 and 1991 and between 1992 and 2015 by 89, 61, 43, and 52 percent, respectively (see Table 3.4-3 in Chapter 3). Available data also show a long-term decline in escapement of steelhead from the Sacramento and San Joaquin River basins (^McEwan 2001). Hatcheries now provide most of the salmon and steelhead caught in the commercial and recreational fisheries.

At least one salmonid run is migrating through the Delta or holding in the upper Sacramento River watershed each month of the year. Adult salmonids require continuous tributary flows of sufficient magnitude to provide the olfactory cues to find, enter, hold, and spawn in their natal stream. Warm water temperatures and low flows delay or inhibit adult immigration, spawning, juvenile rearing, and juvenile outmigration in many tributaries. Anadromous salmonids and other native species also are affected by export pumping at the CVP and SWP facilities, which can cause Old and Middle Rivers (OMR) reverse flows and draw large numbers of fish into the interior Delta, resulting in their entrainment into these facilities.

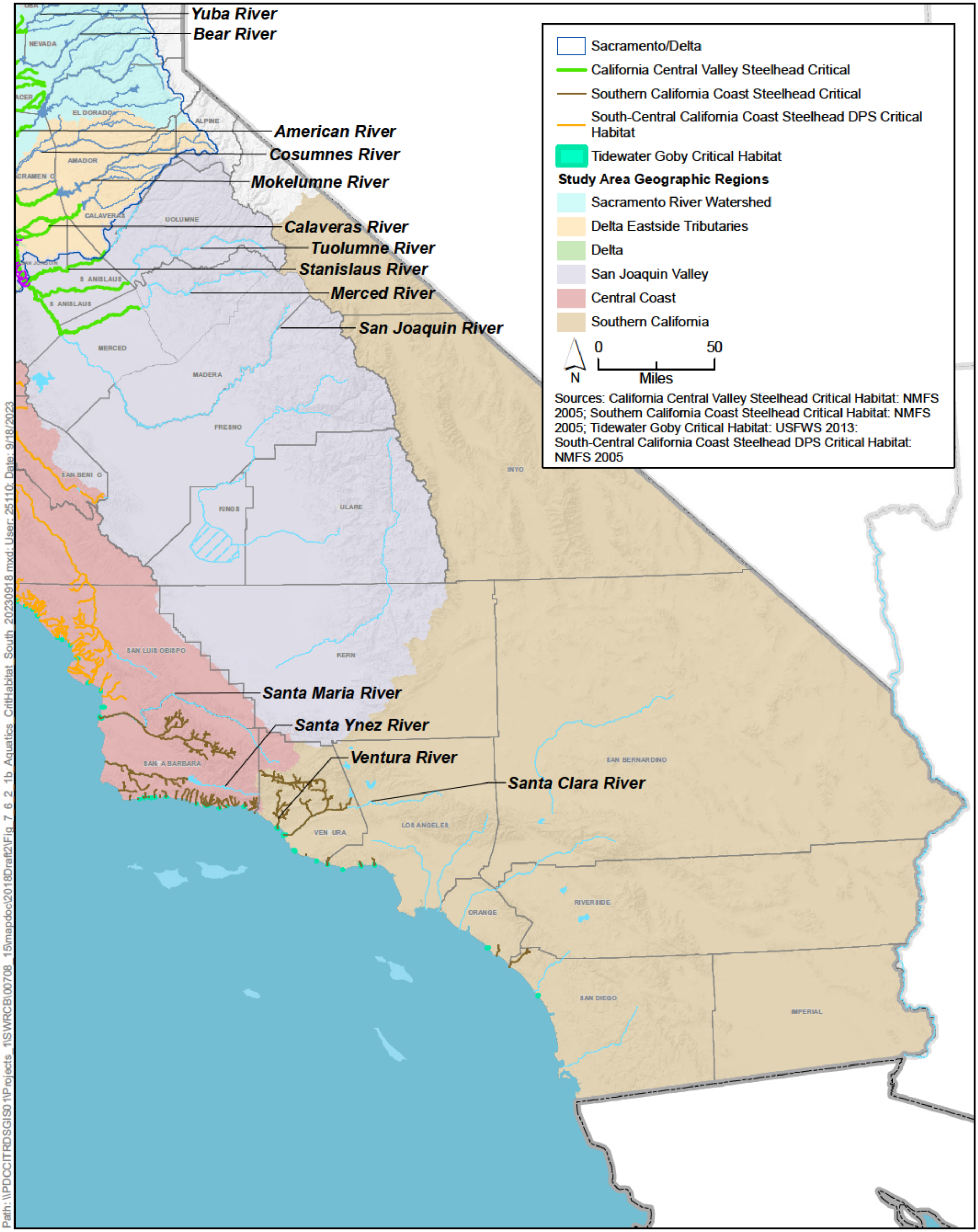
[1] The term *unregulated* here refers to a tributary that does not have a dam and reservoir capable of controlling flows.

[2] X2 is the location in the Bay-Delta where the tidally averaged bottom salinity is 2 parts per thousand. It is expressed as the distance in kilometers from the Golden Gate Bridge.



Path: \\PDCCITRDSGIS01\Projects_1\SWRCB\00708_15\mapdoc\2018Draft2\Fig_7_6_2_1a_Aquatics_CritHabitat_North_20230918.mxd; User: 25110; Date: 9/18/2023

Figure 7.6.2-1a
Critical Habitat in the Study Area (northern)



Path: \\PDCCITRDSGIS01\Projects 1\SWRCB\00708 15\mapdoc\2018Draft2\Fig 7 6 2 1b Aquatics CritHabitat South 20230918.mxd; User: 25110; Date: 9/18/2023

Figure 7.6.2-1b
Critical Habitat in the Study Area (southern)

Salmonids require adequate cold water and flow conditions through their spawning and rearing period. Historically, before construction of reservoirs and other habitat alterations, salmonids generally had access to cold water habitat in higher altitudes year-round. Since construction of dams and other habitat alterations, access for salmonids to cold water habitat has been eliminated or substantially reduced to the detriment of salmonid populations. Remaining populations that would otherwise migrate to upstream habitat are now dependent on maintenance of suitable conditions in the downstream reaches below dams. During summer and fall, when air temperatures exert a strong influence on river temperatures, the release of cold water from reservoirs is important for maintaining suitable cold water habitat below dams. For example, prior to construction of Shasta Reservoir on the Sacramento River, winter-run Chinook salmon spawning and early rearing habitat encompassed approximately 200 miles of snow-fed cold water streams in the upper reaches of the Sacramento River and its tributaries. With the construction and operation of Shasta and Keswick Dams, winter-run Chinook salmon no longer have access to this historical habitat. The only remaining habitat is limited to a small stretch of the Sacramento River below Keswick Dam, where cooler temperatures are dependent on reservoir releases. Extensive efforts (e.g., modeling, operation of a temperature control device [TCD] in Shasta Reservoir, protection of carryover storage in Shasta Reservoir, and optimization of Shasta releases) have been made to provide adequate water temperature for winter-run Chinook.

Although there are existing instream flow requirements on some tributaries and other ongoing efforts intended to help protect native fish species and habitat, including cold water habitat, existing regulatory requirements that apply to a limited subset of streams and for a limited number of reservoirs are insufficient to protect native fish species in the Sacramento/Delta. On the Sacramento River, minimum instream flows are required under Water Right Order 90-5. On the American River, minimum stream flows are managed through the 2017 Lower American River Modified Flow Management Standard (2017 LAFMS). The minimum instream flows on the Feather River are managed through the 1986 Memorandum of Understanding between CDFW and the California Department of Water Resources (DWR). Multiple Sacramento/Delta tributaries have no minimum instream flow requirements, including Mill Creek, Deer Creek, and Butte Creek. Similar shortcomings exist for regulatory requirements for temperature management and protection of cold water habitat. While a very limited number of tributaries have temperature objectives, including the Sacramento River (Water Right Order 90-5) and the American River (2017 LAFMS), most tributaries lack any temperature objectives to protect native fish and maintain cold water habitat. It is apparent that existing laws (e.g., Fish and Game Code section 5937, Basin Plan Water Quality Objectives for Temperature) are applied unevenly or not implemented in many locations.

Special-Status Species in the Study Area

Special-status species are those that are considered sufficiently rare that they require special consideration or protection and should be legally protected or otherwise considered sensitive by federal, state, or local resource agencies. For the purposes of this analysis, special-status fish species include those that are listed, proposed, or candidates for listing as threatened or endangered under ESA and CESA; species that are federally designated as a species of concern; California species of special concern; and California fully protected species.

Table 7.6.2-1 summarizes special-status fish species and their current distribution in the study area. Table 7.6.2-1 was developed based on a review of listing documents (Federal Register), species status reviews, databases (e.g., California Natural Diversity Database [CNDDB 2020]), published reviews of the biology and status of special-status fish species in California (e.g., ^Moyle et al. 2015), recovery plans and 5-year reviews for federally listed species (USFWS 1984, 1985, 1993, 1998, 2005, 2009a, 2009b, 2017; NMFS 2012a, 2012b, 2013, ^2014a, 2016a, 2018) and other sources (e.g., CDFW's Inland Deserts Region Native Fish Conservation website [CDFW 2023]). Additional native California fish distribution information was obtained from Calfish (UC ANR 2020), CalTrout and UCD (2017), and Santos et al. (2014).

Table 7.6.2-1 identifies the distribution of species within the study area; however, some of these fish species migrate to habitat areas outside the study area. For example, Central California Coast coho salmon use habitat within the study area as well as habitat along the California and Oregon coastline, outside the study area.

In addition to the special-status fish species identified in Table 7.6.2-1, a number of special-status fish species occur in the Sacramento River watershed above Shasta Reservoir, including several special-status fish species in the McCloud River (e.g., McCloud River redband trout) and Pit River watersheds (e.g., Goose Lake redband trout).

Table 7.6.2-1. Special-Status Fish Species That Occur in the Study Area

Species	Legal Status [a]	Current Distribution in the Study Area
Mojave tui chub (*Siphateles bicolor mohavensis*)	FE, SE, FP	Southern California
Owens pupfish (*Cyprinodon radiosus*)	FE, SE, FP	Southern California
Unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*)	FE, SE, FP	Central Coast, Southern California
Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*)	FE, SE	Sacramento River, Delta, Suisun Bay and Marsh, San Francisco Bay, Pacific Ocean
Coho salmon, Central California Coast ESU (*Oncorhynchus kisutch*)	FE, SE	San Francisco Bay Area, Central Coast, Pacific Ocean
Desert pupfish (*Cyprinodon macularius*)	FE, SE	Southern California
Owens tui chub (*Siphateles bicolor snyderi*)	FE, SE	Southern California
Tidewater goby (Eucyclogobius newberryi)	FE, SSC	San Francisco Bay Area, Central Coast, Southern California
Delta smelt (*Hypomesus transpacificus*)	FT, SE	San Francisco Bay Area, Delta, Suisun Bay and Marsh
Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*)	FT, ST	Sacramento River watershed, Delta, Suisun Bay and Marsh, San Francisco Bay Area, Pacific Ocean
Southern DPS North American green sturgeon (*Acipenser medirostris*)	FT, SSC	Sacramento River watershed, Delta, Suisun Bay and Marsh, San Francisco Bay Area, Pacific Ocean
Steelhead, California Central Valley DPS (*Oncorhynchus mykiss*)	FT	Sacramento River watershed, Delta eastside tributaries, Delta, Suisun Bay and Marsh, San Francisco Bay Area, San Joaquin Valley, Pacific Ocean

Species	Legal Status [a]	Current Distribution in the Study Area
Steelhead, Central California Coast DPS (*Oncorhynchus mykiss*)	FT	San Francisco Bay Area, Central Coast. Pacific Ocean
Little Kern golden trout (*Oncorhynchus mykiss whitei*)	FT, SSC	San Joaquin River watershed
Steelhead, South-Central California Coast DPS *(Oncorhynchus mykiss)*	FT	Central Coast, Pacific Ocean
Steelhead, Southern California DPS (*Oncorhynchus mykiss*)	FE	South-Central/Southern California Coast, Pacific Ocean
Santa Ana sucker (*Catostomus santaanae*)	FT, SSC	Southern California
Longfin smelt Bay-Delta DPS (*Spirinchus thaleichthys*)	FPE, ST	Delta, Suisun Bay and Marsh, San Francisco Bay Area, Pacific Ocean
Central Valley fall-run Chinook salmon (*Oncorhynchus tshawytscha*)	FSC, SSC	Sacramento River watershed, Delta eastside tributaries, Delta, Suisun Bay and Marsh, San Francisco Bay Area, San Joaquin Valley, Pacific Ocean
Central Valley late fall-run Chinook salmon (*Oncorhynchus tshawytscha*)	FSC, SSC	Sacramento River watershed, Delta, Suisun Bay and Marsh, San Francisco Bay Area, Pacific Ocean
Clear Lake hitch (*Lavinia exilicauda chi*)	ST	Sacramento River watershed (Clear Lake basin)
Cottonball Marsh pupfish (*Cyprinodon salinus milleri*)	ST	Southern California
Clear Lake prickly sculpin (*Cottus asper* spp.)	SSC	Sacramento River watershed (Clear Lake basin)
Clear Lake roach (*Lavinia symmetricus* ssp.)	SSC	Sacramento River watershed (Clear Lake basin)
Clear Lake tule perch (*Hysterocarpus traskii lagunae*)	SSC	Sacramento River watershed (Clear Lake basin)
Sacramento hitch (*Lavinia exilicauda exilicauda*)	SSC	Sacramento River watershed, Delta eastside tributaries, Delta, San Francisco Bay Area, San Joaquin Valley, Southern California
Riffle sculpin (*Cottus gulosus*)	SSC	Sacramento River watershed, Delta eastside tributaries, San Joaquin Valley, San Francisco Bay Area, Central California
Sacramento splittail (*Pogonichthys macrolepidotus*)	SSC	Sacramento River watershed, Delta, Suisun Bay and Marsh, San Francisco Bay Area
White sturgeon (*Acipenser transmontanus*)	SSC	Sacramento River watershed, Delta, Suisun Bay and Marsh, San Francisco Bay Area, Pacific Ocean

Species	Legal Status [a]	Current Distribution in the Study Area
Pacific lamprey (*Entosphenus tridentatus*)	SSC	Sacramento River watershed, Delta eastside tributaries, Delta, Suisun Bay and Marsh, San Francisco Bay Area, Pacific Ocean, San Joaquin Valley, Southern California
Western river lamprey (*Lampetra ayresi*)	SSC	Sacramento River watershed, Delta eastside tributaries, Delta, San Francisco Bay Area, San Joaquin Valley, Pacific Ocean
Western brook lamprey (*Lampetra richardsoni*)	SSC	Sacramento River watershed, Delta, San Francisco Bay Area, Pacific Ocean
Central California roach (*Lavinia symmetricus* spp.)	SSC	Sacramento River watershed, Delta eastside tributaries, San Francisco Bay Area, San Joaquin Valley
Hardhead (*Mylopharodon conocephalus*)	SSC	Sacramento River watershed, Delta eastside tributaries, Delta, San Joaquin Valley
Tomales roach (*Lavinia symmetricus* ssp.)	SSC	San Francisco Bay Area
California golden trout (*Oncorhynchus mykiss aguabonita*)	SSC	San Joaquin River watershed
Kern brook lamprey (*Entosphenus hubbsi*)	SSC	San Joaquin Valley
Kern River rainbow trout (*Oncorhynchus mykiss gilberti*)	SSC	San Joaquin River watershed
Red Hills roach (*Lavinia symmetricus* ssp.)	SSC	San Joaquin Valley
Monterey roach (*Lavinia symmetricus subditus*)	SSC	Central Coast
Amargosa Canyon speckled dace (*Rhinichthys osculus* ssp.)	SSC	Southern California
Amargosa pupfish (*Cyprinodon nevadensis amargosae*)	SSC	Southern California
Arroyo chub (*Gila orcuttii*)	SSC	Central Coast, Southern California
Long Valley speckled dace (*Rhinichthys osculus* ssp.)	SSC	Southern California
Owens speckled dace (*Rhinichthys osculus* ssp.)	SSC	Southern California
Owens sucker (*Catostomus fumeiventris*)	SSC	Southern California
Salt Creek pupfish (*Cyprinodon salinus salinus*)	SSC	Southern California
Santa Ana speckled dace (*Rhinichthys osculus* ssp.)	SSC	Southern California

Species	Legal Status [a]	Current Distribution in the Study Area
Saratoga Springs pupfish (*Cyprinodon nevadensis nevadensis*)	SSC	Southern California
Shoshone pupfish (*Cyprinodon nevadensis shoshone*)	SSC	Southern California

San Francisco Bay = San Pablo, Central, and South Bays but not their tributaries

San Francisco Bay Area = San Francisco Bay and tributaries

DPS = distinct population segment

ESU = evolutionarily significant unit

[a] Special-Status Species Listing Categories

Federal Listing Categories:

FE = Listed as endangered under the federal Endangered Species Act (ESA).
FT = Listed as threatened under the ESA.

FPE = Proposed for listing as endangered under the ESA.

FC = Candidate for protection under the ESA.
FSC = Federally designated as a species of concern.

State Listing Categories:
SE = Listed as endangered under the California Endangered Species Act (CESA).
ST = Listed as threatened under CESA.
SSC = Designated as a California species of special concern.
FP = Fully protected under the California Fish and Game Code.

Figures 7.6.2-1a and 7.6.2-1b identify critical habitat in the study area for several species identified in Table 7.6.2-1. Figure 7.6.2-1a displays critical habitat for Central California Coast steelhead distinct population segment (DPS), Central Valley spring-run Chinook salmon, California Central Valley steelhead DPS, Delta smelt, southern DPS North American green sturgeon, tidewater goby, Sacramento River winter-run Chinook salmon, and South-Central California Coast steelhead DPS. Figure 7.6.2-1b displays critical habitat for California Central Valley steelhead DPS, southern California Coast steelhead DPS, South-Central California steelhead DPS, and tidewater goby.

Additional common native and nonnative fish species inhabit waterbodies in the study area. Some native fish species have been introduced to waters beyond their historical habitat. For example, rainbow trout is native to many streams and rivers in the Sierra Nevada but has been introduced to higher elevation waters in many locations. Some nonnative fish species, such as brown trout, also have been introduced widely. Many larger lakes and reservoirs and some streams in the Sacramento/Delta are managed for and receive heavy recreational fishing use. Many nonnative fish species also occur in the Delta. Descriptions of special-status fish species identified in Table 7.6.2-1 with distributions in either one or more of the Sacramento/Delta tributaries and/or downstream of one or more of the export reservoirs are provided below. Additional fish species of special concern occur in streams and rivers in study area regions identified in Table 7.6.2-1, but descriptions of some species are not provided below because the species are not native to the region.

Unarmored threespine stickleback (*Gasterosteus aculeatus williamsoni*) is federally listed as endangered, state listed as endangered, and a California fully protected species. A recovery plan for the unarmored threespine stickleback was published in 1985 (USFWS 1985). The species is at critical risk for extinction (^Moyle et al. 2015). The unarmored threespine stickleback is a small (up to 2 inches in length) scaleless fish that inhabits slow-moving stream and river reaches (USFWS 2009b). Favorable habitat includes areas shaded by dense vegetation, algal mats, or barriers (e.g., sand bars, floating vegetation) that provide refuge (USFWS 2009b). The unarmored threespine stickleback is believed to live for only 1 year, and reproduction occurs in pools and sheltered areas within the stream (USFWS 2009b). The species were abundant in most streams in the Los Angeles basin (^Moyle 2002), and is now restricted to three areas: the upper Santa Clara River and its tributaries in Los Angeles County, San Antonio Creek on Vandenberg Air Force Base in Santa Barbara County, and the Shay Creek vicinity (which includes Shay Pond, Sugarloaf Pond, Juniper Springs, Motorcycle Pond, Shay Creek Wiebe Pond, and Baldwin Lake) in San Bernardino County (USFWS 2009b). A small, transplanted population of unarmored threespine stickleback also may occur in San Felipe Creek in San Diego County; however, the current status is unknown (USFWS 2009b).

Below export reservoirs, the species occurs in the Santa Clara River and lower Castaic Creek (USFWS 2009b; CDFW 2014a).

Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) is federally and state listed as endangered. A multispecies recovery plan that includes Sacramento River winter-run Chinook salmon was published in 2014 (^NMFS 2014a). Adult winter-run Chinook salmon spawn between late April and mid-August and must hold in fresh water for several months before they are capable of reproducing. Rearing occurs in the Delta and in the Sacramento River below the Red Bluff Diversion Dam (RBDD) during July through June. Sacramento River winter-run Chinook salmon are unique among Central Valley anadromous salmonid populations because they complete sexual development and spawn during summer when air temperature in the Central Valley approaches an annual maximum. Since construction of Shasta and Keswick Dams, winter-run Chinook salmon have been blocked from reaching their native spawning grounds in the upper Sacramento River, including the Pit, McCloud, Fall, and Little Sacramento Rivers (^Yoshiyama et al. 1998). Consequently, spawning is now restricted to the area between Keswick Dam and the RBDD where releases of cold water from Shasta Dam are used to maintain suitable water temperatures for spawning and incubation (Good et al. 2005). Water temperature control is achieved by managing reservoir storage levels and operating a TCD, which was installed at Shasta Dam in 1998 (^NMFS 2009 BiOp). The abundance of winter-run Chinook salmon has declined significantly since the 1960s (see Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*).

Tidewater goby (*Eucyclogobius newberryi*) is federally listed as endangered and is a state species of special concern. A recovery plan for the tidewater goby was published in 2005 (USFWS 2005). The tidewater goby is a small grey-brown fish that rarely exceeds 2 inches in length. The tidewater goby is endemic to California and historically ranged from lagoons, estuaries, and stream mouths in Del Norte County to San Diego County (USFWS 2005) but has been extirpated from some coastal watersheds within its historical range. Tidewater gobies typically occur within the freshwater–saltwater interface, typically at salinities of less than 10 parts per thousand (Swift et al. 1989). Tidewater goby critical habitat is designated in portions of Del Norte, Humboldt, Mendocino, Sonoma, Marin, San Mateo, Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, Ventura, Los Angeles, Orange, and San Diego Counties (USFWS 2011).

Below export reservoirs, the species is known to occur in the lagoons of the Santa Ynez River and Santa Clara River (CDFW 2014a), and critical habitat is designated in portions of the Santa Clara River (see Figure 7.6.2-1b).

Southern California steelhead DPS (*Oncorhynchus mykiss*) is federally listed as endangered. A recovery plan for the Southern California steelhead DPS was published in 2012 (NMFS 2012a). The Southern California steelhead DPS occurs in southern California coastal watersheds between the Santa Maria River watershed and the United States–Mexico border. Small but persistent annual runs of steelhead are monitored in several basins within the range of this DPS (NMFS 2016a), and critical habitat is designated for the Southern California steelhead DPS in several coastal watersheds in Santa Barbara, Ventura, Los Angeles, Orange, and San Diego Counties (Figure 7.6.2-1b).

Below export reservoirs, the Southern California steelhead DPS occurs in the Santa Ynez, Santa Clara, and Santa Margarita Rivers; and critical habitat is designated within the Santa Ynez and Santa Clara Rivers (CDFW 2014a; NMFS 2005, 2012a).

Delta smelt (*Hypomesus transpacificus*) is state listed as endangered and was warranted for federal reclassification from threatened to endangered by USFWS in 2010 (75 Fed. Reg. 17667). The decline of Delta smelt led to implementation of the Delta Smelt Resiliency Strategy (see Section 7.6.2.3 *Regulatory Setting*, *Delta Smelt Resiliency Strategy*) by state and federal agencies in 2016, aimed at improving this species' growth, reproduction, and survival (CNRA 2016). Delta smelt are a small (55–70 millimeters [mm]) endemic fish to the Bay-Delta, and generally spend their entire life cycle in the open surface waters of the upper San Francisco estuary. The primary geographic distribution of Delta smelt includes the low-salinity and freshwater zones of the upper San Francisco estuary, including Suisun Bay, Suisun Marsh, the lower Sacramento River, the Cache–Lindsey Slough Complex, and the Sacramento River Deep Water Ship Channel. Delta smelt complete their life cycle either within the low-salinity zone of the upper San Francisco estuary, in the freshwater region of the north Delta, or move between the two regions of fresh water and low salinity (^Bennett 2005; Hobbs et al. 2019). Since 2003, the population abundance of larval Delta smelt in spring has been positively correlated with the magnitude of Delta outflow during the previous winter-spring and fall periods (see Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*). Delta smelt are entrained and lost at the CVP and SWP pumping facilities when adults migrate into the Delta in winter and early spring to spawn and again when the larvae migrate back downstream to the low salinity zone (LSZ) in late spring and early summer. Data presented in the summer flow augmentation rationale by CDFW (^2016b) also suggests that Delta smelt abundance in fall is positively related to Delta outflow during the prior summer (see Chapter 3).

Central Valley spring-run Chinook salmon (*Oncorhynchus tshawytscha*) is state and federally listed as threatened. A multispecies recovery plan that includes Central Valley spring-run Chinook salmon was published in 2014 (^NMFS 2014a, entire ref). Central Valley spring-run Chinook salmon were likely historically the most abundant salmon run in the Central Valley. Spring-run Chinook salmon used the headwaters of all the major rivers to spawn and rear (^NMFS 2014a). Spring-run Chinook salmon migrate to natal streams between February and September, with peak migration in May and June (^Yoshiyama et al. 1998). Following the summer holding period, spawning occurs between late August and November with a peak in October and November (^Moyle 2002). In the Central Valley, ambient summer water temperatures are only suitable above 500 to 1,500 feet elevation, and most of this habitat is now upstream of impassable dams (^NMFS 2014a). As a result, spring-run Chinook salmon have suffered the most severe decline of the four runs of Chinook salmon in the Sacramento River basin (^Fisher 1994).

North American green sturgeon (southern DPS) (*Acipenser medirostris*) is federally listed as threatened and identified as a California species of special concern. A recovery plan for the southern DPS of North American green sturgeon was published in 2018 (NMFS 2018). North American green sturgeon range along the Pacific coast from Mexico to Alaska (Colway and Stevenson 2007; ^Moyle 2002). The southern DPS of green sturgeon includes all green sturgeon populations south of the Eel River, with the majority of the spawning population being in the Sacramento River. Green sturgeon spawning also has been documented in the Feather River and possibly in the Yuba River (Seesholtz et al. 2014; ^Bergman et al. 2011). Within the Central Valley, green sturgeon have been observed in San Francisco Bay, San Pablo Bay, Suisun Bay, the Delta, Sacramento River, Feather River, Yuba River, Sutter Bypass, and Yolo Bypass (74 Fed. Reg. 52300; Israel and Klimley 2008; ^Moyle 2002; Dubois et al. 2014; Dubois and Harris 2015, 2016; Dubois and Danos 2017, 2018; NMFS 2018). Spawning is believed to have historically occurred on the Sacramento River above Shasta Dam and possibly on the upper Feather River (^USFWS 1996). Construction of Shasta and Oroville Dams blocked upstream spawning access above the dams (^USFWS 1996; ^Beamesderfer et al. 2004; ^CDFG 2002). Adult green sturgeon are present in every month of the year in the San Francisco Bay, Delta, and Sacramento River (Miller et al. 2020). Juveniles spend 1 to 4 years in freshwater and estuarine habitats before they enter the ocean (Nakamoto et al. 1995). As discussed in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, average Delta outflow of 37,000 cubic feet per second (cfs) or larger between March and July appears to be needed to consistently produce strong white sturgeon recruitment. It is assumed that green sturgeon recruitment has a similar relationship to flow.

California Central Valley steelhead DPS (*Oncorhynchus mykiss*) is federally listed as threatened. A multispecies recovery plan that includes California Central Valley steelhead DPS was published in 2014 (^NMFS 2014a). California Central Valley steelhead DPS was historically widely distributed throughout the Sacramento and San Joaquin River watersheds prior to dam and reservoir construction (^NMFS 1996; ^McEwan 2001). Their distribution in the upper Sacramento River basin likely included the upper Sacramento and Pit Rivers, Sacramento River tributaries on both the east and west side of the river, and as far south as the Kings River in the San Joaquin River basin (^Yoshiyama et al. 1996; ^Lindley et al. 2006). Existing native steelhead populations now occur in the Sacramento, Yuba, Feather, Bear, and American Rivers and in Cottonwood, Butte, Big Chico, Cow, Stony, Thomes, Deer, Mill, Antelope, Clear, and Battle Creeks in the Sacramento River watershed (^NMFS 2014a). On the east side of the Delta, returning adult steelhead have been observed in the Mokelumne, Cosumnes, and Calaveras Rivers. Adult steelhead typically migrate upstream and spawn during winter months when river flows are high and water clarity is low. Unlike Chinook salmon, adult steelhead may not die after spawning and can return to coastal ocean waters. Juvenile steelhead rear for 1 or 2 years in cool, clear, fast-flowing permanent streams and rivers (^Moyle 2002).

Central California Coast steelhead DPS (*Oncorhynchus mykiss*) is federally listed as threatened. A multispecies recovery plan that includes Central California Coast steelhead DPS was published in 2016 (NMFS 2016a). The Central California Coast steelhead DPS occurs between the Russian River basin south to Aptos Creek in Santa Cruz County and the drainages of San Francisco Bay, San Pablo Bay, and Suisun Bay. Critical habitat is designated for the Central California Coast steelhead DPS in multiple coastal watersheds in the Bay Area and in San Francisco Bay and some of its tributaries (Figure 7.6.2-1a)

Below export reservoirs, Central California Coast steelhead DPS may occur in Coyote Creek and streams of the Alameda Creek watershed (occasionally including Arroyo Valle), and critical habitat is designated in Coyote Creek (CDFW 2014a; NMFS 2005).

Santa Ana sucker (*Catostomus santaanae*) is federally listed as threatened and identified as a California species of special concern. A recovery plan for Santa Ana sucker was published in 2017 (USFWS 2017). The Santa Ana sucker is a small (usually less than 16 centimeters [cm] standard length) sucker that resembles and is closely related to the mountain sucker (^Moyle 2002). Santa Ana suckers require cool (less than 22 degrees Celsius [°C]) flowing water (^Moyle 2002). The species spawns in gravelly riffles, from mid-March to early July (^Moyle 2002). The listed populations occur in the Los Angeles, San Gabriel, and Santa Ana River systems. The species is also found in the Santa Clara River system, but this population was not included in the species' federal listing because it was thought to have been introduced (USFWS 2000). However, a recent genetic analysis indicates that the Santa Ana sucker also may be native to the Santa Clara River (Richmond et al. 2017).

Below export reservoirs, the Santa Ana sucker occurs in Piru Creek and the Santa Clara River.

Longfin smelt (*Spirinchus thaleichthys*) is state listed as threatened. The Bay-Delta DPS was found to be warranted for protection. The DPS is now proposed for listing as an endangered species under the federal ESA (87 Fed. Reg. 60957). Longfin smelt are a small pelagic anadromous fish that can occupy a wide range of salinities. Populations of longfin smelt have been documented north of the San Francisco estuary in Humboldt Bay, the Eel River estuary, the Klamath River estuary, the Mad River, and the Russian River watershed (Brennan et al. 2022; Garwood 2017). Longfin smelt also have been detected in small central California estuaries, including Pescadero Creek and Moss Landing (Garwood 2017). The longfin smelt Bay-Delta DPS predominantly resides and rears in the San Francisco estuary, including the nearshore ocean outside the Golden Gate. They spawn demersal adhesive eggs that have not been observed in the wild in the San Francisco estuary, leaving the spawning habitat unknown. Spawning locations have been estimated using field observations and through particle-tracking modeling to suggest that spawning extends to the LSZ where brackish and fresh waters meet (Grimaldo et al. 2017, Gross et al. 2022), in tidal wetlands of South San Francisco Bay (Lewis et al. 2020), and in San Pablo and lower South Bay during wet years (Grimaldo et al. 2020). Longfin smelt migrate from areas of high salinity to brackish or fresh water for spawning from November through March and spawn by April (Rosenfield 2010; Lewis et al. 2019). Longfin smelt usually live for 2 years, spawn, and then die, although some individuals may spawn as 1 year-old or 3 year-old fish before dying (^Moyle 2002). Abundance indices for the longfin smelt Bay-Delta DPS have significantly declined over time and have a strong relationship to winter-spring flow (^Stevens and Miller 1983; ^Kimmerer 2002b). The rate of decline has been particularly steep, especially in the years following invasion of the *Potamocorbula* overbite clam in 1987, which had a substantial grazing impact on the base of the food web (^Kimmerer 2002a). As discussed in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, the abundance of juvenile longfin smelt in fall is positively correlated with Delta outflow during the previous spawning season. Average daily outflows of 42,800 cfs in January to June are associated with a 50-percent probability of positive population growth.

Central Valley fall-run Chinook salmon (*Oncorhynchus tshawytscha*) is a California species of special concern. Central Valley fall/late fall-run Chinook salmon are also identified as a federal species of concern.[3] Although Central Valley fall-run Chinook salmon are currently the most abundant of all Central Valley salmon runs, natural production of fall-run Chinook salmon in the mainstem Sacramento River has declined since 1967–1991 (see Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*). Historically, fall-run Chinook salmon likely occurred in all Central Valley streams with adequate flow during fall (^Yoshiyama et al. 2001). Because much of fall-run Chinook salmon historical spawning and rearing habitat included the

[3] NMFS groups Sacramento fall- and late fall-run Chinook salmon in a single evolutionarily significant unit, which is currently listed as a federal species of concern (69 Fed. Reg. 19975). CDFW distinguishes between Sacramento fall- and late fall-runs; both are identified as California species of special concern (^Moyle et al. 2015).

reaches downstream of major dams, fall-run Chinook salmon populations in the Central Valley were not as severely affected by early water projects as were spring-run Chinook salmon and steelhead, which ascend to higher elevations to spawn (Reynolds et al. 1993; ^Yoshiyama et al. 1996; ^McEwan 2001). Central Valley fall-run spawn from late September through January. Generally, fall-run juveniles emigrate from their natal streams during winter through spring.

Central Valley late fall-run Chinook salmon (*Oncorhynchus tshawytscha*) is a California species of special concern. Central Valley fall/late fall-run Chinook salmon are also identified as a federal species of concern. Central Valley late fall-run Chinook salmon was recognized as distinct only after construction of the RBDD in 1966 (^Yoshiyama et al. 2001), and the historical abundance and distribution of the late fall-run Chinook salmon is not known. Historically, late fall-run Chinook salmon probably spawned above Shasta Reservoir in the upper Sacramento River and its tributaries (^Yoshiyama et al. 2001). The primary spawning habitat for late fall-run is now in the Sacramento River above the RBDD. Some spawning also has been observed in Clear, Mill, Cottonwood, Salt, Battle, and Craig Creeks and in the Yuba and Feather Rivers. Annual production from these watersheds is thought to constitute only a minor fraction of total population abundance.

Clear Lake hitch (*Lavinia exilicauda chi*) is state listed as threatened. Clear Lake hitch is a subspecies of Sacramento hitch (^Moyle et al. 2015) and is endemic to Clear Lake and its tributaries. Clear Lake hitch are a lake-adapted form of hitch; juveniles and adults use habitat in Clear Lake (Center for Biological Diversity 2012). Clear Lake hitch spawn in the lower reaches of tributaries to Clear Lake, mainly in gravel-bottomed sections. The population's abundance has declined in recent decades as a result of several factors, such as habitat loss and alteration, migration barriers, invasive fish, and pollutants (Center for Biological Diversity 2012).

Clear Lake prickly sculpin (*Cottus asper* ssp.) is a California species of special concern. Clear Lake prickly sculpin is a subspecies of prickly sculpin that occurs in Clear Lake and may occur in Upper and Lower Blue Lakes in the Clear Lake watershed. Clear Lake prickly sculpin are adapted to warm (summer temperatures 25°C to 28°C), shallow lake habitat (^Moyle et al. 2015). Clear Lake prickly sculpin spawning occurs during March and April (^Moyle et al. 2015). Clear Lake prickly sculpin feed primarily on benthic invertebrates and small fish. Although prickly sculpin appear to be abundant in Clear Lake, changes in water quality and nonnative species may affect the long-term persistence of the Clear Lake prickly sculpin (^Moyle et al. 2015).

Clear Lake roach (*Lavinia symmetricus* ssp.) is a California species of special concern. Clear Lake roach are small cyprinids and are similar to the Central California roach in appearance. Clear Lake roach occur in tributaries to Clear Lake, from headwater tributaries to low-elevation reaches (^Moyle et al. 2015). Clear Lake roach are believed to share a similar life history with Central California roach, but little information is available (^Moyle et al. 2015).

Clear Lake tule perch (*Hysterocarpus traskii lagunae*) is a California species of special concern. Clear Lake tule perch is a subspecies of tule perch endemic to Clear Lake, Upper Blue Lake, and Lower Blue Lake in the Clear Lake basin. Clear Lake tule perch are relatively long lived (6 to 7 years), and females begin reproducing at age 2 or 3. The main population of Clear Lake tule perch spends its entire life cycle in Clear Lake, which is warm (25°C to 28°C summer temperatures) and shallow. The species has not been confirmed in Lower Blue Lake in recent years, and tule perch populations appear to have dropped to low levels in Clear Lake in recent decades (^Moyle et al. 2015). Several factors may be negatively affecting the abundance of Clear Lake tule perch, including but not limited to, changes in Clear Lake water quality, landscape modification, and increased predation from nonnative species (^Moyle et al. 2015).

Sacramento hitch (*Lavinia exilicauda exilicauda*) is a California species of special concern. The species historically occurred in low-elevation streams throughout the Sacramento and San Joaquin Valleys and in the Delta but now exist mainly as scattered small populations over a fairly broad geographic area and appear to be in long-term decline (^Moyle et al. 2015). The species distribution is now fragmented, with increasingly isolated populations. In the Sacramento River, Sacramento hitch are believed to occur up to and in Shasta Lake, as well as in some San Francisco Bay estuary tributaries and some sloughs in the Delta (^Moyle et al. 2015). Sacramento hitch occur in warm waters, including streams, lakes, and reservoirs, and have high temperature tolerances. However, Sacramento hitch tend to be most abundant in the wild in waters cooler than 25°C during summer (^Moyle et al. 2015). Hitch spawn over gravel riffles at temperatures of 14°C to 26°C (^Moyle 2002).

Sacramento hitch also have become established through introductions to a few reservoirs, such as San Luis Reservoir, and have been carried to several Southern California reservoirs by the California Aqueduct (^Moyle 2002). Below export reservoirs, there are historical records (pre-water development of the 1950s) of Sacramento hitch in Arroyo Valle, Coyote Creek, and Alameda Creek. Hitch are also present in several Bay Area reservoirs where they have become established through introductions or after populations were isolated above the dams. For example, in Del Valle Lake (Alameda Creek watershed), hitch may have been established from stream populations or through water transfers into the reservoir from the Central Valley (Leidy 2007).

Riffle sculpin (*Cottus gulosus*) is a California species of special concern. Riffle sculpin are endemic to California (^Moyle et al. 2015) and have a fragmented distribution. In the Central Valley, riffle sculpin are found mostly in mid-elevation stream reaches of many watersheds, such as the Putah Creek, Deer Creek, Mokelumne River, American River, Feather River, and Yuba River watersheds (^Moyle et al. 2015). They inhabit permanent, cool headwater streams where riffles and rocky substrates predominate (^Moyle 2002). Most adult riffle sculpin are 2 to 3 years old, and spawning occurs in February through April (^Moyle 2002). Riffle sculpin are vulnerable to habitat changes that result in reduced flows or increased temperatures (^Moyle et al. 2015). They often co-occur with rainbow trout.

Below export reservoirs, the species is found in Coyote Creek and Alameda Creek.

Sacramento splittail (*Pogonichthys macrolepidotus*) was listed as threatened under federal ESA in 1999 but was removed from the list in 2003 (64 Fed. Reg. 5963; 68 Fed. Reg. 55139). It is a California species of special concern. Sacramento splittail is a large minnow endemic to the San Francisco estuary, predominantly found in the Central Valley and Bay-Delta but with another small distinct population in the Napa and Petaluma Rivers of San Pablo Bay (^Baerwald et al. 2007; Mahardja et al. 2015). Individuals live from 7 to 9 years and generally begin spawning at 1 to 2 years. Adult splittail migrate upstream from November through February to spawn in seasonal floodplains or flooded edge habitats (^Moyle et al. 2015; ^Crain et al. 2004). Spawning typically occurs from February through early July and peaks between March and April (^Wang 1986; ^Crain et al. 2004). Strong year classes occur only in years with significant protracted (at least 30 days) floodplain inundation (^Sommer et al. 1997), particularly in the Sutter and Yolo Bypasses (^Moyle et al. 2004; ^Feyrer et al. 2006b). Sufficient inundation periods are essential to allow for spawning, incubation, and rearing of larvae as splittail embryos cannot move with rapidly receding water (^Moyle et al. 2004). Even with a limited distribution from habitat loss, Sacramento splittail has demonstrated its resiliency and has benefited from management actions in Suisun Marsh and floodplain restoration in the Cosumnes River and Yolo Bypass (^Sommer et al. 1997; ^Moyle et al. 2004; Moyle et al. 2020). The UC Davis Suisun Marsh monthly sampling program has shown population estimate increases in the last 20 years but also have shown downward trends during periods of extended drought (^Moyle et al. 2004; Stompe et al. 2020). Analyses presented in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, indicate that Delta outflow of 30,000 to 47,000 cfs is needed between February and May to provide strong splittail recruitment.

White sturgeon (*Acipenser transmontanus*) is a California species of special concern. White sturgeon is a long-lived, late maturing iteroparous species (^Moyle 2002). Males and females become sexually mature at around 10 and 12 to 16 years of age, respectively (^Moyle 2002). Spawning occurs every 2 to 4 years for females and every 1 to 2 years for males (^Chapman et al. 1996; ^Moyle 2002). White sturgeon begin their upstream spawning migration in late fall and early winter, triggered by increased outflow (^Kohlhorst et al. 1991; ^Fish 2010; ^Schaffter 1997). Spawning occurs from mid-February through June, with peak spawning activity in March through May (^Kohlhorst 1976; ^Schaffter 1997). After hatching, undeveloped larvae disperse downstream. The Sacramento River between Knights Landing and Colusa is the primary spawning habitat for white sturgeon (^Kohlhorst 1976), although some spawning has been observed in the San Joaquin River (^Gruber et al. 2012; ^Jackson and Van Eenennaam 2013). Historically, spawning may also have occurred in both the upper Feather and Sacramento River basins, but these areas are now inaccessible because of the construction of Shasta and Oroville Dams (^Kohlhorst 1976). As discussed in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, average Delta outflow of 37,000 cfs or larger between March and July appears to be needed to consistently produce strong white sturgeon recruitment.

Pacific lamprey (*Entosphenus tridentatus*) is a California species of special concern. In California, Pacific lamprey occur from Los Angeles to Del Norte Counties (^Moyle et al. 2015). In the Central Valley, Pacific lamprey occur in the lower Sacramento River and San Joaquin River and many of their tributaries. Pacific lamprey are anadromous; adults typically migrate to fresh water between March and late June. Spawning habitat requirements appear to be similar to those of salmonids. Gunckel et al. (2009) found that lamprey predominantly spawned in pool tail-outs and low-gradient riffles that were rich in gravel. Pacific lamprey eggs hatch into ammocoetes after 19 days at 59 degrees Fahrenheit (°F) and then drift downstream to suitable areas with sand or mud. Ammocoetes remain in fresh water for approximately 5 to 7 years, where they bury into silt and mud and feed on algae, organic material, and microorganisms. Ammocoetes change into juveniles when they reach 14 to 16 cm total length. Downstream migration begins when the change is complete and generally coincides with high-flow events in winter and spring (^Moyle 2002).

Pacific lamprey are declining in abundance, with high threats of local extirpation in southern California (^Moyle 2002). Below export reservoirs, Pacific lamprey may occur in the Alameda Creek watershed (recorded downstream of Arroyo Valle), Coyote Creek, and the Santa Margarita River (CDFW 2014a; Leidy 2007).

Western river lamprey (*Lampetra ayresi*) is a California species of special concern. Their distribution ranges from Juneau, Alaska to San Francisco Bay. The biology of the river lamprey has not been well studied in California. As a result, much of this discussion is derived from information known for river lamprey from British Columbia. Thus, timing and life history events may be dissimilar due to differences in abiotic factors that are unique to California river systems (e.g., temperature, hydrology). River lamprey have been recorded in the Delta while migrating, in tributaries to San Francisco Bay, and in tributaries to the Sacramento and San Joaquin Rivers such as

Cache Creek (^Moyle et al. 2015). River lamprey are anadromous and begin their migration into fresh water in the fall toward suitable spawning areas upstream. However, river lamprey can spend their entire lives in fresh water as adults (such as the land-locked population of Sonoma Creek) (^Wang 1986). Spawning occurs February to May in gravelly riffles. The eggs hatch into ammocoetes that remain in fresh water for approximately 3 to 5 years in silty or sandy low-velocity backwaters or stream edges where they bury into the substrate and filter-feed on algae, detritus, and microorganisms (Moyle et al. 1995). River lamprey adults are parasitic during both freshwater and saltwater phases (^Wang 1986). Adults feed on a variety of host fish species that are small to intermediate size (Moyle et al. 1995).

Western brook lamprey (*Lampetra richardsoni*) is a California species of special concern. Western brook lampreys are small and nonpredaceous. The species distribution ranges from Alaska to California; in California, western brook lamprey has been identified in the Sacramento River watershed, including some remote areas such as Kelsey Creek above Clear Lake (^Moyle 2002). The biology of the western brook lamprey has not been well studied in California, and most information comes from studies in Washington (^Moyle 2002). Unlike the Pacific and western river lamprey, the western brook lamprey does not prey on fish but instead filter feeds on algae and detritus at the stream bottom. Spawning behavior of the western brook lamprey is similar to that of Pacific lamprey (^Moyle 2002).

Central California roach (*Lavinia symmetricus symmetricus*) is a California species of special concern. Central California roach generally occur in small warm streams, and individuals occupy a wide variety of habitats, often isolated by downstream barriers. California roach are most abundant in mid-elevation streams in the Sierra Nevada foothills (^Moyle et al. 2015). They are tolerant of relatively high water temperatures (30°C to 35°C [86°F to 95°F) and low oxygen levels (1–2 parts per million). They also thrive in cold, clear, well-aerated streams (Brown and Moyle 1993). Roach usually mature after reaching 45 to 60 mm total length at 2 to 3 years of age. Spawning is from March through early July, depending on water temperature, usually occurring when temperatures exceed 16°C (60.8°F) (^Moyle 2002).

Below export reservoirs, the species is found in Coyote Creek and Arroyo Valle.

Hardhead (*Mylopharodon conocephalus*) is a California species of special concern. Hardhead are widely distributed in low- to mid-elevation streams in the Sacramento and San Joaquin River basins and scattered in tributary streams. Optimal temperatures for hardhead are determined to be 75°F to 83°F; in most streams where hardhead are present, summer temperatures are in excess of 68°F. At higher temperatures, hardhead are relatively intolerant of low oxygen levels, a factor that may limit its distribution to well-oxygenated streams and reservoir surface waters (^Moyle 2002). Hardhead prefer clear, deep pools and runs with sand-gravel-boulder substrates and slow velocities. These fish are primarily riverine or fresh water; hardhead are typically found in association with Sacramento pikeminnow (*Ptychocheilus grandis*) and Sacramento sucker (*Catostomus occidentalis*) (^Moyle 2002). Hardhead tend to be absent from streams where introduced species, especially centrarchids, predominate (Brown and Moyle 1993).

Hardhead mature in their third year and spawn mainly in April and May (Grant and Maslin 1999). Juvenile recruitment patterns suggest that spawning may extend into August in some foothill streams. Hardhead from larger rivers or reservoirs may migrate 30 to 75 kilometers (km) or more upstream in April and May, usually into tributary streams (Moyle et al. 1995). In small streams, hardhead may move only a short distance from their home pools for spawning, either upstream or downstream (Grant and Maslin 1999). Although hardhead are still fairly common, populations are generally in decline, similar to many other native fish species (^Moyle 2002). The cause of this decline appears to be habitat loss and predation by nonnative fishes.

Arroyo chub (*Gila orcuttii*) is a California species of special concern. Arroyo chubs are small fish that typically grow to 70 to 100 mm in length. Arroyo chub use aquatic habitat characterized by slow-moving water and are adapted to survive in habitats with low oxygen concentrations and wide temperature fluctuations (^Moyle et al. 2015). Arroyo chub spawning occurs in low velocity habitat with temperatures of 14°C to 22°C, and spawning occurs primarily in June and July (^Moyle et al. 2015). Arroyo chub are native to Southern California and historically inhabited only the Malibu and San Juan Creeks and the Los Angeles, San Gabriel, San Luis Rey, Santa Ana, and Santa Margarita Rivers (^Moyle et al. 2015). Currently, within its native range arroyo chub are abundant only in Malibu Creek, Big Tujunga Creek, the upper Santa Margarita River and De Luz Creek, portions of Trabuco Creek, portions of San Juan Creek, and West Fork San Gabriel River below Cogswell Reservoir (^Moyle et al. 2015). Arroyo chub have been introduced to, and become established in, the Santa Ynez, Ventura, Santa Maria, Cuyama, Santa Clara, and Mojave watersheds, as well as many other small and coastal streams of Southern and Central California (Miller 1968; ^Moyle 2002).

Below export reservoirs, the species is found within its native range in the Santa Margarita River watershed, and outside its native range in the Santa Ynez, Santa Clara, and Mojave Rivers (CDFW 2014a).

Export Reservoirs

There are multiple export reservoirs, or reservoirs in other regions that receive Sacramento/Delta water supplies, in the Bay Area, San Joaquin Valley, Central Coast, and Southern California. Several export reservoirs are on-stream reservoirs that release water to downstream natural waterways, including some downstream waterways that support native fish species. The largest on-stream export reservoirs are listed in Table 7.6.2-2, along with the total reservoir storage capacities and the streams on which they occur. Other smaller lakes and reservoirs also receive Sacramento/Delta water, and numerous additional reservoirs also may receive deliveries indirectly through water transfers or agreements.

Table 7.6.2-2. On-Stream Export Reservoirs: Capacities, Streams Impounded, River Basins, and Geographic Regions

Reservoir	Capacity (TAF)	Stream	River Basin	Geographic Region
Lake Anderson	91	Coyote Creek	Coyote Creek	San Francisco Bay Area
Lake Del Valle	77	Arroyo Valle	Alameda Creek	San Francisco Bay Area
Lake Cachuma	207	Santa Ynez River	Santa Ynez River	Central Coast
Pyramid Lake	179	Piru Creek	Santa Clara River	Southern California
Lake Piru	100	Piru Creek	Santa Clara River	Southern California
Castaic Lake	324	Castaic Creek	Santa Clara River	Southern California
Silverwood Lake	78	West Fork Mojave River	Mojave River	Southern California
Diamond Valley Lake	800	Warm Springs Creek	Santa Margarita River	Southern California

Sources: DWR 2017; USACE 2018.

TAF = thousand acre-feet.

Several of the export reservoirs receive Sacramento/Delta supplies that far exceed natural reservoir inflows. For example, approximately 795 thousand acre-feet (TAF) of water flows through Silverwood Lake annually, of which approximately 14 TAF is natural inflow and the remaining 781 TAF (98 percent) is SWP water (^DWR 2016a). Similarly, the majority of the inflow to Pyramid Lake is Sacramento/Delta water; approximately 3 percent of the total inflow to Pyramid Lake is from natural inflow (^DWR and LADWP 2016). Conversely, Lake Cachuma receives Sacramento/Delta supplies, but SWP deliveries account for a small fraction of the reservoir's capacity.

Some other export reservoirs, such as San Luis Reservoir and Lake Perris, do not impound a natural waterway and are considered off-stream storage reservoirs. Off-stream export reservoirs are excluded from Table 7.6.2-2. These reservoirs release water directly into aqueducts or pipelines, and the reservoir releases do not affect local streams.

Several of the export reservoirs listed in Table 7.6.2-2 have existing reservoir release or downstream flow requirements. Those reservoir releases or downstream flow requirements are summarized below and generally include minimum instream flows to supply downstream senior water right holders or to support downstream aquatic resources. In general, for these reservoirs and streams, flow requirements are identified under the National Marine Fisheries Service (NMFS) biological opinions (BiOps), water right orders, 401 water quality certifications, Federal Energy Regulatory Commission (FERC) license requirements, or as conditions in water right permits and licenses. For example, on the Santa Ynez River below Lake Cachuma, required minimum instream flows for the protection of fish and other public trust resources in the Santa Ynez River below Bradbury Dam depend on the hydrologic conditions that are present. Water Right Order WR 2019-0148 requires that during below normal, dry, or critical water years the instream flow requirements are those in the NMFS 2000 BiOp (SWRCB 2019; NMFS 2000); in wet or above normal water years, the instream flow requirements are greater than those in the NMFS 2000 BiOp. On lower Piru Creek below Santa Felicia Dam, minimum instream flows are required under a 401 water quality certification for the United Water Conservation District Operational Changes at the Santa Felicia Project (FERC Project No. 2153). On Lake Del Valle, water right permits 11319 and 11320 identify that a live, flowing stream must be maintained from Del Valle Dam to a downstream gaging station on Arroyo del Valle, and Lake Del Valle releases must be sufficient to supply downstream senior water right holders. On Anderson Reservoir, under water right licenses 10607 and 7212, releases are required to the extent necessary to satisfy downstream prior rights and/or extent not authorized under license.

Some on-stream export reservoirs are operated to provide releases that match natural inflows. For example, Pyramid Lake flow releases into middle Piru Creek are required to match natural inflow into Pyramid Lake to the extent operationally feasible and consistent with safety requirements (^DWR and LADWP 2016). Some of the export reservoirs are located on naturally intermittent streams. For example, reservoir releases from Silverwood Lake on the West Fork Mojave River are governed to match natural inflow (DWR 2019). However, the West Fork Mojave River is naturally intermittent. Flow records for Warm Springs Creek near Murrieta, California (USGS 11042800) show that releases to Warm Springs Creek from Diamond Valley Lake may occur at times, but there is no flow in Warm Springs Creek for many days each year (USGS 2013).

Several of the special-status fish species identified in Table 7.6.2-1 occur in rivers and streams below the export reservoirs. Those species are Santa Ana sucker, Southern California Coast steelhead DPS, Central California Coast steelhead DPS, unarmored threespine stickleback, tidewater goby, Pacific lamprey, riffle sculpin, Sacramento hitch, Central California roach, and arroyo chub. At least one of these listed species occurs in each of the streams identified in Table 7.6.2-2 or in streams that receive their flow.

7.6.2.3 Regulatory Setting

Relevant state and federal programs, policies, plans, or regulations related to aquatic biological resources are described below. Additional regulatory setting related to terrestrial biological resources is described in Section 7.6.1, *Terrestrial Biological Resources*.

Bay-Delta Plan and State Water Board Decision 1641

The Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Bay-Delta Plan) establishes water quality objectives for the protection of beneficial uses in the Bay-Delta and a program of implementation to achieve the objectives. The water quality objectives include narrative and numeric objectives. The numeric objectives included in the Bay-Delta Plan are flow-dependent objectives directed at protecting beneficial uses from the effects of water diversions, including impacts from changes in flows and other operational effects.

Currently, the Bay-Delta Plan is primarily implemented through Water Right Decision 1641 (D-1641). In D-1641, the State Water Board accepted various agreements between DWR and the U.S. Bureau of Reclamation (Reclamation) and other water users to assume responsibility for meeting specified Bay-Delta Plan objectives for a period of time through conditions on DWR's and Reclamation's water rights for the SWP and CVP, respectively. D-1641 assigns responsibility to DWR and Reclamation for meeting these flow requirements through conditions of their water rights for the SWP and CVP. Existing flows generally exceed minimum D-1641 Delta outflow objectives for February through June, which means that, over time with increasing water development, existing outflows will likely diminish with additional diversions without additional regulatory requirements. The current requirements are very minimal and focused on the Delta without considering the needs of the watershed or how those flows are provided.

There are currently no other instream flow requirements for the Sacramento River basin and Delta eastside tributaries in the Bay-Delta Plan. However, numerous other agreements and various regulatory requirements exist that apply some flow requirements to specific tributaries. Nonetheless, a number of tributaries do not have any instream flow requirements to protect fish and wildlife or have minimal requirements.

On December 12, 2018, the State Water Board adopted amendments to the Bay-Delta Plan for southern Delta salinity and Lower San Joaquin River flows and a Final Substitute Environmental Document. Bay-Delta Plan amendments include revised southern Delta salinity objectives; new and revised flow objectives for the Lower San Joaquin, Stanislaus, Tuolumne, and Merced Rivers; and a program of implementation for achieving the new and revised salinity and flow objectives. On February 25, 2019, the Office of Administrative Law approved the Bay-Delta Plan amendments. Several actions to support implementation of the new and revised flow and salinity requirements in the Bay-Delta Plan have been initiated since the Office of Administrative Law approval, including developing proposed biological goals for Lower San Joaquin River fall-run Chinook salmon; draft compliance methods for the Lower San Joaquin River flow objectives; approval of the monitoring and special study plan for southern Delta salinity; and formation of the Stanislaus, Tuolumne, and Merced Working Group. On August 8, 2022, the State Water Board released a Notice of Preparation for a proposed regulation to implement the Lower San Joaquin River flow and southern Delta salinity requirements in the Bay-Delta Plan. However, the Lower San Joaquin River flow and southern Delta salinity objectives from the 2006 Bay-Delta Plan remain in regulatory effect through Water Right Decision 1641 (D-1641) until the implementing regulation is completed and approved by the Office of Administrative Law.

The existing Bay-Delta Plan and D-1641 are discussed in more detail in Chapter 5, *Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta*.

Water Right Order 90-5

In May 1990, the State Water Board issued Water Right Order 90-5 to implement water quality objectives established by the Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins. Water Right Order 90-5 establishes water right requirements on Reclamation's operations of Keswick Dam, Shasta Dam, the Spring Creek Power Plant, and the Trinity River Division related to water quality in the upper Sacramento River for protection of fishery resources and requires monitoring and reporting to evaluate compliance with those requirements. Order 90-5 requires Reclamation to meet a daily average water temperature of 56°F on the Sacramento River at RBDD during periods when higher temperatures will be detrimental to fish. Order 90-5 also includes requirements for turbidity and dissolved oxygen between Keswick Dam and Hamilton City.

If there are factors beyond Reclamation's reasonable control that prevent Reclamation from meeting 56°F at RBDD, Reclamation may prepare a Temperature Management Plan for consideration by the State Water Board, proposing that the compliance point be moved upstream. When proposing a new compliance point, Order 90-5 requires Reclamation to consult with CDFW, NMFS, and the U.S. Western Area Power Administration in development of the Temperature Management Plan designating the new compliance location. The Temperature Management Plan describes Reclamation's method for meeting the temperature requirement of 56°F at the new compliance location while salmonids are at risk from thermal effects, typically from late spring to late fall. The plan must be developed and submitted to the State Water Board by April for approval.

2003 USEPA Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards

The U.S. Environmental Protection Agency's (USEPA) *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards* (^USEPA 2003) includes recommended stream temperature criteria that apply to summer maximum temperatures to protect cold water salmonids in the Pacific Northwest. The 2003 USEPA guidance is based on a comprehensive review and synthesis of a large body of peer-reviewed studies and published papers, including temperature studies on Central Valley salmonids, and subsequent review by an independent scientific panel and the public. The scientific basis for the 2003 USEPA guidance is presented in a series of technical summaries available at USEPA's Region 10 website.[4] The 2003 USEPA guidance includes the following temperature criteria, which use the 7-day average of the daily maximum water temperature (7DADM) unit of measurement.

- Salmon/Trout Migration plus "Non-Core" Juvenile Rearing: 18°C (64°F) 7DADM.
- Salmon/Trout Migration: 20°C (68°F) 7DADM, plus a provision to protect and restore the natural thermal regime.
- Salmon/Trout Spawning, Egg Incubation, and Fry Emergence: 13°C (55°F) 7DADM.
- Salmon/Trout "Core" Juvenile Rearing: 16°C (61°F) 7DADM.
- Steelhead Smoltification: 14°C (57°F) 7DADM.

The 7DADM is identified as an appropriate metric because it describes the maximum temperatures that fish are exposed to over weekly periods while protecting against acute effects (e.g., migration blockage) and harmful or chronic effects (e.g., temperature effects on growth, disease, smoltification, competition) (^USEPA 2003).

The USEPA temperature criteria have been used for multiple water temperature evaluations in California, including several recent instream flow studies on Sacramento/Delta tributaries. CDFW considered the USEPA temperature criteria in its recent temperature and passage assessments for salmonids in Mill and Deer Creeks (CDFW 2017a, 2017b). The USEPA temperature criteria also were considered in a recent passage assessment for Chinook salmon and steelhead in lower Antelope Creek (Stillwater Sciences 2020). Evidence from a number of studies in California support the use of the USEPA criteria for assessment purposes and establishing temperature targets or objectives as part of recent temperature management and regulatory actions to protect Central Valley and California Coastal Chinook salmon and steelhead populations (Welsh et al. 2001; Hines and Ambrose n.d. Deas et al. 2004; Sacramento River Temperature Task Group 2016; USEPA 2011; Carter 2005).

Federal Endangered Species Act

The purpose of the federal ESA is to protect and recover imperiled species and the ecosystems upon which they depend. (16 U.S.C., § 1531 et seq.). ESA provides for the conservation of endangered and threatened species by prohibiting the "take" of listed species, defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." (16 U.S.C. § 1532.) An endangered species is defined as "… any species which is in danger of extinction throughout all or a significant portion of its range." (16 U.S.C., § 1532, subd. (6).) A threatened

[4] https://www.epa.gov/wa/northwest-water-quality-temperature-guidance-salmon-steelhead-and-bull-trout

species is defined as "… any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range." (16 U.S.C., § 1532, subd. (20).) The two agencies that oversee ESA are the U.S. Fish and Wildlife Service (USFWS), with jurisdiction over freshwater and terrestrial species, and NMFS, with jurisdiction over anadromous fish and marine species. Section 9 of ESA prohibits take of threatened or endangered species by any person, defined to include both natural persons and public and private entities.

ESA also requires the designation of critical habitat for listed species. Critical habitat is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, if they contain physical or biological features essential to a species' conservation, and those features may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species if the agency determines that the area itself is essential for conservation (USFWS 1973; ^NMFS 2009 BiOp). Several fish species identified in Table 7.6.2-1 are listed under ESA, and critical habitat for several of these species is shown in Figure 7.6.2-1a and Figure 7.6.2-1b.

Section 7 of the ESA mandates that federal agencies consult with USFWS and NMFS to ensure that any action authorized, funded, or carried out by such federal agency does not jeopardize the continued existence of a listed species or destroy or adversely modify its critical habitat. If a federal agency believes that its action may jeopardize a listed species or destroy or adversely modify critical habitat, the agency must request formal consultation with USFWS or NMFS, as appropriate, under section 7 of the ESA. (16 U.S.C., § 1536.) USFWS or NMFS then issues a BiOp as to whether the action is likely to jeopardize a listed species or to destroy or adversely modify its critical habitat. If the action will not result in jeopardy, USFWS or NMFS, as appropriate, may issue a statement specifying the amount or extent of anticipated take of species that is allowed as exempt from the section 9 prohibition (Incidental Take Statement [ITS]). If the action includes coordinated operations with non-federal agencies, the ITS will cover the non-federal agencies. If an action will jeopardize the continued existence (i.e., result in a jeopardy opinion), USFWS or NMFS will provide the consulting federal agency with reasonable and prudent alternatives (RPAs) to its proposed action that will avoid jeopardy. A non-federal entity that seeks to avoid potential take liability from an action may apply to USFWS or NMFS for an incidental take permit (ITP) under section 10 of the ESA. Non-federal agencies covered by the ITS do not need to apply for an ITP. To obtain an ITP, the applicant must prepare a habitat conservation plan (HCP) that meets the following five issuance criteria.

- The taking will be incidental to an otherwise lawful activity.
- The applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such taking.
- The applicant will ensure that adequate funding for HCP implementation will be provided.
- The taking will not appreciably reduce the likelihood of the survival and recovery of the species in the wild.
- Other measures that USFWS and NMFS require as being necessary or appropriate for purposes of the HCP will be met. (16 U.S.C. § 1539(a)(2)(A)).

The HCP, if approved, is accompanied by an ITP specifying the amount or extent of anticipated take of species that is allowed as exempt from the section 9 prohibition.

California Endangered Species Act

CESA (Fish & G. Code, § 2050 et seq.) expresses state policy to conserve, protect, restore, and enhance any endangered or threatened species or its habitat. CESA states that all native species or subspecies of a fish, amphibian, reptile, mammal, or plant and their habitats that are threatened with extinction and those experiencing a significant decline that, if not halted, would lead to a threatened or endangered designation will be protected or preserved. Under CESA, the California Fish and Game Commission has the responsibility for maintaining a list of threatened and endangered species (Fish & G. Code, § 2070). CESA generally prohibits take (defined, in part, as hunt, pursue, catch, capture, or kill) of listed species, although it may allow for take incidental to otherwise lawful activities (Fish & G. Code, § 2080 et seq.). In accordance with section 2081 of the California Fish and Game Code, a permit from CDFW is required for projects "that could result in the incidental take of a wildlife species state-listed as threatened or endangered." Several fish species identified in Table 7.6.2-1 are listed under CESA.

If an otherwise lawful activity will take state-listed species, but the party implementing the action received an ITS or ITP under ESA that also meets CESA's requirements, CDFW can issue a "consistency determination" finding that no further authorization or approval is necessary (Fish & G. Code, § 2080.1). If there is no federal ESA approval or the ESA approval is inconsistent with state law, an ITP from CDFW is required (Fish & G. Code, § 2081).

Natural Community Conservation Planning Act

The Natural Community Conservation Planning Act recognizes the importance of conserving California's biodiversity by reducing the conflict between protection of the state's fish and wildlife resources and the reasonable use of natural resources for economic development. The Natural Community Conservation Planning program, which was established as a result of the Natural Community Conservation Planning Act, provides guidance to stakeholders interested in preparing a natural community conservation plan (NCCP). Any individual, state, or federal agency, independently or cooperatively, may voluntarily enter into an agreement with CDFW to prepare an NCCP (Fish & G. Code, § 2800 et seq.) as an alternative to a permit under Fish and Game Code section 2081. An NCCP can address both listed and unlisted species (*covered species*) in the covered area. An NCCP provides for the protection of habitat, natural communities, and species diversity on a landscape or ecosystem level within its boundaries through the creation and long-term management of habitat reserves or other measures that provide equivalent conservation of covered species appropriate for land, aquatic, and marine habitats. An NCCP provides measures necessary to conserve and manage natural biological diversity while allowing compatible and appropriate economic development, growth, and other human uses. At the time of an NCCP's approval, CDFW may authorize by permit the taking of any covered species, including species designated as fully protected species, whose conservation and management is provided for in the NCCP. (Fish & G. Code, § 2835.)

Numerous HCPs and NCCPs have been developed in California. The full list of HCPs in California is available on the USFWS Environmental Conservation Online System (ECOS) website (USFWS 2023), and the full list of NCCPs in California is available on the CDFW website (CDFW 2023). There are several HCPs and NCCPs in the study area, including many conservation plans that include covered fish species (Table 7.6.2-3). Additional HCPs and NCCPs also have been developed for other locations in the study area but are not listed in Table 7.6.2-3 because they do not cover any of the special-status fish species listed in Table 7.6.2-1. Approved HCPs and NCCPs contain conservation strategies composed of a variety of actions or measures that incidental take permittees are required to implement to meet their permit conditions. The primary conservation actions under most HCP and NCCPs are a combination of land preservation through acquisition in fee title or conservation easement and restoration of natural communities.

Table 7.6.2-3. Habitat Conservation Plans and Natural Community Conservation Plans with Covered Fish Species

Conservation Plan	Location (County) and Size (acres)	Plan Preparers	Covered Species
Butte Regional Conservation Plan (HCP/NCCP) *Status: Final (2019)*	564,200 acres in Butte County	Butte County; Cities of Oroville, Chico, Biggs, and Gridley; Butte County Association of Governments; California Department of Transportation; Western Canal Water District; Biggs-West Gridley Water District, Butte Water District; Richvale Irrigation District	25 wildlife and plant species, including 7 bird, 2 reptile, 2 amphibian, 4 fish (Central Valley steelhead, Central Valley spring-run Chinook salmon, Central Valley fall/late fall-run Chinook salmon, green sturgeon), 4 invertebrate, and 6 plant species
Placer County Conservation Plan (HCP/NCCP) *Status: Final (2020)*	962,000 acres in Placer County	Placer County; City of Lincoln; South Placer Regional Transportation Authority; Placer County Water Agency; Placer Conservation Authority	14 wildlife and plant species, including 4 bird, 2 reptile, 2 amphibian, 2 fish (Central Valley steelhead, Central Valley fall/late fall-run Chinook salmon), and 4 invertebrate species
San Joaquin County Multi-Species Conservation and Open Space Plan (HCP) *Status: Final (2000)*	Over 900,000 acres in San Joaquin County	San Joaquin County; Cities of Stockton, Lodi, Manteca, Tracy, Ripon, Escalon, and Lathrop	97 wildlife and plant species, including 10 invertebrate, 4 fish (Delta smelt, Sacramento splittail, longfin smelt, green sturgeon), 4 amphibian, 4 reptile, 33 bird, 14 mammal, and 28 plant species
Solano Multispecies Habitat Conservation Plan (HCP) *Status: Public Draft (2012)*	577,000 acres in Solano County and approximately 8,000 acres in Yolo County	Solano County Water Agency; Cities of Vacaville, Fairfield, Suisun City, Vallejo, Rio Vista, and Dixon; Solano Irrigation District; Maine Prairie Water District; Reclamation District No. 2068; Dixon Resource Conservation District; Dixon Regional Watershed Joint Powers Authority; Vallejo Sanitation and Flood Control District; Fairfield-Suisun Sewer District	31 wildlife and plant species, including 6 invertebrate, 5 bird, 12 plant, 6 fish (Sacramento River winter-run Chinook salmon, Central Valley winter, spring-run Chinook salmon, and Central Valley fall/late fall- run Chinook salmon; Delta smelt, longfin smelt, Sacramento splittail, Central Valley steelhead, Central Coast steelhead; and green sturgeon), 1 mammal, and 1 reptile species

Conservation Plan	Location (County) and Size (acres)	Plan Preparers	Covered Species
Western Riverside County Habitat Conservation Plan (HCP) *Status: Final (2003)*	1.26 million acres in western Riverside County	Riverside County; Cities of Temecula, Murrieta, Lake Elsinore, Canyon Lake, Norco, Corona, Riverside, Moreno Valley, Banning, Beaumont, Calimesa, Perris, Hemet, and San Jacinto	146 wildlife and plant species, including 5 amphibian, 46 bird, 2 fish (Santa Ana sucker, arroyo chub), 5 invertebrate, 14 mammal, 12 reptile, and 62 plant species
Coachella Valley Multispecies Habitat Conservation Plan (HCP) *Status: Final (2008)*	1.2 million acres in eastern Riverside County	Cities of Cathedral, Coachella, Desert Hot Springs, Indian Wells, Indio, La Quinta, Palm Desert, Palm Springs, and Rancho Mirage; County of Riverside; Caltrans; Coachella Valley Water District; Imperial Irrigation District; Riverside County Flood Control and Water Conservation District; Riverside County Regional Park and Open Space District; Riverside County Waste Resources Management District; California Department of Parks and Recreation; Coachella Valley Mountains Conservancy	27 wildlife and plant species, including 5 plant, 2 invertebrate, 1 fish (desert pupfish), 1 amphibian, 3 reptile, 11 bird, and 4 mammal species
Orange County Transportation Authority (HCP/NCCP) *Status: Final (2016)*	511,500 acres in Orange County	Orange County Transportation Authority	13 wildlife and plant species, including 3 plant, 1 fish (arroyo chub), 3 reptile, 4 bird, and 2 mammal species
County of Orange Central/Coastal Sub regional NCCP *Status: Final (1996)*	132,000 acres in Orange County and the Cleveland National Forest	Orange County; Rancho Mission Viejo; Santa Margarita Water District	32 wildlife and plant species, including 12 bird, 2 amphibian, 7 reptile, 2 fish (arroyo chub, partially armored threespine stickleback), 2 invertebrate, and 7 plant species

California Department of Fish and Wildlife Species Designations

Species of Special Concern

CDFW maintains an informal list of "species of special concern." The intent of the designation is to focus on plant and wildlife species that are at conservation risk, stimulate research on poorly known species, and achieve conservation and recovery of species before they are listed under CESA. Species of special concern have factors in common such as small, isolated populations, marked population decline, fragmented habitat, and association with habitats that are declining in California. Several fish species identified in Table 7.6.2-1 are species of special concern.

Fully Protected Species

Fish and Game Code sections 3511, 4700, 5050, and 5515 identify lists of fully protected birds, mammals, amphibians and reptiles, and fish, respectively. These sections of the Fish and Game Code prohibit take or possession of fully protected species. CDFW is unable to authorize incidental take of fully protected species when activities are proposed in areas inhabited by these species, except pursuant to an approved NCCP. Fish and Game Code section 5515 lists fully protected fish species. Many fully protected species are also listed as threatened or endangered species under ESA or CESA. Several fish species identified in Table 7.6.2-1 are fully protected species.

Long-Term Central Valley Project Operations Criteria and Plan and Biological Opinions

In May 2008, Reclamation and DWR requested reinitiation of ESA Section 7 consultation with USFWS and NMFS on the Coordinated Long-Term Operations of the CVP and SWP as to whether the proposed CVP and SWP operations would jeopardize listed species. In December 2008, USFWS issued a BiOp concluding that the proposed operations were likely to jeopardize the continued existence of the Delta smelt and adversely modify its critical habitat. In June 2009, NMFS issued a BiOp concluding that the proposed operations were likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, California Central Valley steelhead, and the Southern DPS of North American green sturgeon, and were likely to destroy or adversely modify their critical habitats. NMFS also concluded that the proposed operations were likely to jeopardize Southern resident killer whales. To avoid jeopardy of the species and adverse modification of their critical habitats, USFWS and NMFS provided RPAs to the proposed action.

In August 2016, Reclamation and DWR requested reinitiation of consultation with USFWS and NMFS following multiple years of drought, low population abundances of listed species, and new scientific information developed since the 2008 and 2009 BiOps. In October 2019, USFWS and NMFS released BiOps on the Coordinated Long-Term Operation of the CVP and SWP, concluding that Reclamation's proposed revised operations were not likely to jeopardize threatened or endangered species or adversely modify their critical habitat.

The long-term operations plan included in the 2019 BiOps and associated Final Environmental Impact Study incorporated several components of the RPAs that were included in the 2008 and 2009 BiOps; however, it did not include several key components of the RPAs, considerably weakening the protective measures for listed fish species. Major provisions of the 2019 BiOps include the following.

- Reservoir operations to minimize water temperature and flow fluctuation-related effects on anadromous salmonids and provide spring pulse flows to enhance juvenile salmonid emigration survival.
- Delta Cross Channel (DCC) operations to minimize entrainment of migrating salmonids into the Central Delta.
- Management of flows in Old and Middle Rivers to minimize salmonid and smelt entrainment into the south Delta pumping facilities.

- Summer-fall habitat actions to improve Delta smelt food supply and habitat.
- Supplementation of the Delta smelt population with hatchery-cultured fish.
- Tidal habitat restoration.

In addition, many other provisions to minimize effects of CVP and SWP operations on ESA-listed fish species were included in the BiOps.

On September 30, 2021, Reclamation and DWR requested reinitiation of consultation with USFWS and NMFS due to anticipated modifications to operation of the CVP and SWP that could cause effects to ESA-listed species or designated critical habitat that were not analyzed in the 2019 USFWS and NMFS BiOps. USFWS and NMFS agreed to reinitiate consultation on October 1, 2021. Reclamation and DWR are in the process of developing a biological assessment for submittal to USFWS and NMFS.

State Water Project Incidental Take Permit

Currently, DWR operates the SWP in accordance with an ITP for the Long-Term Operation of the SWP in the Sacramento-San Joaquin Delta (CESA ITP No. 2081-2019-066-00), which was issued by CDFW in March 2020. The current ITP expires in March 2030. This permit covers four species protected under CESA: Delta smelt, longfin smelt, winter-run Chinook salmon, and spring-run Chinook salmon. In addition to fish protective measures identified in the 2019 BiOps, the ITP includes other protective measures. Additional protective criteria included in the ITP are as follows.

- Daily loss thresholds for winter-run Chinook salmon and spring-run Chinook salmon surrogates to facilitate real-time management at CVP and SWP export facilities.
- April-May ratio of San Joaquin River flow at Vernalis to the combined CVP and SWP export (import to export [I:E] ratio) limits of 4 to 1 in wet and above normal years, 3 to 1 in below normal years, 2 to 1 in dry years, and 1 to 1 (or 1,500 cfs, whichever is greater) in critically dry years to protect native fish. This applies to the SWP's proportional share for the I:E ratios.
- November through June OMR flow limit: no more negative than -1,250 to -5000 cfs when triggered, or -6,250 cfs for storm flex operations.
- Protective measures for longfin smelt: OMR flow criteria, spring Delta outflow criteria, and habitat restoration.
- Summer-fall habitat actions, through flow management and Suisun Marsh Salinity Control Gates operations, for the protection of Delta smelt and other estuarine species.
- Release of a flexible 100 TAF block of water to enhance Delta outflow during spring, summer, or fall months during wet and above normal water years.

Several ITP provisions are also included in the proposed Bay-Delta Plan amendments.

Previously, DWR operated the SWP in accordance with the ITP issued for the protection of longfin smelt, a CESA-listed species, and consistency determinations from CDFW, pursuant to section 2080.1 of the California Fish and Game Code, that the 2008 USFWS and 2009 NMFS BiOps were consistent with the requirements of CESA for aquatic species listed under both ESA and CESA (i.e., Delta smelt, winter-run Chinook salmon, and spring-run Chinook salmon). The previous ITP and consistency determinations were issued in 2009. The 2009 ITP's original expiration date of December 2018 was amended to March 31, 2020, to accommodate preparation of the 2020 ITP.

Coordinated Operation Agreement

Originally signed in 1986, the Coordinated Operation Agreement (COA) defines how the state and federal water projects share water quality and environmental flow obligations (Reclamation and DWR 1986). The COA defines the SWP and CVP facilities, sets forth procedures for coordination of operations, identifies methods for sharing responsibilities to meet Delta standards (as the standards existed in State Water Board D-1485) and other legal uses of water, identifies how unstored flow will be shared, and sets up a framework for exchange of water and services between the SWP and CVP. The agreement calls for periodic review to determine whether updates are needed as a result of changing conditions. In December 2018, DWR and Reclamation agreed to an addendum to the 1986 COA to update how the CVP and SWP are operated to meet water quality and environmental flow regulations. A new article of the COA describes sharing of applicable export capacity when exports are constrained (Reclamation and DWR 2018). DWR and Reclamation also signed a memorandum of agreement in December 2018 to formalize the cost-sharing formula for projects needed to meet joint endangered species act responsibilities (DWR and Reclamation 2018).

Magnuson-Stevens Fishery Conservation and Management Act

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended by the Sustainable Fisheries Act (Pub. L. 104-297), was enacted primarily to establish a management system for conserving and managing commercial fisheries within the 200-mile federal waters boundary of the United States. The MSA requires that all federal agencies consult with NMFS on activities or proposed activities authorized, funded, or undertaken by that agency that may adversely affect essential fish habitat (EFH) of commercially managed marine and anadromous fish species. EFH includes specifically identified waters and substrate necessary for fish spawning, breeding, feeding, or growing to maturity. EFH also includes all habitats necessary to allow the production of commercially valuable aquatic species, to support a long-term sustainable fishery, and to contribute to a healthy ecosystem (16 U.S.C., § 1802(10)).

The Pacific Fishery Management Council has designated the Delta, San Francisco Bay, and Suisun Bay as EFH to protect and enhance habitat for coastal marine fish and macroinvertebrate species that support commercial fisheries such as Pacific salmon. Because EFH applies only to commercial fisheries, all Chinook salmon habitats are included, but not those of steelhead.

There are three fishery management plans (for Pacific salmon, coastal pelagic, and groundfish species) issued by the Pacific Fishery Management Council that cover species and designate EFH within the Bay-Delta estuary.

- The Pacific Coast Groundfish Fishery Management Plan designates EFH for starry flounder (PFMC 2019).
- The Coastal Pelagic Species Fishery Management Plan designates EFH for Pacific sardine and northern anchovy (central and northern subpopulations) (PFMC 1998).
- The Pacific Coast Salmon Plan designates EFH for the three species of Pacific salmon commercially harvested (Chinook, coho, and pink salmon) (PFMC 2014).

Pacific coast salmon EFH includes those waters and substrate necessary for salmon production to support a long-term sustainable salmon fishery and salmon contributions to a healthy ecosystem (PFMC 2022). Freshwater EFH for Pacific salmon in the Sacramento/Delta watershed (Sacramento River winter-run, Central Valley spring-run, and Central Valley fall-/late fall-run Chinook salmon) includes waters currently or historically accessible to salmon within the Central Valley ecosystem. Pacific salmon EFH also includes aquatic areas above all artificial barriers except Nimbus Dam on the American River, Capay Dam on Cache Creek, Camp Far West Dam on the Bear River, Keswick Dam on the Sacramento River, Whiskeytown Dam on Clear Creek, Fish Barrier Dam on the Feather River, and Monticello Dam on Putah Creek (PFMC 2014). However, activities occurring above impassable barriers that are likely to adversely affect EFH below impassable barriers are subject to the EFH consultation provisions of the MSA. Recommended conservation measures to address adverse effects on Pacific salmon EFH include changes in dam operations and facility modifications to improve flow and temperature conditions for adult attraction and passage, spawning and incubation, and juvenile rearing and migration; implementation of non-flow actions to restore spawning (e.g., gravel augmentation) and rearing habitat (riparian, floodplain, and marsh restoration); and modifications of DCC operations, export pumping, and fish screen design and salvage operations to reduce fish entrainment, predation, and salvage mortality (^NMFS 2009 BiOp).

Recovery Plan for Sacramento–San Joaquin Delta Native Fish Species

The *Recovery Plan for the Sacramento–San Joaquin Delta Native Fishes* was released in 1996 by USFWS with the basic goal of establishing self-sustaining populations of species of concern (^USFWS 1996). The recovery objectives of the plan were to delist Delta smelt and restore Sacramento splittail, longfin smelt, green sturgeon, spring-run Chinook salmon, late fall-run Chinook salmon, San Joaquin fall-run Chinook salmon, and Sacramento perch. Several recovery actions were identified in the plan, including but not limited to the following.

- Higher freshwater flows through the Delta to provide transport and attraction flows and low-salinity rearing habitat in Suisun Bay.
- Restoration of shallow water, riparian, and tidal marsh habitat.
- Pumping restrictions and improved fish screening and salvage operations at the SWP and CVP export facilities and other Delta diversions.
- Actions to reduce inputs of contaminants from agricultural, industrial, and municipal sources.
- Improved hatchery management practices.
- Improved invasive species prevention and control measures.

Since the recovery plan was released, new information regarding the status, biology, and threats to Delta native species has emerged. USFWS is currently developing a specific recovery plan for Delta smelt (^USFWS 2019 BiOp). NMFS has developed recovery plans for green sturgeon (NMFS 2018) and spring-run Chinook Salmon (^NMFS 2014a).

Recovery Planning for Salmon and Steelhead in California

The final *Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the California Central Valley Steelhead DPS* was released in July 2014 (^NMFS 2014a). The California Central Valley recovery domain extends from the upper Sacramento River Valley to the northern portion of the San Joaquin River Valley (^NMFS 2014a). The goal of the recovery plan is to recover the threatened and endangered Chinook salmon and steelhead populations in the Central Valley. For recovery of the Central Valley Chinook salmon Evolutionarily Significant Units and the California Central Valley steelhead DPS to be achieved, each diversity group must be represented, and population redundancy within the groups must be met to achieve diversity group recovery. The recovery plan identifies and prioritizes recovery actions by geographic area or diversity group.

The recovery plan identifies a number of recovery actions including habitat restoration activities, enhanced flows, and other actions. Some of the high-priority recovery actions are presented below.

- Develop, implement, and enforce new Delta flow objectives that mimic historical natural flow characteristics, including increased freshwater flows (from both the Sacramento and San Joaquin Rivers) into and through the Delta and more natural seasonal and interannual variability.
- Minimize the frequency, magnitude, and duration of reverse flows in OMR to reduce the likelihood of diversion of fish from the San Joaquin or Sacramento Rivers into the southern or central Delta.
- Provide pulse flows of approximately 17,000 cfs or higher as measured at Freeport periodically during the winter-run Chinook salmon emigration season to facilitate emigration past Chipps Island.
- Modify DCC gate operations to reduce diversion of listed species from the Sacramento River into the central and southern Delta.
- Improve fish screening and salvage operations to reduce mortality from entrainment and salvage at the SWP and CVP export facilities.
- Restore, improve, and maintain salmonid rearing and migratory habitats in the lower Sacramento River, Yolo Bypass, and Delta, including restoration of channel, floodplain, tidal slough, and wetland habitat.
- Implement fish passage and screening projects to improve fish passage and reduce entrainment and predation at weirs, diversions, and other water control structures.
- Implement long-term gravel augmentation projects to increase and maintain spawning habitat for listed salmonids downstream of dams.
- Implement structural and operational improvements at dams to improve cold water pool management and meet water temperature requirements for listed fish species in the reaches below the dams.

Recovery plans for Chinook salmon and steelhead in California also have been developed for Southern California steelhead, South-Central California steelhead, California Coastal Chinook salmon, Northern California steelhead, and Central California Coast steelhead (NMFS 2012a, 2013, 2016a).

Delta Smelt Resiliency Strategy

In 2016, state and federal agencies began implementing a Delta Smelt Resiliency Strategy aimed at improving this species' growth, reproduction, and survival (CNRA 2016). The Delta Smelt Resiliency Strategy is being implemented to address both immediate and near-term needs of Delta smelt, to promote their resiliency to drought conditions as well as future variations in habitat conditions. The strategy includes 13 near- and mid-range management actions aimed at creating higher quality habitat, more food, and higher turbidity, along with reduced levels of weeds, predators, and HABs. The smelt food production action also involves partnering with local agricultural water agencies and farmers. The strategy includes studies on seasonal outflow augmentation to ameliorate effects of predation, HABs, and food shortages. State and federal agencies have begun to implement several components of the strategy (CNRA 2017).

Recovery Planning for Green Sturgeon

The final *Recovery Plan for the Southern DPS of North American Green Sturgeon* was released in August 2018 (NMFS 2018). The goal of the plan is to recover the southern DPS of North American green sturgeon and consequently remove it from the Federal List of Endangered and Threatened Wildlife. To achieve delisting, the objective of the recovery plan is to increase southern DPS green sturgeon abundance, distribution, productivity, and diversity by alleviating significant threats. The recovery actions identified in the recovery plan include actions related to passage, flow and temperature, entrainment, take, contaminants, habitat and climate change, predation, sediment, and oil and chemical spills. The recovery actions include, but are not limited to, actions to reduce stranding of green sturgeon at weirs, dams, and other structures; modifications of the Oroville-Thermalito Complex on the Feather River to maintain suitable water temperatures and flows for spawning and rearing; development and application of operations and/or screening guidelines to diversions on the Sacramento, Feather, and Yuba Rivers and Bay-Delta estuary to limit entrainment of early life stages; and improvement of compliance and implementation of best management practices to reduce input of point- and nonpoint-source pollutants in the Sacramento River basin and Bay-Delta estuary.

Central Valley Project Improvement Act

The Central Valley Project Improvement Act (CVPIA) was enacted in 1992 to balance the needs of fish and wildlife with other uses of CVP water. The purposes of the CVPIA are listed below.

- Protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California.
- Address impacts of the CVP on fish, wildlife, and associated habitats.
- Improve the operational flexibility of the CVP.
- Increase water-related benefits provided by CVP to the state of California through expanded use of voluntary water transfers and improved water conservation.
- Contribute to California's interim and long-term efforts to protect the Bay-Delta estuary.
- Achieve a reasonable balance among competing demands for use of CVP water, including the requirements of fish and wildlife, agricultural, municipal and industrial, and power contractors.

The CVPIA added mitigation, protection, and restoration of fish and wildlife to the purposes of the CVP; dedicated 800 TAF of CVP yield for the primary purpose of implementing fish, wildlife, and habitat restoration; and created a Central Valley Project Restoration Fund to carry out CVPIA programs, projects, plans, and habitat restoration, improvement, and acquisition provisions. Among the CVPIA programs that benefit salmonids and other fish species are the Anadromous Fish Restoration Program (AFRP), the Anadromous Fish Screen Program (AFSP), and the Water Acquisition Program (WAP). The AFRP conducts monitoring, education, and restoration projects directed toward recovery of anadromous fish species in the Central Valley. Restoration projects funded through the AFRP include fish passage, fish screening, riparian easement and land acquisition, development of watershed planning groups, instream and riparian habitat improvement, and gravel replenishment. The AFSP combines federal funding with state and private funds to prioritize and construct fish screens on major water diversions mainly in the upper Sacramento River. The goal of the WAP is to acquire water supplies to meet the habitat restoration and enhancement goals of the CVPIA and to improve the U.S. Department of the Interior's ability to meet regulatory water quality requirements.

Under the provisions of section 3406(b)(2) of the CVPIA, 800 TAF of CVP yield is dedicated annually to implement fish, wildlife, and habitat restoration measures authorized by the CVPIA, as well as assist in meeting the 1995 Delta Water Quality Control Plan requirements and post-1992 obligations under the federal ESA. These measures include fishery actions that target flow and habitat requirements of salmon, steelhead, and estuarine fish species, including the provision of releases from upstream reservoirs that, if specified by the USFWS, are allowed to move through the Delta and contribute to Delta outflow. To assist in decision-making and coordination of (b)(2) actions, an interagency team of project operators and resource agency biologists consisting of representatives from Reclamation, DWR, CDFW, USFWS, and NMFS was established to discuss information and seek input regarding the annual (b)(2) fishery action plan and integration of the plan with the operations forecast. Reclamation and USFWS jointly develop an initial daily accounting of (b)(2) actions that is updated monthly and presented in an annual report at the end of the accounting period. Monitoring of fish and habitat conditions is conducted annually through existing monitoring programs (e.g., the Interagency Ecological Program) to assess the biological results and effectiveness of (b)(2) water. The assessment of decisions for dedication and management of (b)(2) water is reported in annual reports on CVPIA implementation.

Federal Power Act and Clean Water Act Water Quality Certification

Under the Federal Power Act, FERC is responsible for determining under what conditions to issue licenses, or relicense, non-federal hydropower projects. Under the provisions of section 10(j) of the Federal Power Act, each hydropower license issued by FERC is required to include conditions for the protection, mitigation, or enhancement of fish and wildlife resources affected by a project. These required conditions are to be based on recommendations of federal and state fish and wildlife agencies. FERC may reject or alter the recommendations on several grounds, including if FERC determines they are inconsistent with the purposes and requirements of the Federal Power Act or other applicable law. The State Water Board exercises authority over hydropower projects through section 401 of the 1972 Clean Water Act, which requires an applicant for a federal license or permit that conducts an activity that results in a discharge into the navigable waters of the United States to apply for a certification from the state that the discharge will comply with state and federal water quality standards. Water quality certifications issued by the State Water Board for new and renewed FERC licenses contain various terms and conditions for the facilities to meet water quality standards in applicable State Water Board and regional water board basin plans. Biological, scientific, and legal conditions have changed since original licenses were issued.

Some recent water quality certifications have included terms and conditions such as water temperature requirements, ramping criteria, development of plans for managing the cold water pool in reservoirs to minimize exceedances of downstream temperature requirements, and development of plans for facility modifications if facilities cannot meet specified water temperature requirements. For example, as part of the relicensing effort for the Oroville Facilities Hydroelectric Project, studies showed inhospitable conditions for spawning and rearing in the Feather River below the Thermalito Afterbay Outlet. Additional requirements in the State Water Board's 2010 water quality certification (Order WQ 2010-0016) and 2016 NMFS BiOp will be integrated into the new FERC license (NMFS

2016b). However, older FERC licenses may lack any measures for the protection of cold water species.

California Fish and Game Code Section 5937

Fish and Game Code section 5937 requires that "[t]he owner of any dam shall allow sufficient water at all times to pass through a fishway, or in the absence of a fishway, allow sufficient water to pass over, around, or through the dam to keep in good condition any fish that may be planted or exist below the dam." Minimum instream flow requirements are not identified for Sacramento/Delta tributaries under Fish and Game Code section 5937.

7.6.2.4 Impact Analysis

The impact analysis for aquatic resources uses quantitative and qualitative assessments of potential effects on native fish species and their habitat from changes in hydrology and water supply under the proposed Plan amendments. Chapter 6, *Changes in Hydrology and Water Supply*, includes Sacramento Water Allocation Model (SacWAM) modeling results for instream flow changes in increments of 10 percent, from 35 percent up to 75 percent unimpaired flow (referred to as numbered flow scenarios such as "35 scenario," "45 scenario"). The proposed program of implementation for the proposed Plan amendments provides for a range of flow scenarios from 45 to 65, with default implementation starting at the 55 scenario. The 35 and 75 flow scenarios are also presented to inform the analyses of low and high flow alternatives in Section 7.24, *Alternatives Analysis*. The modeling results for each flow scenario reflect each tributary's proportional contribution to Delta inflows. The modeling of reservoir operations; tributary inflows; and Delta inflows, outflows, and interior flows incorporates existing instream flow requirements and other regulatory requirements.

This analysis assumes that each individual Sacramento/Delta tributary meets the proposed numeric inflow objective as it applies to that tributary's proportional contribution to Delta outflow under unimpaired conditions. However, the proposed Plan amendments allow water users on two or more tributaries to work together to meet their numeric objectives downstream as long as each tributary is meeting the narrative inflow objective. In addition, certain assumptions regarding reservoir operations were incorporated into the model to ensure storage thresholds sufficient to maintain cool release temperatures; however, reservoir levels may need to be higher or lower than that modeled to protect cold water habitat (see Appendix A1c, *Preliminary Assessment of Effect of Reservoir Storage on Reservoir Release Temperatures*). The proposed Plan amendments provide flexibility to tailor operations or implement alternative temperature controls. It would be speculative to anticipate which tributaries might take advantage of that allowance and how they might do so. This analysis considers and incorporates the most conservative assumptions to ensure comprehensive impact conclusions. However, it is expected that many parties would take advantage of the flexibility to optimize operations and avoid or minimize environmental impacts.

Changes in hydrology could have adverse effects on native fish and their habitat in limited circumstances. While the proposed Plan amendments include a cold water habitat objective that would require water temperature management, potential impacts on native fish species and their habitat could occur in some cases if reductions in reservoir storage limit the availability of cold water to protect anadromous salmonids and other native fish in tributaries in the Sacramento River watershed and Delta eastside tributaries. Adverse impacts also could occur if reductions in Sacramento/Delta supplies to export reservoirs change flows and habitat quality in streams below the export reservoirs. In addition, changes in water supply, including increased groundwater pumping or use of other water management actions such as groundwater storage and recovery and water recycling could result in adverse effects on native fish species and their habitat through potential reductions in streamflows.

The impact analysis does not evaluate aquatic resources in the Sacramento River watershed above Shasta Reservoir. The historical inflow to Shasta Reservoir is very close to unimpaired, at 99 percent (see Chapter 2, *Hydrology and Water Supply*). This demonstrates that the proposed inflow objective would not likely affect aquatic biological resources including fish above Shasta Reservoir. There would be no impact and this area is not further evaluated.

Section 7.21, *Habitat Restoration and Other Ecosystem Projects*, and Section 7.22, *New or Modified Facilities*, describe and analyze potential aquatic resource impacts from various actions that involve construction.

Impact AQUA-a: Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game or U.S. Fish and Wildlife Service

Impact AQUA-d: Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites

The discussion of Impact AQUA-a and Impact AQUA-d is combined because fish migration is integral to the discussion of effects on special-status species generally.

Changes in Hydrology

Overall, the proposed Plan amendments are intended to provide for the reasonable protection of native fish and wildlife in the Sacramento/Delta. Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, presents evidence indicating that native fish and other aquatic species require more flows that mimic a natural pattern than is currently required to provide appropriate habitat and to support specific functions needed to protect these species. This information suggests that new and modified inflow and cold water habitat, interior Delta flow, and Delta outflow requirements could work together in a comprehensive framework with other complementary actions to protect the Bay-Delta ecosystem. Specifically, the proposed Plan amendments would provide for flow conditions in the Sacramento/Delta regions to support successful spawning, rearing, migration, and other life history stages of native fish and wildlife—including the magnitude, frequency, timing, duration, and rate of change of flow conditions to which native species are adapted. The proposed Plan amendments would provide flexibility to allow these flows to be managed based on the unique temporal and spatial needs, conditions in those tributaries and the Delta, and on new information.

Delta Outflows

The proposed Plan amendments would result in changes to Delta inflows and Delta outflows, which could benefit fish species that occur in or migrate through the Delta. SacWAM results show that Delta inflows under the proposed Plan amendments (45 to 65 scenarios) would generally increase during December through June and decrease in July through September compared with baseline (see Chapter 6, *Changes in Hydrology and Water Supply*, and Appendix A1, *Sacramento Water Allocation Model Methods and Results*). Delta outflow generally would increase during all months, except for reductions during August and for the lowest flows in January, May, and June. These changes would more closely resemble a natural flow regime to which native species have adapted. Native anadromous and estuarine fish species, including but not limited to, Chinook salmon, steelhead, green and white sturgeon, Sacramento splittail, Delta smelt, and longfin smelt, would benefit from these changes.

Changes in Delta inflows under the proposed Plan amendments would support improved migratory conditions for emigrating juvenile salmonids and other anadromous and estuarine fishes that migrate through the Delta and lower reaches of the Sacramento and San Joaquin Rivers, as well as provide improved attraction and homing cues for adult salmon, steelhead, sturgeon, and other species migrating upstream. Delta outflows provide for ecological processes, including continuity of flows from tributaries through the Delta to San Francisco Bay to protect native estuarine and anadromous aquatic species that inhabit the Bay-Delta and its tributaries throughout the year as juveniles or adults. Delta outflows are needed to provide appropriate habitat conditions for migration and rearing of estuarine and anadromous fish species. Flows are important for protecting native species populations by supporting key functions, including maintaining appropriate LSZ habitat, migratory cues, reduced stranding and straying, and other functions (see Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*).

Under the proposed Plan amendments, higher winter and spring Delta inflows and outflows would improve Delta and estuarine flow and habitat conditions needed to support the key ecosystem functions and life stage needs of native anadromous, estuarine, and resident fish species in the Bay-Delta estuary. The expected benefits include, but would not be limited to, improved juvenile Chinook salmon survival and reduced juvenile salmonid entrainment into the interior Delta during emigration. As discussed in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, Sacramento River at Rio Vista flows of approximately 20,000 cfs and higher from April through June correspond to increasing abundance of fall-run Chinook salmon smolts exiting the Delta. In addition, Sacramento River at Rio Vista flows of approximately 20,000 cfs and higher during February through April correspond to increasing abundance of winter-run Chinook salmon entering and exiting the Delta. Under the proposed Plan amendments (45 to 65 scenarios), the frequency of flows exceeding 20,000 cfs in the Sacramento River at Rio Vista in April through June and February through April would increase compared with baseline, which should increase the survival of juvenile fall-run Chinook salmon and juvenile winter-run Chinook salmon, during key emigration periods (Table 7.6.2-4).

Table 7.6.2-4. Percent of Months within Each Season That Exceed Sacramento and Delta Flows Associated with Successful Juvenile Chinook Salmon Emigration through the Delta

Species Flows	Baseline	35	45	55	65	75
Fall-run Chinook salmon smolts: Rio Vista flows >20,000 cfs (Apr–Jun)	26	28	29	33	38	47
Winter-run Chinook salmon smolts: Rio Vista flows >20,000 cfs (Feb–Apr)	57	61	67	68	77	83
Juvenile salmonids: Freeport flows >17,000 cfs (Nov–May)	51	53	56	63	66	68
Juvenile salmonids: Freeport flows >20,000 cfs (Nov–May)	44	46	49	54	58	62

cfs = cubic feet per second

SacWAM results also show that the frequency of Sacramento River at Freeport flows above 17,000 cfs and 20,000 cfs November through May would increase under the proposed Plan amendments compared with baseline (Table 7.6.2-4), which should reduce entrainment of emigrating Chinook salmon and steelhead smolts into the interior Delta via the DCC and Georgiana Slough. As discussed in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, flows of 17,000 cfs (^USDOI 2010) to 20,000 cfs (^Perry et al. 2015) or higher on the Sacramento River at Freeport are sufficient to prevent tidal reversals at DCC and Georgiana Slough and are expected to decrease entrainment of juvenile salmonids into the interior Delta. An increase in the frequency of Sacramento River at Freeport flows of 17,000 to 20,000 cfs or higher in November through May should increase overall juvenile salmonid survival through the Delta. Overall, higher Delta outflows during these months would benefit Chinook salmon and steelhead.

Increased Delta outflows during winter and spring months would also benefit estuarine fishes (e.g., longfin smelt, Delta smelt) that use the Bay-Delta estuary for migration, spawning, and rearing. The importance of high winter-spring (January through June) outflows (or X2 position) for native fishes, including native estuarine fishes, is explained in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, (see Section 3.2.2, *Freshwater Flow and Estuarine Resources*). Generally, the further X2 is located downstream of the confluence of the confined deep channels of the Sacramento and San Joaquin Rivers (and the effects of the SWP and CVP export facilities) and downstream into the broad, shallow, cool channels of Suisun Marsh and Suisun Bay, the better fish and other species respond. Figure 7.6.2-2 shows that the January through June median position of X2 during critical water years should shift from above Chipps Island under baseline conditions through the 45 scenario to Chipps Island and downstream under 55 to 75 scenarios. The median position of X2 under all water year types combined should also shift downstream from above Port Chicago under baseline conditions through the 45 scenario to below Port Chicago under the 55 through 65 scenarios. In critical years, the area of LSZ increases as X2 moves seaward from baseline at km 81 (5,313 hectares) to the location of X2 under the 75 scenario at km 72 (8,539 hectares) (Figure 7.6.2-2) (Brown et al. 2014). Conversely, under all water years combined, the area of LSZ decreases as X2 moves seaward from baseline at km 68 (8,474 hectares) to the location of X2 under the 75 scenario at km 61 (4,498 hectares).

Table 7.6.2-5 identifies the frequency of meeting an X2 position at Collinsville (81 km), Chipps Island (75 km), and Port Chicago (64 km) under baseline conditions and the proposed Plan amendments (45 to 65 scenarios) from January through June. Overall, SacWAM results show that the frequency of meeting an X2 position at or downstream of Chipps Island and Port Chicago would increase under the proposed Plan amendments (45 to 65 scenarios) compared with baseline.

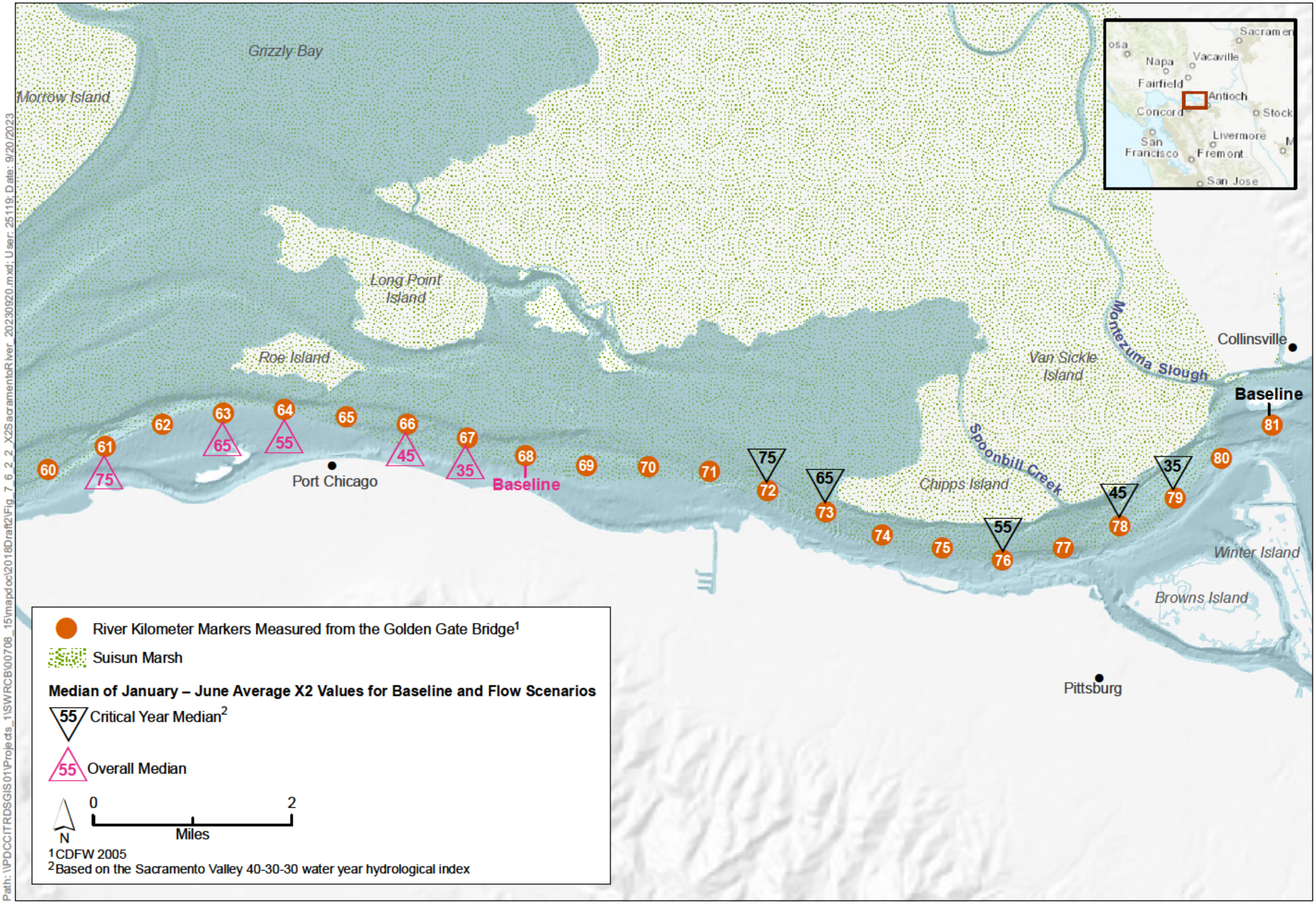
Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, identifies winter-spring outflows that are needed to improve population abundance for certain species (bay shrimp, green and white sturgeon, longfin smelt, Sacramento splittail, and starry flounder) based on species flow-abundance relationships, which were developed based on available data including actual winter-spring daily Delta outflows and abundance indices from annual CDFW fall midwater trawl and San Francisco Bay Study otter trawl surveys. These species-specific Delta outflows range from 20,000 to 47,000 cfs for certain months during winter and spring. Table 7.6.2-5 identifies the frequency at which winter-spring outflows associated with positive population growth for these species (20,000 to 47,000 cfs) are met or exceeded under the proposed Plan amendments and under baseline conditions based on SacWAM results. All of these flows occur at a greater frequency under the proposed Plan amendments compared with baseline conditions and should contribute to increased population abundance for bay shrimp, green and white sturgeon, longfin smelt, Sacramento splittail, and starry flounder. Other native aquatic species that use estuarine habitat likely also should benefit from the more natural hydrologic regime, including increased Delta outflows, that would occur as a result of the proposed Plan amendments.

Table 7.6.2-5. Frequency of Meeting Winter–Spring Delta Outflows to Benefit Estuarine Habitat and Species (percent of months)

X2 Position or Species	Baseline	35	45	55	65	75
Collinsville [a]	99	99	99	100	100	100
Chipps Island [b]	81	87	88	95	96	98
Port Chicago [c]	41	43	46	48	55	59
Bay shrimp – High [d]	43	48	49	61	71	75
Bay shrimp – Low [e]	51	59	70	73	82	87
Green and White sturgeon [f]	15	15	15	19	24	28
Longfin smelt [g]	30	31	31	32	34	37
Sacramento splittail – High [h]	25	26	27	29	31	38
Sacramento splittail – Low [i]	40	45	49	54	62	70
Starry flounder [j]	44	49	52	63	72	80

[a] X2 position at Collinsville (81 kilometers [km] from January through June)
[b] X2 position at Chipps Island (75 km from January through June)
[c] X2 position at Port Chicago (64 km from January through June)
[d] 25,000 cubic feet per second (cfs) (March through May)
[e] 20,000 cfs (March through May)
[f] 37,000 cfs (March through July)
[g] 42,800 cfs (January through June)
[h] 47,000 cfs (February through May)
[i] 30,000 cfs (February through May)
[j] 21,000 cfs (March through June)

Higher winter–spring outflows would increase the frequency of years when the winter-spring LSZ would be positioned largely in Suisun and Grizzly Bays and X2 would be positioned between Collinsville and Port Chicago. Figure 7.6.2-3 is an exceedance plot that shows the distributions of average Delta outflows over the January-through-June period, with dashed horizontal lines

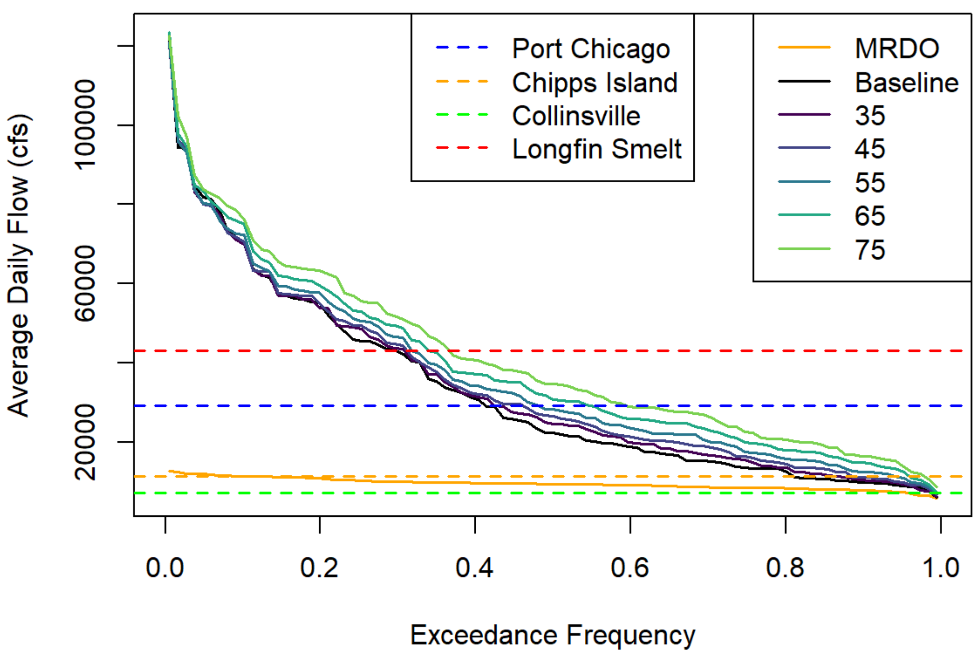


Path: \\PDCCITRDSGIS01\Projects_1\SWRCB\00708_15\mapdoc\2018Draft2\Fig_7_6_2_2_X2SacramentoRiver_20230920.mxd; User: 25119; Date: 9/20/2023

Figure 7.6.2-2
X2 Position for Baseline and Flow Scenarios Presented as Median of the January through June Average Values

indicating each of the flows over that period identified (1) to achieve the longfin smelt population level identified in Table 7.6.2-5 and in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*; and (2) to achieve an X2 position at Collinsville, Chipps Island, and Port Chicago. Figure 7.6.2-3 shows an increased frequency that the average X2 position would be positioned at or downstream of Chipps Island and Port Chicago under the 45 to 65 scenarios compared with baseline, which should benefit native estuarine species. The LSZ (i.e., X2 position) is correlated with the survival and abundance of many species. While the exact mechanisms behind this relationship are not fully understood, these more westerly X2 positions generally provide significantly improved habitat conditions for native species.

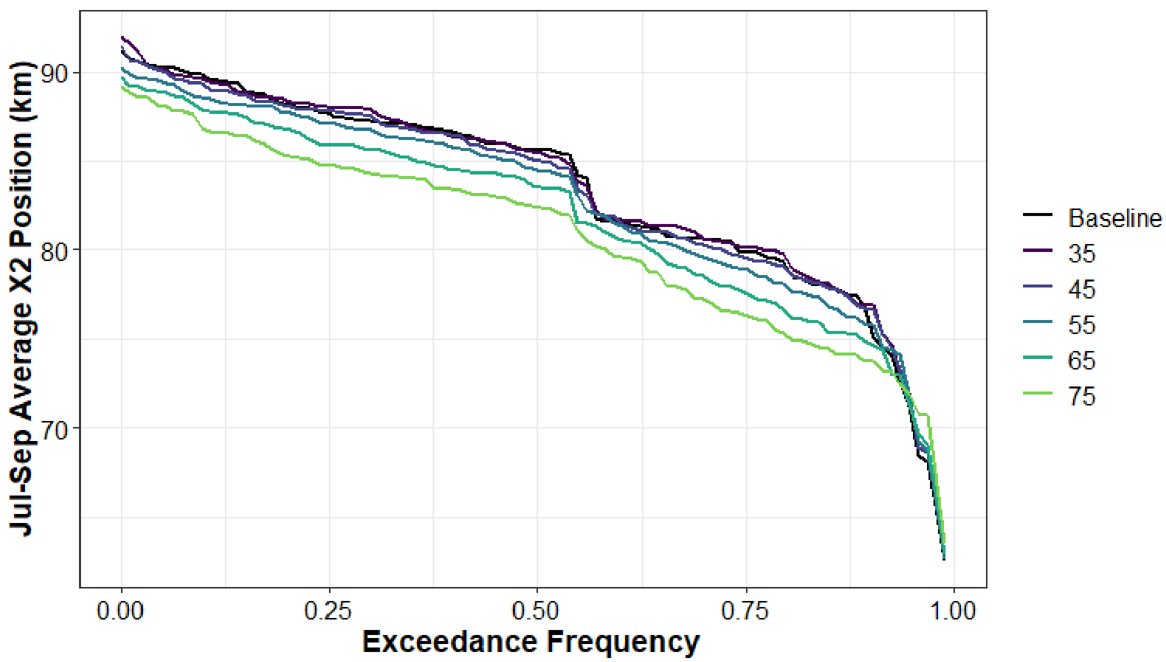
The proposed Plan amendments would also protect existing Delta outflows, which are often higher than the minimum required Delta outflow (MRDO) under baseline. Figure 7.6.2-3 compares the MRDO pursuant to the requirements of the existing Bay-Delta Plan, D-1641, the 2019 USFWS BiOp, and 2020 CDFW ITP with modeled Delta outflows for existing conditions and the 35 through 75 scenarios. Figure 7.6.2-3 shows that MRDO is often substantially lower than Delta outflows observed under baseline as well as under the 45 to 65 scenarios. The difference between the MRDO line and the existing flow level in Figure 7.6.2-3 represents flows that could be diminished in the future as the result of additional diversions in the absence of additional flow requirements. The substantial difference between these flow levels indicates that the existing Bay-Delta Plan and BiOp flow requirements are not adequate to ensure Delta outflow conditions necessary for the reasonable protection of fish and wildlife beneficial uses, including longfin smelt.



Conditions (position and extent of the low salinity zone [LSZ] as measured by X2) beneficial to estuarine species (longfin smelt) for baseline condition and 35 to 75 flow scenarios.
cfs = cubic feet per second
MRDO = minimum required Delta outflow

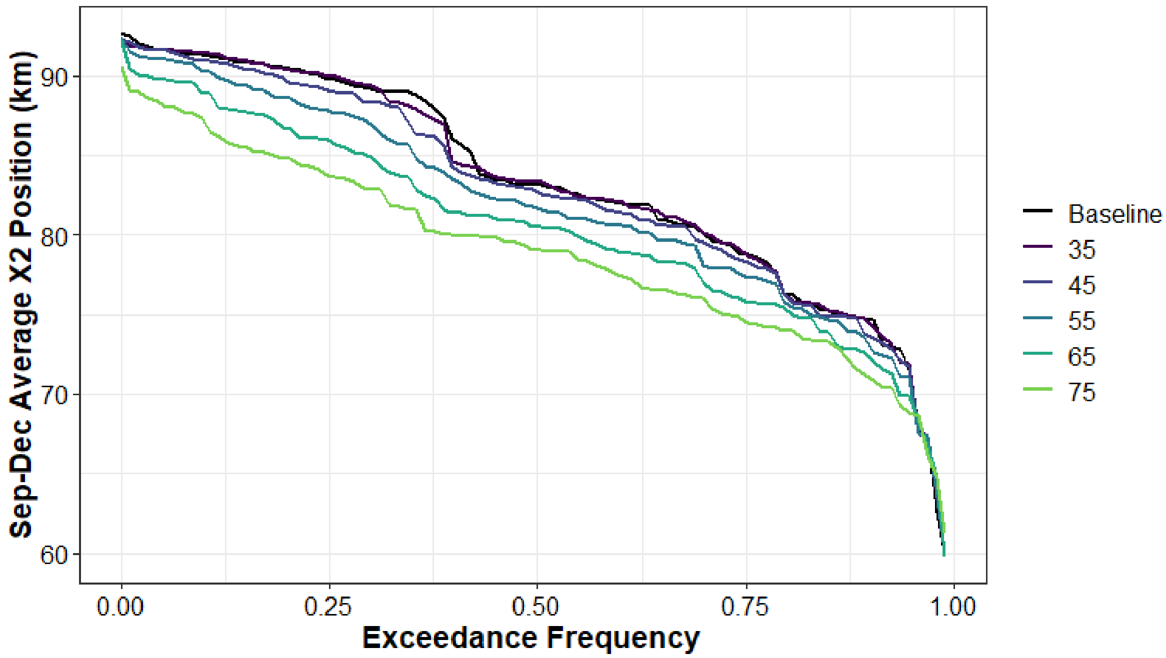
Figure 7.6.2-3. Frequency of Meeting January–June Delta Outflows Corresponding to Estuarine Habitat Conditions

Fall and summer outflows are also important to Delta smelt and possibly other fish species. Delta outflow during late spring and early summer influences the position of the LSZ, which provides important habitat for several pelagic fish species such as Delta smelt (^Baxter et al. 2015; Dege and Brown 2004; Mahardja et al. 2021; Rosenfield 2010). Low outflow increases Delta smelt residence time in the Delta, probably leading to increased exposure to higher water temperatures and increased risk of entrainment at the CVP and SWP pumping facilities (see Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*) (^Moyle 2002). SacWAM modeling of the proposed Plan amendments (45 to 65 scenarios) shows that summer and fall habitat conditions (as indicated by the position of X2) associated with higher survival and abundance of Delta smelt would generally be maintained or improved relative to baseline. Modeled outflows over the range of flow scenarios indicate that average summer and fall X2 positions would be equal to or lower (more westward) than the baseline condition in most years (Figure 7.6.2-4 and Figure 7.6.2-5). Overall, these changes in Delta outflows would benefit Delta smelt during summer (July through September) and fall (September through December).



River kilometers (km) are measured from the Golden Gate Bridge (50 = Benicia Bridge).

Figure 7.6.2-4. SacWAM Results for July–September Average X2 Positions for Baseline and 35 to 75 Scenarios



km = kilometers

Figure 7.6.2-5. SacWAM Results for September–December Average X2 Position for Baseline and 35 to 75 Scenarios

Interior Delta Flows

Under existing conditions, export pumping at the SWP and CVP export facilities can cause OMR reverse flow that may result in the movement of large numbers of fish, including but not limited to longfin smelt, into the interior Delta and result in their entrainment (^USFWS 2008 BiOp; ^NMFS 2009 BiOp). Net OMR reverse flows occur because the major fresh water source, the Sacramento River, enters on the northern side of the Delta while the two major pumping facilities (the SWP and CVP) are located in the south. This results in a net water movement across the Delta in a north-south direction along a web of channels including Old and Middle Rivers instead of the more natural pattern from east to west or from land to sea. A negative value, or a reverse flow, indicates a net water movement across the Delta up Old and Middle River channels to the export facilities. High net OMR reverse flows have several negative ecological consequences. First, net reverse OMR flows draw fish, especially the weaker swimming larval and juvenile forms, into the SWP and CVP export facilities. Second, net OMR reverse flows reduce spawning and rearing habitat for native species, like Delta smelt. Third, net OMR reverse flows result in a confusing environment for migrating juvenile salmonids leaving the San Joaquin River basin. Finally, net OMR reverse flows reduce the natural variability in the Delta by drawing Sacramento River water across and into the interior Delta.

Table 7.6.2-6 through Table 7.6.2-9 show SacWAM results for interior Delta flows. The SacWAM results show that the frequency of positive OMR flows would remain largely unchanged in January through March and in June. However, in April, the frequency of positive OMR flows is less under the 35 through 55 scenarios; in May, they would be greater under all scenarios, including 23 percent greater under the 65 scenario (Table 7.6.2-6). Overall, these changes are unlikely to reduce the potential for entrainment into the interior Delta except possibly in April and May of some years. SacWAM results indicate that the frequency of years with mean monthly OMR reverse flows greater than or equal to -1,250 cfs remain largely unchanged from January through March under the 45 to 65 scenarios except for the 65 scenario in March. In April and May, there are decreases under the 45 to 55 scenarios with increases in frequency under the 65 scenario and under the 45 to 65 scenarios in June (Table 7.6.2-7).

For OMR reverse flows of -2,500 cfs, SacWAM results indicate that the frequency of OMR reverse flows remains largely unchanged, with slight increases and decreases under the 45 to 55 scenarios in January through May. The largest increase in frequency occurs under the 65 scenario in January through May, with an increase in frequency under the 45 to 65 scenarios in June (Table 7.6.2-8). SacWAM results indicate that the frequency of years with mean monthly OMR reverse flows greater than or equal to -5,000 cfs do not change under the 45 to 65 scenarios in the months of March through June (Table 7.6.2-9). However, in January and February, there are increases above the baseline under the 45 to 65 scenarios. These changes would not likely constrain the ability of DWR and Reclamation to meet OMR requirements under the current adaptive management process. Export operations would continue to be managed adaptively from December through June to meet OMR flow requirements[5] within a range of -1,250 to -5,000 cfs based on fish salvage and other environmental and biological triggers in accordance with the NMFS and USFWS BiOps and provisions of the CDFW ITP.

Table 7.6.2-6. SacWAM Results for Frequency (Percent of Months) of Positive Old and Middle River Flows

Scenario	Jan	Feb	Mar	Apr	May	Jun
Baseline	2	4	3	43	43	1
35	3	3	3	40	45	1
45	2	4	3	39	52	2
55	2	4	3	40	57	2
65	2	3	3	46	66	4
75	2	3	4	51	71	12

Table 7.6.2-7. SacWAM Results for Frequency (Percent of Months) of Old and Middle River Flows More Positive than -1,250 cubic feet per second

Scenario	Jan	Feb	Mar	Apr	May	Jun
Baseline	4	5	5	87	86	9
35	6	4	5	81	83	24
45	4	6	5	81	86	38
55	4	4	6	85	87	54
65	4	5	12	88	92	69
75	10	28	32	92	99	90

[5] Requirements include daily maximum OMR reverse flows based on 14-day and 5-day running averages of net (tidally filtered) flows in addition to other requirements, depending on the date and other triggers related to entrainment risk of listed salmonids, Delta smelt, and longfin smelt.

Table 7.6.2-8. SacWAM Results for Frequency (Percent of Months) of Old and Middle River Flows More Positive than -2,500 cubic feet per second

Scenario	Jan	Feb	Mar	Apr	May	Jun
Baseline	8	9	14	88	90	13
35	8	8	10	86	90	26
45	8	9	12	88	92	41
55	8	9	15	89	91	57
65	11	19	33	91	98	84
75	38	47	68	95	100	96

Table 7.6.2-9. SacWAM Results for Frequency (Percent of Months) of Old and Middle River Flows More Positive than -5,000 cubic feet per second

Scenario	Jan	Feb	Mar	Apr	May	Jun
Baseline	73	92	100	100	100	100
35	74	92	100	100	100	100
45	75	92	100	100	100	100
55	77	92	100	100	100	100
65	81	96	100	100	100	100
75	97	99	100	100	100	100

Under existing conditions, net reverse flows also can occur in the San Joaquin River at Jersey Point, which decrease the survival of smolts migrating through the lower San Joaquin River (USFWS 1992). Net reverse flows on the lower San Joaquin River and diversions into the central Delta also may result in reduced survival for Sacramento River fall-run Chinook salmon (^USFWS 1995).

Table 7.6.2-10 displays the SacWAM results for frequency (percent of months) of positive Jersey Point flows for the baseline and 35 to 75 scenarios. The SacWAM results show that the frequency of positive Jersey Point flows for October through June would increase under the 45 to 65 scenarios compared with baseline, except for December and January under the 45 scenario. The frequency of positive Jersey Point flows would increase most substantially during October through December. The frequency of positive Jersey Point flows for April and May would not change under the 45 to 65 scenarios compared with baseline. Overall, because changes in hydrology would increase the frequency of positive Jersey Point flows for nearly all months during October through June for the 45 to 65 scenarios, the proposed Plan amendments could improve the survival of emigrating juvenile Chinook salmon through the lower San Joaquin River.

Table 7.6.2-10. SacWAM Results for Frequency (Percent of Months) of Positive Jersey Point Flows

Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Baseline	31	11	42	66	84	96	100	100	88
35	48	15	40	67	84	92	100	100	96
45	66	19	39	66	88	97	100	100	99
55	85	34	49	71	89	97	100	100	100
65	97	65	86	77	99	100	100	100	100
75	100	99	98	100	100	100	100	100	100

Table 7.6.2-11 displays SacWAM results for the average ratio of San Joaquin River inflow (Vernalis) to south Delta exports during the fall anadromous salmonid adult immigration period and January through June juvenile outmigration period. As discussed in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, higher San Joaquin River I:E ratios result in higher survival through the Delta (^SST 2017). Juvenile salmonids migrate out of the San Joaquin River basin during January through June and may need protection from export-related mortality at any time during this period to preserve life history diversity. Although peak emigration occurs in April and May, recent research has shown that individuals leaving their natal tributaries as fry in February and March can make up a substantial fraction of individuals that ultimately return to spawn (^Sturrock et al. 2015). In addition, higher San Joaquin River I:E ratios during fall (October to November) have been shown to be negatively correlated with straying rate (percentage of San Joaquin River-origin adults that stray to the Sacramento River basin), suggesting improved homing ability of adults as San Joaquin River inflows increase and Delta exports decrease (^Marston et al. 2012). In general, SacWAM results show positive but little change in fall (generally less than 0.2) and less than 0.1 during winter and spring except for May and June in San Joaquin River I:E ratios under the 45 to 65 scenarios compared with baseline. These results indicate that, other than May, the proposed Plan amendments would be unlikely to significantly affect the San Joaquin River I:E ratio during the majority of juvenile salmonid outmigration.

The proposed Plan amendments include interior Delta flow and fall Delta outflow provisions, including additional restrictions on exports as a function of San Joaquin River flows (I:E), OMR reverse flow constraints, and fall Delta outflow requirements, that are based on NMFS and USFWS BiOps and CDFW ITP provisions for operations of the CVP and SWP. These BiOp and ITP requirements are included in the baseline condition for the purpose of the environmental analysis, and therefore are not expected to result in a change in the environment. The proposed program of implementation includes provisions to allow for adaptive management of these provisions consistent with changes to the BiOps or ITP, provided those changes are in conformance with the narrative objective. Modular Alternative 4a, Exclusion of Interior Delta Flow and Fall Delta Outflow Related Amendments, evaluates the effects of excluding the new interior Delta flow and fall Delta outflow components of the proposed Plan amendments. The environmental impacts of Alternative 4a are evaluated in Section 7.24, *Alternatives Analysis*.

Table 7.6.2-11. SacWAM Results for Average San Joaquin Inflow to Export (I:E) Ratios

Scenario	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Baseline	0.36	0.24	0.30	0.54	0.60	0.78	2.32	2.40	0.65
35	0.39	0.24	0.29	0.57	0.58	0.76	2.19	2.45	0.81
45	0.42	0.27	0.30	0.54	0.61	0.76	2.16	2.61	1.07
55	0.53	0.30	0.33	0.54	0.59	0.78	2.23	2.84	1.40
65	0.80	0.42	0.41	0.57	0.64	0.87	2.34	3.09	1.75
75	1.16	0.78	0.55	0.69	0.80	1.04	2.46	3.09	2.10

Sacramento/Delta Tributary Inflows

Generally, changes in flow and timing of flows on Sacramento/Delta tributaries under the proposed Plan amendments would result in a more natural flow regime that would benefit native aquatic species adapted to these hydrologic conditions. Tributary inflows that more closely mimic the natural hydrologic conditions to which native fish species are adapted, including the relative magnitude, duration, timing, quality, and spatial extent of flows as they would naturally occur, would be expected to improve protection of native species. Anadromous salmonids, including Chinook salmon and steelhead, would benefit from the changes in Sacramento/Delta tributary flows that would occur as a result of the proposed Plan amendments. At least one salmonid run is migrating through, rearing in, or holding in the Sacramento River watershed, Delta eastside tributaries, or Delta each month of the year—necessitating the need for year-round tributary inflows (see Table 3.4-1 in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*). Adult salmonids require tributary flows of sufficient magnitude to provide cues to find, enter, hold, and spawn in their natal streams. Juvenile salmonids also require continuous tributary flows with adequate temperature and dissolved oxygen levels for rearing and successful emigration. A lack of tributary flow affects hydrologic connectivity between tributaries and the mainstem Sacramento River and Delta, and reduces juvenile rearing habitat quantity and quality.

The proposed new inflow objective is intended to maintain inflow conditions from the Sacramento/Delta tributaries sufficient to support and maintain the natural production of viable native fish populations and to contribute to Delta outflows and would provide for flow conditions that benefit native fish and wildlife in the Sacramento/Delta watershed, including special-status fish species. In general, the proposed new inflow objective would maintain or improve ecosystem functions on the tributaries, including by providing appropriate habitat conditions for adult salmonid immigration and holding and juvenile rearing and outmigration, and connecting flows from upstream tributaries to the Delta. The new inflow objective is intended to set the foundation for integrating inflows, cold water habitat protection, and outflows to provide a unified framework for comprehensive protection of the Bay-Delta ecosystem.

The proposed inflow objective also is intended to provide for increased frequency and duration of floodplain inundation during late winter through spring months in the Sacramento/Delta. These changes would be expected to benefit multiple native fish species and life history stages, including adult Sacramento splittail spawning and juvenile Sacramento splittail, Chinook salmon, and steelhead rearing. Increased frequency and duration of floodplain inundation during late winter through spring months also would contribute to production of benthic macroinvertebrate prey and other food supplies that support native fish species. Under the proposed Plan amendments (45 to 65 scenarios), ecologically meaningful floodplain inundation in the Sacramento/Delta would increase on select tributaries (Feather, Mokelumne, and Yuba Rivers) during February through June (see Section 3.14.2, *Salmonid Tributary Habitat Analysis*), which would likely result in positive population responses by salmonids and other native fishes. Increased flows in the lower Yolo Bypass are expected to increase floodplain inundation and suitable habitat for Delta species (see Section 6.3.1.2, *Sacramento Valley Flood Bypasses*) and result in positive responses from native fishes and migratory salmonids. Benefits would extend to a variety of aquatic and terrestrial species served by flow-related ecosystem processes, including deposition of sediment and nutrients onto floodplains, succession of riparian vegetation, water quality improvements, and primary and secondary production in flooded riparian zones (see Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*).

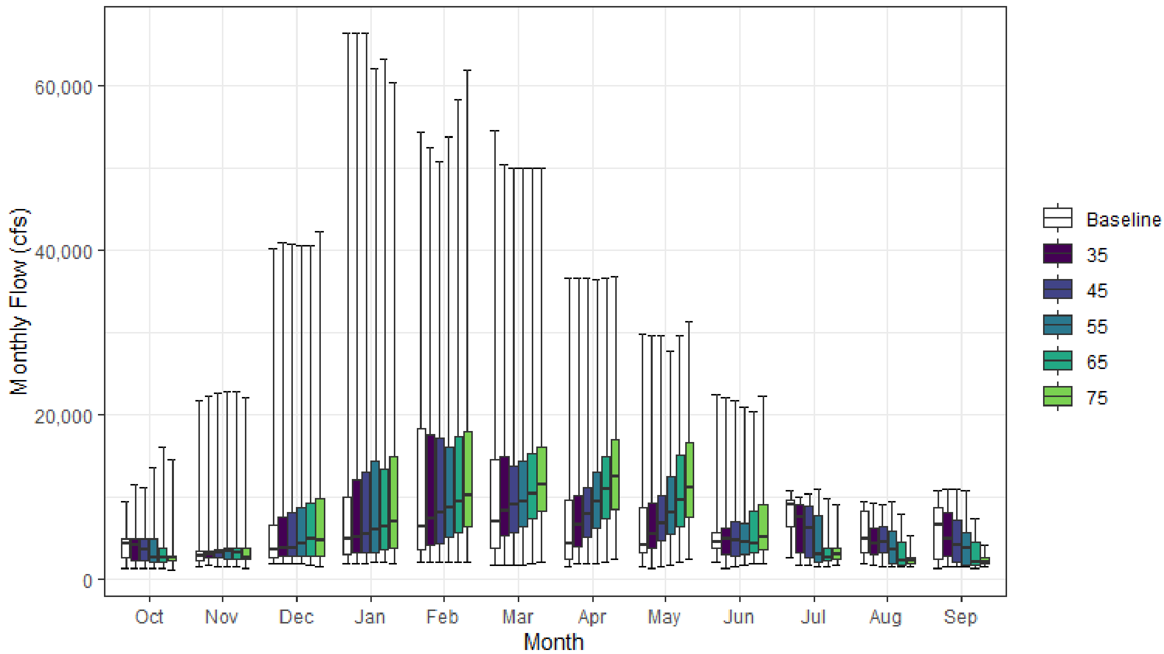
For individual Sacramento/Delta tributaries, SacWAM results show different changes under the proposed Plan amendments for regulated tributaries versus unregulated tributaries, which are discussed separately below.

Regulated Tributaries

Regulated tributaries are tributaries that contain a major storage reservoir or other flow-regulating infrastructure. Overall, on regulated tributaries, the SacWAM results show that the proposed Plan amendments would result in streamflows downstream of rim reservoirs that would generally increase during late winter and spring (February to May), decrease or remain unchanged during summer and fall (June to October), and increase or remain unchanged during winter months (November to January) compared with baseline. Higher winter and spring flows that more closely resemble the natural hydrograph to which native species have adapted would improve habitat conditions for native fish species such as Chinook salmon and steelhead. The restoration of a more natural flow regime would also have beneficial effects on natural physical and ecological processes and other habitat components that act as major stressors on native fish species, including improvements in the quality and extent of riparian, wetland, and floodplain habitat. These improvements would result from increases in longitudinal and lateral connectivity of riverine, floodplain, and riparian habitats and the processes supporting natural regeneration of native riparian and wetland vegetation (see Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*). These changes could also benefit special-status plants and wildlife that occur in riparian, wetland, and floodplain habitat. See Section 7.6.1, *Terrestrial Biological Resources*, for additional discussion.

The following discussion provides examples of some of the types of hydrologic changes and associated flow-related benefits to anadromous salmonids that would be expected to occur on individual regulated tributaries.

In general, on regulated tributaries, late winter and spring flows under the proposed Plan amendments would increase compared with baseline. Increased instream flows during late winter and spring months would support juvenile salmonid rearing habitat and could contribute to increased floodplain inundation. For example, on the Feather River, baseline flows during spring months are often highly impaired (see Chapter 2, *Hydrology and Water Supply*). SacWAM results show that Feather River flows under the proposed Plan amendments (45 to 65 scenarios) would generally increase relative to baseline conditions during December through June (Figure 7.6.2-6). The frequency of meaningful floodplain events on the Feather River sufficient to support the offspring of 25 percent of the doubling goal at the fry stage during February through June would be expected to increase from 47 percent of years under baseline conditions to 67 to 83 percent under the proposed Plan amendments (see Section 3.14.2, *Salmonid Tributary Habitat Analyses*). This increase in floodplain area would increase the quantity and quality of available juvenile salmonid rearing habitat on the Feather River. A more natural hydrologic regime on the Feather River during spring months also could provide other ecosystem benefits, such as improved temperature and migratory conditions.

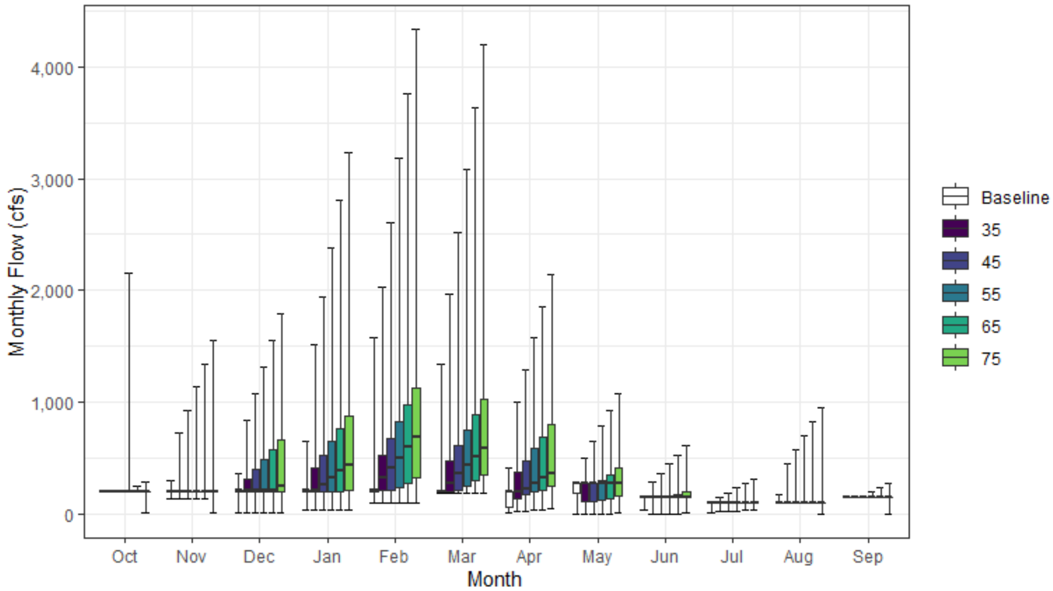


cfs = cubic feet per second

Figure 7.6.2-6. SacWAM Results for Feather River Flows (SWRCB Feather River) for Baseline Condition and 35 to 75 Scenarios

Other Sacramento/Delta tributaries could see similar ecosystem benefits resulting from increased instream flows during spring months. Increased instream flows during spring months also would be expected to benefit adult and juvenile anadromous salmonids on some regulated tributaries by providing a more natural and variable hydrologic regime. For example, on Clear Creek, changes in hydrology would result in higher and more variable winter and spring flows compared with baseline conditions (Figure 7.6.2-7), which could benefit spring-run Chinook salmon and steelhead. Figure 7.6.2-7 shows SacWAM results for Clear Creek flows at the confluence with the Sacramento River (below Whiskeytown Reservoir); these results show that Clear Creek flows would generally increase during winter and early spring months, particularly during January through April. Under existing conditions, Whiskeytown Reservoir releases are identified as frequently insufficient for attraction and passage of migrating adult spring-run Chinook salmon to upstream holding and spawning areas (^NMFS 2014a). Higher spring flows also could enhance opportunities to manage reservoir releases to optimize downstream flow and temperature conditions and to provide spring pulse flows. Pulse flows could be used to encourage adult spring-run Chinook salmon to move upstream in Clear Creek to holding and spawning habitat. Pulse flows also can help juvenile fish to swim toward the ocean. Historically in the Central Valley, relatively low-magnitude natural pulse flows occurred from late fall until early spring in response to rainfall, followed by snowmelt-driven pulses from spring through early summer (Zeug et al. 2014).

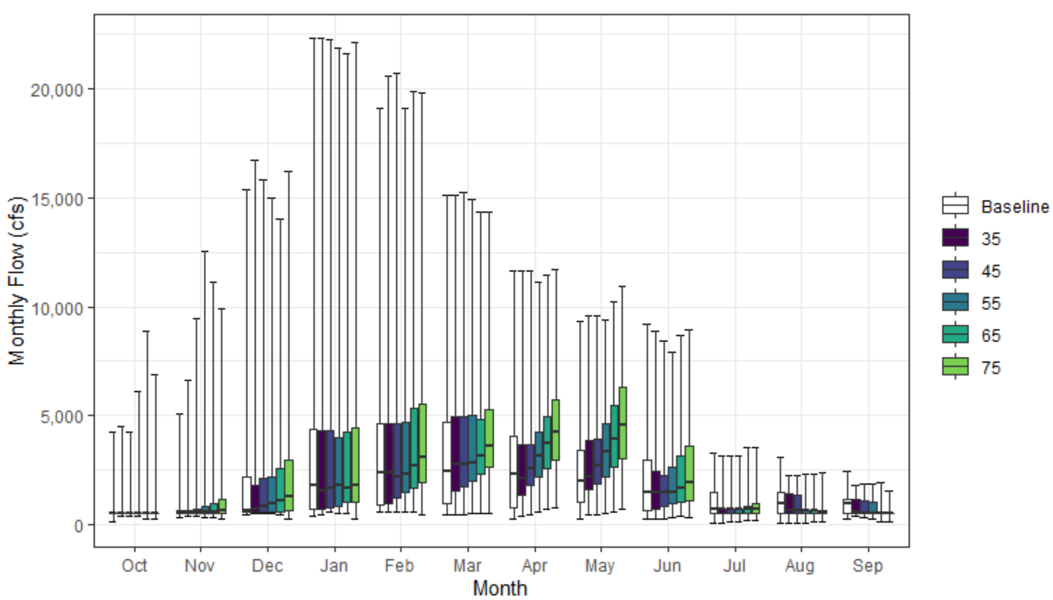
Similar benefits related to increased spring flows also would be expected to occur on other Sacramento/Delta tributaries.



cfs = cubic feet per second

Figure 7.6.2-7. SacWAM Results for Lower Clear Creek Flows (SWRCB Clear Creek) for Baseline Condition and 35 to 75 Scenarios

Some tributaries such as the Yuba River show some increases in flow during early winter through spring months (Figure 7.6.2-8). These flows could benefit anadromous salmonids during key migration periods, particularly if fall and early winter flows are managed to provide for variable flows, including fall pulse flows that could help to cue adult fall-run Chinook salmon and adult steelhead migration.



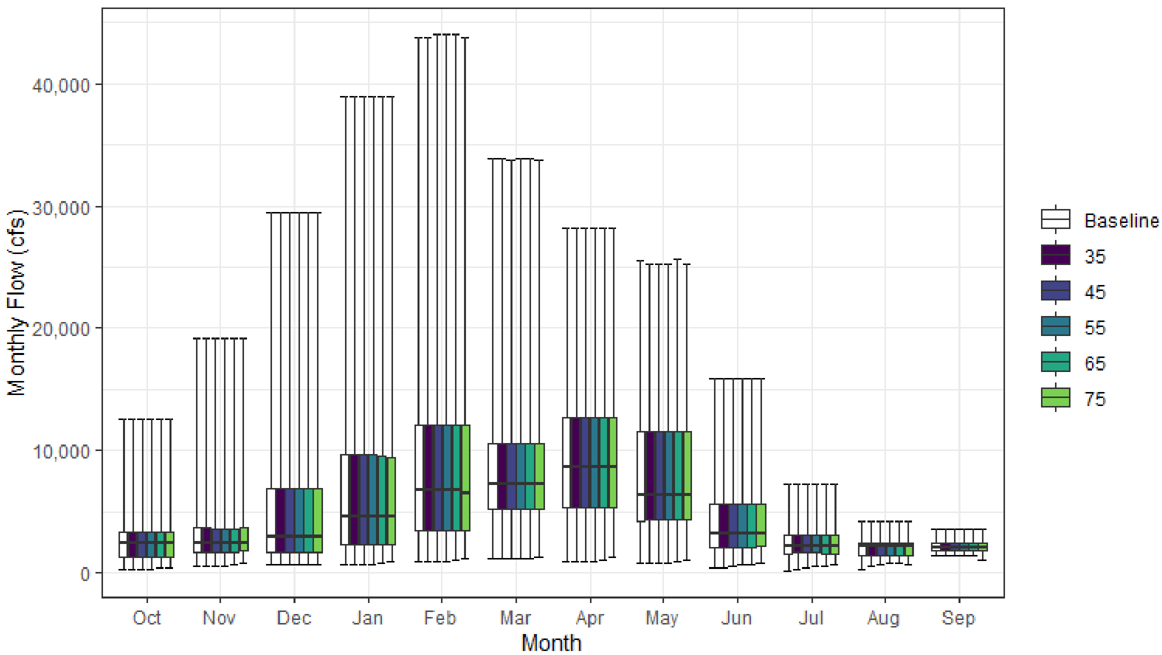
cfs = cubic feet per second

Figure 7.6.2-8. SacWAM Results for Lower Yuba River Flows (SWRCB Yuba River) for Baseline Condition and 35 to 75 Scenarios

Upper Watershed Tributaries

Under the proposed Plan amendments, flows also would be required above major rim reservoirs in the Sacramento/Delta, which would contribute to flow conditions downstream and support ecological processes that provide important benefits to native fish species in upstream reaches. Several special-status native fish species occur in some upper watershed streams, lakes, and reservoirs, such as Pacific lamprey, hardhead, Central California roach, and riffle sculpin. Other native fish species, such as rainbow trout, also occupy the intermediate to upper-elevation streams, lakes, and reservoirs in the Sacramento/Delta.

On some upper watershed tributaries, the proposed Plan amendments would be unlikely to result in changes in flow and would not likely significantly affect aquatic biological resources, including fish that occur in these reaches. For example, flows on the Feather River directly above Oroville would generally remain unchanged under the 45 to 65 scenarios compared with baseline. Figure 7.6.2-9 shows the SacWAM results for the Feather River above Lake Oroville (SWRCB Oroville Inflow).

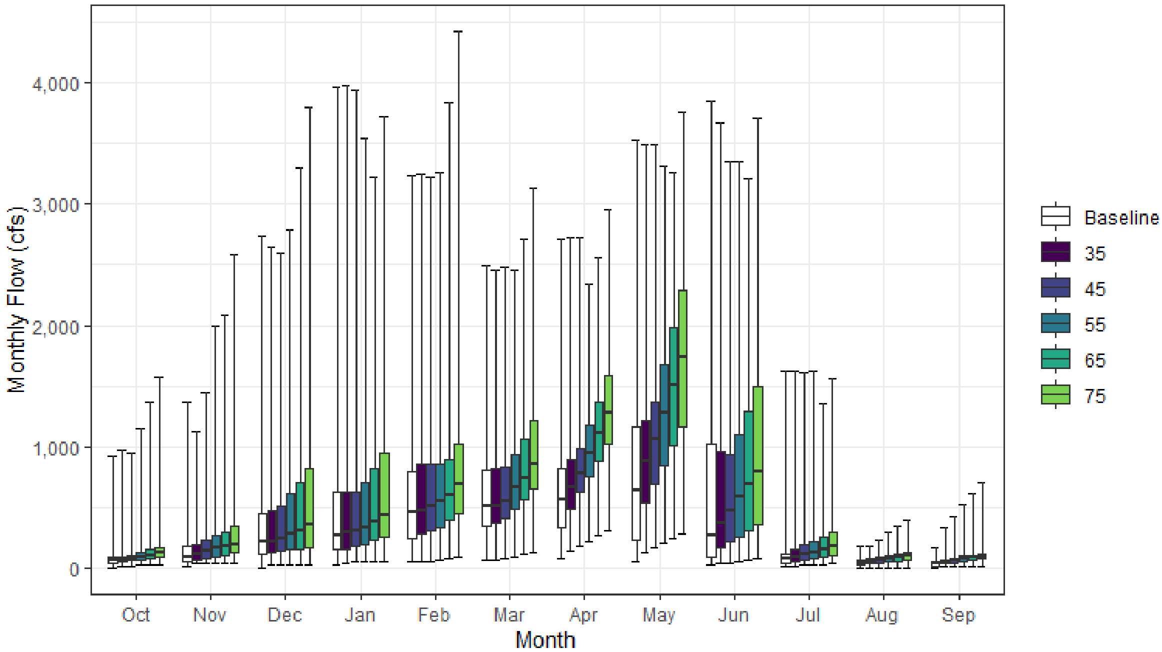


cfs = cubic feet per second

Figure 7.6.2-9. SacWAM Results for Feather River above Oroville Reservoir (SWRCB Oroville Inflow)

On other upper watershed tributaries, the proposed Plan amendments could result in changes in flow, particularly in reaches that are affected by diversions and interbasin transfers. Modeled flows for South Yuba River above Englebright Reservoir and below Lake Spaulding are shown as an example of an upper watershed tributary that has been re-operated to meet the proposed instream flow requirements (Figure 7.6.2-10). SacWAM results for the South Yuba River downstream of Lake Spaulding show higher flows during all months. These increases in flow that more closely resemble the natural hydrologic regime may benefit native aquatic resources, including fish present in this reach below Lake Spaulding. However, increases in flow on the South Yuba River would be associated with reductions in flow on the Bear River due to reduced imports from Lake Spaulding.

The potential effects of changes to interbasin transfers are discussed below in the context of water temperature.



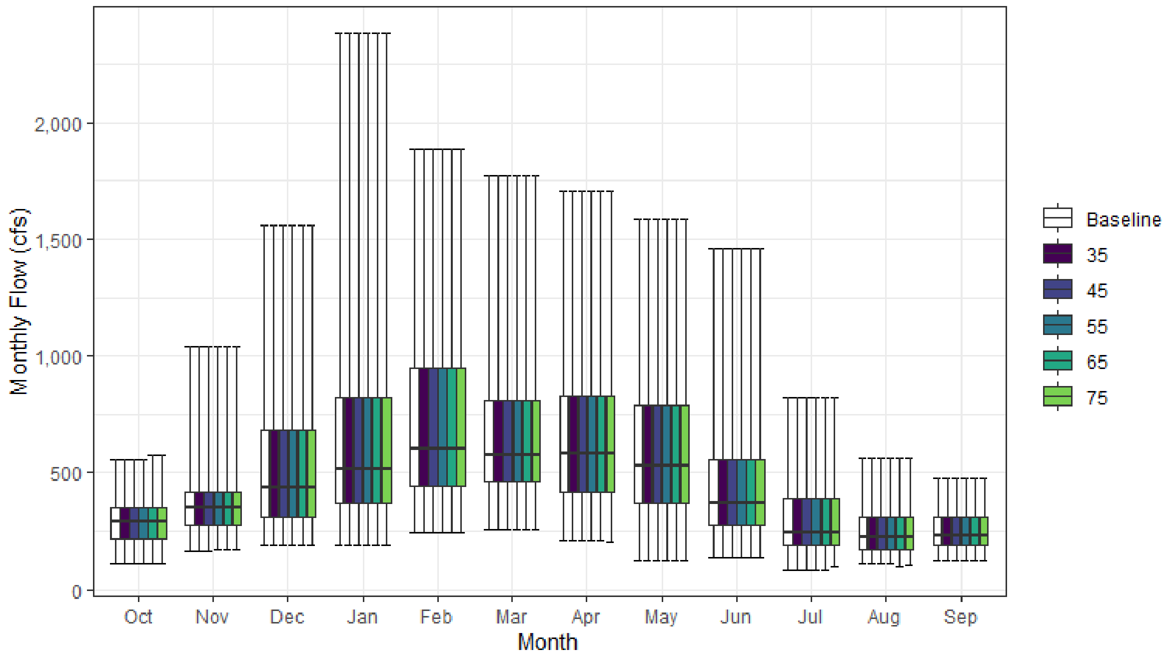
cfs = cubic feet per second

Figure 7.6.2-10. SacWAM Results for South Yuba River above Englebright Reservoir Flows (SWRCB S Yuba Inflow) for Baseline Condition and 35 to 75 Scenarios

Unregulated Tributaries

Unregulated tributaries are tributaries that lack a major storage reservoir or other flow-regulating infrastructure. There are two general categories of unregulated tributaries in the Sacramento River watershed and Delta eastside tributaries regions: (1) unregulated tributaries that exhibit low surface water demand relative to water availability; and (2) unregulated tributaries that exhibit high surface water demand relative to water availability. Although unregulated tributaries provide a small contribution to Delta inflows, multiple unregulated tributaries are recognized for their high aquatic resource value. For example, Mill, Deer, and Butte Creeks support the only remaining self-sustaining populations of threatened Central Valley spring-run Chinook salmon (^Lindley et al. 2007).

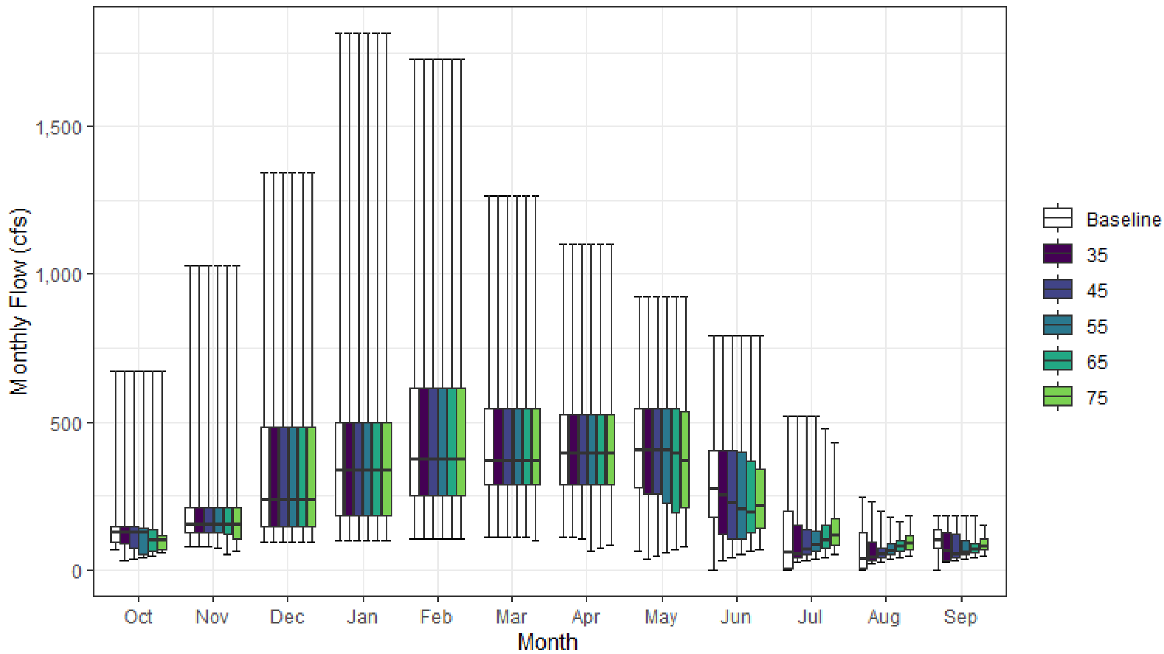
Monthly streamflows in unregulated tributaries with relatively low surface water demand (e.g., Battle Creek) would generally remain unchanged under the proposed Plan amendments (Figure 7.6.2-11). These tributaries may contain some hydrologic impairments under existing conditions, but unregulated tributaries with relatively low surface water demand generally exhibit less substantially altered hydrology on a monthly time step compared with other Sacramento/Delta tributaries. In addition, although the SacWAM results show that monthly flows would not change substantially on these tributaries, many unregulated tributaries lack a minimum instream flow requirement under existing conditions and could be affected in the future by new or increased diversions. Implementation of the proposed inflow objective would protect the existing flow regime on these tributaries and ensure that potential future water demand would not adversely affect native cold water species.



cfs = cubic feet per second

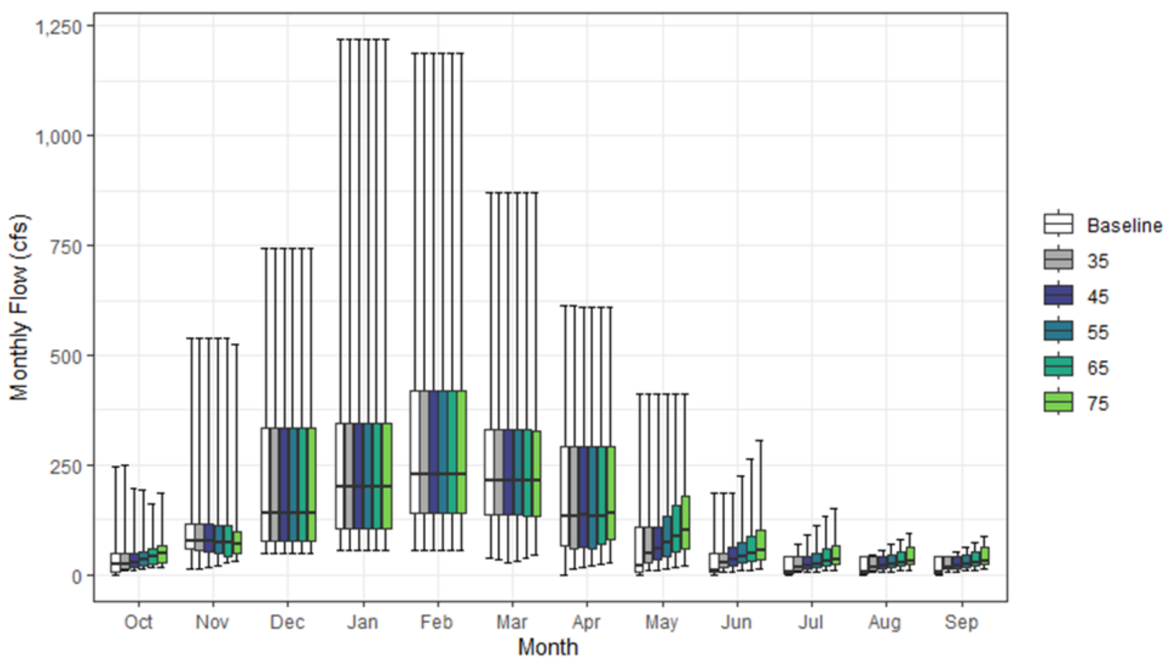
Figure 7.6.2-11. SacWAM Results for Battle Creek Flows (SWRCB Battle Creek) for Baseline Condition and 35 to 75 Scenarios

SacWAM results show that monthly streamflows on several unregulated tributaries with higher surface water demand would increase during summer and fall under the 45 to 65 scenarios relative to the baseline condition, but there would be little change in flow outside of the irrigation season. Figure 7.6.2-12 and Figure 7.6.2-13 show the SacWAM results for Mill Creek and Antelope Creek, respectively, under baseline conditions and the 35 to 75 scenarios; these figures show that lower Mill Creek and Antelope Creek flows would be expected to change during May through November. As modeled, Mill Creek flows slightly increase compared with baseline conditions during July and August—with some decreases in September, October, and June—and remain largely unchanged November through May. As modeled, Antelope Creek flows increase during May through October and are largely unchanged in November. Detailed results for Mill, Antelope, and Deer (not shown) Creeks should be interpreted with caution due to the spatial resolution of agricultural demands in SacWAM. On these creeks, surface water demand is generally highest during the spring through fall irrigation season, which is also the period when streamflows are naturally lower. During winter months, streamflows are naturally higher and water demand tends to be lower; streamflows during these months would not change significantly under the proposed Plan amendments compared with baseline conditions.



cfs = cubic feet per second

Figure 7.6.2-12. SacWAM Results for Mill Creek Flows (SWRCB Mill Creek) for Baseline Condition and 35 to 75 Scenarios



cfs = cubic feet per second

Figure 7.6.2-13. SacWAM Results for Antelope Creek Flows (SWRCB Antelope Creek) for Baseline Condition and 35 to 75 Scenarios

In general, increased flows during the spring through fall irrigation season on unregulated tributaries with higher water demand would be expected to benefit native fish species, including

Chinook salmon and steelhead. In particular, these changes would benefit anadromous fish populations during key adult immigration and juvenile outmigration periods. For example, on Antelope, Deer, and Mill Creeks, increased flows during the irrigation season would improve passage conditions for adult and juvenile Chinook salmon and steelhead during spring and fall migration periods (Figure 7.6.2-12 and Figure 7.6.2-13). Antelope, Mill, and Deer Creeks contain relatively undisturbed habitat in their upper reaches (SWRCB 2015). However, diversions in the lower watersheds can decrease instream flows and make it difficult for anadromous salmonids to migrate past diversion structures and critical riffles to habitat in the upper watersheds (NMFS 2015). In addition, salmonid migration can be impeded by warm water temperatures exacerbated by stream diversions (CDFW 2017a; 2017b). The proposed Plan amendments would result in higher spring through fall flows in lower reaches of Antelope, Deer, and Mill Creeks, which would improve passage and temperature conditions on these tributaries during key anadromous salmonid migration periods. Other native aquatic species that occur on unregulated tributaries could also benefit from a more natural hydrologic regime during these months.

Many unregulated tributaries have minimal or no instream flow requirements under baseline conditions. Additional diversions could occur in the future in the absence of additional regulatory flow requirements, which could further reduce instream flows. Minimum instream flows on unregulated tributaries would provide for adult salmonid passage during critical migration periods, salmonid egg incubation, and juvenile rearing habitat; pulses of flow at times to ensure successful migration, and to maintain minimum streamflow for out-migrating juvenile fish, particularly during drier years when streamflows are naturally lower. If a tributary inflow objective is not adopted for unregulated tributaries, short-term agreements or drought emergency regulations may be necessary to protect Chinook salmon and steelhead on these or other unregulated tributaries under future drought conditions. In 2014 and 2015, the State Water Board adopted drought emergency regulations, including minimum flow requirements for the protection of Central Valley spring-run Chinook salmon and California Central Valley steelhead in Mill Creek, Deer Creek, and Antelope Creek. The emergency regulation went into effect in Deer Creek in 2014, and in 2015 for Deer and Antelope Creeks. Voluntary agreements between diverters and CDFW and NMFS in 2014 provided for flows in Mill and Antelope Creeks and provided for flows in Mill Creek in 2015. Similar emergency regulations for Mill and Deer Creeks were adopted by the State Water Board in 2021 and 2022. The emergency regulations were considered a short-term instream flow effort and are no longer in effect.

Geomorphic Flows

Floods, and their associated sediment transport, are important drivers of the river-riparian system. Small-magnitude frequent floods maintain channel size, shape, and bed texture; while larger infrequent floods provide beneficial disturbance to both the channel and its adjacent floodplain and riparian corridor. Scour and bed mobilization, associated with geomorphic processes that are driven by high flows, rejuvenate riparian forests and revitalize gravel for salmon (^Poff et al. 1997). Native fish and other aquatic species have adapted their life cycle to these processes and exploit the diversity of physical habitats these processes create (^Poff et al. 1997; ^Thompson and Larsen 2002; ^Lytle and Poff 2004). During the wet season, large-magnitude flows typically transport a substantial portion of the annual sediment load and restructure the channel and floodplain landforms. However, wet season flows that are too low may lead to sediment deficiencies downstream or a surplus of deposited sediment if a river channel is highly constricted.

On regulated Sacramento/Delta tributaries, the SacWAM results show that monthly streamflows downstream of rim reservoirs would generally increase during late winter and spring under the proposed Plan amendments compared with existing conditions. This could result in increased frequency of small-magnitude frequent floods that maintain channel size, shape, and bed texture and could provide ancillary ecosystem benefits. However, the erosion and flood risk analysis presented in Section 7.12.1, *Surface Water,* identifies that, for most regulated tributaries, instream flow and reservoir storage levels stay the same or decrease compared with baseline conditions for the top 10 percent monthly flows during the high-flow months. Although the SacWAM results show that the magnitude of the highest monthly flows could decrease under the proposed Plan amendments compared with existing conditions, special-status fish species likely would not be adversely affected. Flood disturbance can pose a risk to salmonid eggs and embryos in redds by causing scour and filling spawning areas. As discussed in Section 7.12.1, the very highest flows can cause flooding and excessive, large-scale erosion. The velocity associated with these flows is high enough to move large pieces of channel substrate, such as spawning gravel. More moderate rainy-season flows may be more beneficial, potentially allowing the ecological benefits of floodplain inundation without significant erosive damage. These more moderate flows generally move only fine sediment or sand, which may improve spawning gravel quality and cause modest increases in turbidity. Overall, the effect of changes in wet season flows on special-status aquatic species or their habitat and on the movement of any native resident or migratory fish would be less than significant.

On unregulated Sacramento/Delta tributaries, SacWAM results show that the proposed Plan amendments would not result in changes in streamflows during the wet season months (see Appendix A1, *Sacramento Water Allocation Model Methods and Results*). Because the proposed Plan amendments would not result in changes in winter peak flows on unregulated tributaries, there would likely be no change to sediment transport processes on these tributaries and no impact on aquatic biological resources, including fish.

Implementation of the proposed Plan amendments also would provide opportunities for variable winter flows while minimizing potential detrimental impacts related to erosion. The intent of the proposed Plan amendments is to provide flexibility to allow flows to be managed based on the unique temporal and spatial needs and conditions on Sacramento/Delta tributaries, including geomorphic flows. As described in Chapter 5, *Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta*, the proposed program of implementation would allow refinement of implementation measures on a tributary basis over time to maximize benefits for native fish and wildlife, including shaping or shifting of flows to maximize ecological functions and benefits to fish and wildlife. Flows could be sculpted to provide for peak flows, such as targeted pulses to cue migration, floodplain inundation, and other functions. These implementation provisions could benefit aquatic biological resources, including native fish. In addition, on regulated tributaries, the upstream sediment supply typically is trapped behind the dams, creating a sediment mass balance deficit downstream. If the relationship between flood duration, which correlates with total transport capacity, is not in balance with the limited sediment available below a dam, subsequent scour and bed degradation can occur (^Yarnell et al. 2015). Therefore, on many tributaries an effective approach for achieving geomorphic benefits could involve a combination of flow and non-flow actions, such as removing or setting back levees, enhancing in-channel complexity, and augmenting spawning gravels (see Section 7.21, *Habitat Restoration and Other Ecosystem Projects*) in addition to implementing the Delta inflow objective.

Changes in Reservoir Levels

Chapter 6, *Changes in Hydrology and Water Supply*, describes the types of changes in reservoir water levels that could result from implementation of the proposed Plan amendments. Under the proposed Plan amendments, reservoir storages would likely fall within historical ranges, but the distribution of those storages could change based on changes in operations. Although reservoirs may eventually be operated using protocols that differ from the scenarios as modeled, the model results are indicative of potential effects on reservoir levels. In general, the proposed Plan amendments may result in lower storage in rim reservoirs at the beginning of the irrigation season and less total water being released in summer months, eventually resulting in carryover storage that is closer to baseline conditions. The modeling indicates that carryover storage at rim reservoirs with the proposed Plan amendments could be lower, similar, or greater than baseline conditions depending on reservoir and water year type. Carryover storage could be reduced in a few rim reservoirs, with the largest reductions occurring under the 65 scenario. In the upper watersheds, substantial effects on storage are not expected in most reservoirs. However, some upper watershed reservoirs might experience substantial effects, especially those involved with interbasin diversions and those that need to release additional water to meet inflow requirements for the rim reservoirs downstream (see Chapter 6, *Changes in Hydrology and Water Supply*). Water levels of re-regulatory reservoirs below rim dams are not expected to change.

As described in Chapter 6, *Changes in Hydrology and Water Supply*, Sacramento/Delta water also is supplied to export reservoirs in the Bay Area, San Joaquin Valley, Central Coast, and Southern California regions. Decreases in Sacramento/Delta water supplies to these regions may result in changes in reservoir levels in the export reservoirs. Export reservoirs and their receiving streams are not explicitly modeled in SacWAM. However, historical observations of storage in export reservoirs during periods of lower Sacramento/Delta supplies show lower storage patterns for some reservoirs. This suggests that, when Sacramento/Delta supplies are reduced, storage in some export reservoirs is reduced.

Changes in reservoir levels in the Sacramento River watershed and Delta eastside tributaries regions and in export reservoirs in other regions could affect the extent of habitat for aquatic species that use these reservoirs. However, the fish species inhabiting these reservoirs generally differ from the species in the streams below the reservoirs. In Sacramento River watershed and Delta eastside tributaries regions reservoirs and in export reservoirs, reservoir fishes are mostly nonnative species or are stocked to support recreational fisheries. Impacts on these recreational fish species are discussed in Section 7.18, *Recreation*. Some native fish species, such as minnows and suckers, do use some reservoirs. However, these species generally are not dependent on reservoir habitat for their persistence, and any impacts on these native species would therefore be less than significant.

Several of the export reservoirs in the Bay Area, Central Coast, and Southern California regions are on-stream reservoirs (see Table 7.6.2-2). For these reservoirs, changes in reservoir levels could affect downstream flows and water temperatures, which could also affect downstream aquatic biological resources (see following discussion under *Water Temperature*).

Water Temperature

Water temperature is a key factor in defining habitat suitability for aquatic organisms. High water temperature can be stressful for many aquatic organisms (^Kammerer and Heppell 2012), particularly fish that are near the southern edge of their distribution (^Matthews and Berg 1997). High water temperature also increases the growth and distribution of many nonnative species, increasing their ability to successfully compete for limited food and habitat with native organisms (^Kiernan et al. 2012). Major factors that increase water temperature and negatively affect the health of the Bay-Delta ecosystem include disruptions of historical streamflow patterns, loss of riparian forest vegetation, reduced flows, discharges from agricultural drains, and climate change. Many of these factors occur in the Sacramento River and its tributaries and negatively affect salmonid spawning and rearing. The effect of elevated temperature on juvenile and adult salmonids in tributaries is discussed in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*.

Exposure of Chinook salmon and steelhead populations to elevated water temperature is a major factor contributing to their decline (see Chapter 4, *Other Aquatic Ecosystem Stressors*) (^Myrick and Cech 2001). Reductions in cold water storage impede reservoirs from meeting suitable downstream water temperature, especially during critically dry years (^NMFS 2009 BiOp, ^2014a). Dams and reservoirs now block Chinook salmon and steelhead access to much of these species' historical higher elevation habitat, which consistently provide colder water temperatures suitable for successful spawning and juvenile rearing. In the Central Valley, dams block Chinook salmon and steelhead from 72 to 95 percent of their historical spawning habitat (California Advisory Committee on Salmon and Steelhead Trout 1988; ^Yoshiyama et al. 2001) and green sturgeon from 9 percent of their historical spawning habitat (^Mora et al. 2009); spawning and rearing habitat is now restricted to river reaches below impassable rim dams. Physical and operational measures, including TCDs and seasonal storage targets, are employed at Central Valley reservoirs to improve the reliability of cold water discharge during critical summer and fall spawning and rearing periods.[6] Increasing water demand and climate change are expected to further limit the effectiveness of reservoir releases and water temperature management in protecting anadromous fish populations below reservoirs (^Lindley et al. 2007; ^Cloern et al. 2011).

Changes in flow and reservoir storage under the proposed Plan amendments could affect stream temperatures and the availability of cold water. The proposed inflow objective would generally result in higher spring flows on regulated tributaries compared with baseline conditions. While higher spring flows that more closely resemble the natural hydrologic regime would benefit native anadromous salmonids and other native species, higher spring flows also could result in a reduction in reservoir storage at the end of spring and a smaller cold water pool volume in summer and fall months. In streams with reservoirs with limited cold water supplies, providing greater volumes of cold water early in the year could reduce the cold water supply available later in the year.

Overall, in the Sacramento/Delta, implementation of the narrative cold water habitat objective and the flexibility provided in the inflow requirements would be expected to improve water temperature conditions for native cold water fish. However, it is possible that there would be some instances on some streams where temperatures could increase. In particular, while the specific cold water habitat implementation measures are refined, there may be some challenges with meeting suitable temperatures at all times on all tributaries while meeting the flow requirements and water deliveries, particularly those with significant water diversions and smaller storage capacity.

[6] TCDs have been installed for thermal regulation at Shasta, Folsom, Oroville, and Whiskeytown Reservoirs. Shasta, Folsom, and Oroville Reservoirs use outlet shutters to control water temperatures. A thermal curtain is used in Lewiston and Whiskeytown Reservoirs to isolate cold inflowing waters on the Trinity River to maintain cold water outflows.

For locations not represented with water temperature modeling, SacWAM simulations were used to evaluate where challenges with meeting suitable temperatures while meeting the proposed flow requirements and water supply deliveries may exist due to reduced reservoir storage levels and reduced flows in summer and fall in some tributaries. Because the cold water habitat objective is narrative and is intended to be implemented based on the specific circumstances of each watershed, the modeling did not include specific prescriptive requirements. Instead, it included assumptions that generally reflect reservoir management actions that could be taken to provide cold water habitat protection with a focus on the rim reservoirs.

Under the proposed Plan amendments, reservoir storages would likely fall within historical ranges, but the distribution of those storages could change based on changes in operations. Reservoir end-of-September storage was targeted to maintain cold water throughout the year. Reservoir operations that result in low storage in late summer and fall months (i.e., August through November) can cause release temperatures to become too warm for cold water fish, such as Chinook salmon and steelhead. The purpose of simulating this type of reservoir operation is to approximate operations needed to meet the cold water objective. Each reservoir has a slightly different elevation-volume relationship, and the elevation of the outlet and the maximum surface elevation influences the minimum carryover (end-of-September) storage that provides a cold water release. For reservoirs with documented or clear historical storage-temperature relationships, storage thresholds sufficient to maintain cool release temperatures were incorporated into the modeling. The development of reservoir end-of-September carryover storage targets for use in SacWAM flow scenarios from historical storage-temperature relationships is described in Appendix A1c, *Preliminary Assessment of Effect of Reservoir Storage on Reservoir Release Temperatures*. The specific targets included in the flow scenarios are specified in Appendix A1, *Sacramento Water Allocation Model Methods and Results*. For example, for Folsom Reservoir, historical operations show that, when end-of-September storage is above 400 TAF, cooler downstream temperatures are more often achieved. In the modeling scenarios, CVP allocations were adjusted to maintain end-of-September storage above 400 TAF as frequently as baseline storage.

For upper watershed reservoirs, specific cold water storage assumptions were not included in the modeling because there is not enough available information, and the focus of the analysis is on the anadromous reaches of the tributaries with the cold water habitat requirement. As described in Chapter 5, *Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta*, cold water habitat measures could be required for these upper watershed reaches if water temperature concerns exist or become problematic as a result of implementation of the proposed Plan amendments.

Many reservoirs have existing problems with temperature for which existing temperature controls may not be sufficient (e.g., see Appendix A1c, *Preliminary Assessment of Effect of Reservoir Storage on Reservoir Release Temperatures.* Reservoir owners and operators may need to meet the proposed cold water habitat requirements by implementing some combination of cold water releases, TCDs including reservoir outlet shutters and thermal curtains, and fish passage improvements. Section 7.21, *Habitat Restoration and Other Ecosystem Projects*, discusses and evaluates the potential environmental impacts, including construction impacts, of habitat restoration and other ecosystem projects (e.g., use of TCDs and fish passage improvement projects) that entities may undertake toward achieving the overall goal of improving conditions for fish and wildlife in the Sacramento/Delta. While it is expected that many parties would take advantage of the provided flexibility to optimize operations and avoid environmental impacts, this analysis considers and incorporates the most conservative assumptions to ensure comprehensive impact conclusions.

Overall, although the proposed cold water habitat objective would generally be expected to maintain or improve temperature conditions in the Sacramento/Delta, uncertainties exist regarding temperature impacts that may result from implementation of the proposed Plan amendments independently or in combination with problems resulting from existing dams and diversions and their ongoing impacts on fisheries. Ultimately, management of cold water habitat must be based on further analysis that considers times of year that various life stages of anadromous fish are present, locations in the river that are utilized by anadromous fish, and the flow required to maintain suitable water temperatures far enough downstream to protect sensitive life stages from adverse temperature effects. The flow needed to provide suitable temperature conditions for native cold water fish species depends on reservoir release temperature, channel geometry, meteorology, and shade. Additionally, SacWAM is a hydrologic and systems operations model, not a temperature model. Therefore, some uncertainties exist regarding the temperature conditions that would occur below rim reservoirs as a result of the proposed flow requirements. As described in more detail below, additional temperature analyses using HEC-5Q models were conducted for the three largest tributaries in the Sacramento/Delta to better quantify potential changes in temperature from changes in hydrology. It is expected that additional information will become available as tributaries submit management plans and annual operation plans for major reservoirs. Future investigations could reveal that the actual storage level for a given reservoir may need to be higher or could be lower than that modeled to protect cold water habitat.

Sacramento/Delta Regulated Tributaries

This section describes potential effects in tributaries using water temperature simulations in HEC-5Q, specifically in the Sacramento, American, and Feather Rivers.

Changes in hydrology under the proposed Plan amendments could result in some reductions in summer and fall flows on Sacramento/Delta tributaries with major storage reservoirs, due to several different interrelated factors. The existing flow regime on regulated tributaries can include substantially elevated flows above required flow levels and above unimpaired conditions (i.e., greater than 100 percent unimpaired flow) in summer and fall to supply downstream water diversions from the streams and the Delta or when flood control releases are made. In order to meet the instream flow and cold water habitat objective and to retain more water in storage for cold water habitat protection, summer diversions likely would be reduced from existing conditions, which could reduce flows on some tributaries at times. For example, summer and early fall flows likely would be reduced to some extent for tributaries in which substantial storage releases to support downstream diversions create artificially high summer and early fall flows under existing conditions. Increased flows during spring, as well as water supply diversions, can affect reservoir cold water storage volumes. Installation of TCDs or other structural modifications may be necessary on some tributaries to address these issues. These issues are highlighted below in a discussion of the Sacramento, Feather, and American Rivers to illustrate these points.

Methods for Analysis of Water Temperature Effects on Native Anadromous Fish

As described in Section 7.12.1, *Surface Water*, water temperature was simulated in HEC-5Q for water years 1923 through 2015 for the three largest tributaries in the Sacramento River watershed: the Sacramento, Feather, and American Rivers. The following discussion summarizes the methodology used for evaluating the temperature results for effects on native anadromous fish in these rivers, including winter-run, spring-, and fall-/late fall-run Chinook salmon; Central Valley steelhead; and green sturgeon. More details on the methodology are provided in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*.

Simulated water temperatures at multiple river locations were compared with a suite of temperature criteria for all upstream life stages of the fish species analyzed. Most of these criteria were obtained from scientific literature and correspond to scientifically determined biological outcomes, such as suitable, optimal, or lethal temperature ranges. As such, they have purely biological relevance and do not imply any regulatory weight. For example, many of the criteria are not consistently met under the baseline conditions. The suite of criteria is presented in Table A6-48 through Table A6-50 in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*; these tables include citations for the origin of each criterion. Some criteria are based on a daily average temperature and others are based on a 7DADM temperature.

The evaluation of temperature effects on fish consisted of three steps. First, the percent of days that exceeded a given criterion for each month and water year type was determined for the baseline and each flow scenario. The difference in frequency of exceedance between the baseline and each flow scenario was then calculated for each month and water year type.

Second, for all days when the modeled temperature exceeded a given temperature criterion, the average daily magnitude of exceedance above the criterion was calculated for each month and water year type. The difference in average daily magnitude of exceedance between the baseline and each flow scenario was then calculated for each month and water year type.

In the final step, a biologically meaningful screening tool was used to determine whether further investigation was warranted. A *biologically meaningful* effect was defined as the months and water year types in which water temperature results met two criteria: (1) the difference in frequency of exceedance between baseline and a flow scenario was greater than 5 percent; and (2) the difference in average daily exceedance between baseline and a flow scenario was greater than 0.5°F. The screening process requires both criteria to be met because brief periods of elevated temperatures or longer periods of minimal increases in temperature are not expected to substantially affect fish populations. In addition, small differences between simulated baseline and flow scenario temperatures are expected due to noise in the modeling results, so small increases should not be flagged for concern.

The 5-percent criterion is based on best professional judgment of fisheries biologists from NMFS, CDFW, DWR, and Reclamation and is consistent with the assumed level of model noise associated with hydrologic and water temperature modeling. The 0.5°F criterion is based on (1) a review of the water temperature-related mortality rates for steelhead eggs and juveniles that indicated changes in temperature of <0.5°F had little effect on survival (DWR 2016, Appendix 5.D); and (2) a reasonable water temperature differential that could be detected in measurements that track the effect of changes in real-time operations. The 0.5°F value was applied to all species/races and life stages, although it was partially based on data for steelhead eggs and juveniles.

For those months and water year types that met these two criteria, a thorough review was conducted to determine whether these patterns were persistent across multiple year types and months. In addition, the occurrence of exceedance relative to the temporal and spatial patterns of fish presence, the magnitude of temperature increase, and whether the differences could be alleviated during real-time operations (i.e., the results are due to a model artifact when in reality, the system would not be operated in this way) were considered.

Sacramento River

In Shasta Reservoir, temperature management is an ongoing concern under existing conditions. With the construction and operation of Shasta and Keswick Dams, winter-run Chinook salmon no longer have access to historical cold water habitat above Shasta Reservoir. Their only remaining habitat is limited to a small stretch of the Sacramento River below Keswick Dam, where cooler temperatures are dependent on reservoir releases. During the temperature management season (May 15 to October 31), the Shasta Dam TCD is operated to selectively withdraw colder water from deeper depths of the reservoir to meet instream temperature requirements for winter-run Chinook salmon in the upper Sacramento River. Spring-run Chinook salmon and fall-run Chinook salmon also inhabit the upper Sacramento River and are similarly affected by Shasta Reservoir operations. Shasta Reservoir on the Sacramento River is currently operated in accordance with Water Right Order 90-5 and the 2019 NMFS BiOp; although, as part of ongoing litigation, certain operational requirements from the 2019 NMFS BiOp were modified by an interim operations plan for water year 2022 (2022 IOP) and may be modified in the future with completion of new BiOps for the continued operation of the CVP and SWP. Order 90-5 requires Reclamation to take actions reasonably within its control to protect winter-run Chinook salmon and other native species from elevated temperatures and other adverse conditions created by its operations on the Sacramento River. Order 90-5 establishes temperature requirements on Reclamation's operations of Keswick Dam, Shasta Dam, the Spring Creek Power Plant, and the Trinity River Division related to temperature control in the upper Sacramento River for the protection of fishery resources, and requires monitoring and reporting to evaluate compliance with those requirements. In accordance with Order 90-5, if there are factors beyond Reclamation's reasonable control that prevent it from meeting 56°F at RBDD, Reclamation may prepare a Temperature Management Plan for consideration by the State Water Board proposing that the compliance point be moved upstream.

Also, in accordance with the 2019 BiOp, Reclamation manages the cold water pool at Shasta Reservoir to protect winter-run Chinook salmon using a tiered approach based on hydrology and available cold water to achieve a target of 53.5°F to 56°F or higher in the upper Sacramento River above Clear Creek from May 15 to October 31. The cold water management approach from the 2019 NMFS BiOp was modified for the 2022 water year as part of the 2022 IOP by (1) reducing maximum temperatures in critical (55°F) and dry and below normal years (54°F); and (2) requiring that Reclamation determine an end-of-September carryover storage goal for Shasta Reservoir that would vary according to water year type and availability of water (the 2019 NMFS BiOp had no carryover storage goals). Shasta Reservoir cold water pool management may be modified in future years as a result of the ongoing ESA reconsultation and the resulting BiOps.

The potential water temperature-related effects of each flow scenario in the Sacramento River were evaluated for the following fish species: winter-, spring- and fall-/late fall-run Chinook salmon; Central Valley steelhead; and green sturgeon. Suitable water temperature criteria for these species are presented in Table A6-48 of Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*. As described under the *Methods for Analysis of Water Temperature Effects on Native Anadromous Fish*, these criteria were taken from peer-reviewed literature and agency technical reports. Section 7.12.1, *Surface Water*, provides a description of the modeled changes in Shasta storage and release flows that can drive changes in Sacramento River temperatures along with a description of the resulting temperature effects. Water temperatures are generally similar under the baseline and flow scenarios, except during two times of year. In June and July, the 90th percentile of water temperatures is generally higher under the flow scenarios compared with baseline (Table 7.12.1-8). In October, the 90th percentile of water temperatures is generally lower under the flow scenarios relative to the baseline.

Winter-Run Chinook Salmon

Adult winter-run Chinook salmon primarily hold and spawn in the coldest portion of the Sacramento River from below Keswick Dam down to Clear Creek from January through October. Between 2006 and 2020, 99.1 percent of winter-run redds in the Sacramento River were located upstream of Airport Road Bridge, which is approximately 5 miles downstream of Clear Creek (CDFW 2021). Fry and juveniles rear and migrate in the Sacramento River between July and March.

Model results indicate that water temperatures under the baseline scenario would generally be lower than the winter-run criteria, except during the spawning, embryo, and alevin incubation period. At Keswick and Clear Creek, there would be up to 24.7 and 35.8 percent of days that exceed the spawning, egg incubation, and alevin temperature criteria, respectively, depending on the criterion evaluated (Table 7.6.2-12). At Balls Ferry, Bend Bridge, and Red Bluff, where <1 percent of winter-run redds were located between 2006 and 2020 (CDFW 2021), baseline conditions would be above the temperature criteria in 66.2 to 88.4 percent of days during April through October. This indicates that baseline conditions are inhospitable for winter-run spawning, egg incubation, and alevins in all but the most upstream locations and generally reflects observed spawning location data. In addition, 33.4 percent of days under the baseline would be above the 64°F fry and juvenile rearing and emigration temperature criterion at Wilkins Slough.

Table 7.6.2-12. Average Percent of Days above Each Winter-Run Chinook Salmon Water Temperature Criterion under Baseline, Sacramento River

Life Stage	Months Present	Location	Criteria (°F) Daily Average	Criteria (°F) 7DADM	Average Percent of Days above Criteria under Baseline [a]
Adult immigration	December through August	Keswick		68	0.0
		Bend Bridge		68	0.1
		Red Bluff		68	0.0
Adult holding	January through August	Keswick		61	0.1
		Balls Ferry		61	0.5
		Red Bluff		61	4.6
Spawning, egg incubation, and alevins	April through October	Keswick		55.4	9.8
		Clear Creek		55.4	34.8
		Balls Ferry		55.4	66.2
		Bend Bridge		55.4	80.7
		Red Bluff		55.4	88.4
	May through October	Keswick	53.5		24.7
		Clear Creek	53.5		35.8
		Keswick	56		4.8
		Clear Creek	56		10.1
Fry and Juvenile	July through March	Keswick		61	1.4
		Clear Creek		61	2.0
		Balls Ferry		61	2.0

Life Stage	Months Present	Location	Criteria (°F) Daily Average	7DADM	Average Percent of Days above Criteria under Baseline [a]
Rearing and Emigration		Bend Bridge		61	2.8
		Red Bluff		61	4.5
		Wilkins Slough		64	33.4

°F = degrees Fahrenheit

7DADM = Seven-day average daily maximum

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on winter-run Chinook salmon is provided in Table 7.6.2-13. Detailed results for all months and water year types when the species is present at each location are provided in Tables A6-56 through A6-76 in Appendix A6, *Water Temperature Modeling for the Sacramento, Feather, and American Rivers*. The frequency of favorable and unfavorable results for the 45, 55, and 65 scenarios would be low for adult immigration and holding life stages (Table 7.6.2-13). The frequency of unfavorable results would generally be low for the spawning, egg incubation, and alevins, and fry and juvenile rearing and emigration life stages under the 45, 55, and 65 scenarios, although the frequency of unfavorable results under the 65 scenario for spawning, egg incubation, and alevin life stage would be 10.5 percent There would be 4.4 to 10.2 percent of month-water year type combinations with favorable outcomes for these life stages under the 45, 55, and 65 scenarios, indicating that there would be a higher frequency of favorable compared with unfavorable results for the 45 and 55 scenarios.

Table 7.6.2-13. Summary of Potential Effects of Flow Scenarios on Winter-Run Chinook Salmon, Sacramento River

Life Stage	Flow Scenario 35	45	55	65	75
Adult Immigration					
Favorable [a]	0%	0%	0%	0%	0%
Unfavorable [b]	0%	0%	0%	0%	0%
Adult Holding					
Favorable	3.3%	3.3%	1.7%	0.8%	1.7%
Unfavorable	2.5%	3.3%	1.7%	3.3%	8.3%
Spawning, Egg Incubation, and Alevins					
Favorable	9.2%	10.2%	10.2%	9.8%	7.1%
Unfavorable	2.0%	3.1%	3.4%	10.5%	23.4%
Fry and Juvenile Rearing and Emigration					
Favorable	8.5%	8.1%	9.3%	4.4%	0.7%
Unfavorable	0.7%	0.7%	1.1%	2.2%	7.4%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline, and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline, and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

Spring-Run Chinook Salmon

Spring-run Chinook salmon adults migrate upstream and hold in the upper Sacramento River between March and September. Spawning occurs between August and December mostly upstream of Balls Ferry, although spawning in the mainstem Sacramento River has been rare since the 1990s (Azat 2022; CDFW 2021). Although the majority of spring-run emigrate in the spring as fry, a small proportion oversummer in their natal habitat and exit on the first flush in the fall or winter (called *yearlings*). Combined, fry and yearlings can be observed rearing in the Sacramento River year-round, although most yearlings rear in their natal streams.

Modeled water temperatures under the baseline scenario would generally be lower than the spring-run Chinook salmon water temperature criteria used for this analysis for adult migration and holding life stages (Table 7.6.2-14). There are between 13.6 and 56.1 percent of days above the water temperature criteria for spawning and embryo incubation under the baseline scenario, depending on location. This indicates that baseline conditions are inhospitable for a substantial portion of the spring-run spawning period, and conditions worsen from upstream to downstream. Water temperatures under the baseline scenario during the fry and juvenile emigration period are rarely above the temperature criteria at all locations except at Wilkins Slough, where temperatures are above the 64°F criterion in 41 percent of days.

Table 7.6.2-14. Average Percent of Days above Each Spring-Run Chinook Salmon Water Temperature Criterion under Baseline, Sacramento River

Life Stage	Months Present	Location	Criterion (7DADM) (°F)	Average Percent of Days above Criterion under Baseline [a]
Adult immigration	March through September	Keswick	68	0.0
		Bend Bridge	68	0.1
		Red Bluff	68	0.2
Adult holding	April through September	Keswick	61	1.0
		Balls Ferry	61	1.9
		Red Bluff	61	9.4
Spawning, egg incubation, and alevins	August through December	Keswick	55.4	13.6
		Clear Creek	55.4	33.8
		Balls Ferry	55.4	42.8
		Bend Bridge	55.4	47.9
		Red Bluff	55.4	56.1
Fry and juvenile rearing and emigration	Year-round	Keswick	61	1.1
		Clear Creek	61	1.5
		Balls Ferry	61	1.6
		Bend Bridge	61	3.0
		Red Bluff	61	5.5
		Wilkins Slough	64	41.0

7DADM = Seven-day average daily maximum
°F = degrees Fahrenheit
[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on spring-run Chinook salmon is provided in Table 7.6.2-15. Detailed results for all months and water year types when the species is present at each location are provided in Tables A6-77 through A6-93 in Appendix A6, *Water Temperature Modeling for the Sacramento, Feather, and American Rivers*. There would be no favorable or unfavorable results during the adult immigration life stage for the 45, 55, or 65 flow scenarios (Table 7.6.2-15). For the remaining life stages of spring-run Chinook salmon, the frequency of favorable results would range from 4.8 to 12.0 percent depending on life stages and flow scenario. In the 45, 55, and 65 scenarios for these life stages, the frequency of favorable results would be equal to or greater than the frequency of unfavorable results.

Table 7.6.2-15. Summary of Potential Effects of Flow Scenarios on Spring-Run Chinook Salmon, Sacramento River

	Flow Scenario				
Life Stage	35	45	55	65	75
Adult Immigration					
Favorable [a]	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable [b]	0.0%	0.0%	0.0%	0.0%	0.0%
Adult Holding					
Favorable	8.9%	6.7%	5.6%	5.6%	3.3%
Unfavorable	3.3%	4.4%	2.2%	4.4%	14.4%
Spawning, Egg Incubation, and Alevins					
Favorable	8.8%	9.6%	12.0%	4.8%	3.2%
Unfavorable	0.0%	0.0%	0.0%	4.8%	13.6%
Fry and Juvenile Rearing and Emigration					
Favorable	6.4%	6.4%	8.1%	5.6%	3.1%
Unfavorable	1.4%	1.9%	1.4%	2.8%	6.9%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline, and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline, and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

Fall-Run Chinook Salmon

Fall-run Chinook salmon adults migrate upstream through the Sacramento River between July and December and spawn within 2 to 4 weeks after arrival to their spawning grounds. Spawning, egg incubation, and alevin presence typically occurs between September through January, mostly upstream of the former location of the RBDD, although redds are regularly found as far downstream as Princeton Ferry even after the 2013 removal of the RBDD (CDFW 2021). Juveniles rear and emigrate from December through June.

Modeled water temperatures under the baseline scenario would generally be lower than the fall-run Chinook salmon water temperature criteria used for this analysis for adult migration and holding life stages (Table 7.6.2-16). There are between 13.6 and 36.2 percent of days above the water temperature criteria for spawning and embryo incubation under the baseline condition, depending on location. This indicates that baseline conditions are inhospitable for a sizable portion of the fall-run spawning period, and conditions worsen from upstream to downstream. Water temperatures under the baseline scenario during the fry and juvenile emigration period would rarely be above the temperature criteria at all locations except at Wilkins Slough, where temperatures are above the 64°F criterion in 27.5 percent of days.

Table 7.6.2-16. Average Percent of Days above Each Fall-Run Chinook Salmon Water Temperature Criterion under Baseline, Sacramento River

Life Stage	Months Present	Location	Criterion (7DADM) °F)	Average Percent of Days above Criterion under Baseline [a]
Adult immigration	July through December	Keswick	68	0.0
		Bend Bridge	68	0.1
		Red Bluff	68	0.2
Adult holding	July through August	Keswick	61	0.6
		Balls Ferry	61	1.2
		Red Bluff	61	5.7
Spawning, egg incubation, and alevins	September through January	Keswick	55.4	13.0
		Clear Creek	55.4	27.7
		Balls Ferry	55.4	26.3
		Bend Bridge	55.4	28.0
		Red Bluff	55.4	36.2
Fry and juvenile rearing and emigration	December through June	Keswick	61	0.0
		Clear Creek	61	0.0
		Balls Ferry	61	0.2
		Bend Bridge	61	1.6
		Red Bluff	61	3.7
		Wilkins Slough	64	27.5

7DADM = Seven-day average daily maximum

°F = degrees Fahrenheit

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on fall-run Chinook salmon is provided in Table 7.6.2-17. Detailed results for all months and water year types when the species is present at each location are provided in Tables A6-94 through A6-110 in Appendix A6, *Water Temperature Modeling for the Sacramento, Feather, and American Rivers*. There would be no favorable or unfavorable results during the adult immigration life stage (Table 7.6.2-17). The frequency of favorable results would be higher than the frequency of unfavorable results for all remaining life stages for the 45 and 55 flow scenarios and in all but one life stage, adult holding, for the 65 flow scenario.

Table 7.6.2-17. Summary of Potential Effects of Flow Scenarios on Fall-Run Chinook Salmon, Sacramento River

	Flow Scenario				
Life Stage	35	45	55	65	75
Adult Immigration					
Favorable [a]	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable [b]	0.0%	0.0%	0.0%	0.0%	0.0%
Adult Holding					
Favorable	13.3%	13.3%	6.7%	3.3%	3.3%
Unfavorable	3.3%	3.3%	3.3%	6.7%	26.7%
Spawning, Egg Incubation, and Alevins					
Favorable	6.4%	8.0%	11.2%	4.8%	3.2%
Unfavorable	0.0%	0.0%	0.0%	4.0%	10.4%
Fry and Juvenile Rearing and Emigration					
Favorable	0.0%	0.5%	1.9%	3.8%	4.3%
Unfavorable	1.4%	2.4%	1.0%	1.9%	2.4%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline, and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline, and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

Late Fall-Run Chinook Salmon

Late fall-run Chinook Salmon adults migrate upstream through the Sacramento River between November and April and spawn shortly after arrival to their spawning grounds. Spawning, egg incubation and alevin presence typically occurs between December and June mostly upstream of Clear Creek (CDFW 2021). Juveniles rear and emigrate in the Sacramento River from March through January.

Modeled water temperatures under the baseline would generally be lower than the late fall-run Chinook salmon water temperature criteria used for this analysis for the adult migration life stage (Table 7.6.2-18). There are between 6.6 and 38.7 percent of days above the water temperature criteria for spawning and embryo incubation under baseline, depending on location. This indicates that baseline conditions are inhospitable for a sizable portion of the late fall-run spawning period, and conditions worsen from upstream to downstream. Water temperatures under baseline during the fry and juvenile emigration period are rarely above the temperatures criteria at all locations except at Wilkins Slough, where temperatures would be above the 64°F criterion in 44.8 percent of days.

Table 7.6.2-18. Average Percent of Days above Each Late Fall-Run Chinook Salmon Water Temperature Criterion under Baseline, Sacramento River

Life Stage	Months Present	Location	Criterion (7DADM) (°F)	Average Percent of Days above Criterion under Baseline [a]
Adult immigration	November through April	Keswick	68	0.0
		Bend Bridge	68	0.0
		Red Bluff	68	0.0
Spawning, egg incubation, and alevins	December through June	Keswick	55.4	6.6
		Clear Creek	55.4	18.7
		Balls Ferry	55.4	30.3
		Bend Bridge	55.4	35.6
		Red Bluff	55.4	38.7
Fry and juvenile rearing and emigration	March through January	Keswick	61	1.2
		Clear Creek	61	1.6
		Balls Ferry	61	1.8
		Bend Bridge	61	3.3
		Red Bluff	61	1.0
		Wilkins Slough	64	44.8

7DADM = Seven-day average daily maximum

°F = degrees Fahrenheit

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on late fall-run Chinook salmon is provided in Table 7.6.2-19. Detailed results for all months and water year types when the species is present at each location are provided in Tables A6-111 through A6-124 in Appendix A6, *Water Temperature Modeling for the Sacramento, Feather, and American Rivers*. There are no month-water year type combinations for the adult migration life stage in which results would be considered favorable or unfavorable under any flow scenario (Table 7.6.2-19). For the spawning, egg incubation, and alevin life stage, the frequencies of favorable and unfavorable results are generally low, except for the 65 flow scenario, in which favorable results would occur in 8 percent of month-water year type combinations. For the fry and juvenile rearing and emigration life stage, favorable results would occur in 5.2 to 6.4 percent of month-water year type combinations under the 45, 55, and 65 flow scenarios, whereas unfavorable results would occur in 0.9 to 1.8 percent of month and water year type combinations. The frequency of favorable results would consistently be higher than or equal to the frequency of unfavorable results for the spawning, egg incubation, and alevin and the fry and juvenile rearing and emigration life stages.

Table 7.6.2-19. Summary of Potential Effects of Flow Scenarios on Late Fall-Run Chinook Salmon, Sacramento River

	Flow Scenario				
Life Stage	35	45	55	65	75
Adult Immigration					
Favorable [b]	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable [c]	0.0%	0.0%	0.0%	0.0%	0.0%
Spawning, Egg Incubation, and Alevins					
Favorable	0.0%	1.1%	3.4%	8.0%	6.9%
Unfavorable	1.1%	1.1%	2.3%	4.6%	8.0%
Fry and Juvenile Rearing and Emigration					
Favorable	5.8%	6.4%	8.5%	5.2%	2.4%
Unfavorable	0.9%	1.5%	0.9%	1.8%	5.8%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline, and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline, and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

Central Valley Steelhead

Adult Central Valley steelhead migrate into freshwater systems in the fall and winter and spawn in their natal streams in winter and spring. Juvenile steelhead rear in freshwater habitats for 1 to 4 years before emigrating to the ocean. A small proportion of adults migrate downstream after spawning, called *kelts*, during approximately February through May.

Modeled water temperatures under baseline are generally lower than the Central Valley steelhead water temperature criteria used for this analysis for all life stages, except spawning, egg incubation, and alevins (

Table 7.6.2-20). For the spawning, egg incubation, and alevin life stage, there are between 6.6 and 38.7 percent of days above the water temperature criteria under baseline, depending on location and criteria. This indicates that baseline conditions may be inhospitable for a sizable portion of the steelhead spawners, eggs, and alevins.

Table 7.6.2-20. Average Percent of Days above Each Central Valley Steelhead Water Temperature Criterion under Baseline, Sacramento River

			Criteria (°F)		Average Percent of Days above Criteria under Baseline
Life Stage	Months Present	Location	Daily Average	7DADM	Daily Average [a]
Adult immigration	August through March	Keswick		68	0.0
			70		0.0
		Bend Bridge		68	0.1
			70		0.0

Life Stage	Months Present	Location	Criteria (°F) Daily Average	7DADM	Average Percent of Days above Criteria under Baseline Daily Average [a]
		Red Bluff		68	0.2
			70		0.0
Adult holding	August through November	Keswick		61	3.2
		Balls Ferry		61	4.4
		Red Bluff		61	8.6
Spawning, egg incubation, and alevins	November through April	Keswick	53		23.4
			56		3.3
		Clear Creek	53		25.0
			56		4.2
		Balls Ferry	53		19.8
			56		4.9
		Bend Bridge	53		21.0
			56		7.2
		Red Bluff	53		21.9
			56		8.8
Kelt emigration	February through May	Keswick		68	0.0
			70		0.0
		Bend Bridge		68	0.0
			70		0.0
		Red Bluff		68	0.0
			70		0.0
Juvenile rearing	Year-round	Keswick	63		0.6
				69	0.0
		Clear Creek	63		0.6
				69	0.0
		Balls Ferry	63		0.6
				69	0.0
		Bend Bridge	63		0.6
				69	0.0
		Red Bluff	63		0.7
				69	0.0
Smolt emigration (excluding migrant parr)	November through June	Keswick		61	0.1
				64	0.0
		Clear Creek		61	0.3
				64	0.0
		Balls Ferry		61	0.3
				64	0.0
		Bend Bridge		61	1.4
				64	0.0
		Red Bluff		61	3.3

Life Stage	Months Present	Location	Criteria (°F) Daily Average	7DADM	Average Percent of Days above Criteria under Baseline Daily Average [a]
				64	0.1
Smoltification	January through March	Keswick	54		0.3
		Clear Creek	54		0.5
		Balls Ferry	54		0.6
		Bend Bridge	54		1.5
		Red Bluff	54		2.5

°F = degrees Fahrenheit

7DADM = Seven-day average daily maximum

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on Central Valley steelhead is provided in

Table 7.6.2-21. Detailed results for all months and water year types when the species is present at each location are provided in Tables A6-125 through A6-174 in Appendix A6, *Water Temperature Modeling for the Sacramento, Feather, and American Rivers*. There would be low frequencies of favorable and unfavorable results for the 45, 55, and 65 flows scenarios for all life stages except adult holding and spawning, egg incubation, and alevins (

Table 7.6.2-21). For the adult holding life stage, the frequency of favorable results would range from 13.3 to 21.7 percent under the 45, 55, and 65 flow scenarios. For the spawning, egg incubation, and alevin life stage, the frequency of favorable results would range from 0.3 to 8.7 percent under the 45, 55, and 65 flow scenarios.

Table 7.6.2-21. Summary of Potential Effects of Flow Scenarios on Central Valley Steelhead, Sacramento River

Life Stage	Flow Scenario 35	45	55	65	75
Adult Immigration					
Favorable [a]	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable [b]	0.0%	0.0%	0.0%	0.0%	0.0%
Adult Holding					
Favorable	23.3%	20.0%	21.7%	13.3%	3.3%
Unfavorable	0.0%	0.0%	0.0%	0.0%	10.0%
Spawning, Egg Incubation, and Alevins					
Favorable	0.0%	0.3%	5.0%	8.7%	8.0%
Unfavorable	0.0%	0.0%	0.0%	0.0%	0.0%
Kelt Emigration					
Favorable	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable	0.0%	0.0%	0.0%	0.0%	0.0%
Juvenile Rearing					
Favorable	0.8%	0.8%	1.2%	0.8%	0.0%

Life Stage	Flow Scenario 35	45	55	65	75
Unfavorable	0.2%	0.2%	0.0%	0.0%	0.8%
Smoltification					
Favorable	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable	0.0%	0.0%	0.0%	0.0%	0.0%
Smolt Emigration (excluding migrant parr)					
Favorable	0.0%	0.3%	0.3%	0.0%	0.3%
Unfavorable	1.0%	1.5%	0.5%	1.0%	1.3%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline, and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline, and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

Green Sturgeon

Non-spawning adult green sturgeon can be present year-round in the Sacramento River near Knights Landing and present farther upstream spawning grounds near Hamilton City to Bend Bridge between August and February. Spawning and embryo incubation occurs during March through July. Larvae and juveniles rear and emigrate downstream throughout the river year-round. Eggs, due to their limited mobility, and larvae and juveniles, because they are more sensitive to temperatures, are considered of higher importance to green sturgeon than other life stages.

Modeled water temperatures under baseline are generally lower than the green sturgeon water temperature criteria used for this analysis for all life stages, with some exceptions at Hamilton City and Knights Landing (Table 7.6.2-22). This indicates that baseline conditions are generally acceptable for green sturgeon except at downstream locations.

Table 7.6.2-22. Average Percent of Days above Each Green Sturgeon Water Temperature Criterion under Baseline, Sacramento River

Life Stage	Months Present	Location on Sacramento River	Criterion (Daily Average) (°F)	Average Percent of Days above Criteria under Baseline Daily Average [a]
Spawning and embryo incubation	March through July	Bend Bridge	63	0.0
		Red Bluff	63	0.1
		Hamilton City	63	20.9
Non-spawning adult presence	August through February	Bend Bridge	66	0.2
			73	0.0
		Red Bluff	66	0.3
			73	0.0
		Hamilton City	66	2.0
			73	0.0

Life Stage	Months Present	Location on Sacramento River	Criterion (Daily Average) (°F)	Average Percent of Days above Criteria under Baseline Daily Average [a]
	Year-round	Knights Landing	66	34.7
			73	6.7
Larval and juvenile rearing and emigration	Year-round	Bend Bridge	66	0.1
		Red Bluff	66	0.2
		Hamilton City	66	2.5
		Knights Landing	66	34.7

°F = degrees Fahrenheit

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on green sturgeon is provided in

Table 7.6.2-23. Detailed results for all months and water year types when the species is present at each location are provided in Tables A6-174 through A6-189 in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*. For the spawning and embryo incubation life stage, the frequency of favorable results would be ≤2.7 percent; and the frequency of unfavorable results would be 5.3 to 8.0 percent under the 45, 55, and 65 scenarios (

Table 7.6.2-23). For the non-spawning adult and larval and juvenile rearing and emigration life stages, the frequency of favorable and unfavorable results would be ≤4.2 percent under the 45, 55, and 65 scenarios.

Table 7.6.2-23. Summary of Potential Effects of Flow Scenarios on Green Sturgeon, Sacramento River

	Flow Scenario				
Life Stage	35	45	55	65	75
Spawning and Embryo Incubation					
Favorable [a]	0.0%	0.0%	1.3%	2.7%	1.3%
Unfavorable [b]	5.3%	8.0%	6.7%	5.3%	8.0%
Non-Spawning Adult Presence					
Favorable	1.5%	3.0%	3.3%	3.9%	3.6%
Unfavorable	1.2%	1.2%	1.2%	1.8%	3.6%
Larval and Juvenile Rearing and Emigration					
Favorable	1.7%	2.9%	3.8%	4.2%	4.2%
Unfavorable	1.7%	1.3%	0.8%	1.7%	3.3%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

American River

Temperature management on the American River is challenging under existing conditions. The lower American River flow schedule specified in the Water Forum's Flow Management Standard (FMS) (^Reclamation et al. 2006) was included in the 2009 NMFS BiOp (RPA Action II.1). The FMS was established in 2006 as a framework to improve the conditions of aquatic resources in the lower American River, particularly fall-run Chinook and steelhead. While the FMS is not a water right condition, the 2019 NMFS BiOp includes a Modified FMS for the American River, which was developed by the American River Water Forum and is intended to improve conditions on the lower American River, reduce the risk of dead pool conditions in Folsom Reservoir, and avoid redirected impacts on Sacramento River salmonids. The 2019 long-term operations plan also includes a commitment to modify the shutters by increasing the number of potential shutter configurations in drought conditions to improve temperature management (^NMFS 2019 BiOp).

The potential water temperature-related effects of each flow scenario in the American River were evaluated for the following fish species: winter- and fall-run Chinook salmon and Central Valley steelhead. Suitable water temperature criteria for these species are presented in Table A6-49 in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*. As described below under the *Methods for Analysis of Water Temperature Effects on Native Anadromous Fish*, these criteria were taken primarily from peer-reviewed scientific literature and agency technical reports. Section 7.12.1, *Surface Water*, provides a description of the modeled changes in Folsom Reservoir storage and release flows that can drive changes in American River temperatures, along with a description of the resulting temperature effects. Water temperatures are generally similar under the baseline and flow scenarios, except during two times of year. During April through August, the 50th and 90th percentiles release temperatures from Folsom Dam were higher than baseline temperatures, particularly for the 65 scenario (see Table 7.12.1-11). At Watt Avenue, the 90th percentile of water temperatures under flow scenarios would be lower than those under the baseline. During March through May, the 90th percentile of water temperatures would be generally lower under the flow scenarios relative to the baseline. During June through August, the 50th and 90th percentiles of water temperatures would be higher under the flow scenarios relative to baseline.

<u>Winter-Run Chinook Salmon</u>

Genetically-confirmed juvenile winter-run Chinook salmon have been caught in rotary screw traps in the American River at Watt Avenue in most years between 2014 and 2021 (Day 2022). These individuals are thought to have spawned outside the American River and moved with high Sacramento River flows backing up into the American River (Phillis et al. 2017).

Model results indicate that water temperatures under baseline would be above the winter-run criterion in 37 percent of days, indicating that baseline conditions are inhospitable for winter-run Chinook salmon rearing during a substantial portion of time (Table 7.6.2-24).

Table 7.6.2-24. Average Percent of Days above the Winter-Run Chinook Salmon Non-Natal Juvenile Rearing Water Temperature Criterion under Baseline, American River

Life Stage	Months Present	Location	Criterion (Daily Average) (°F)	Average Percent of Days above Criterion under Baseline [a]
Non-natal rearing	July through April	Watt Ave	64	37.0

°F = degrees Fahrenheit

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on winter-run Chinook salmon juvenile non-natal rearing in the American River is provided in Table 7.6.2-25. Detailed results for all months and water year types are provided in Table A6-191 in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*. Generally, the frequency of unfavorable results for winter-run Chinook salmon would increase along the gradient of the 45 to 65 flow scenarios, whereas the frequency of favorable results would peak at the 55 flow scenario (Table 7.6.2-25). The frequency of favorable and unfavorable results would be similar for the 45 and 55 flow scenarios, but unfavorable results (6 percent) would be slightly more frequent than favorable results (2 percent) under the 65 flow scenario.

Table 7.6.2-25. Summary of Potential Effects of Flow Scenarios on Winter-Run Chinook Salmon, American River

	Flow Scenario				
Life Stage	35	45	55	65	75
Non-Natal Rearing					
Favorable [a]	2%	2%	4%	2%	2%
Unfavorable [b]	0%	2%	4%	6%	14%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

Fall-Run Chinook Salmon

Fall-run Chinook salmon adults migrate through the American River between July and December and stage for a short period (~2 to 4 weeks) before spawning. Spawning, egg incubation, and alevin presence typically occur between October through February between Watt Avenue and Nimbus Dam. Juveniles rear in and emigrate through the American River from January through May.

Water temperature modeling reveals that baseline conditions in the American River are inhospitable during much of fall-run Chinook salmon freshwater presence (Table 7.6.2-26). Baseline conditions would be somewhat better upstream at Hazel Avenue compared with Watt Avenue.

Table 7.6.2-26. Average Percent of Days above Each Fall-Run Chinook Salmon Water Temperature Criterion under Baseline, American River

Life Stage	Months Present	Location	Criteria (°F) Average Daily	Criteria (°F) 7DADM	Average Percent of Days above Criteria under Baseline [a]
Adult immigration	July through December	Hazel Ave.		68	6.2
		Watt Ave.		68	35.6
Adult holding	July through December	Hazel Ave.		61	49.1
		Watt Ave.		61	69.7
	October	Watt Ave.	60		90.4
Spawning, egg incubation, and alevins	October through February	Hazel Ave.		55.4	49.8
		Watt Ave.		55.4	50.3
	November through December	Watt Ave.	56		57.6
Fry and juvenile rearing and emigration	January through May	Hazel Ave.		61	1.1
		Watt Ave.		64	8.6

°F = degrees Fahrenheit.

7DADM = Seven-day average daily maximum

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on fall-run Chinook salmon is provided in Table 7.6.2-27. Detailed results for all months and water year types when the species is present at each location are provided in Tables A6-192 through A6-201 in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*. Generally, there would be no favorable or unfavorable results for the spawning, egg incubation, and alevin life stages across flow scenarios (Table 7.6.2-27). For the adult immigration and holding life stages, there would be from 6.2 to 13.8 percent of month and water year type combinations in which unfavorable results would be observed under the 45, 55, and 65 flow scenarios, but no favorable results. For the fry and juvenile rearing and emigration life stages, there would be from 10.0 to 12.0 percent of month and water year type combinations in which favorable results would be observed under the 45, 55, and 65 flow scenarios, and no unfavorable results.

Table 7.6.2-27. Summary of Potential Effects of Flow Scenarios on Fall-Run Chinook Salmon, American River

Life Stage	Flow Scenario 35	45	55	65	75
Adult Immigration					
Favorable [a]	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable [b]	3.3%	10.0%	11.7%	13.3%	30.0%
Adult Holding					
Favorable	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable	1.5%	7.7%	6.2%	13.8%	16.9%

Life Stage	Flow Scenario 35	45	55	65	75
Spawning, Egg Incubation, and Alevins					
Favorable	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable	0.0%	0.0%	0.0%	0.0%	0.0%
Fry and Juvenile Rearing and Emigration					
Favorable	8.0%	10.0%	12.0%	10.0%	10.0%
Unfavorable	0.0%	0.0%	0.0%	0.0%	0.0%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

Central Valley Steelhead

Adult steelhead migrate into the American River during October through April. They spawn and eggs and alevins are present between December and May. Juvenile steelhead rear in freshwater habitats for 1 to 4 years before emigrating to the ocean. Kelt migration occurs between February through May.

Modeled water temperatures under baseline would generally be lower than the Central Valley steelhead water temperature criteria used for this analysis for kelt emigration and adult immigration (

Table 7.6.2-28). The baseline for other life stages has up to 57.9 percent of days with water temperatures that would exceed the steelhead criteria. This indicates that baseline conditions may be inhospitable for a sizable portion of these life stages.

Table 7.6.2-28. Average Percent of Days above Each Central Valley Steelhead Water Temperature Criterion under Baseline, American River

Life Stage	Months Present	Location	Criteria (°F) Daily Average	7DADM	Average Percent of Days above Criteria under Baseline Daily Average [a]
Adult immigration	October through April	Hazel Avenue		68	0.9
			70		0.0
		Watt Avenue		68	3.7
			70		0.5
Adult holding	October through November	Hazel Avenue		61	40.2
		Watt Avenue		61	57.9
Spawning, egg incubation, and alevins	December through May	Hazel Avenue	53		30.1
		Watt Avenue	53		48.3

			Criteria (°F)		Average Percent of Days above Criteria under Baseline
Life Stage	Months Present	Location	Daily Average	7DADM	Daily Average [a]
Kelt emigration	February through May	Hazel Avenue		68	0.0
			70		0.0
		Watt Avenue		68	3.2
			70		0.6
Juvenile rearing	Year-round	Hazel Avenue	63		16.8
				69	1.8
		Watt Avenue	63		30.6
				69	16.4
	May 15 - October 31	Watt Avenue	65		44.7
			68		20.8
Smoltification	January through March	Hazel Avenue	54		1.4
		Watt Avenue	54		11.5
Smolt emigration (excluding migrant parr)	December through June	Hazel Avenue		61	3.6
		Watt Avenue		64	11.0

°F = degrees Fahrenheit

7DADM = Seven-day average daily maximum

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on Central Valley steelhead is provided in Table 7.6.2-29. Detailed results for all months and water year types when the species is present at each location are provided in Tables A6-202 through A6-223 in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*. There would be low frequencies of favorable and unfavorable results for the 45, 55, and 65 flow scenarios for adult immigration, adult holding, and kelt emigration (Table 7.6.2-29). There would be a higher frequency of favorable than unfavorable results for the spawning, egg incubation, alevin, and smoltification life stages but a higher frequency of unfavorable than favorable results for the juvenile rearing life stage under the 45, 55, and 65 flow scenarios. There would be similar frequencies of favorable and unfavorable results for the smolt emigration life stage under the 45, 55, and 65 flow scenarios.

Table 7.6.2-29. Summary of Potential Effects of Flow Scenarios on Central Valley Steelhead, American River

	Flow Scenario				
Life Stage	35	45	55	65	75
Adult Immigration					
Favorable [a]	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable [b]	0.0%	0.0%	0.0%	0.0%	0.7%
Adult Holding					
Favorable	0.0%	0.0%	0.0%	0.0%	0.0%

Life Stage	Flow Scenario 35	45	55	65	75
Unfavorable	0.0%	0.0%	0.0%	0.0%	5.0%
Spawning, Egg Incubation, and Alevins					
Favorable	0.0%	3.3%	8.3%	6.7%	10.0%
Unfavorable	0.0%	0.0%	0.0%	1.7%	3.3%
Kelt Emigration					
Favorable	2.5%	2.5%	3.8%	3.8%	2.5%
Unfavorable	0.0%	0.0%	0.0%	0.0%	0.0%
Juvenile Rearing					
Favorable	2.0%	2.3%	3.7%	3.3%	3.3%
Unfavorable	3.7%	9.0%	12.3%	16.7%	26.7%
Smoltification					
Favorable	0.0%	6.7%	6.7%	6.7%	10.0%
Unfavorable	0.0%	0.0%	0.0%	0.0%	0.0%
Smolt Emigration (excluding migrant parr)					
Favorable	5.7%	7.1%	8.6%	7.1%	7.1%
Unfavorable	2.9%	5.7%	8.6%	8.6%	7.1%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

Feather River

Temperature management on the Feather River is challenging under existing conditions. The Oroville Facilities Hydroelectric Project (FERC No. 2100) is currently undergoing FERC relicensing. The project is currently operating under an annual license which extends the terms of the original license. In 2010, the State Water Board issued a water quality certification (WQ 2010-0016) for the Oroville Facilities Hydroelectric Project that will become a part of the Commission’s 30- to 50-year operating license for the Oroville Facilities.

The water quality certification identified inadequate protection of downstream cold water beneficial uses. DWR’s studies showed that water temperatures in the low flow channel (LFC) and high flow channel (HFC) were contributing to adverse conditions for anadromous salmonids. Studies have shown that conditions are inhospitable to spawning and rearing in the Feather River below the Thermalito Afterbay Outlet (HFC). Water temperature monitoring in 2002 and 2003 showed that the temperature of water released from Thermalito Afterbay was as much as 11.3°F higher than that of incoming water. DWR concluded that increased incidence of disease, developmental abnormalities, in-vivo egg mortality, and temporary cessation of migration could occur due to elevated water temperatures in some areas of the lower Feather River.

In 2006, DWR signed a Settlement Agreement, which contains interim water temperature targets and a framework for developing final temperature requirements based on implementation of facility modifications to improve cold water management capabilities in the Feather River (DWR 2006). The State Water Board's 2010 water quality certification includes more than 20 elements of the Settlement Agreement. The 2010 water quality certification states that the water temperatures specified in the 2006 Settlement Agreement are necessary for the protection of cold freshwater, spawning, and migration beneficial uses of the Feather River. As part of the Settlement Agreement and under the water quality certification, DWR is required to develop a Feasibility Study and Implementation Plan (FSIP) for Facility Modification(s) to improve temperature conditions for spawning, incubation, rearing, and holding of anadromous fish within 3 years of FERC license issuance. The FSIP will select a preferred alternative based on the potential range of facility modification alternatives identified in the 2006 Reconnaissance Study, which was a precursor study to the FSIP. The primary objectives of the FSIP are to improve accessibility to the cold water pool in Lake Oroville, minimize heat gains from the dam to targeted downstream locations in the Feather River, and reduce cold and warm water mixing in Thermalito Afterbay (NMFS 2016b). The FSIP will include a recommended alternative that may include both structural and operational modifications, which will be designed to meet specific temperature objectives in the LFC and HFC during all years except those years considered severe dry years under the Oroville Temperature Management Index (DWR 2006). The FSIP will include a proposed implementation schedule, fisheries monitoring program, and adaptive management framework. The water quality certification also includes temperature requirements for the Feather River Fish Hatchery to aid in managing disease outbreaks. The State Water Board's water quality certification includes interim and final deadlines for completing the FSIP and any required facility modifications to meet interim and final temperature requirements in the LFC, HFC, and Feather River Fish Hatchery. Multiple ongoing efforts are being conducted to further inform the upcoming FSIP, including updated water temperature modeling for the Oroville Facilities project area, the development of a 2006 Reconnaissance Study Addendum that will include information on regulatory requirement changes and other recent advancements such as the Comprehensive Needs Assessment and the River Valve Outlet System, and reoccurring technical advisory group meetings to inform these efforts.

In addition, reservoirs above Oroville contribute to existing temperature problems. For example, the North Fork Feather River is listed as impaired for temperature due to hydromodification and flow regulation, with summer temperatures frequently exceeding 20°C, which has been widely accepted as a temperature target needed to reasonably protect cold freshwater habitat. Pacific Gas and Electric Company (PG&E), the owner and operator of the Upper North Fork Feather River Hydroelectric Project (FERC Project No. 2105), has studied a number of different infrastructure improvements (e.g., installation of thermal curtains) and changes in project operations (e.g., supplemental releases from Canyon Dam) to address the problem in its relicensing process.

The potential water temperature-related effects of each flow scenario in the Feather River were evaluated for the following fish species: winter-, spring- and fall-run Chinook salmon; Central Valley steelhead; and green sturgeon. Suitable water temperature criteria for these species are presented in Table A6-50 in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*. As described below under the *Methods for Analysis of Water Temperature Effects on Native Anadromous Fish*, these criteria were taken from peer-reviewed literature and agency technical reports. Section 7.12.1, *Surface Water*, describes the modeled changes in Oroville Reservoir storage and release flows that can drive changes in Feather River temperatures, along with a description of the resulting temperature effects. In the LFC, the

50th and 90th percentiles of water temperatures would generally be reduced in March and April but would increase during September and October (Table 7.12.1-9). In the HFC, the 50th percentile of water temperatures would generally be reduced during April and May, and the 50th and 90th percentiles would generally increase during July through December.

A sensitivity analysis was conducted to evaluate a scenario in which the Oroville power bypass could start contributing to outflow when Oroville Reservoir storage was less than 1.50 million acre-feet (MAF). The purpose of the exercise was to demonstrate that the simulated temperatures do not necessarily represent final temperature effects and that further actions and optimization could further improve temperatures for fish. The fish analysis was re-run on the entire suite of index values for each flow scenario for the 1.50-MAF power bypass level and compared with the 1.19-MAF power bypass level model runs (Table A6-277 and Table A6-278). For nearly all flow scenarios, species/races, and life stages, there were lower or similar percentages of month-water year type combinations with unfavorable results and higher or similar percentages of month-water year type combinations with favorable results under the 1.50-MAF power bypass level compared with results under the 1.19-MAF power bypass level.

Winter-Run Chinook Salmon

Juvenile winter-run-sized Chinook salmon have been caught in rotary screw traps at the downstream end of the LFC and in the HFC of the Feather River (Bilski and Kindopp 2009). Phillis et al. (2017) found limited otolith microchemistry evidence that winter-run Chinook salmon rear in the Feather River on their way to the ocean.

Model results indicate that water temperatures under baseline would be above the winter-run criterion in 24.8 percent of days at Gridley, indicating that baseline conditions in the Feather River HFC are inhospitable for winter-run Chinook salmon rearing during a sizable portion of time (Table 7.6.2-30).

Table 7.6.2-30. Average Percent of Days above the Winter-Run Chinook Salmon Non-Natal Juvenile Rearing Water Temperature Criterion under Baseline, Feather River

Life Stage	Months Present	Location	Criterion (Daily Average) (°F)	Average Percent of Days above Criterion under Baseline [a]
Non-natal rearing	July through March	Above Thermalito Afterbay Outlet	64	9.5
		Gridley	64	24.8

°F = degrees Fahrenheit

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on winter-run Chinook salmon juvenile non-natal rearing in the Feather River is provided in Table 7.6.2-31. Detailed results for all months and water year types by location are provided in Tables A6-225 through A6-226 in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*. There would be no favorable results to winter-run Chinook salmon rearing; between 10.0 and 16.7 percent of month-water year type combinations would have unfavorable results (Table 7.6.2-31). The frequency of unfavorable results for winter-run Chinook salmon would increase along the gradient of the 45 to 65 flow scenarios.

Table 7.6.2-31. Summary of Potential Effects of Flow Scenarios on Winter-Run Chinook Salmon, Feather River

	Flow Scenario				
Life Stage	35	45	55	65	75
Non-Natal Rearing					
Favorable [a]	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable [b]	4.4%	10.0%	11.1%	16.7%	21.1%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

Spring-Run Chinook Salmon

Spring-run Chinook salmon adults migrate through the Feather River between March and June and hold through September. Spawning and egg incubation occur and alevins are present from September through February; fry and juvenile rearing and emigration typically take place between November and June.

Water temperature modeling reveals that baseline conditions in the Feather River are inhospitable during much of the time spring-run Chinook salmon are present, particularly in the HFC (Table 7.6.2-32). Over the past two decades, the majority of Chinook salmon have spawned and reared in the LFC relative to the HFC (DWR 2021), due at least in part to the poor habitat conditions that exist in the HFC.

Table 7.6.2-32. Average Percent of Days above Each Spring-Run Chinook Salmon Water Temperature Criterion under Baseline, Feather River

Life Stage	Months Present	Location	Criterion (7DADM) (°F)	Average Percent of Days above Criterion under Baseline [a]
Adult immigration	March through June	LFC below Fish Barrier Dam	68	0
		HFC below Thermalito Afterbay Outlet	68	4.1
Adult holding	April through September	LFC below Fish Barrier Dam	61	15.8
		HFC below Thermalito Afterbay Outlet	61	69.9
Spawning, egg incubation, and alevins	September through February	LFC below Fish Barrier Dam	55.4	17.6
		HFC below Thermalito Afterbay Outlet	55.4	36.4

Life Stage	Months Present	Location	Criterion (7DADM) (°F)	Average Percent of Days above Criterion under Baseline [a]
Fry and juvenile rearing and emigration	November through June	LFC below Fish Barrier Dam	61	1.0
		HFC below Thermalito Afterbay Outlet	64	11.4

7DADM = Seven-day average daily maximum; °F = degrees Fahrenheit; LFC = low flow channel; HFC = high flow channel

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on spring-run Chinook salmon is provided in Table 7.6.2-33. Detailed results for all months and water year types when the species is present at each location are provided in Tables A6-227 through A6-234 in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*. There would be no favorable or unfavorable results for the adult immigration life stage under the 45, 55, and 65 flow scenarios (Table 7.6.2-33). For the adult holding and spawning, egg incubation, and alevin life stages, there would be more unfavorable than favorable instances for the 45, 55, and 65 flow scenarios. The frequency of both favorable and unfavorable results for fry and juvenile rearing and emigration life stages would be low under the 45, 55, and 65 flow scenarios.

Table 7.6.2-33. Summary of Potential Effects of Flow Scenarios on Spring-Run Chinook Salmon, Feather River

	Flow Scenario				
Life Stage	35	45	55	65	75
Adult Immigration					
Favorable [a]	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable [b]	0.0%	0.0%	0.0%	0.0%	5.0%
Adult Holding					
Favorable	3.3%	5.0%	10.0%	11.7%	13.3%
Unfavorable	8.3%	8.3%	15.0%	15.0%	26.7%
Spawning, Egg Incubation, and Alevins					
Favorable	1.7%	1.7%	0.0%	0.0%	0.0%
Unfavorable	18.3%	18.3%	18.3%	18.3%	35.0%
Fry and Juvenile Rearing and Emigration					
Favorable	3.8%	2.5%	2.5%	2.5%	2.5%
Unfavorable	1.3%	0.0%	2.5%	3.8%	5.0%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

Fall-Run Chinook Salmon

Fall-run Chinook salmon adults migrate through the Feather River between August and December and stage for a short period (~2 to 4 weeks) before spawning. Spawning, egg incubation, and alevin presence typically occur between October through February mostly in the LFC, but also in the HFC. Juveniles rear in and emigrate through the Feather River from November through May.

Water temperature modeling reveals that baseline conditions in the Feather River are inhospitable during the adult holding and spawning, egg incubation, and alevin life stages of fall-run Chinook salmon, particularly in the HFC (Table 7.6.2-34). Over the past two decades, the majority of Chinook salmon have spawned and reared in the LFC relative to the HFC (DWR 2021), due at least in part to the poor habitat conditions that exist in the HFC.

Table 7.6.2-34. Average Percent of Days above Each Fall-Run Chinook Salmon Water Temperature Criterion under Baseline, Feather River

Life Stage	Months Present	Location	Criterion (7DADM) (°F)	Average Percent of Days above Criterion under Baseline [a]
Adult immigration	August through December	LFC below Fish Barrier Dam	68	0.1
		HFC below Thermalito Afterbay Outlet	68	5.2
Adult holding	August through December	LFC below Fish Barrier Dam	61	11.3
		HFC below Thermalito Afterbay Outlet	61	31.5
Spawning, egg incubation, and alevins	October to February	LFC below Fish Barrier Dam	55.4	15.8
		HFC below Thermalito Afterbay Outlet	55.4	23.7
Fry and juvenile rearing and emigration	November through May	LFC below Fish Barrier Dam	61	0.0
		HFC below Thermalito Afterbay Outlet	64	2.6

7DADM = Seven-day average daily maximum; °F = degrees Fahrenheit; LFC = low flow channel; HFC = high flow channel

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on fall-run Chinook salmon is provided in Table 7.6.2-35. Detailed results for all months and water year types when the species is present at each location are provided in Tables A6-235 through A6-242 in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*. There would be unfavorable results for fall-run adult immigration that range from 2 percent of month-water year type combinations under the 45 flow scenario to 8 percent of combinations under the 65 flow scenario (Table 7.6.2-35). Compared with the adult immigration life stage, there would be a larger incidences of unfavorable results (14 to 26 percent) for the adult holding, spawning, egg incubation, and alevin life stages under the 45, 55, and 65 flow scenarios. There would be no unfavorable results for fry and juvenile rearing and emigration life stages under the 45, 55, and

65 flow scenarios. Generally, there would be no or minimal favorable results for any fall-run Chinook salmon life stage under the 45, 55, and 65 flow scenarios.

Table 7.6.2-35. Summary of Potential Effects of Flow Scenarios on Fall-Run Chinook Salmon, Feather River

	Flow Scenario				
Life Stage	35	45	55	65	75
Adult Immigration					
Favorable [a]	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable [b]	0.0%	2.0%	4.0%	8.0%	22.0%
Adult Holding					
Favorable	2.0%	2.0%	0.0%	0.0%	0.0%
Unfavorable	10.0%	22.0%	26.0%	22.0%	44.0%
Spawning, Egg Incubation, and Alevins					
Favorable	2.0%	2.0%	0.0%	0.0%	0.0%
Unfavorable	18.0%	16.0%	14.0%	14.0%	32.0%
Fry and Juvenile Rearing and Emigration					
Favorable	2.9%	2.9%	2.9%	2.9%	2.9%
Unfavorable	0.0%	0.0%	0.0%	0.0%	1.4%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

Central Valley Steelhead

Adult steelhead migrate into the Feather River during August through March. They spawn, and eggs and alevins are present between December and May, primarily in the LFC. Juvenile steelhead rear primarily in the LFC for 1 to 4 years before emigrating through the Feather River toward the ocean during December through June. Kelt migration occurs between February through May.

Modeled water temperatures under baseline are generally lower than the Central Valley steelhead water temperature criteria used for this analysis for adult immigration and kelt emigration (Table 7.6.2-36). The baseline for other life stages have up to 45.7 percent of days throughout the modeling period with water temperatures that would exceed the steelhead criteria. This indicates that baseline conditions may be inhospitable for a sizable portion of these life stages, particularly in the HFC. Over the past two decades, the majority of steelhead have spawned and reared in the LFC relative to the HFC (DWR 2021), due at least in part to the poor habitat conditions that exist in the HFC.

Table 7.6.2-36. Average Percent of Days above Each Central Valley Steelhead Water Temperature Criterion under Baseline, Feather River

Life Stage	Months Present	Location	Criteria (°F)		Average Percent of Days above Criteria under Baseline
			Daily Average	7DADM	Daily Average [a]
Adult immigration	August through March	LFC below Fish Barrier Dam		68	0.1
			70		0.0
		HFC below Thermalito Afterbay Outlet		68	3.3
			70		0.2
Adult holding	Sept through November	LFC below Fish Barrier Dam		61	2.8
		HFC below Thermalito Afterbay Outlet		61	19.4
Spawning, egg incubation, and alevins	December through May	LFC below Fish Barrier Dam	53		32.8
		HFC below Thermalito Afterbay Outlet	53		45.7
Kelt emigration	Feb through May	LFC below Fish Barrier Dam		68	0.0
		LFC below Fish Barrier Dam	70		0.0
		HFC below Thermalito Afterbay Outlet		68	0.2
		HFC below Thermalito Afterbay Outlet	70		0.0
Juvenile rearing	Year-round	LFC below Fish Barrier Dam	63		0.3
		LFC below Fish Barrier Dam		69	0.0
		HFC below Thermalito Afterbay Outlet	63		21.6
		HFC below Thermalito Afterbay Outlet		69	2.4
Smoltification	January through March	LFC below Fish Barrier Dam	54		7.6
		HFC below Thermalito Afterbay Outlet	54		16.3

Life Stage	Months Present	Location	Criteria (°F) Daily Average	7DADM	Average Percent of Days above Criteria under Baseline Daily Average [a]
Smolt emigration	December through June	LFC below Fish Barrier Dam		61	1.1
		HFC below Thermalito Afterbay Outlet		64	13.1

°F = degrees Fahrenheit; 7DADM = Seven-day average daily maximum; LFC = low flow channel; HFC = high flow channel

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on Central Valley steelhead is provided in Table 7.6.2-37. Detailed results for all months and water year types when the species is present at each location are provided in Tables A6-243 through A6-262 in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*. There would be low frequencies of favorable and unfavorable results for the 45, 55, and 65 flow scenarios for adult immigration, kelt emigration, and smolt emigration life stages (Table 7.6.2-37). There would be a higher frequency of favorable than unfavorable results for the spawning, egg incubation, alevin, and smoltification life stages but more unfavorable than favorable results for the adult holding and juvenile rearing life stages under the 45, 55, and 65 flow scenarios.

Table 7.6.2-37. Summary of Potential Effects of Flow Scenarios on Central Valley Steelhead, Feather River

Life Stage	Flow Scenario 35	45	55	65	75
Adult Immigration					
Favorable [a]	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable [b]	0.0%	0.6%	1.3%	3.8%	11.9%
Adult Holding					
Favorable	3.3%	3.3%	0.0%	0.0%	0.0%
Unfavorable	16.7%	33.3%	36.7%	30.0%	60.0%
Spawning, Egg Incubation, and Alevins					
Favorable	5.0%	6.7%	10.0%	11.7%	21.7%
Unfavorable	1.7%	1.7%	1.7%	3.3%	1.7%
Kelt Emigration					
Favorable	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable	0.0%	0.0%	0.0%	0.0%	0.0%
Juvenile Rearing					
Favorable	1.3%	1.3%	1.3%	1.3%	1.3%
Unfavorable	2.1%	4.6%	6.7%	13.8%	18.3%
Smoltification					
Favorable	3.3%	6.7%	6.7%	10.0%	13.3%
Unfavorable	3.3%	3.3%	3.3%	3.3%	0.0%

Life Stage	Flow Scenario 35	45	55	65	75
Smolt Emigration (excluding migrant parr)					
Favorable	4.3%	2.9%	2.9%	2.9%	2.9%
Unfavorable	1.4%	0.0%	2.9%	4.3%	5.7%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

Green Sturgeon

Non-spawning adult green sturgeon can be present in the Feather River between August and November. Spawning and embryo incubation occurs during March through July. Larvae and juveniles rear and emigrate downstream throughout the river year-round.

Modeled water temperatures under baseline generally would be lower than the green sturgeon water temperature criteria used for this analysis for all life stages in the LFC (Table 7.6.2-38). Temperatures under baseline in the HFC would be higher than the criteria up to 44.2 percent of the time, depending on location and criteria used for each life stage. This indicates that baseline conditions may be inhospitable for a sizable portion of these life stages in the HFC.

Table 7.6.2-38. Average Percent of Days above Each Green Sturgeon Water Temperature Criterion under the Baseline Flow Scenario, Feather River

Life Stage	Months Present	Location	Criterion (Daily Average) °F)	Average Percent of Days above Criterion under Baseline Daily Average [a]
Non-spawning adult presence	August through November	LFC below Fish Barrier Dam	66	0.1
			73	0.0
		HFC below Thermalito Afterbay Outlet	66	8.5
			73	0.0
		HFC at Gridley	66	14.0
			73	0.1
Spawning and embryo incubation	March through July	LFC below Fish Barrier Dam	63	0.0
		HFC below Thermalito Afterbay Outlet	63	32.9
		HFC at Gridley	63	44.2
Larval to juvenile rearing and emigration	Year-round	LFC below Fish Barrier Dam	66	0.0
		HFC below Thermalito Afterbay Outlet	66	6.9
		HFC at Gridley	66	11.6

°F = degrees Fahrenheit; LFC = low flow channel; HFC = high flow channel

[a] Shading provided only to attract attention to higher values.

A summary of potential temperature-related effects of the flow scenarios on green sturgeon is provided in Table 7.6.2-39. Detailed results for all months and water year types when the species is present at each location are provided in Tables A6-262 through A6-274 in Appendix A6, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, and American Rivers*. There would be moderate frequencies of both favorable and unfavorable results for spawning and embryo incubation life stages under the 45, 55, and 65 flow scenarios (Table 7.6.2-39). There would be minimal to moderate frequencies of unfavorable results for the non-spawning adult and larval and juvenile rearing and emigration life stages under the 45, 55, and 65 flow scenarios. The frequency of unfavorable results would increase between the 45 and 65 flow scenarios.

Table 7.6.2-39. Summary of Potential Effects of Flow Scenarios on Green Sturgeon, Feather River

	Flow Scenario				
Life Stage	35	45	55	65	75
Spawning and Embryo Incubation					
Favorable [a]	5.3%	9.3%	10.7%	10.7%	12.0%
Unfavorable [b]	4.0%	6.7%	13.3%	16.0%	21.3%
Non-Spawning Adult Presence					
Favorable	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable	0.8%	1.7%	3.3%	10.8%	23.3%
Larval and Juvenile Rearing and Emigration					
Favorable	0.0%	0.0%	0.0%	0.0%	0.0%
Unfavorable	1.7%	3.3%	6.7%	11.7%	20.6%

Presented as the percent of month-water year type combinations with favorable and unfavorable results of the flow scenario compared with baseline at all locations combined.

[a] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% lower than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5 degree Fahrenheit (°F) lower than the exceedance under the baseline.

[b] The following criteria are met: (1) frequency of exceedance above the temperature criteria under the flow scenario was >5% higher than the frequency of exceedance under the baseline; and (2) average daily exceedance above the temperature criteria under the flow scenario was >0.5°F higher than the exceedance under the baseline.

The analysis of temperature-related effects in Sacramento River watershed regulated tributaries other than the Sacramento, American, and Feather Rivers relied on a qualitative interpretation of SacWAM reservoir storage and flow results. The qualitative analysis used the basic assumption that increases in flow and/or reservoir storage will cause a reduction in water temperatures at or downstream of the location. Results indicate that some reservoirs could experience reductions in carryover storage. Some reservoirs (e.g., Black Butte Reservoir on Stony Creek, Camanche Reservoir on the Mokelumne River) show end-of-September carryover storage that decreases from baseline under most storage conditions and all flow scenarios. Reduced carryover storage could lead to lower flows during fall months. Reductions in flows and carryover storage could reduce cold water habitat and affect special-status fish species in the reaches below these reservoirs.

Sacramento/Delta Upper Watersheds

The proposed Plan amendments could result in changes in streamflows in some locations in the upper watersheds above the valley floor. In general, SacWAM results show higher streamflows in spring and less water released from storage in upper watershed reservoirs during summer months, although substantial effects on storage are not expected in most of these reservoirs. Higher spring flows in the upper watersheds could benefit aquatic biological resources, including fish. However, similar to the valley floor below rim reservoirs, higher spring flows could result in a reduction in reservoir storage at the end of spring and a smaller cold water pool volume in summer and fall months in some upper watershed reservoirs. While many upper watershed reservoirs in the Sacramento/Delta watershed show little change in storage under the proposed Plan amendments, large changes in reservoir water levels and downstream flows could occur for some upper watershed reservoirs, which could affect water temperatures in the reservoirs and downstream reaches. These changes could affect aquatic biological resources, including some special-status fish species that occur in some upper watershed streams (e.g., hardhead, California roach, riffle sculpin). Additional fish species such as rainbow trout and speckled dace also occur in some upper watershed locations and also could be affected by changes in upper watershed reservoir levels and changes in downstream water temperatures.

The proposed Plan amendments could result in changes in interbasin transfers, which could affect upper watershed streamflows and stream temperatures. Several stream reaches below the reservoirs and canals associated with Nevada Irrigation District's Yuba-Bear Hydroelectric Project (FERC Project No. 2266) and PG&E's Drum-Spaulding Project (FERC Project No. 2310) could see large changes in flows compared with existing conditions, which could affect aquatic biological resources (including fish) in these reaches. Together, under existing conditions, these hydroelectric projects involve the transfer of water from the Middle Yuba River, South Yuba River, and North Fork of the North Fork American River to the Bear River watershed; and the transfer of water from the Bear River to the Sacramento River basin. In general, SacWAM results show that Middle and South Yuba River flows could increase during nearly all months compared with existing conditions, and Bear River flows below Drum Canal inflows could decrease during all months compared with existing conditions. In addition to potential changes in flow, these potential changes could affect water temperatures. In areas where streamflows could increase compared with existing conditions, some aquatic biological resources could benefit from these changes. For example, under existing conditions, the South Yuba River is listed as impaired for temperature under Clean Water Act section 303(d). Increased flows in the South Yuba River below Lake Spaulding could provide some temperature-related benefits for native fish species and could increase the extent of suitable habitat for rainbow trout (FERC 2014). However, optimal flow conditions can differ significantly among the various aquatic resources present in these streams. It is possible that some species (e.g., hardhead) could be adversely affected by a change that could benefit other species (e.g., rainbow trout). In addition, in upper watershed locations where streamflows could decrease compared with existing conditions, changes in streamflows and temperatures could adversely affect cold water fish species.

Interbasin transfers also occur under the DeSabla-Centerville Hydroelectric Project (FERC Project No. 803), which includes diversion of water from the West Branch Feather River to Butte Creek via the Toadtown Canal. Under existing conditions, diversions from the West Branch Feather River provide cold water for spring-run Chinook salmon holding below Lower Centerville Diversion Dam in Butte Creek (CDFW 2014b). Changes in interbasin transfers under the DeSabla-Centerville Hydroelectric Project could affect spring-run Chinook salmon and other cold water species. However, the SacWAM results for the 45 to 65 scenarios show that average Toadtown Canal inflows would not change from baseline conditions. Therefore, it is unlikely that the proposed Plan amendments would result in significant changes in water temperatures that would affect spring-run Chinook salmon in Butte Creek. The DeSabla-Centerville Hydroelectric Project is currently operating under an expired FERC license (license expiration date: October 2009). In 2017, PG&E withdrew its application from FERC for a new license and announced its intent to sell the project (NOAA 2023). The future of this FERC project is currently unknown, but if the project is not sold, FERC could initiate an "orphaned project" proceeding that could result in decommissioning.

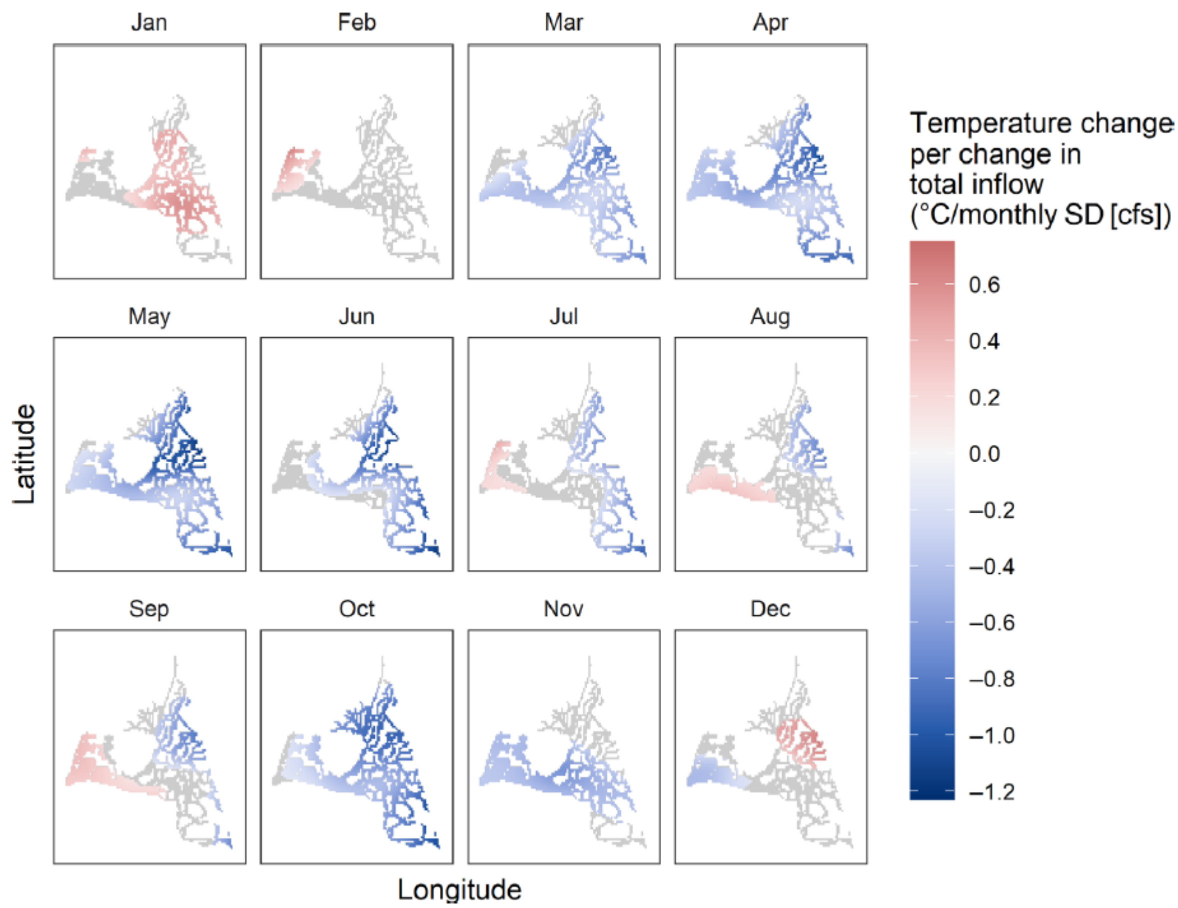
It is important to note that the modeling scenarios represent only one possible operation of these systems. The proposed Plan amendments provide for one or more tributaries to meet flow requirements so long as narrative objectives are met. Parties may develop operational scenarios that reduce the drawdown effects currently reflected in the modeling scenarios.

Sacramento/Delta Unregulated Tributaries

Unregulated tributaries in the Sacramento/Delta with significant spring through fall diversions (e.g., Mill, Deer, and Antelope Creeks) would be expected to have higher streamflows during the spring through fall irrigation season under the 45 to 65 scenarios compared with existing conditions. These changes would include increased flows during key anadromous salmonid migration periods, which would improve passage conditions at critical riffles and other low-flow passage impediments. Increased streamflows during anadromous salmonid migration periods also could provide temperature-related benefits, particularly in the lower watersheds of these tributaries. On unregulated tributaries such as Mill and Deer Creeks, salmonid migration is potentially impeded by warm water temperatures exacerbated by stream diversions (CDFW 2017a, 2017b). Overall, on unregulated tributaries, the proposed Plan amendments would be expected to improve flow and temperature conditions during critical migration periods for adult and juvenile Chinook salmon and steelhead, which would benefit these species.

Sacramento-San Joaquin Delta

There is limited influence of Delta inflow on Delta water temperatures because water generally approaches equilibrium with atmospheric conditions by the time it reaches the Delta. Of the limited influence, Delta water temperature generally increases as Delta inflow declines, although this varies by time of year and location within the Delta (Bashevkin and Mahardja 2022; Vroom et al. 2017; Wagner et al., 2011). During December to February and in the western regions (e.g., West of Franks Tract) during July to September, water temperature decreases as Delta inflow declines (Figure 7.6.2-14) (Bashevkin and Mahardja 2022), but the causal basis of the relationship was not evaluated. Other factors affecting in-Delta water temperatures in addition to meteorological conditions and inflows include snowmelt and tidal dispersion (Gleichauf 2015; Knowles and Cayan 2002; Bashevkin and Mahardja 2022).



Relationship between monthly standardized Delta inflow and surface water temperature presented in Bashevkin and Mahardja (2022). Only areas with significant ($p < 0.001$) temperature-inflow relationships are colored, with gray areas representing no significant temperature-inflow relationship.

°C = degrees Celsius; cfs = cubic feet per second; SD = standard deviation of Delta inflow

Figure 7.6.2-14. Relationship between Delta Inflow and Surface Water Temperature

Changes in hydrology under the proposed Plan amendments would increase Delta inflow during winter and spring months (December through June) when juvenile salmonids are present (see Appendix A1, *Sacramento Water Allocation Model Methods and Results,* Figure A1-46). This increase in Delta inflow may cause a minor increase in water temperatures during winter months (December through February; Figure 7.6.2-14), although available evidence indicates that the positive temperature-inflow relationships in these months may be more related to meteorological effects than effects of inflow (Bashevkin and Mahardja 2022). However, even if increases did occur, water temperatures are not expected to be near any upper limits for these species during these months. Instead, an increase in water temperature could lead to a minor beneficial effect because, if food is not limiting, fish grow faster in warmer water due to higher metabolism, resulting in larger individuals with potentially higher survival (Ward et al. 1989; ^Sommer et al. 2001a). During spring months, the increase in Delta inflow may cause a minor reduction in water temperatures in the Delta and, therefore, potentially a minor beneficial effect or no effect on these species, depending on whether water temperatures are near upper limits for the species. Juvenile salmonids are not typically present in the Delta during July through November, and adult emigrants, which are present in most months, are more tolerant of higher water temperatures than juveniles.

Effects from changes in hydrology on juvenile green sturgeon, which are present in the Delta year-round, are expected to be similar to those described above for juvenile salmonids during winter and spring months. During July through September, the proposed Plan amendments would cause a reduction in Delta inflows, which could reduce water temperatures in the western Delta Figure 7.6.2-14) and potentially provide a minor benefit to green sturgeon juveniles. In October and November, the proposed Plan amendments would cause a reduction in Delta inflows, which could increase water temperatures in the Delta (Figure 7.6.2-14) and potentially cause a minor negative effect on green sturgeon juveniles.

Effects of changes in hydrology on adult Delta smelt immigrating to and spawning in the Delta during December through May would vary by month. During December and January, increased Delta inflow could cause an increase in water temperatures in the Delta (Figure 7.6.2-14), although water temperatures would not be near any upper limits for Delta smelt during this time of year. During February, an increase in Delta inflow would not likely cause changes to water temperature in the Delta (Figure 7.6.2-14) and, therefore, not affect adult Delta smelt. During March through May, increased Delta inflow could cause a decrease in water temperatures in the Delta, potentially providing a minor benefit to adult Delta smelt. Larval Delta smelt are present in the central Delta from March through June. The proposed Plan amendments would increase Delta inflows during this period, which could reduce water temperatures slightly in the Delta, potentially benefiting Delta smelt larvae. Juveniles and sub-adults are present in the central and western Delta during June through December. Those individuals in the central Delta would benefit slightly from increases in Delta inflow associated with proposed Plan amendments during June, October, and November but would not likely be affected during July through September and December. Juveniles and sub-adults in the western Delta would benefit slightly throughout much of the period because the timing of expected increases and decreases in Delta inflow could result in decreases in temperature in the western Delta during all months except December.

Overall, it is important to note that water temperature-related effects on aquatic species associated with changes in Delta inflow are expected to be very minor because water from upstream reservoirs approaches equilibrium with atmospheric conditions by the time it reaches the Delta. Furthermore, the extent of the causal influence of inflow on water temperatures is an area of active uncertainty (Bashevkin and Mahardja 2022).

Streams below Export Reservoirs

Changes in Sacramento/Delta supplies could lead to reduced water levels in export reservoirs and reduced streamflows below these reservoirs, which could affect water temperatures. Aquatic biological resources, including fish, occur in the export reservoirs; and downstream reaches and some fish species could be affected by changes in cold water habitat availability below reservoirs. The effects of changes in reservoir levels on fish that use reservoir habitat is discussed above under *Changes in Reservoir Levels*. Fish species inhabiting these reservoirs generally differ from species in the streams below the reservoirs. Reservoir fishes are mostly nonnative species stocked into the reservoirs to support recreational fisheries. Stream fishes are generally a mix of native and nonnative species, including species of recreational value and native special-status species. The special-status fish species identified to occur below export reservoirs are unarmored threespine stickleback, tidewater goby, Central California Coast steelhead DPS, Southern California steelhead DPS, Santa Ana sucker, Sacramento hitch, riffle sculpin, Pacific lamprey, Central California roach, and arroyo chub.

Historical observations of storage in export reservoirs during periods of lower Sacramento/Delta supplies show lower storage patterns for some reservoirs. This suggests that, when Sacramento/Delta supplies are reduced, storage in some export reservoirs is reduced. Many of the streams below export reservoirs have streamflow requirements that would not allow for reductions below the historical minimum flows (see Chapter 6, *Changes in Hydrology and Water Supply*). However, some of these streamflow requirements are based on hydrologic conditions or reservoir storage; if reservoir storage is reduced, the streamflow requirements may also be reduced. Further, it is possible that existing flow requirements may change in the future. Therefore, there is uncertainty in how reservoir operators may respond to changes in Sacramento/Delta supplies, and it is possible that streamflows below export reservoirs receiving Sacramento/Delta supplies could be reduced as a result of the proposed Plan amendments.

Such changes would potentially affect downstream flow and water temperatures and could affect aquatic biological resources, including the special-status fish species identified in Table 7.6.2-1. While steelhead and other native species evolved under periodic low-flow conditions in many of the streams below export reservoirs, existing flow requirements in these streams may only partially offset other factors that affect the viability of these populations such as loss of habitat in upper watershed areas and degradation of habitat within occupied reaches. In addition, Southern California Coast steelhead and Central California Coast steelhead that occur below export reservoirs can no longer access historical habitat in the upper watershed. These factors continue to be among the key stressors that threaten the long-term viability of these species.

Conclusion—Water Temperature

In summary, implementation of the narrative cold water habitat objective and the flexibility provided in the inflow requirements are expected to generally improve water temperature conditions in the Sacramento/Delta watershed for native fish species. However, it is possible that there could be some instances on some streams where temperatures could increase, particularly while the specific cold water habitat implementation measures are refined. Changes in flow and reservoir storage under the proposed Plan amendments could affect stream temperatures and could affect the availability of cold water to protect anadromous salmonids and other native fishes. The proposed inflow objective would generally result in higher spring flows compared with baseline conditions on regulated tributaries. While higher spring flows that more closely resemble the natural hydrologic regime would be expected to benefit native anadromous salmonids and other native species, higher spring flows could also result in a reduction in reservoir storage at the end of spring and a smaller cold water pool volume in summer and fall months, particularly on tributaries with significant water diversions and smaller storage capacity. There could also be significant changes in storage in some upper watershed reservoirs, which could affect downstream flows and water temperatures. Changes in interbasin transfers could affect water temperatures in some locations. In addition, changes in Sacramento/Delta supplies to other regions could affect reservoir levels in export reservoirs, which could affect reservoir releases and downstream water temperatures.

Because the potential exists that in some instances on some streams temperatures could increase, changes in water temperatures could affect native fish species; this impact would be potentially significant. Implementation of the cold water habitat objective would be expected to minimize potential temperature-related impacts on aquatic biological resources in the Sacramento/Delta watershed. However, identifying and taking the appropriate actions to meet the cold water habitat objective in some locations may not result in immediate improvements, and temperature concerns could occur until the tributary is in full compliance with the objective. As described in Section 7.6.2.2, *Environmental Setting*, and in Chapter 5, *Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta*, existing temperature protections are in place for some stream reaches and reservoirs, but legal requirements are applied unevenly and, in many locations, not at all. Implementation of the proposed cold water habitat objective is intended to address these conditions and to ensure that salmonids have access to cold water habitat at critical times and that adequate water is available for minimum instream flow purposes downstream of reservoirs. Cold water habitat conditions, species needs, and the measures for best implementing the narrative objective will vary among the tributaries due in part to the complexities identified above and other tributary-specific complexities.

In some locations, the need to reserve a cold water pool could justify operating to provide inflows at the lower end of the range of flow requirements at certain times (i.e., 45 scenario). Additionally, the proposed program of implementation identifies habitat restoration measures, including through EcoRestore and other efforts, as well as other complementary ecosystem measures to protect fish and wildlife. The proposed Plan amendments allow for and encourage voluntary implementation plans that would facilitate a combination of flow and other ecosystem measures to promote habitat restoration to amplify the ecological benefit of new and existing flows. The program of implementation would allow for voluntary implementation plans with effective habitat restoration and other non-flow measures to be lower in the range so long as the agreement is still within the range of the 45 to 65 scenarios. Under the lower range of flows, the potential impacts associated with reductions in carryover storage and/or lower flows in summer and fall would be reduced.

The intent of the cold water habitat objective is to bolster existing legal protections to ensure comprehensive temperature protection over time. Although approaches may differ among tributaries, the effectiveness of cold water management will require ongoing coordination, collaboration, and technical review among water managers, stakeholders, and technical experts to facilitate both short-term and long-term planning and decision-making efforts. The cold water habitat objective is narrative in order to provide sufficient flexibility for implementation options, including coordination with other regulatory processes on tributaries, such as FERC relicensing.

In the Sacramento/Delta, potential impacts could be reduced through further reductions in water supply allocations or modifications in the operation of multiple reservoirs to address potential carryover impacts in the major storage reservoirs (see discussion of total carryover by watershed in Chapter 6, *Changes in Hydrology and Water Supply*). While the modeling results generally show that end-of-September carryover storage in rim reservoirs could be maintained or improved while meeting the inflow requirements, uncertainties exist regarding the effects on downstream water temperatures. Ultimately, management of cold water habitat must be based on further analysis that considers times of year that various life stages of anadromous fish are present, locations in the river that are utilized by anadromous fish, and the flow required to maintain suitable water temperatures far enough downstream to protect sensitive life stages from adverse temperature effects. The flow needed to provide suitable temperature conditions for native cold water fish species depends on reservoir release temperature, channel geometry, meteorology, and shade.

In some cases, improving temperature conditions on rivers can be achieved through operational and structural measures in reservoirs. Key non-flow actions for managing water temperatures released from dams include installation or modification of selective withdrawal structures (e.g., temperature curtains or shutters). Section 7.21, *Habitat Restoration and Other Ecosystem Projects*, discusses and evaluates the potential environmental impacts, including construction impacts, of habitat restoration and other ecosystem measures such as the use of TCDs and fish passage improvement projects that entities may undertake toward achieving the overall goal of improving conditions for fish and wildlife in the Sacramento/Delta watershed.

Implementation of Mitigation Measures MM-AQUA-a,d: 1 through 3 will avoid or reduce temperature impacts from the proposed Plan amendments. Specifically, implementation of the proposed cold water habitat objective would reduce or avoid temperature impacts on special-status species in the Sacramento/Delta. The proposed Plan amendments would require reservoir operators to develop and implement long-term strategies and annual operations plans for approval by the State Water Board to implement the cold water habitat objective. Because of physical and operational constraints that limit the ability to provide flows while still preserving sufficient cold water to meet downstream habitat needs, the strategies and plans would be based on the unique structural, operational, and hydrological characteristics and species requirements for each tributary. Parties may develop operational measures that reduce the drawdown effects currently reflected in the modeling scenarios of reservoirs. Specific implementation measures may include a combination of cold water storage provisions, TCDs, flow provisions, fish passage to cold water habitat, and other measures. In addition, temperature effects can be minimized due to the flexibility provided in the flow objectives (range of flow levels, shaping and shifting of flows, groups of tributaries working together), voluntary implementation plans, and other proposed provisions of the program of implementation. This includes continuing ongoing habitat planning and restoration efforts under the ESA and CESA. However, because there is some uncertainty regarding the precise implementation measures for the cold water habitat objective and application of the flexibilities provided for in the implementation of the inflow objective (including decisions regarding tradeoffs between flows and cold water supplies), it is possible that, in limited instances, temperature impacts could occur even with mitigation or where mitigation activities take time to implement effectively. Therefore, temperature impacts on special-status fish species from changes in flows and reservoir levels remain potentially significant.

Implementation of Mitigation Measure MM-AQUA-a,d: 1(ii) will reduce or avoid temperature-related impacts on native cold water species below export reservoirs. In exercising its regulatory authorities, the State Water Board will consider temperature needs and ensure that any temperature impacts are avoided or reduced. Specifically, the State Water Board may hold public trust hearings in response to notifications by CDFW, valid public trust complaints, or other relevant evidence indicating that reservoir operations and water temperatures are affecting aquatic resources. In addition, export reservoirs and streams below export reservoirs are subject to other existing regulatory requirements independent of the Bay-Delta Plan, such as FERC license requirements and NMFS BiOp requirements. Implementation of relevant NMFS species recovery plans may also help to protect listed cold water species and provide suitable water temperatures downstream of export reservoirs. Streams below export reservoirs may also be subject to future changes that could result from the issuance of new water right orders or decisions, FERC licenses, and other future regulatory requirements. However, until and unless the mitigation is fully implemented, the impact of changes in reservoir storage levels on temperature in streams below export reservoirs that receive Sacramento/Delta supply remains potentially significant.

Changes in Water Supply

Reduced Sacramento/Delta Supply to Agriculture

Changes in water supply would result in reduced Sacramento/Delta supply for irrigation use (see Section 7.4, *Agriculture and Forest Resources*). These conditions could adversely affect special-status fish species that depend in part on Sacramento/Delta water supply for habitat. For example, desert pupfish habitat includes Coachella Valley agricultural drains and the Salton Sea. This habitat is supported by irrigation runoff that in part originates as Colorado River water delivered under an exchange agreement between Coachella Valley Water District and the Metropolitan Water District of Southern California (MWD). If the proposed Plan amendments lead to reduced Sacramento/Delta water supplies available to MWD, the agency could reduce deliveries of Colorado River water to the Coachella Valley Water District, which could reduce the amount of water available for desert pupfish habitat. The desert pupfish is protected under the Coachella Valley Multiple Species Habitat Conservation Plan which requires monitoring and management of pupfish habitat in agricultural drains to ensure that the Plans' conservation objectives for pupfish are met (CVAG 2016). In addition to pupfish, there may be other aquatic species that rely on Sacramento/Delta water supplies that could be affected by reductions in this supply. It is speculative and unknown what actions individual water districts would take in response to reduced Sacramento/Delta water supply, and the potential for these actions to result in substantial modifications to aquatic habitat may be remote. However, changes in Sacramento/Delta water supply that adversely affect water availability for special-status species or their habitat could result in potentially significant impacts.

Potential impacts on aquatic species such as desert pupfish could be avoided or reduced through implementation of Mitigation Measures MM-AQUA-a,d: 3 and MM-AQUA-a,d: 4. Mitigation Measure MM-AQUA-a,d: 3 identifies habitat protection and restoration actions that are being and should continue to be implemented to protect aquatic species. Mitigation MM-AQUA-a,d: 4 provides generally for management actions to protect special-status species dependent on Sacramento/Delta water that has been used for irrigation.

The proposed Plan amendments are intended to be implemented in an integrated fashion with habitat restoration and other non-flow measures that would provide benefits for both aquatic and terrestrial species, including actions identified in the program of implementation. Specifically, the proposed program of implementation identifies habitat restoration actions, including through California EcoRestore and other efforts, as well as other non-flow actions that others should take to protect fish and wildlife. The proposed Plan amendments also allow for and encourage voluntary implementation plans that would facilitate a combination of flow and non-flow actions to promote habitat restoration to amplify the ecological benefit of new and existing flows (Mitigation Measure MM-AQUA-a,d: 2). Voluntary implementation plans with proven effective habitat restoration may also allow flow requirements lower in the range, and therefore reduce the potential impacts associated with reduced Sacramento/Delta water supply, such as impacts on agriculture and associated impacts on aquatic species. Voluntary implementation plans are required to include measures to avoid or minimize impacts on aquatic species of concern.

In addition, management measures exist that agricultural water users can implement to avoid or minimize impacts on special-status species. While the State Water Board has some authority to ensure that mitigation is implemented for some actions, other mitigation measures are largely within the jurisdiction and control of other agencies or depend on how water users respond to the proposed Plan amendments. Accordingly, the State Water Board cannot guarantee that measures will always be adopted or applied to fully mitigate potential impacts on aquatic species. Therefore, unless and until the mitigation is fully implemented, the impacts remain potentially significant.

Reduced Sacramento/Delta Supply to Municipal Use

Reductions in water supply to municipalities, as well as increased water recycling and indoor conservation, could alter the flow and chemical constituent concentrations of WWTP influent and subsequently could affect WWTP effluent discharges to receiving waters. As described in Section 7.12.1, *Surface Water*, several factors could influence the type or degree of these effects. In some locations, these changes may have little or no effect on the facility or receiving waters; in other locations, WWTP operators may need to adjust operations to ensure continued compliance with NPDES discharge requirements to avoid effects on some streams. If operational changes at affected locations are insufficient, modified or additional facilities may be needed. Physical modifications to WWTPs are further discussed in Section 7.20, *Utilities and Service Systems*, and impacts from the construction of new or modified treatment plants are evaluated in Section 7.22, *New or Modified Facilities*.

In locations where WWTP operators are unable to implement proper adjustments to their facilities, changes in WWTP discharges could result in effects on water quality and flow that could affect special-status aquatic species occurring in these streams.

Depending on the volume and timing of flow reductions and effects on receiving water quality, it is possible that resulting changes in streamflow could adversely affect aquatic biological resources, including special-status fish species. For example, the City of Roseville is required to maintain four million gallons per day discharge into Dry Creek as an in-stream flow requirement (City of Roseville 2016). Miners Ravine and Secret Ravine, located above Roseville's Dry Creek WWTP, are the primary spawning and rearing areas for fall-run Chinook salmon and steelhead (DWR 2002). Therefore, the portion of Dry Creek below the discharge area is a migratory corridor for spawning adults and outmigrating juveniles (ECORP 2003). Discharges from the WWTP have minimal effect on Dry Creek during wet months; however, they can compose a high proportion of flows during dry months (^NMFS 2014b). If reductions in water supply to municipalities, as well as increased water recycling and indoor conservation actions, reduce wastewater inflows and thus outflows into the Dry Creek WWTP during dry months, flows in the migratory corridor could be significantly reduced. This could affect adult and juvenile salmonids (e.g., fish health, spawning migration delays for adults, lower egg-to-fry survival, and lower outmigration survival for juveniles) and would be a potentially significant impact.

Implementation of Mitigation Measures MM-AQUA-a,d: 5 and 6 will reduce potential violations of waste discharge requirements that could alter instream flows or water quality conditions affecting special-status species. Mitigation Measure MM-AQUA-a,d: 5 incorporates Mitigation Measure MM-SW-a,f: 1 for regulation of waste discharges that is accomplished primarily through the State Water Board and regional water board waste discharge permits, including NPDES permits for point-source discharges. A variety of funding programs provide loans and grants for capital improvements to WWTPs. The State Water Board and regional water boards will continue to regulate waste discharges and will continue to promote and support future funding sources as appropriate. Additionally, to avoid or minimize impacts associated with reduced wastewater instream, when processing wastewater change petitions pursuant to Water Code section 1211, the State Water Board will ensure that the change in wastewater discharge does not affect instream flows or water quality for special-status species. Unless and until the mitigation is fully implemented and proven effective, the impacts remain potentially significant.

Changes in Groundwater

As discussed in Section 7.12.2, *Groundwater*, a reduction in Sacramento/Delta surface water supplies could result in an increase in groundwater pumping to replace lost surface water supplies and a reduction in incidental groundwater recharge from applied irrigation water and agricultural conservation measures that could lower groundwater levels in some locations in the Sacramento/Delta watershed and other regions. Potential changes in groundwater levels could affect stream-aquifer interactions (i.e., streambed seepage) in some locations and negatively affect some of the special-status fish species identified in Table 7.6.2-1. Native fish species such as anadromous salmonids, can be affected by even short-term, localized disruptions in flow to provide suitable conditions for completion of their freshwater life cycle. The potential for changes in groundwater levels to affect stream-aquifer interactions in any given stream can vary by stream reach and depends on several factors, such as the underlying geology, proximity and connectivity of groundwater wells to the stream, rate and duration of groundwater pumping, and groundwater recharge rates.

Under existing conditions, flow in some streams is already affected by high levels of groundwater pumping, including in areas where declining groundwater levels have been observed. For example, in the Cosumnes River watershed, high levels of groundwater pumping are known to affect flows during fall months and have converted the Cosumnes River to a losing reach in the lower watershed. In recent years, the entire lower river has frequently remained dry throughout most of the fall-run Chinook salmon adult migration period of October through December (Fleckenstein et al. 2004). In the lower Cosumnes River and other locations where flows are already affected by groundwater overdraft, actions taken by water users in response to the proposed Plan amendments, including increased groundwater pumping and changes in incidental recharge, could exacerbate the effects of groundwater overdraft on streamflows. These impacts would be potentially significant.

Implementation of Mitigation Measures MM-AQUA-a,d: 2, and 7 through 9 will reduce or avoid potential impacts on aquatic biological resources resulting from changes in stream-aquifer interactions from lower groundwater levels. The proposed program of implementation provides for voluntary implementation plans that would be required to include measures to coordinate implementation of the proposed Plan amendments with groundwater management activities, including implementation of the SGMA. In addition, voluntary implementation plans may allow flow requirements lower in the range if complementary measures are implemented to provide equivalent protection that reduces potential impacts associated with decreased consumptive water uses, including impacts on groundwater, subject to the requirements of SGMA. These measures include groundwater mitigation measures to reduce lowering of groundwater levels. SGMA could reduce or eliminate impacts, particularly in medium- and high-priority groundwater basins. In developing and implementing a groundwater sustainability plan, groundwater sustainability agencies are required to avoid undesirable results, including depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of surface water.

In addition, the State Water Board has several authorities that are independent of SGMA, including authority to act to prevent waste, unreasonable use, unreasonable method of use, and unreasonable method of diversion of water. The State Water Board may exercise this authority through quasi-adjudicative or quasi-legislative proceedings as appropriate and necessary to minimize potential impacts on special-status aquatic species from changes in groundwater and surface water supplies. The State Water Board could also act under its public trust authority to regulate depletion of interconnected surface water by groundwater pumping.

More generally, water users can and should diversify their water supply portfolios in an environmentally responsible manner and in accordance with the law to mitigate for groundwater impacts and possible changes in stream-aquifer interactions that could affect aquatic biological resources. This includes sustainable use of groundwater and groundwater storage and recovery and conjunctive use, water transfers, water conservation and efficiency upgrades, and recycled water. The State Water Board will continue efforts to encourage and promote environmentally sound recharge projects that use surplus surface water, increased use of recycled water, sustainable water transfers, and conservation. While the State Water Board has some authority to ensure that mitigation is implemented for some actions, other mitigation measures are largely within the jurisdiction and control of other agencies or depend on how water users respond to the proposed Plan amendments. The State Water Board cannot guarantee that measures will always be adopted or applied in a manner that fully mitigates the impact. Therefore, unless and until the mitigation is fully implemented, impacts of changes in groundwater levels and stream-aquifer interactions on aquatic biological resources remain potentially significant.

Other Water Management Actions

Water users often rely on a variety of water sources (water supply portfolios), including groundwater, water transfers, and water recycling (see Section 7.1, *Introduction, Project Description, and Approach to Environmental Analysis*, for additional discussion of other water management actions). Reducing reliance on the Delta is state policy, along with an associated mandate for improving regional self-reliance (Wat. Code, § 85021). In response to reductions in surface water supplies attributable to the proposed Plan amendments, water users may further expand and modify their water portfolios by implementing groundwater storage and recovery projects, water transfers, water recycling, or water conservation measures. The use of other water management actions could reduce the magnitude of impacts associated with changes in Sacramento/Delta surface water supply but could also result in environmental impacts that must be evaluated.

Groundwater Storage and Recovery

Groundwater storage and recovery and conjunctive use projects have the potential to benefit native aquatic species by reducing surface water diversions during dry periods. When implemented in an environmentally responsible manner, groundwater storage and recovery projects can help to reduce reliance on surface water during dry season months and can help to maintain streamflows during critical periods for native aquatic species, such as key anadromous salmonid migration periods. Groundwater storage and recovery projects also can provide greater flexibility in optimizing flows for fisheries protection and other beneficial uses. State Water Board staff supports sustainable conjunctive use efforts and recently developed a streamlined permitting process for diversions of water from winter high-flow events to underground storage. Groundwater sustainability agencies and local agencies as defined by SGMA are eligible for this streamlined permitting process. Diversion of peak flows for groundwater recharge usually occurs when flows are already high. Substantial reductions in flow could affect aquatic resources because peak flows provide important ecosystem and habitat functions (e.g., floodplain inundation). This impact would be potentially significant. Implementation of Mitigation Measure MM-AQUA a,d: 9 will mitigate the impacts of groundwater storage and recovery projects to a less-than-significant level. The diversion of high flows for groundwater storage and recovery projects should be carefully managed to avoid or minimize impacts on aquatic species and their habitat. A water right permit is required to capture streamflows, including peak storm events, for groundwater recharge and later beneficial use.

Water Transfers

Water transfers also have the potential to affect aquatic species. The potential effects of water transfers depend on the type of water transfer, the volume of water being transferred, the timing and duration of the transfer, and the changes in place and use of the water being transferred. Some surface water transfers and cropland idling transfers could benefit aquatic species by enhancing tributary flows during key periods. However, changes in water transfers could result in altered hydrologic patterns that affect aquatic species and natural ecological processes. For example, native fish species could be affected if the timing of flows for transfers is modified in a way that results in straying, dewatering, or stranding. In addition, some surface water transfers could result in reduced reservoir levels, which could affect cold water supplies for the protection of anadromous salmonids and other native cold water species below reservoirs. Surface water transfers from the Sacramento/Delta to south-of-Delta water users via the SWP and CVP pumping facilities could affect flows in the Delta, which could affect native estuarine-dependent species such as Delta smelt and longfin smelt. These transfers could affect fish if pumping operations related to transfers causes entrainment or impingement. In addition, groundwater substitution transfers could exacerbate the impacts already described related to groundwater levels. These impacts would be potentially significant. Implementation of Mitigation Measure MM-AQUA-a,d: 10 will avoid or reduce impacts on aquatic biological resources from water transfers. As discussed in Section 7.1, *Introduction, Project Description, and Approach to Environmental Analysis,* transfers generally require environmental review and approval by different agencies that would be expected to address impacts on special-status species and their habitats. Water transfers should be carefully planned and coordinated to avoid or minimize impacts on special-status species and their habitats. Transfers based on crop idling approved by the State Water Board and/or facilitated by DWR or Reclamation are required to avoid unreasonable impacts on fish and wildlife and prevent injury to other legal users of water. These approvals generally include the need for CEQA and/or National Environmental Policy Act documentation and federal ESA and CESA consultation to address fish and wildlife resources. To avoid or minimize impacts, when processing petitions for transfers, the State Water Board will ensure that the transfer would not result in diminished habitat for special-status aquatic species and their habitats. The State Water Board cannot guarantee that mitigation will be implemented for transfers not subject to State Water Board approval. Unless and until the mitigation is fully implemented, the impacts remain potentially significant.

Water Recycling

Increased water recycling could benefit aquatic species by maximizing the use of existing water supplies and reducing demand for surface water or groundwater. It is expected that any increase in recycled water production would continue to meet all appropriate treated wastewater effluent limitations and standards and would not affect special-status aquatic species or their habitat. However, increased use of recycled water could decrease the volume of treated wastewater effluent discharged into streams because the recycled water would instead be distributed to end users for use on landscaping, potable use, or agricultural fields. In some locations, reductions in flow could alter water quality in some streams, particularly in streams with low flows that are dominated by relatively high-quality WWTP effluent and have local input of poor-quality water (see Section 7.12.1, *Surface Water*). These conditions could diminish to some extent the ecological benefits of instream flow, especially in dry seasons and in low-flow conditions where streamflow is dependent on wastewater discharges.

Depending on the volume and timing of these reductions, it is possible that resulting changes in streamflow could adversely affect aquatic biological resources, including special-status fish species. This impact would be potentially significant.

Implementation of Mitigation Measure MM-AQUA-a,d: 6 will reduce potential impacts on special-status species from increased water recycling to less-than-significant levels. As discussed in Section 7.1, *Introduction, Project Description, and Approach to Environmental Analysis*, various regulatory requirements govern the use of recycled water. To avoid or minimize potential impacts on special-status species, the State Water Board, when processing wastewater change petitions pursuant to Water Code section 1211, will ensure that the change in wastewater discharge does not diminish ecological benefits of instream flows, especially in dry seasons and in low-flow conditions where the stream is dependent on wastewater discharges.

Potential effects associated with increased water recycling are also discussed and mitigation identified under *Reduced Sacramento/Delta Supply to Municipal Use*.

Water Conservation

Increased implementation of water conservation measures, such as reduced water use and tailwater reuse, could result in less runoff from lawns, impervious surfaces, agricultural fields, and other areas. Reduction in this type of drainage or discharge could result in a reduction in contaminants entering surface waters. Where these changes result in water quality improvements, aquatic biological resources would benefit.

Potential effects associated with indoor water conservation measures are discussed and mitigation identified under *Reduced Sacramento/Delta Supply to Municipal Use*. Potential effects associated with agricultural conservation measures are discussed and mitigation identified under *Changes in Groundwater*.

Impact AQUA-f: Conflict with the provisions of an adopted habitat conservation plan, natural community conservation plan, or other approved local, regional, or state habitat conservation plan

HCPs and NCCPs (or conservation plans) are plans adopted under the federal ESA and the California Natural Communities Conservation Planning Act that require conservation actions, such as the purchase or protection of specific habitat land in connection with certain "covered actions," such as the approval and construction of residential development. Public agencies are generally the permittees under such plans. In exchange for the conservation actions, the permittees are given authority for their covered actions to "take" the special-status species listed in the conservation plan. In addition to conservation plans, multiple species recovery plans have been developed for populations of anadromous salmonids and other special-status fish species (see Section 7.6.2.1, *Environmental Setting,* and Section 7.6.2.2, *Regulatory Setting*).

Table 7.6.2-3 identifies HCPs and NCCPs that include special-status fish species. An activity could impede an HCP, NCCP, or other approved local, regional, or state habitat conservation plan if it would substantially reduce the effectiveness of the plan's conservation strategies or otherwise prevent attainment of the plan's goals and objectives. This could result from reducing the viability of populations that are targets of the plan's goals, objectives, and conservation strategies. Also, certain activities could impede plan implementation and reduce the habitat value of conserved lands (e.g., by creating adjacent, incompatible land uses), interfere with the management of conserved lands (e.g., by eliminating access or water supplies), or eliminate opportunities for conservation activities (e.g., by developing land identified for preservation in the plan).

The proposed Plan amendments would not create adjacent incompatible land uses, develop land, or otherwise result in actions incompatible with conservation plans or activities as the proposed Plan amendments do not require or result in those types of activities. However, the proposed Plan amendments could impede an HCCP or NCCP if they would impair a permittee's ability to undertake the required conservation actions or comply with the provisions of a plan. Many such inconsistencies, however, would not lead to a formal conflict between the action and the plan because once the plan is approved, both the federal ESA and CESA protect the permittee from changes in circumstances: the permittee maintains its take authority and is not required to take further action, including the acquisition of land or water, not contemplated under the plan, in order to respond to unforeseen circumstances.

In the Sacramento/Delta, changes in tributary flows, Delta inflows, and Delta outflows would likely complement many required actions identified in conservation plans and species recovery plans that preserve and restore riverine and estuarine habitat and associated special-status species. As described in Chapter 5, *Proposed Changes to the Bay-Delta Plan for the Sacramento/Delta*, the State Water Board's proposed flow requirements for the Sacramento/Delta are proposed to work together with other federal and state statutes and planning efforts (including HCPs and NCCPs) to provide comprehensive protection to fish and wildlife from their natal streams through the Delta and San Francisco Bay. The general approach of the existing protections is to protect and restore essential habitats and natural processes supporting the life cycle and habitat requirements of special-status species through flow and complementary ecosystem projects see *Existing Regulatory Protections* in Section 7.6.2.2).

The proposed Plan amendments, including flow requirements, are compatible with these existing plans because they are based on a common scientific framework, including recognition of the major role of freshwater flow and natural hydrologic variability in maintaining diverse, productive riverine and estuarine ecosystems. They also share an implementation approach that recognizes the importance of monitoring and adaptive management. For example, the primary conservation actions of the Solano Multispecies HCP include the maintenance of water quality and natural hydrologic, geomorphic, and ecological processes supporting the conservation and recovery needs of the covered species (Chinook salmon, steelhead, green sturgeon, Delta smelt, longfin smelt, and Sacramento splittail) (^Solano County Water Agency 2012). The proposed Plan amendments, by promoting a more natural flow regime consistent with these needs, support the Solano Multispecies HCP.

Outside of the Sacramento/Delta watershed, in the Bay Area, San Joaquin Valley, Central Coast, and Southern California regions, it is possible that changes in Sacramento/Delta water supply could frustrate certain efforts identified in an HCCP or NCCP if Sacramento/Delta water supplies are used to support management actions. For example, the Coachella Valley Multispecies HCP requires establishment of a permanent water source for desert pupfish habitat that may be more difficult to obtain if MWD has less water available. Similarly, the Western Riverside County Multiple Species HCP requires flow maintenance to protect the habitat of Santa Ana sucker and arroyo chub in the Santa Ana River. These flows are maintained largely by wastewater treatment plants and therefore could be affected if water recycling or other water conservation actions reduce wastewater inflows into these plants. At the same time, the HCP notes that wastewater treatment plant outflows could be sold in the future. Changes in water supply under the proposed Plan amendments could motivate such sales, which also could reduce river flows.

However, under the terms of this and other HCPs, any failure to perform conservation actions because of unforeseen imported water-supply reductions would not violate the permittee's duties and would not cause a formal conflict with the HCP. This impact would be less than significant.

7.6.2.5 Mitigation Measures

MM-AQUA-a,d: Mitigate impacts on aquatic special-status species and wildlife movement or wildlife nurseries

1. **Temperature Control and Reservoir Management**

    i. Implement Cold Water Habitat Objective

    - For reservoirs in the Sacramento River watershed and Delta eastside tributaries regions, a new narrative cold water habitat objective is proposed to ensure that salmonids have access to cold water habitat at critical times and to ensure that adequate water is available for minimum instream flow purposes downstream of reservoirs. Long-term strategy and annual operation plans for rim reservoirs are required to be designed and implemented to avoid or reduce temperature impacts. The long-term strategy and operation plans will also consider and include measures to avoid or reduce any potential impacts on the following resources: aesthetic, terrestrial biological species, cultural, energy, recreation, and water quality (including applicable provisions of State Water Board's Statewide Mercury Control Program for Reservoirs). Upstream water users would be required to participate in development of the strategies to the extent that their operations affect achievement of the narrative objective below the rim reservoirs.

        - Long-Term Temperature Management Strategies: The strategies would be required to evaluate measures that can be taken to improve temperature management in both the short term and long term and to identify the feasibility and suitability of those measures. The strategies also would be required to include processes for implementing feasible temperature control measures in a timely and effective manner. Temperature control measures that should be evaluated include installation and improvements in TCDs, cold water bypasses, passage, riparian reforestation, operational changes, and other relevant improvements identified by the State Water Board and fisheries agency staff. The strategies would be required to include provisions for developing the annual plans, including time schedules that provide for planning and coordination with the State Water Board and fisheries agencies and other appropriate stakeholders, decision-making processes for temperature operations, modeling and monitoring to support development and implementation of the annual plans, adaptive management, and other measures.

        - Operation Plans: Annual operations plans would be required to be developed each year in coordination with the State Water Board and fisheries agencies identifying how temperature protection and related operations for the protection of salmonids and other native species will be achieved each year, including provisions for reservoir carryover storage levels; minimum and maximum flow releases and ramping rates to provide appropriate temperature protection, preserve cold water supplies, and avoid stranding and dewatering concerns; reservoir TCD operations; adaptive management; and other relevant provisions, as well as the technical basis for those provisions. The annual plans would be subject to approval and potential modification by the Executive Director.

  - Upstream Reservoirs: As determined by the Executive Director, reservoir operators in the upstream watersheds may also be required to develop their own strategies and operational plans if their reservoir operations affect achievement of the narrative objective for stream segments above the rim reservoirs. Specifically, if stream segments below those reservoirs are not in compliance with the Central Valley Regional Water Quality Control Board's temperature objectives (including the requirement that temperatures of intrastate waters not be increased more than 5 F above natural receiving water temperatures) or are otherwise causing elevated temperatures above current conditions, a temperature management strategy would be required. A temperature management strategy also may be required if the Executive Director of the State Water Board determines that the stream segment is not otherwise in compliance with the cold water habitat objective based on information from the fisheries agencies and others.

- Implement Flow Objectives: The proposed Plan amendments include tributary inflow and cold water habitat objectives that will be implemented together on regulated tributaries in a manner that preserves cold water for fish. Temperature effects can be reduced due to the flexibility provided in the flow objectives (range of flow levels, shaping and shifting of flows, groups of tributaries working together) and other proposed provisions of the program of implementation.

ii. Implement Existing Laws that Protect and Mitigate Fisheries Impacts from Dams and Diversions

- Existing Regulatory Requirements: Reservoir owners and operators are subject to existing regulatory requirements intended to protect water quality in reservoirs and streams below reservoirs. Consistent with California Fish and Game Code section 5937, cold water flows from reservoirs should be maintained and timed to provide for downstream temperatures at critical times of the year to ensure that fish below dams are kept in good condition. Additional regulatory authorities that protect cold water habitat include FERC license requirements, NMFS BiOp requirements, regional water board basin plan requirements for the protection of beneficial uses, and State Water Board public trust authority.

- State Water Board Regulatory Authorities: In exercising its regulatory authorities, the State Water Board will consider temperature needs and ensure that any temperature impacts are avoided or reduced. In addition, the State Water Board will consider aesthetics, terrestrial biological species, cultural, energy, and recreation resources and ensure that any impacts are avoided or reduced. The proposed program of implementation indicates that upon receipt of information indicating that there are temperature management issues in reservoirs, the State Water Board will investigate and take measures, as appropriate, under its authorities to address temperature concerns to protect fish and wildlife. Specifically, the State Water Board may hold a public trust hearing in response to notification by CDFW, a valid public trust complaint, or other relevant evidence indicating problematic reservoir operations.

- Species Recovery Plans: The NMFS Salmon and Steelhead Recovery Plan identifies temperature management as a high priority action that is needed to recover salmon and steelhead. Actions identified in the recovery plan include minimum reservoir storage levels, instream flow management, planning for temperature management, physical modifications to control temperatures, upstream passage to cold water habitat, monitoring, and other measures. Implement applicable recovery plans for streams below export reservoirs.

2. **Voluntary Implementation Plans:** The proposed program of implementation promotes habitat restoration as a potential component in voluntary implementation plans that could amplify the ecological benefit of new and existing flows. Habitat restoration may allow flow requirements lower in the range, and therefore reduce the potential impacts associated with reductions in carryover storage and/or lower flows in summer and fall. Voluntary implementation plans could reduce potential temperature impacts on aquatic species associated with interbasin diversions if two or more tributaries work together to meet numeric objectives downstream.

3. **Habitat Protection and Restoration Actions**:

   i. Habitat Restoration Actions: The proposed Plan amendments include actions that other entities should take to restore habitat, including as part of California EcoRestore and other efforts.

   ii. Species Recovery Plans: State and federal resource agencies and other appropriate entities should also continue and expand management efforts for special-status aquatic and terrestrial species. State and federal resource agencies should continue to develop, refine, and implement species recovery plans to protect aquatic biological resources, including special-status fish species, and the instream flows they require.

   iii. Funding: The State Water Board will consult and coordinate with state and federal resource agencies and other appropriate entities to secure and distribute funding to support habitat restoration activities that would benefit aquatic biological resources, including special-status fish species.

4. **Special-Status Species Management Measures:** To minimize and avoid impacts on aquatic special-status species (e.g., desert pupfish), water providers and users and land managers should develop and implement appropriate management measures (i.e., best management practices) to encourage the protection, restoration, and management of habitat, such as conducting hydrologic studies for water quality and quantity; monitoring, managing, or and restoring habitat; conducting fish presence surveys; and monitoring for contaminants.

5. **Regulation of Waste Discharges to Streams**: Implement Mitigation Measure MM-SW-a,f: 1 (see Section 7.12.1, *Surface Water*) to reduce potential effects on streamflow and water quality from changes in municipal supply, water recycling, and indoor water conservation that affect WWTP effluent discharge.

6. **Support and Approval of Recycled Water:** The State Water Board will continue efforts to encourage and promote recycled water projects, including projects that involve use of recycled water for groundwater recharge, through expedited permit processes and funding efforts. When processing wastewater change petitions pursuant to Water Code section 1211, the State Water

Board will ensure that the change in wastewater discharge does not diminish ecological benefits of instream flows or impact water quality (including cold water for special-status fish species), especially in dry seasons and in low flow conditions where the stream is dependent on wastewater discharges.

7. **Reduce Impacts on Groundwater:**

   i. Implement Mitigation Measures MM-GW-b: 1 through 7 (see Section 7.12.2, *Groundwater*) to reduce potential impacts of lowered groundwater levels on surface water quality and aquatic resources.

   ii. The State Water Board may take action to protect aquatic biological resources, including special-status fish species, from impacts of groundwater diversions. These authorities include the authority to prevent waste, unreasonable use, unreasonable method of use, and unreasonable method of diversion of water. The State Water Board could also act under its public trust authority to regulate depletion of interconnected surface water by groundwater pumping.

8. **Diversify Water Portfolios:** Water users can and should diversify their water supply portfolios to the extent possible in an environmentally responsible manner and in accordance with the law to reduce reliance on the Sacramento/Delta and groundwater overdraft. This includes sustainable conjunctive use, groundwater storage and recovery, water transfers, water recycling, and water conservation and efficiency upgrades.

9. **Support and Approval of Groundwater Storage and Recovery:** The State Water Board will continue efforts to encourage and promote environmentally sound groundwater recharge projects that use surplus surface water, including prioritizing the processing of temporary and long-term water right permits for projects that enhance the ability of a local or state agency to capture high runoff events for local storage or recovery (Governor's Exec. Order No. B-39-17 [April 6, 2017]). In processing water right applications that involve groundwater storage, the State Water Board will consider the need to preserve ecological functions of high-flow events and other relevant factors in accordance with the Water Code to ensure that enough flow remains instream to protect ecological benefits.

10. **Oversight and Approval of Water Transfers:**

   i. When processing petitions for transfers, the State Water Board will ensure that the transfer would not result in unreasonable effects on fish and wildlife or other instream beneficial uses.

   ii. When processing transfers, DWR and Reclamation should require the transferor to show that the transfer would not result in unreasonable effects on fish and wildlife or other instream beneficial uses in the source area or the area receiving the transfer.

7.6.2.6 References Cited

Common References

^Baerwald, M., V. Bien, F. Feyrer, and B. May. 2007. Genetic Analysis Reveals Two Distinct Sacramento Splittail (*Pogonichthys macrolepidotus*) Populations. *Conservation Genetics* 8:159–167.

^Baxter, R., L. R. Brown, G. Castillo, L. Conrad, S. D. Culberson, M. P. Dekar, M. Dekar, F. Feyrer, T. Hunt, K. Jones, and J. Kirsch. 2015. *An Updated Conceptual Model of Delta Smelt Biology: Our Evolving Understanding of an Estuarine Fish*. Interagency Ecological Program, California Department of Water Resources. Technical Report 90.

^Beamesderfer, R., M. Simpson, G. Kopp, J. Inman, A. Fuller, and D. Demko. 2004. *Historical and Current Information on Green Sturgeon Occurrence in the Sacramento and San Joaquin Rivers and Tributaries*. Prepared by S. P. Cramer & Associates, Inc., Oakdale, CA. August. Sacramento, CA.

^Bennett, W. A. 2005. Critical Assessment of the Delta Smelt Population in the San Francisco Estuary, California. *San Francisco Estuary and Watershed Science* 3(2):1–71.

^Bergman, P., J. Merz, and B. Rook. 2011. *Cramer Fish Sciences Memo: Green Sturgeon Observations at Daguerre Point Dam, Yuba River, CA*. Available: https://www.noaa.gov/sites/default/files/legacy/document/2020/Oct/07354626599.pdf.

^California Department of Fish and Game (CDFG). 2002. *California Department of Fish and Game Comments to NMFS Regarding Green Sturgeon Listing.*

^California Department of Fish and Wildlife (CDFW). 2016b. *CDFW Rationale for Summer Delta Flow Augmentation for Improving Delta Smelt Survival*. July 8.

^California Department of Water Resources (DWR). 2016a. *Devil Canyon Project Relicensing, Final Pre-Application Document*. August.

^California Department of Water Resources (DWR) and Los Angeles Department of Water and Power (LADWP). 2016. *South SWP Hydropower Relicensing, FERC Project No. 2426*. Final Pre-Application Document. August.

^Chapman, F. A., J. P. Van Eenennaam, and S. I. Doroshov. 1996. The Reproductive Condition of White Sturgeon, *Acipenser transmontanus*, in San Francisco Bay, California. *Fishery Bulletin* 94:628–634.

^Cloern, J. E., N. Knowles, L. R. Brown, D. Cayan, M. D. Dettinger, T. L. Morgan, D. H. Schoellhamer, M. T. Stacey, M. Van Der Wegen, R. W. Wagner, and A. D. Jassby. 2011. Projected Evolution of California's San Francisco Bay-Delta: River System in a Century of Climate Change. C*limate Change and San Francisco Estuary-Watershed* 6:9.

^Crain, P. K., K. Whitener, and P. B. Moyle. 2004. Use of a Restored Central California Floodplain by Larvae of Native and Alien Fishes. *American Fisheries Society Symposium* 39:125–140.

^Feyrer, F., T. Sommer, and W. Harrell. 2006b. Managing Floodplain Inundation for Native Fish: Production Dynamics of Age-0 Splittail (*Pogonichthys macrolepidotus*) in California's Yolo Bypass. *Hydrobiologia* 573:213–226.

^Fish, M. A. 2010. White Sturgeon Year-Class Index for the San Francisco Estuary and its Relation to Delta Outflow. *Interagency Ecological Program for the Sacramento-San Joaquin Estuary Newsletter* 23(2):80–84.

^Fisher, F. W. 1994. Past and Present Status of Central Valley Chinook Salmon. *Conservation Biology* 8:870–873.

^Fleenor, W., W. Bennett, P. Moyle, and J. Lund. 2010. On Developing Prescriptions for Freshwater Flows to Sustain Desirable Fishes in the Sacramento–San Joaquin Delta. Delta Solutions, Center for Watershed Sciences, University of California, Davis.

^Gruber, J. J., S. J. Jackson, and J. P. Van Eenennaam. 2012. *2011 San Joaquin River Sturgeon Spawning Survey*. Final Annual Report. Lodi, CA: U.S. Fish and Wildlife Service, Stockton Fish and Wildlife Office, Anadromous Fish Restoration Program.

^Jackson, Z. J., and J. P. Van Eenennaam. 2013. *2012 San Joaquin River Sturgeon Spawning Survey. Final Annual Report*. March. U.S. Fish and Wildlife Service, Stockton Fish and Wildlife Office, Anadromous Fish Restoration Program. May. Lodi, CA.

^Kammerer, B. D. and S. A. Heppell. 2012. Individual Condition Indicators of Thermal Habitat Quality in Field Populations of Redband Trout (*Oncorhynchus mykiss gairdneri*). *Environmental Biology Fishes* 96:823–835.

^Kiernan, J. D., P. B. Moyle, and P. K. Crain. 2012. Restoring Native Fish Assemblages to a Regulated California Stream Using the Natural Flow Regime Concept. *Ecological Applications* 22(5):1472–1482.

^Kimmerer, W. J. 2002a. Physical, Biological, and Management Responses to Variable Freshwater Flow into the San Francisco Estuary. *Estuaries* 25(6B):1275–1290.

^Kimmerer, W. J. 2002b. Effects of Freshwater Flow on Abundance of Estuarine Organisms: Physical Effects or Trophic Linkages? *Marine Ecology Progress Series* 243:39–55.

^Kohlhorst, D. W. 1976. Sturgeon Spawning in the Sacramento River in 1973, As Determined by Distribution of Larvae. *California Fish and Game* 62:32–40.

^Kohlhorst, D. W., L. W. Botsford, J. S. Brennand, and G. M. Caillet. 1991. Aspects of the Structure and Dynamics of an Exploited Central California Population of White Sturgeon (*Acipenser transmontanus*). In P. Williott (ed.). *Acipenser*. Bordeaux, France: Cemagref Publishers.

^Lindley, S. T., R. Schick, A. Agrawal, M. Goslin, T. E. Pearson, E. Mora, J. J. Anderson, B. May, S. Greene, C. Hanson, A. Low, D. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2006. Historical Population Structure of Central Valley Steelhead and its Alteration by Dams. *San Francisco Estuary and Watershed Science* 4(1).

^Lindley, S. T., R. S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, … and C. Swanson. 2007. Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento–San Joaquin Basin. *San Francisco Estuary and Watershed Science* 5(1).

^Lytle, D. A. and N. L. Poff. 2004. Adaptation to Natural Flow Regimes. *Trends in Ecology and Evolution* 19:94–100.

^Marston, D., C. Mesick, A. Hubbard, D. Stanton, S. Fortmann-Roe, S. Tsao, and T. Heyne. 2012. Delta Flow Factors Influencing Stray Rate of Escaping Adult San Joaquin River Fall-Run Chinook Salmon (*Oncorhynchus tshawytscha*). *San Francisco Estuary and Watershed Science* 10(4).

^Matthews, K., and N. Berg. 1997. Rainbow trout responses to water temperature and dissolved oxygen stress in two southern California stream pools. *Journal of Fish Biology* 50:50–67.

^McEwan, D. 2001. Central Valley Steelhead. In R. Brown (ed.). *Contributions to the Biology of Central Valley Salmonids*. California Department of Fish and Game. *Fish Bulletin* 179(1).

^Mora, E. A., S. T. Lindley, D. L. Erickson, and A. P. Klimley. 2009. Do Impassable Dams and Flow Regulation Constrain the Distribution of Green Sturgeon in the Sacramento River, California? *Journal of Applied Ichthyology* (25):39-47.

^Moyle, P. B. 2002. *Inland Fishes of California*. Revised. University of California Press. Berkeley, CA.

^Moyle, P. B., R. D. Baxter, T. Sommer, T. C. Foin, and S. A. Matern. 2004. Biology and Population Dynamics of Sacramento Splittail (*Pogonichthys macrolepidotus*) in the San Francisco Estuary: A Review. *San Francisco Estuary and Watershed Science* 2(2).

^Moyle, P. B., R. B. Quinones, J. V. Katz, and J. Weaver. 2015. *Fish Species of Special Concern.* Third Edition. California Department of Fish and Wildlife. July. Sacramento, CA.

^Moyle, P. B. 2002. *Inland Fishes of California*. Second Edition. Berkeley, CA: University of California Press.

^Myrick, C. A. and J. J. Cech, Jr. 2001. Temperature Effects on Chinook Salmon and Steelhead: A Review Focusing on California's Central Valley Populations. *Bay-Delta Modeling Forum Technical Publication* 01-1:1–57.

^National Marine Fisheries Service (NMFS). 1996. *Factors for Decline: A Supplement to the Notice of Determination for West Coast Steelhead Under the Endangered Species Act.* Protected Species Branch, Portland, OR, and Protected Species Management Division, Long Beach, CA.

^National Marine Fisheries Service (NMFS). 2009. *Biological Opinion and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project*. Endangered Species Act Section 7 Consultation. Southwest Region. June 4.

^National Marine Fisheries Service (NMFS). 2014a. *Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead.* West Coast Region. Sacramento, CA.

^National Marine Fisheries Service (NMFS). 2014b. *Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of California Central Valley Steelhead.* Appendix A: Central Valley Watershed Profiles. California Central Valley Area Office. July.

^National Marine Fisheries Service (NMFS). 2016b. *5-Year Review: Summary and Evaluation of Southern California Coast Steelhead Distinct Population Segment*. West Coast Region. Central Coastal Office. Long Beach, CA.

^National Marine Fisheries Service (NMFS). 2019. Biological Opinion on the Long-Term Operation of the Central Valley Project and State Water Project. National Marine Fisheries Service, West Coast Region. October 21.

^Perry, R. W., P. L. Brandes, J. R. Burau, P. T. Sandstrom, and J. R. Skalski. 2015. Effect of Tides, River Flow, and Gate Operations on Entrainment of Juvenile Salmon into the Interior Sacramento–San Joaquin River Delta. *Transactions of the American Fisheries Society* 144:445–455.

^Poff, N. L., J. K. Allan, M. B. Bain, J. R. Karr, K. L. Prestegaard, B. D. Richter, R. E. Sparks, and J. C. Stromberg. 1997. The Natural Flow Regime. *Bioscience* 47:769–784.

^Salmonid Scoping Team (SST). 2017. *Effects of Water Project Operations on Juvenile Salmonid Migration and Survival in the South Delta. Appendix E*. Prepared for the Collaborative Adaptive Management Team.

^Schaffter, R. 1997. White Sturgeon Spawning Migrations and Location of Spawning Habitat in the Sacramento River, California. *California Department of Fish and Game* 83:1–20.

^Solano County Water Agency. 2012. *Solano Multispecies Habitat Conservation Plan*. October.

^Sommer, T. R., R. D. Baxter, and B. Herbold. 1997. Resilience of Splittail in the Sacramento–San Joaquin Estuary. *Transactions of the American Fisheries Society* 126(6):961–976.

^Sommer, T. R., M. L. Nobriga, W. C. Harrell, W. Batham, and W. J. Kimmerer. 2001a. Floodplain Rearing of Juvenile Chinook Salmon: Evidence of Enhanced Growth and Survival. *Canadian Journal of Fisheries and Aquatic Sciences* 58:325–333.

^Stevens, D. E. and L. W. Miller. 1983. Effects of River Flow on Abundance of Young Chinook Salmon, American Shad, Longfin Smelt, and Delta Smelt in the Sacramento-San Joaquin River System. *North American Journal of Fisheries Management* 3(4):425–437.

^Sturrock A. M., J. D. Wikert, T. Heyne, C. Mesick, A. E. Hubbard, T. M. Hinkelman, P. K. Weber, G. E. Whitman, J. J. Glessner, and R. C. Johnson. 2015. Reconstructing the Migratory Behavior and Long-Term Survivorship of Juvenile Chinook Salmon under Contrasting Hydrologic Regimes. *PLoS ONE* 10(5): e0122380. doi:10.1371/journal.pone.0122380.

^Thompson, L. C. and R. Larsen. 2002. *Fish Habitat in Freshwater Streams.* ANR Publication 8112:12.

^U.S. Bureau of Reclamation (Reclamation), U. S. Fish and Wildlife Service, National Oceanographic and Atmospheric Administration, California Department of Fish and Game, and Water Forum. 2006. *Lower American River Flow Management Standard*. Draft. July.

^U.S. Fish and Wildlife Service (USFWS). 1995. *Working Paper on Restoration Needs: Habitat Restoration Actions to Double Natural Production of Anadromous Fish in the Central Valley of California.* Volume 2. Prepared for the U.S. Fish and Wildlife Service under the Direction of the Anadromous Fish Restoration Program Core Group. May 9. Stockton, CA.

^U.S. Fish and Wildlife Service (USFWS). 1996. *Sacramento-San Joaquin Delta Native Fishes Recovery Plan*. U.S. Fish and Wildlife Service and Oregon Fish and Wildlife Office. Approved in 2006. Portland, OR.

^U.S. Fish and Wildlife Service (USFWS). 2008. *Formal Endangered Species Act Consultation and Biological Opinion on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP).* December 15.

^U.S. Fish and Wildlife Service (USFWS). 2019. *Biological Opinion for the Reinitiation of Consultation on the Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP).*

^Wang, J. C. S. 1986. *Fishes of the Sacramento-San Joaquin Estuary and Adjacent Waters, California: A Guide to the Early Life Histories.* Technical Report 9. Prepared for the Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary.

^Yarnell, S.M., G. E. Petts, J. C. Schmidt, A. A. Whipple, E. E. Beller, C. N. Dahm, P. Goodwin, and J. H. Viers. 2015. Functional Flows in Modified Riverscapes: Hydrographs, Habitats and Opportunities. *BioScience* 65(10):963–972.

^Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 1996. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California. In *Sierra Nevada Ecosystem Project: Final Report to Congress, Vol. III—Assessments, Commissioned Reports, and Background Information*. Centers for Water and Wildland Resources, University of California, Davis.

^Yoshiyama, R. M., F. W. Fisher, and P. B. Moyle. 1998. Historical Abundance and Decline of Chinook Salmon in the Central Valley Region of California. *North American Journal of Fisheries Management* 18:487–521.

^Yoshiyama, R. M., E. R. Gerstung, F. W. Fisher, and P. B. Moyle. 2001. Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California. In R. L. Brown (ed.). Contributions to the Biology of Central Valley Salmonids. *Fish Bulletin* 179(1):71–176.

^U.S. Department of the Interior (USDOI). 2010. *Comments Regarding the California SWRCB Notice of Public Information Proceedings to Develop Delta Flow Criteria for the Delta Ecosystem Necessary to Protect Public Trust Resources (Exhibit 1).*

^U.S. Environmental Protection Agency (USEPA). 2003. EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards. EPA 910-B-03-002. Region 10 Office of Water, Seattle, WA.

Section References

Azat, J. 2022. California Central Valley Chinook Escapement Database Report. California Department of Fish and Wildlife. Grandtab 2022.07.07.

Bashevkin, S. M., and B. Mahardja. 2022. Seasonally Variable Relationships between Surface Water Temperature and Inflow in the Upper San Francisco Estuary. *Limnology and Oceanography*. 67:684–702. January.

Bilski, R. and J. Kindopp. 2009. Emigration of Juvenile Chinook Salmon *(Oncorhynchus tshawytscha)* in the Feather River, 2005–2007. Department of Water Resources, Division of Environmental Services. January.

Brennan, C. A., J. L. Hassrick, A. Kalmbach, D. M. Cox, M. C. Sabal, R. L. Zeno, L. F. Grimaldo, and S. Acuña. 2022. Estuarine Recruitment of Longfin Smelt (*Spirinchus thaleichthys*) North of the San Francisco Estuary. *San Francisco Estuary and Watershed Science*, 20(3).

Brown, L. R. and P.B. Moyle. 1993. Distribution, Ecology, and Status of the Fishes of the San Joaquin River Drainage, California. *California Fish Game* 79:96–113.

Brown, L.R., R. Baxter, G. Castillo, L. Conrad, S. Culberson, G. Erickson, F. Feyrer, S. Fong, K. Gehrts, L. Grimaldo, B. Herbold, J. Kirsch, A. Mueller-Solger, S. B. Slater, T. Sommer, K. Souza, E. Van Nieuwenhuyse. 2014. *Synthesis of Studies in the Fall Low-Salinity Zone of the San Francisco Estuary, September—December 2011*. Scientific Investigations Report 2014-5041. U.S. Department of the Interior, U.S. Geological Survey. In cooperation with the Bureau of Reclamation and Interagency Ecological Program.

California Advisory Committee on Salmon and Steelhead Trout. 1988. *Restoring the Balance: 1988 Annual Report*.

California Department of Fish and Game (CDFG). 2008. *A Status Review of the Threatened Delta Smelt (Hypomesus transpacificus) in California*. Report to the Fish and Game Commission. June.

California Department of Fish and Wildlife (CDFW). 2014a. California Native Fish Species by Watershed [ds 1353] GIS Dataset. Available: https://map.dfg.cagov/bios/?al=ds1353. March 2018.

California Department of Fish and Wildlife (CDFW). 2014b. Study Plan: Upstream Passage Assessment for Adult Spring-Run Chinook Salmon in Lower Butte Creek, Butte County. California Department of Fish and Wildlife (CDFW). 2017a. *Instream Flow Evaluation: Temperature and Passage Assessment for Salmonids in Mill Creek, Tehama County*. Stream Evaluation Report 17-1. January. Sacramento, CA.

California Department of Fish and Wildlife (CDFW). 2017b. *Instream Flow Evaluation: Temperature and Passage Assessment for Salmonids in Deer Creek, Tehama County*. Stream Evaluation Report 17-2. October. Sacramento, CA. California Department of Fish and Wildlife (CDFW). 2023. Inland Deserts Region Native Fish Conservation. CDFW Inland Deserts Region. Available: https://wildlife.ca.gov/Regions/6/Desert-Fishes-Copy. Accessed: September 18, 2023.

California Department of Fish and Wildlife (CDFW). 2021. Unpublished Data. 2021 Aerial Redd Sacramento River Summary as of January 21, 2021. Obtained from D. Killiam, CDFW, on April 1, 2021.

California Department of Fish and Wildlife (CDFW). 2023. NCCP Plan Summaries. Available: NCCP Plan Summaries (ca.gov). Accessed: April 3, 2023.

California Department of Water Resources (DWR). 2002. *Miners Ravine Habitat Assessment*. Prepared by C. Lee under supervision of M. Meeks and T. Frink. October.

California Department of Water Resources (DWR). 2006. Settlement Agreement Recreation Management Plan, Oroville Facilities FERC Project No. 2100. March.

California Department of Water Resources (DWR). 2016. *Biological Assessment for the California WaterFix, Appendix 5. D.: Quantitative Methods and Detailed Results for Effects Analysis of Chinook Salmon, Central Valley Steelhead, Green Sturgeon, and Killer Whale*. July.

California Department of Water Resources (DWR). 2017. *Dams within Jurisdiction of the State of California*. September.

California Department of Water Resources (DWR). 2019. *Devil Canyon Project Relicensing, FERC Project Number 14797, Final License Application*. Volume I. November.

California Department of Water Resources (DWR). 2021. Unpublished Data on Salmonid Escapement (2000–2019) and Redd Surveys (2003–2011) in the Feather River Low Flow and High Flow channels. Data provided by Jason Kindopp, Senior Environmental Scientist at the California Department of Water Resources.

California Department of Water Resources (DWR) and U. S. Bureau of Reclamation (Reclamation). 2018. *Memorandum of Agreement for the Implementation of the 2008 and 2009 Biological*

Opinions for the Coordinated Long-Term Operation of the Central Valley Project and State Water Project. December.

California Natural Diversity Database (CNDDB). 2020. RareFind 5 [Internet]. California Department of Fish and Wildlife [Version 5.2.14].

California Natural Resources Agency (CNRA). 2016. *Delta Smelt Resiliency Strategy*. July. Sacramento, CA.

California Natural Resources Agency (CNRA). 2017. *Delta Smelt Resiliency Strategy. Progress Report*. June.

California Trout and UC Davis Center for Watershed Sciences (CalTrout and UCD). 2017. *SOS II: Fish in Hot Water. Status, Threats and Solutions for California Salmon, Steelhead, and Trout*.

Carter, K. 2005. *The Effects of Temperature on Steelhead Trout, Coho Salmon, and Chinook Salmon Biology and Function by Life Stage.* Implications for Klamath Basin TMDLs. California Regional Water Quality Control Board, North Coast Region.

Center for Biological Diversity. 2012. Petition to List the Clear Lake Hitch (*Lavinia exilicauda chi*) as Threatened Under the California Endangered Species Act. Submitted to California Fish and Game Commission.

City of Roseville. 2016. *Final 2015 Urban Water Management Plan*. May. Roseville, CA.

Coachella Valley Association of Governments (CVAG). 2016. Final Major Amendment to the Coachella Valley Multispecies Habitat Conservation Plan (CVMSHCP). Prepared by Coachella Valley Mountains Conservancy. August. Available: Plan Documents – Coachella Valley Conservation Commission (cvmshcp.org). Accessed: September 1, 2023.

Colway, C. and D. E. Stevenson. 2007. Confirmed Record of Two Green Sturgeon from the Bering Sea and Gulf of Alaska. *Northwestern Naturalist* 88(3):188–192.

Day, L. 2022. Juvenile Salmonid Emigration Monitoring in the Lower American River, California. Version 2. Environmental Data Initiative. Available: https://doi.org/10.6073/pasta/d8390fcb74ad1df56f1b94630f7ab5c0. Accessed: October 18, 2022.

Deas, M., J. Bartholow, C. Hanson, and C. Myrick. 2004. *Peer Review of Water Temperature Objectives Used as Evaluation Criteria for The Stanislaus-Lower San Joaquin River Water Temperature Modeling and Analysis*. Report to California Bay Delta Authority as Part of Project Number ERP-02-P28. July. Moraga, CA.

Dege, M. and L. Brown. 2004. Effect of Outflow on Spring and Summertime Distribution and Abundance of Larval and Juvenile Fishes in the Upper San Francisco Bay Estuary. *American Fisheries Society Symposium* 39:49–65.

Dubois, J., M. D. Harris, and J. Mauldin. 2014. *2013 Sturgeon Fishing Report Card: Preliminary Data Report*. Prepared by the California Department of Fish and Wildlife. Stockton, CA.

Dubois, J. and M. D. Harris. 2015. *2014 Sturgeon Fishing Report Card: Preliminary Data Report*. Prepared by the California Department of Fish and Wildlife. February 10. Stockton, CA.

Dubois, J. and M. D. Harris. 2016. *2015 Sturgeon Fishing Report card: Preliminary Data Report*. Prepared by the California Department of Fish and Wildlife. Stockton, CA.

DuBois, J. and A. Danos. 2017. *2016 Sturgeon Fishing Report Card: Preliminary Data Report*. Prepared by the California Department of Fish and Wildlife. Stockton, CA.

Dubois, J. and A. Danos. 2018. *2017 Sturgeon Fishing Report Card: Preliminary Data Report*. Prepared by the California Department of Fish and Wildlife. Stockton, CA.

ECORP Consulting, Inc. (ECORP). 2003. Dry Creek Watershed Coordinated Resource Management Plan. Placer and Sacramento Counties, CA. December 31.

Federal Energy Regulatory Commission (FERC). 2014. *Final Environmental Impact Statement for Hydropower License.* FERC/EIS-F-0244. Upper Drum-Spaulding Hydroelectric Project - Project No. 2310-193, Lower Drum Hydroelectric Project - Project No. 14531-000, Deer Creek Hydroelectric Project – Project No. 14530-000, Yuba-Bear Hydroelectric Project – Project No. 2266-102. December. Washington, DC.

Fleckenstein, J., M. Anderson, G. Fogg, and J. Mount. 2004. Managing Surface Water-Groundwater to Restore Fall Flows in the Cosumnes River. *Journal of Water Resources Planning and Management* 130(4):301–310.

Garwood, R.S., 2017. Historic and Contemporary Distribution of Longfin Smelt (*Spirinchus thaleichthys*) along the California Coast. *California Fish and Game* 103(3):96–117.

Gleichauf, K. T. 2015. *Temperature and Tidal River Junction Dynamics in the Sacramento-San Joaquin River Delta, California*. A Dissertation submitted to the Department of Civil and Environmental Engineering and the Committee on Graduate Studies of Stanford University. December.

Good, T. P., R. S. Waples, and P. Adams (eds.). 2005. *Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead*. NOAA Technical Memorandum NMFS-NWFSC-66. U.S. Department of Commerce.

Grant, G. C. and P. E. Maslin. 1999. Movements and Reproduction of Hardhead and Sacramento Squawfish in a Small California Stream. *The Southwestern Naturalist* 296–310.

Grimaldo, L., F. Feyrer, J. Burns, and D. Maniscalco. 2017. Sampling Uncharted Waters: Examining Rearing Habitat of Larval Longfin Smelt (*Spirinchus thaleichthys*) in the Upper San Francisco Estuary. *Estuaries and Coasts* 40(6):1771–1784.

Grimaldo, L., J. Burns, R. E. Miller, A. Kalmbach, A. Smith, J. Hassrick, and C. Brennan. 2020. Forage Fish Larvae Distribution and Habitat Use during Contrasting Years of Low and High Freshwater Flow in the San Francisco Estuary. *San Francisco Estuary and Watershed Science* 18(3).

Gross, E., W. Kimmerer, J. Korman, L. Lewis, S. Burdick, and L. Grimaldo. 2022. Hatching Distribution, Abundance, and Losses to Freshwater Diversions of Longfin Smelt Inferred Using Hydrodynamic and Particle-Tracking Models. *Marine Ecology Progress Series* 700:179–196.

Gunckel, L. S., K. K. Jones, and S. E. Jacobs. 2009. Spawning Distribution and Habitat Use of Adult Pacific and Western Brook Lampreys in Smith River, Oregon*. American Fisheries Society Symposium* 72:173–189.

Hines, D. and J. Ambrose. n.d. *Evaluation of Stream Temperatures Based on Observations of Juvenile Coho Salmon in Northern California Streams*. Campbell Timber Management, Inc., Fort Bragg, CA, and National Marine Fisheries Service, Santa Rosa, CA.

Hobbs, J. A., L. S. Lewis, M. Willmes, C. Denney, and E. Bush. 2019. Complex Life Histories Discovered in a Critically Endangered Fish. *Scientific Reports* 9(1):16772.

Israel, J. A, and A. P. Klimley. 2008. Life History Conceptual Model for North American Green Sturgeon (*Acipenser medirostris*). December 27. Davis, CA.

Knowles, N. and D.R. Cayan. 2002. Potential Effects of Global Warming on the Sacramento/San Joaquin Watershed and the San Francisco Estuary. *Geophysical Research Letters*, Vol. 29, No. 18.

Leidy, R. A. 2007. *Ecology, Assemblage Structure, Distribution, and Status of Fishes in Streams Tributary to the San Francisco Estuary, California*. San Francisco Estuary Institute, Contribution No. 530. April.

Lewis, L., A. Barros, M. Willmes, C. Denney, C. Parker, M. Bisson, J. Hobbs, A. Finger, G. Benjamin, and A. Benjamin. 2019. *Interdisciplinary Studies on Longfin Smelt in the San Francisco Estuary*.

Lewis, L. S., M. Willmes, A. Barros, P. K. Crain, and J. A. Hobbs. 2020. Newly Discovered Spawning and Recruitment of Threatened Longfin Smelt in Restored and Underexplored Tidal Wetlands. *Ecology* 101(1).

Mahardja B., B. May, F. Feyrer, R. Coalter, N. Fangue, T. Foin, and M. R. Baerwald. 2015. Interannual Variation in Connectivity and Comparison of Effective Population Size Between Two Splittail (*Pogonichthys macrolepidotus*) Populations in the San Francisco Estuary. *Conserv. Genet* 16:385–398.

Mahardja, B., V. Tobias, S. Khanna, L. Mitchell, P. Lehman, T. Sommer, L. Brown, S. Culberson, and J. L. Conrad. 2021. Resistance and Resilience of Pelagic and Littoral Fishes to Drought in the San Francisco Estuary. *Ecological Applications*. 31(2):e02243.

Miller, R. R. 1968. Records of Some Native Freshwater Fishes Transplanted into Various Waters of California, Baja California, and Nevada. *California Fish Game* 54:170–179.

Miller, E. A., G. P. Singer, M. L. Peterson, E. D. Chapman, M.E. Johnston, M. J. Thomas, R. D. Battleson, M. Gingras, and A. P. Klimley. 2020. Spatio-temporal distribution of Green Sturgeon (*Acipenser medirostris*) and White Sturgeon (*A. transmontanus*) in the San Francisco Estuary and Sacramento River, California. *Environmental Biology of Fishes*. 103:577-603.

Moyle, P. B., R. M. Yoshiyama, J. E. Williams, and E. D. Wikramanayake. 1995. *Fish Species of Special Concern in California.* Second Edition. Prepared for the State of California Resources Agency, California Department of Fish and Game, Inland Fisheries Division.

Moyle, P. B., D. K. Stompe, and J. R. Durand. 2020. Is the Sacramento Splittail an Endangered Species? *California WaterBlog.* Available: https://californiawaterblog.com/2020/03/03/is-the-sacramento-splittail-an-endangered-species/. Accessed: February 13, 2023.

Nakamoto, R. J., T. T. Kisanuki, and G. H. Goldsmith. 1995. *Age and Growth of Klamath River Green Sturgeon* (*Acipenser medirostris*). Arcata, CA.

National Marine Fisheries Service (NMFS). 2000. *Biological Opinion for the U.S. Bureau of Reclamation Operation and Maintenance of the Cachuma Project on the Santa Ynez River in Santa Barbara County, California*. Southwest Region.

National Marine Fisheries Service (NMFS). 2005. *Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead*. U.S. Department of Commerce, NOAA Technical Memo. NMFS-NWFSC-66.

National Marine Fisheries Service (NMFS). 2012a. *Southern California Steelhead Recovery Plan Summary*. Southwest Regional Office. January. Long Beach, CA.

National Marine Fisheries Service (NMFS). 2012b. *Final Recovery Plan for Central California Coast Coho Salmon Evolutionarily Significant Unit*. Volume 1. Southwest Region. September. Santa Rosa, CA.

National Marine Fisheries Service (NMFS). 2013. South-Central California Steelhead Recovery Plan. West Coast Region. December. Long Beach, CA.

National Marine Fisheries Service (NMFS). 2016a. *Final Coastal Multispecies Recovery Plan*. West Coast Region. October. Santa Rosa, CA.

National Marine Fisheries Service (NMFS). 2016b. *Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response and Fish and Wildlife Coordination Act Recommendations for Relicensing the Oroville Facilities Hydroelectric Project, Butte County California* (FERC Project No. 2100-134). West Coast Region. December. Sacramento, CA.

National Marine Fisheries Service (NMFS). 2018. Recovery Plan for the Southern Distinct Population Segment of North American Green Sturgeon (*Acipenser medirostris*). West Coast Region. Sacramento, CA.

National Oceanic and Atmospheric Administration (NOAA). 2023. West Coast Federal Energy Regulatory Commission (FERC) Licensed Hydroelectric Projects: Sacramento River. Last Updated: January 3, 2023. Available: https://www.fisheries.noaa.gov/west-coast/habitat-conservation/west-coast-federal-energy-regulatory-commission-ferc-licensed-8#desabla-centerville-hydroelectric-project-(p-803). Accessed: September 18, 2023.

Pacific Fishery Management Council (PFMC). 1998. *Appendix D: Description and Identification of Essential Fish Habitat for the Coastal Pelagic Species Fishery Management Plan*. December. Portland, OR.

Pacific Fishery Management Council (PFMC). 2014. *Appendix A to the Pacific Coast Salmon Fishery Management Plan (As Modified by Amendment 18 to the Pacific Coast Salmon Plan): Identification and Description of Essential Fish Habitat, Adverse Impacts, and Recommended Conservation Measures for Salmon*. September. Portland, OR.

Pacific Fishery Management Council (PFMC). 2019. *Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery, Appendix B – Part 2: Groundfish Essential Fish Habitat and Life History Descriptions, Habitat Use Database Description, and Habitat Suitability Probability Information*. June. Portland, OR.

Pacific Fishery Management Council (PFMC). 2022. *Pacific Coast Salmon Fishery Management Plan for Commercial and Recreational Salmon Fisheries Off the Coasts of Washington, Oregon, and California as Revised through Amendment 23*. December. Portland, OR.

Phillis C., A. M. Sturrock, R. C. Johnson, and P. K. Weber. 2017. Endangered Winter-Run Chinook Salmon Rely on Diverse Rearing Habitats in a Highly Altered Landscape. *Biological Conservation* 217:358–362.

Reynolds F. L., T. J. Mills, and R. Benthin. 1993. *Restoring Central Valley Streams: A Plan for Action.* California Department of Fish and Game. November.

Richmond, J. Q., A. R. Backlin, C. Galst-Cavalcante, J. W. O'Brien, and R. N. Fisher. 2017. Loss of Dendritic Connectivity in Southern California's Urban Riverscape Facilitates Decline of an Endemic Freshwater Fish. *Molecular Ecology* 27(2):369–386.

Rosenfield, J.A., 2010. *Life History Conceptual Model and Sub-Models for Longfin Smelt, San Francisco Estuary Population*. Report submitted to the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP). May.

Sacramento River Temperature Task Group. 2016. *Annual Report of Activities: October 1, 2015, through September 30, 2016.*

Santos, N. R., J. V. E. Katz, P. B. Moyle, and J.H. Viers. 2014. A Programmable Information System for Management and Analysis of Aquatic Species Range Data in California. *Environmental Modelling & Software* 53:13–26.

Seesholtz, A., M. Manuel, and J. Eenennaam. 2014. First Documented Spawning and Associated Habitat Conditions for Green Sturgeon in the Feather River, CA. *Environmental Biology of Fishes* 98:905–913.

State Water Resources Control Board (SWRCB). 2015. Curtailment of Diversions due to Insufficient Flow for Specific Fisheries Emergency Regulation Digest. March.

State Water Resources Control Board (SWRCB). 2019. Order WR 2019-0148. In the Matter of Permits 11308 and 11310 (Applications 11331 and 11332) held by the United States Bureau of Reclamation for the Cachuma Project on the Santa Ynez River.

Stillwater Sciences. 2020. *Passage Assessment and Flow Recommendations for Chinook Salmon and Steelhead in Lower Antelope Creek*. September 2020.

Stompe, D. K., P. B. Moyle, A. Kruger, and J. R. Durand. 2020. Comparing and Integrating Fish Surveys in the San Francisco Estuary: Why Diverse Long-Term Monitoring Programs Are Important. *San Francisco Estuary and Watershed Science* 18(2).

Swift, C. C., J. L. Nelson, C. Maslow, and T. Stein. 1989. Biology and Distribution of the Tidewater Goby, *Eucyclogobius newberryi* (Pisces: Gobiidae) of California. *Contributions in Science*. Number 404.Natural History Museum of Los Angeles County. Los Angeles, CA.

University of California, Davis, Agricultural and Natural Resources (UC ANR) 2020. California Fish Website: California Fish Species. Available: http://calfish.ucdavis.edu/species/. Accessed: February 5, 2020.

U.S. Army Corps of Engineers (USACE). 2018. National Inventory of Dams. Available: http://nid.usace.army. mil/. Accessed: November 7, 2018.

U.S. Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR). 1986. Agreement between the United States of America and the State of California for Coordinated Operation of the Central Valley Project and the State Water Project.

U.S. Bureau of Reclamation (Reclamation) and California Department of Water Resources (DWR). 2018. Addendum to the Agreement between the United States of America and the State of California for Coordinated Operation of the Central Valley Project and the State Water Project.

U. S. Environmental Protection Agency (USEPA). 2011. Letter to SWRCB transmitting list of water body-pollutant combinations added by EPA to California's List of Water Quality Limited Segments Still Requiring Total Maximum Daily Loads Pursuant to Clean Water Act, sec. 303(d), and 40 CFR 130.7(d)(2). October

U.S. Fish and Wildlife Service (USFWS). 1973. Endangered Species Act.

U.S. Fish and Wildlife Service (USFWS). 1984. Recovery Plan for the Mojave Tui Chub (*Gila bicolor mojavensis*). Portland, OR.

U.S. Fish and Wildlife Service (USFWS). 1985. Unarmored Threespine Stickleback Recovery Plan (Revised). Portland, OR.

U.S. Fish and Wildlife Service (USFWS). 1992. *Expert Testimony of United States Fish and Wildlife Service on Chinook Salmon Technical Information for State Water Resources Control Board Water Rights Phase of the Bay/Delta Estuary Proceedings*. WRINT-USFWS-7. July 6.

U.S. Fish and Wildlife Service (USFWS). 1993. Desert Pupfish Recovery Plan. Phoenix, AZ.

U.S. Fish and Wildlife Service (USFWS). 1998. Owens Basin Wetland and Aquatic Species Recovery Plan, Inyo and Mono Counties, California. Portland, OR.

U.S. Fish and Wildlife Service (USFWS). 2000. Endangered and Threatened Wildlife and Plants; Threatened Status for Santa Ana Sucker. *Federal Register* 65(71). April.

U.S. Fish and Wildlife Service (USFWS). 2005. Recovery Plan for the Tidewater Goby (*Eucyclogobius newberry*i). Pacific Region.

U.S. Fish and Wildlife Service (USFWS). 2009a. Mohave Tui Chub (*Gila bicolor mohavensis* = *Siphaletes bicolor mohavensis*). 5-Year Review: Summary and Evaluation. Ventura Fish and Wildlife Office. January. Ventura, CA.

U.S. Fish and Wildlife Service (USFWS). 2009b. Unarmored Threespine Stickleback (*Gasterosteus aculeatus williamsoni*). 5-Year Review: Summary and Evaluation. Ventura Fish and Wildlife Office. May. Ventura, CA.

U.S. Fish and Wildlife Service (USFWS). 2011. Service Proposes Critical Habitat for Tidewater Goby. Ventura Fish and Wildlife Office. October.

U.S. Fish and Wildlife Service (USFWS). 2017. Recovery Plan for the Santa Ana Sucker (*Catosomus santaanae*). Sacramento Fish and Wildlife Office. February. Sacramento, CA.

U.S. Fish and Wildlife Service (USFWS) 2022. Endangered and Threatened Wildlife and Plants: Listing Priority Changes in Candidates: Longfin Smelt. *Federal Register* 87(85). May.

U. S. Fish and Wildlife Service (USFWS). 2023.Environmental Conservation Online System, Conservation Plans by Type and Region. Available: Conservation Plans by Type and Region (fws.gov). Accessed: April 3, 2023.

U.S. Geological Survey (USGS). 2013. 11042800 Warm Springs Creek near Murrieta, CA. Water-Data Report 2013.

Vroom, J., M. van der Wegen, R. C. Martyr-Koller, and L. V. Lucas. 2017. What Determines Water Temperature Dynamics in the San Francisco Bay-Delta System? *Water Resources Research* 53:9901-9921.

Wagner, R. W., M. Stacey, L. R. Brown, M. Dettinger. 2011. Statistical Models of Temperature in the Sacramento-San Joaquin Delta Under Climate-Change Scenarios and Ecological Implications. Estuaries and Coasts. 34:544-556.

Ward, B. R., P. A. Slaney, A. R. Facchin, and R. W. Land. 1989. Size-Based Survival in Steelhead Trout: Back-Calculated Lengths from Adults’ Scales Compared to Migrated Smolts at the Keogh River, British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences* 46:1953–1858.

Welsh, H. H., Jr., G. R. Hodgson, B. C. Harvey, and M. F. Roche. 2001. Distribution of Juvenile Coho Salmon in Relation to Water Temperatures in Tributaries of the Mattole River, California. *North American Journal of Fisheries Management* 21(3):464–470.

Zeug, S. C., S. Sellheim, and C. Watry. 2014. Response of Juvenile Chinook Salmon to Managed Flow: Lessons Learned from a Population at the Southern Extent of Their Range in North America. *Fisheries Management and Ecology* 21:155–168.