

**Appendix D**  
**Biological Resources – Aquatic**

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## D.1 Introduction

This appendix contains accounts of special-status fish species that have potential to occur in the Primary and Extended Planning Areas. “Special-status species,” as defined in this document, are fish species legally protected under the federal Endangered Species Act (ESA), California Endangered Species Act (CESA), or other State regulations, and species considered sufficiently rare by the scientific community to warrant conservation concern.

Special-status fish species considered in this appendix are those animal species included in at least one of the following categories:

- ◆ Federally listed as threatened or endangered
- ◆ Proposed for federal listing as threatened or endangered
- ◆ Candidate for federal listing
- ◆ State listed as threatened or endangered
- ◆ Candidate for State listing
- ◆ Fully protected species under the California Fish and Game Code
- ◆ State species of special concern
- ◆ Species on California Department of Fish and Wildlife’s (DFW’s) watch list

Descriptions of these potentially occurring special-status fish species are provided below. Sources used include California Natural Diversity Database (CNDDDB) records; existing species accounts available from DFW, U.S. Fish and Wildlife Service (USFWS), and other agencies; recovery plans for special-status species with potential to occur in the Delta; critical habitat designations; and relevant scientific literature.

## D.2 Fish Species

The species accounts in this appendix provide an overview of special-status fish species that are known to occur or that have an appreciable likelihood of occurring in the Delta and Suisun Marsh and the Extended Planning Area, and are likely to be affected by the implementation of the proposed Delta Plan Amendments. The special-status species that occur, or that have the potential to occur in, the Primary Planning Area and Extended Planning Area are presented in Table D-1.

1 **Table D-1**  
 2 **Special-status Fish Species with the Potential to Occur within the Primary and**  
 3 **Extended Planning Areas**

Common Name	Scientific Name	Status (Federal/State)	Primary Habitat and Critical Seasonal Periods	Occurrence in Primary and Extended Planning Areas
Central Valley Steelhead	<i>Oncorhynchus mykiss</i>	FT/—	Anadromous species using riverine, estuarine, and saltwater habitat. Migration potentially occurs year-round.	Sacramento River, American River, San Joaquin Valley, Delta
California Central Coast/ South-Central Coast	<i>Oncorhynchus mykiss</i>	FT/—	Anadromous species using riverine, estuarine, and saltwater habitat. Migration potentially occurs year-round.	Coastal Mountains, San Francisco Bay Area; documented in SCVWD Service Area in Upper Penitencia, Pacheco, and Coyote creeks and Guadalupe River
Central Valley Chinook salmon, fall/late fall-run	<i>Oncorhynchus tshawytscha</i>	SC/CSC	Anadromous species using riverine, estuarine, and saltwater habitat. Adult migration occurs mainly from September through December but has been observed as late as June. Primary juvenile outmigration occurs from January through June.	Sacramento River, American River, Delta, San Francisco Bay Area, San Joaquin Valley; also known to occur in the Guadalupe River and Coyote Creek
Central Valley spring-run Chinook salmon	<i>Oncorhynchus tshawytscha</i>	FT/ST	Anadromous species using riverine, estuarine, and saltwater habitat. Adult migration potentially occurs from March through May. Juvenile outmigration occurs from November through April.	Sacramento River, Delta, San Joaquin Valley
Sacramento River winter-run Chinook salmon	<i>Oncorhynchus tshawytscha</i>	FE/SE	Anadromous species using riverine, estuarine, and saltwater habitat. Adult migration potentially occurs from January through May. Juvenile outmigration occurs from November through mid-March.	Sacramento River, Delta
Green sturgeon	<i>Acipenser medirostris</i>	FT/CSC	Green sturgeon are an anadromous species, migrating from the ocean to freshwater to spawn. They exist in the Sacramento River system, as well as in the Eel, Mad, Klamath, and Smith rivers in the northwest portion of California.	Sacramento River, American River, San Francisco Bay Area, Delta, San Joaquin Valley

**Table D-1 (continued)**  
**Special-status Fish Species with the Potential to Occur within the Primary and Extended Planning Areas**

Common Name	Scientific Name	Status (Federal/State)	Primary Habitat and Critical Seasonal Periods	Occurrence in Primary and Extended Planning Areas
Delta smelt	<i>Hypomesus transpacificus</i>	FT/SE	Spends most of its life in the Sacramento–San Joaquin estuary. Spawns in shallow, fresh or slightly brackish water upriver from the mixing zone, including in the Sacramento River, Mokelumne River system, Cache Slough region, San Francisco Bay Delta, and Montezuma Slough area.	Sacramento River, American River, Delta
Longfin smelt	<i>Spirinchus thaleichthys</i>	—/ST	The longfin smelt is an anadromous species that spawns in the Delta and rears in the brackish areas of the San Francisco Bay and Delta.	Delta, San Francisco Bay Area
California/San Joaquin Roach	<i>Lavinia symmetricus</i> ssp.	—/CSC	Occurs in small, warm tributaries, to larger streams that flowed through open foothill woodlands of oak and foothill pine. Located in the foothills in much of the same region that contains the pikeminnow- hardhead-sucker assemblage.	Occurs upstream of large reservoir or in tributary streams that would not be affected by the project.
Riffle Sculpin	<i>Cottus gulosus</i>	SC/—	Riffle sculpins live in permanent, cool, headwater streams where riffles and rocky substrates predominate.	Riffle sculpin are found in many increasingly isolated watersheds in the Central Valley drainage and the central coast. They are mostly present in mid-elevation reaches, although they are present below dams with coldwater releases
Sacramento Hitch	<i>Lavinia exilicauda exilicauda</i>	SC/—	Sacramento hitch inhabit warm lowland waters including clear streams, turbid sloughs ,lakes and reservoirs.	In the Sacramento River, hitch appear to be spread across much of their native range up to and including Shasta Reservoir.
Hardhead	<i>Mylopharodon conocephalus</i>	—/CSC	Hardhead are often found at low to mid elevations in relatively undisturbed habitats of larger streams with high water quality (clear, cool).	In the Sacramento River they are common in both the mainstem and tributaries up to 1500 m in elevation.

**Table D-1 (continued)**  
**Special-status Fish Species with the Potential to Occur within the Primary and Extended Planning Areas**

Common Name	Scientific Name	Status (Federal/State)	Primary Habitat and Critical Seasonal Periods	Occurrence in Primary and Extended Planning Areas
River Lamprey	<i>Lampetra ayresii</i>	—/CSC	Adults need clean, gravelly riffles in permanent streams to spawn successfully. Ammocoetes live in silty backwaters and eddies with muddy or sandy substrate into which they burrow.	Occur in the lower Sacramento and San Joaquin River drainages, including the Stanislaus and Tuolumne Rivers.
Pacific Lamprey	<i>Lampetra tridentata</i>	SC/—	Adults need clean, gravelly riffles in permanent streams to spawn successfully. Ammocoetes live in silty backwaters and eddies with muddy or sandy substrate into which they burrow.	Occur in both the lower Sacramento and San Joaquin Rivers and many of their tributaries including the Stanislaus, Tuolumne, Merced, and King Rivers
Sacramento Splittail	<i>Pogonichthys macrolepidotus</i>	—/CSC	Splittail spawn in shallow water over flooded vegetated habitat with a detectable water flow. Splittail larvae and juveniles remain in riparian or annual vegetation along shallow edges on floodplains	The Sacramento splittail is endemic to the San Francisco Estuary and watershed.
Sacramento perch	<i>Archoplites interruptus</i>	—/CSC	Historically found in the sloughs, slow moving rivers, and lakes of the central valley. Prefer warm water. Aquatic vegetation is essential for young. (Within native range only)	Found in isolated quarry lakes in the Livermore Valley and would not be affected by the Project.

Sources: CDFW 2012; Moyle 2002

**Federal Status:**

SC: Species of Concern

FE: Endangered

FT: Threatened

**State Status:**

SE: Endangered

ST: Threatened

CSC: Species of Special Concern

## D.2.1 Anadromous Salmonids

The term anadromous salmonids refers to a group of fishes, including salmon and trout, that spend a portion of their life at sea, but return to spawn in fresh water. In the Central Valley, Chinook salmon and steelhead, the primary anadromous salmonids, share a common life history that typically includes passage through the Delta twice during their lifetime: once as juveniles emigrating to the ocean from the Sacramento and San Joaquin rivers and their tributaries where they were born, and again as adults on their return migration to their natal streams to spawn. Salmon die after spawning, but adult

1 steelhead may return to the ocean after spawning and make the journey more than  
2 once. The timing of upstream migration and spawning varies, with runs of Chinook  
3 salmon identified by their spawning migration period. Four runs of Chinook salmon  
4 occur in the Sacramento River system: fall-run, late-fall-run, winter-run, and spring-run.  
5 Only spring- and winter-run Chinook salmon and Central Valley steelhead are listed  
6 under the federal and/or ESA and are described below.

### 7 **D.2.1.1 Legal Status**

#### 8 **D.2.1.1.1 Spring-run Chinook Salmon**

9 The Central Valley Evolutionarily Significant Unit (ESU) of spring-run Chinook salmon is  
10 federally listed as Threatened and listed as Threatened by the State of California.  
11 Critical habitat for Central Valley spring-run Chinook salmon has been designated within  
12 specified stream reaches in Tehama, Butte, Glenn, Shasta, Yolo, Sacramento, Solano,  
13 Colusa, Yuba, Sutter, Trinity, Alameda, San Joaquin, and Contra Costa counties (70 FR  
14 52488). Critical habitat includes the stream channels within the designated stream  
15 reaches, and includes a lateral extent as defined by the ordinary high-water line (33  
16 CFR 329.11). Critical habitat in estuaries (e.g., San Francisco-San Pablo-Suisun Bay,  
17 Humboldt Bay, and Morro Bay) is defined by the perimeter of the water body as  
18 displayed on standard 1:24,000 scale topographic maps or the elevation of extreme  
19 high water, whichever is greater (70 FR 52488).

20 Essential Fish Habitat (EFH) has been designated for a number of species managed  
21 under a variety of fishery management plans and the Magnuson-Stevens Fishery  
22 Conservation and Management Act. For Chinook salmon, EFH overlaps and extends  
23 Critical Habitat designated for the individual ESUs. Essential Fish Habitat for Chinook  
24 salmon in California includes all streams, lakes, ponds, wetlands, and other water  
25 bodies currently or historically accessible to salmon in California. Chinook Salmon EFH  
26 excludes areas upstream of longstanding naturally impassible barriers (i.e., natural  
27 waterfalls in existence for several hundred years), but includes aquatic areas above all  
28 artificial barriers except specifically named impassible dams. Chinook Salmon EFH also  
29 extends from the nearshore and tidal submerged environments within State territorial  
30 waters out to the full extent of the exclusive economic zone (200 miles or 370.4 km)  
31 offshore of California north of Point Conception.

#### 32 **D.2.1.1.2 Winter-run Chinook Salmon**

33 The Sacramento River ESU of winter-run Chinook salmon is federally listed as  
34 Endangered and listed as Endangered by the State of California. Critical habitat for  
35 Central Valley winter-run Chinook salmon has been designated and includes the  
36 following waterways and adjacent riparian zones: the Sacramento River from Keswick  
37 Dam, Shasta County to Chipps Island at the westward margin of the Delta; all waters  
38 from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly  
39 Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the  
40 Carquinez Bridge; and all waters of San Francisco Bay (north of the San Francisco/  
41 Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge (58 FR 33212).  
42 Essential Fish Habitat for winter-run Chinook salmon is the same as described above  
43 for spring-run Chinook.

**1 D.2.1.1.3 Central Valley Steelhead**

2 The Central Valley Distinct Population Segment (DPS) of steelhead is federally listed as  
3 Threatened. Critical habitat for this DPS of steelhead has been designated within  
4 specified stream reaches in Tehama, Butte, Glenn, Shasta, Yolo, Sacramento, Solano,  
5 Yuba, Sutter, Placer, Calaveras, San Joaquin, Stanislaus, Tuolumne, Merced, Alameda,  
6 Contra Costa (70 FR 52488). Critical habitat includes the stream channels within the  
7 designated stream reaches, and includes a lateral extent as defined by the ordinary  
8 high-water line (33 CFR 329.11). Critical habitat in estuaries (e.g. San Francisco-San  
9 Pablo-Suisun Bay, Humboldt Bay, and Morro Bay) is defined by the perimeter of the  
10 water body as displayed on standard 1:24,000 scale topographic maps or the elevation  
11 of extreme high water, whichever is greater (70 FR 52488).

**12 D.2.1.1.4 Central California Coast Steelhead**

13 The Central California Coast Distinct Population Segment (DPS) of steelhead is  
14 federally listed as Threatened. Critical habitat for this DPS of steelhead has been  
15 designated within specified stream reaches in Lake, Mendocino, Sonoma, Napa, Marin,  
16 San Francisco, San Mateo, Santa Clara, Santa Cruz, Alameda, Contra Costa, and San  
17 Joaquin counties (70 FR 52488). Critical habitat includes the stream channels within the  
18 designated stream reaches, and includes a lateral extent as defined by the ordinary  
19 high-water line (33 CFR 329.11).

**20 D.2.1.2 Distribution****21 D.2.1.2.1 Spring-run Chinook Salmon**

22 Historically, spring-run Chinook salmon were found in the upper and middle elevation  
23 (1,000 to 6,000 feet) reaches of the San Joaquin, American, Yuba, Feather,  
24 Sacramento, McCloud, and Pit rivers, with smaller populations in most tributaries with  
25 sufficient habitat for over-summering adults (NMFS 2009:93). Naturally spawning  
26 populations of spring-run Chinook salmon spring-run have become restricted to only two  
27 self-sustaining populations (Mill and Deer Creek, Butte Creek) and anecdotal  
28 occurrences in other tributaries of the Sacramento (NMFS 2016). A restoration program  
29 has been underway since 2014 to re-establish spring-run Chinook salmon in the  
30 mainstem San Joaquin River below Friant Dam (NMFS 2016).

**31 D.2.1.2.2 Winter-run Chinook Salmon**

32 The historical distribution of winter-run spawning and rearing was limited to the upper  
33 Sacramento River and its tributaries, where spring-fed streams provided cold water  
34 throughout the summer, allowing for spawning, egg incubation, and rearing during the  
35 mid-summer period (Yoshiyama et al. 1998:490). The construction of Shasta Dam in  
36 1943 blocked access to all of these waters except Battle Creek (NMFS 2009:79). The  
37 Battle Creek population was likely extirpated due to hydroelectric operations (Lindley et  
38 al. 2007). Currently only a single population exists in the reach of the Sacramento River  
39 between Keswick Dam near Redding and Red Bluff Diversion (Lindley et al. 2007, NMFS  
40 2016b). Recent studies based on analyses of otolith isotopes as revealed that rearing  
41 habitat may include habitats not previously considered, including tributaries of the Feather  
42 and American Rivers, as well as Mill Creek and Deer Creek (Phillis et al. 2018).



### 1 **D.2.1.2.3 Central Valley Steelhead**

2 Prior to dam construction, water development and watershed perturbations, Central  
3 Valley steelhead were widely distributed throughout the Sacramento and San Joaquin  
4 rivers (McEwan 2001:13). Existing wild steelhead stocks in the Central Valley are  
5 mostly confined to the upper Sacramento River and its tributaries, including Antelope,  
6 Deer, and Mill creeks and the Yuba River. A few wild steelhead are produced in the  
7 American and Feather rivers (McEwan 2001:15). Until recently, steelhead were thought  
8 to be extirpated from the San Joaquin River system. Recent monitoring has detected  
9 small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, and  
10 Calaveras rivers (NMFS 2014).

## 11 **D.2.1.3 Relevant Natural History**

### 12 **D.2.1.3.1 Spring-run Chinook Salmon**

13 Adult spring-run Chinook salmon enter freshwater in the spring, hold over the summer,  
14 and spawn in the fall. Adult spring-run Chinook salmon leave the ocean to begin their  
15 upstream migration in late January and early February (DFG 1998:III-6) and enter the  
16 Sacramento River between March and September, primarily in May and June (Fisher  
17 1994:871 Table 1; Yoshiyama et al. 1998, p.489 Table 1). Adult spring-run Chinook  
18 salmon migrate from the Sacramento River into spawning tributaries primarily between  
19 mid-April and mid-June. Peak spring-run spawning generally occurs in September but  
20 may occur from mid-August to mid-October depending on water temperatures (NMFS  
21 2009:94-95 Table 4-4).

22 Spring-run Chinook salmon fry emerge from the gravel from November to March  
23 (Yoshiyama et al. 1998:489 Table 1) and the emigration timing is highly variable, as  
24 they may migrate downstream as young-of-the-year, as juveniles, or as yearlings.  
25 Depending on flow conditions in their natal streams and the Sacramento River, spring-  
26 run Chinook salmon fry may enter the Delta as early as January and as late as June;  
27 yearlings can enter the Delta from October to March or April (DFG 1998:III-9). Spring-  
28 run juveniles have been observed rearing in the lower reaches of non-natal tributaries  
29 and intermittent streams in the Sacramento Valley during the winter months (Maslin  
30 et al. 1997:17 Table 2).

### 31 **D.2.1.3.2 Winter-run Chinook Salmon**

32 Adult winter-run Chinook salmon enter freshwater in winter or early spring, and delay  
33 spawning until spring or early summer; juvenile winter-run Chinook salmon emigrate to  
34 the sea after only 5 to 9 months of river and estuary life (NMFS 1997:II-1). Adults enter  
35 San Francisco Bay from November through June, enter the Sacramento River basin  
36 between December and July, and migrate past the Red Bluff Diversion Dam (RBDD)  
37 from mid-December through early August (NMFS 1997:II-3). Spawning occurs primarily  
38 in the reach between Keswick Dam and RBDD primarily from mid-April to mid-August,  
39 with the peak occurring in May and June (Yoshiyama et al. 1998:489 Table 1).

40 Winter-run fry begin to emerge from the gravel in late June to early July and emergence  
41 continues through October (Fisher 1994:871 Table 1). Emigration of juvenile winter-run  
42 past RBDD may begin as early as mid-July, typically peaks in September, and can  
43 continue through March in dry years (NMFS 1997:II-4). Juvenile winter-run Chinook

1 salmon occur in the Delta primarily from November through early May (USFWS 2001. p.  
2 16 Table 3). The timing of migration may vary somewhat due to changes in river flows,  
3 dam operations, and water year type (NMFS 2009:81). Winter-run juveniles remain in  
4 the Delta until 5 to 10 months of age, and then begin emigrating to the ocean from  
5 November through May (Fisher 1994:871 Table 1). Recent analyses of isotopes in  
6 juvenile otoliths suggest that a wide diversity of previously unknown habitats are used  
7 as rearing locations including Mill Creek, Deer Creek, Feather River and the American  
8 River (Phillis et al. 2018). Chinook typically will spend two to three years in the ocean,  
9 before returning to spawn.

#### 10 **D.2.1.3.3 Central Valley Steelhead**

11 Central Valley steelhead generally leave the ocean and begin their upstream migration  
12 in August and September (Busby et al. 1996:22 Table 3). They spawn from December  
13 through April, with peak spawning activity from January through March, in small  
14 headwater streams and tributaries where cool, well oxygenated water is available year-  
15 round (Hallock et al. 1961:16; McEwan and Jackson 1996:19). Timing of upstream  
16 migration is correlated with higher flow events, such as freshets, with associated lower  
17 water temperatures (NMFS 2009:104). Steelhead fry usually emerge from the gravel  
18 about 4 to 6 weeks after hatching, but factors such as redd depth, gravel size, siltation,  
19 and temperature can affect emergence timing (Shapovalov and Taft 1954:156). Newly  
20 emerged fry move to the shallow, protected areas associated with the stream margin  
21 (McEwan and Jackson 1996), but soon move to other areas of the stream and establish  
22 and defend feeding territories (Shapovalov and Taft 1954:156).

23 Juvenile steelhead in the Sacramento River basin migrate downstream during most  
24 months of the year, but the peak period of emigration occurs in the spring, with a much  
25 smaller peak in the fall (Hallock et al. 1961, p.14; Nobriga and Cadrett 2001:32-33  
26 Figure 3). Emigrating Central Valley steelhead use the lower reaches of the Sacramento  
27 River and the Delta for rearing and as a migration corridor to the ocean. Some juvenile  
28 steelhead may rear in tidal marsh areas, and connected non-tidal freshwater marshes  
29 and other shallow water areas in the Delta for short periods prior to their final emigration  
30 to the ocean (NMFS 2009:106).

#### 31 **D.2.1.4 Threats**

32 Access to most of the historical upstream spawning habitat for Chinook salmon and  
33 steelhead has been eliminated or degraded by manmade structures (e.g., dams and  
34 weirs) associated with water storage, conveyance, flood control, and diversions and  
35 exports for municipal, industrial, agricultural, and hydropower purposes (Yoshiyama  
36 et al. 1998:500; McEwan 2001:15; Lindley et al. 2006:2). Upstream diversions and  
37 dams have decreased downstream flows and altered the seasonal hydrologic patterns.  
38 Reduced flows from dams and upstream water diversions result in spawning delays,  
39 increased straying, and increased mortality of outmigrating juveniles (Yoshiyama et al.  
40 1998:501; DWR 2005).

41 Channel margins throughout the Delta have been leveed, channelized, and fortified with  
42 riprap for flood protection and island reclamation, which generally degrades the quality  
43 of habitat available for juvenile rearing. Modification of natural flow regimes due to

1 upstream reservoir operations has resulted in a reduction in the extent and duration of  
2 seasonal floodplain inundation and other flow dependent habitat used by migrating  
3 juvenile Chinook salmon (70 FR 52488, Sommer et al. 2001:326; DWR 2005). Reduced  
4 flows have also resulted in increased water temperatures, increased residence times,  
5 and reductions in dissolved oxygen levels in localized areas of the Delta (e.g., Stockton  
6 Deep Water Ship Channel) that adversely affect the quality of rearing habitat for juvenile  
7 salmonids.

8 Predation on juvenile salmon by nonnative fish has been identified as an important  
9 threat to salmon and steelhead in areas with high densities of nonnative fish (e.g.,  
10 smallmouth and largemouth bass, striped bass, and catfish) that prey on outmigrating  
11 juveniles (Lindley and Mohr 2003:321). The invasion of nonnative aquatic vegetation,  
12 such as Brazilian waterweed and water hyacinth, has provided suitable habitat for  
13 nonnative fish that prey on juvenile salmon and steelhead (Brown and Michniuk  
14 2007:196). Channelized waterways (e.g., riprap-lined levees) provide virtually no cover  
15 protection from predators and little spatial diversity.

16 Juvenile salmonids are also subject to entrainment at the SWP and CVP export  
17 facilities, various smaller facilities, and agricultural diversions in the Delta, although the  
18 level of entrainment at the SWP and CVP facilities is regulated by the resource  
19 agencies. Changes in environmental cues as a result of SWP and/or CVP export  
20 operations during the migration period may contribute to delays in migration, attraction  
21 to false migration pathways, or increased movement of migrating salmon toward the  
22 export facilities, which increases the risk that these fish will be entrained into the fish  
23 salvage facilities. For example, net water movement in the central and southern Delta  
24 towards the pumping facilities may alter the migratory cues for emigrating fish in these  
25 regions (NMFS 2009). Unscreened or insufficiently screened intakes can result in the  
26 entrainment of juvenile salmonids into these agricultural diversions. Many juvenile  
27 salmon migrate downstream through the Delta during the late winter or early spring  
28 when many of the agricultural irrigation diversions are not operating or are only  
29 operating at low levels. The effect of entrainment mortality on salmonid population  
30 dynamics and overall adult abundance is not well understood.

31 Operation of the CVP and SWP water projects alter flow patterns in the Delta and  
32 create entrainment issues in the Delta at the pumping and fish facilities (NMFS  
33 2009:131). At the SWP and CVP export facilities, multiple factors influence the  
34 vulnerability of juvenile salmonids to entrainment, including their geographic distribution  
35 within the Delta and hydrodynamic factors such as reverse flows in Old and Middle  
36 rivers. Salmonids respond behaviorally to various cues (e.g., water currents, salinity)  
37 during both upstream adult and downstream juvenile migration through the Delta.  
38 Changes in these cues as a result of SWP and/or CVP export operations during the  
39 migration period may result in delays in their migration. This can increase their time of  
40 residence in the Delta, which may make them more vulnerable to entrainment into the  
41 central and southern Delta waterways, and increase their exposure to predation within  
42 the central and southern Delta waterways (NMFS 2009:313).

43 As a result of the extensive agricultural development within the Central Valley, exposure  
44 to pesticides and herbicides has been identified as a significant concern for salmon and

1 other fish species (Bennett et al. 2001, p.2). Other contaminants of concern for  
2 salmonids include, but are not limited to, mercury, copper, oil and grease, ammonia,  
3 and localized areas of depressed dissolved oxygen (e.g., Stockton Deep Water Ship  
4 Channel). In addition, sublethal concentrations of toxics may interact with other  
5 stressors on salmonids, increasing their vulnerability to mortality as a result of exposure  
6 to seasonally elevated water temperatures, predation, or disease (Werner 2007, slide 25).

7 Chinook salmon and steelhead are subject to illegal harvest (poaching) in inland waters.  
8 Adult spring-run Chinook salmon are particularly vulnerable because they hold in pool  
9 habitat within streams where they are easily accessible during the summer months. The  
10 level and effect of illegal harvest on salmon abundance and reproduction is unknown.

11 Hatchery produced salmon and steelhead in the Central Valley also present multiple  
12 threats to wild salmonid populations, including competition for food and habitat, direct  
13 predation on wild fish, and interbreeding with wild fish that can reduce their genetic  
14 fitness (NMFS 2009:143; Goodman 2005; p. 374). Hatchery production has been shown  
15 to negatively affect the genetic diversity and fitness of wild salmonid populations.  
16 Moderate to high numbers of hatchery fish may impact the genetic diversity of wild  
17 populations of Central Valley salmon. Hatchery fish compete with wild fish for food,  
18 habitat, and mates. Hatchery fish are frequently less productive than wild fish.  
19 Nonetheless, a very large portion of the existing genetic diversity in Central Valley  
20 salmonids is contained in hatchery origin stocks and, in some cases, properly managed  
21 hatchery stocks may be important contributors to recovery of the species.

### 22 ***D.2.1.5 Relevant Conservation Efforts and Guidance***

23 Current conservation efforts and guidance for anadromous salmonids are provided  
24 primarily by National Marine Fisheries Service (NMFS) in its 2019 Biological Opinion for  
25 the Reinitiation of the Long-term Operation of the Central Valley Project (CVP) and  
26 State Water Project (SWP) and the 2014 Recovery Plan for the Evolutionarily  
27 Significant Units of Sacramento River Winter-run Chinook Salmon and Central Valley  
28 Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley  
29 Steelhead (NMFS 2019; NMFS 2014).

## 30 **D.2.2 Delta Smelt**

### 31 ***D.2.2.1 Legal Status***

32 Delta smelt were listed as a threatened species under both the federal ESA and the  
33 California ESA in 1993. In 2009, the California Fish and Game Commission elevated  
34 the status of delta smelt to Endangered under the California ESA in response to an  
35 emergency petition. Critical habitat for Delta smelt was designated by USFWS in 1995  
36 (59 FR 65256). The designated critical habitat extends throughout Suisun Bay  
37 (including Grizzly and Honker bays), the length of Goodyear, Suisun, Cutoff, first  
38 Mallard and Montezuma sloughs, and the contiguous waters of the legal Delta.

### 39 ***D.2.2.2 Distribution***

40 The Delta Smelt is restricted to an area extending from the Sacramento River at the  
41 confluence of Feather, south to the fork of the San Joaquin and Old rivers, and west into

1 the San Pablo Bay, an area of approximately 51,800 ha (Moyle et al. 2016). Delta Smelt  
2 distribution is highly dependent on life stage, however it is usually confined within or  
3 upstream of the estuary's low salinity zone (<7psu) (Bennet 2005, Komoroske et al.  
4 2015). The distribution is variable, based on life stage. This variability has led to rare  
5 observations of Delta Smelt North to Knights Landing on the Sacramento River, East in  
6 to Woodbridge on the Mokelumne River, South down to Mossdale on the San Joaquin,  
7 and West out to the San Francisco Bay (USFWS 2017). Recently their distribution,  
8 especially during summer and fall, has become restricted to the north, east and west  
9 Delta as warmer temperatures and clearer water in the central and south Delta likely  
10 cause survival to drop (Merz et al. 2011, Moyle et al. 2016). Distribution is often referred  
11 to in relation to X<sub>2</sub>, the physical location of the 2ppt salinity isohaline along the axis of  
12 the Delta Estuary (Jassby et al. 1995).

### 13 ***D.2.2.3 Relevant Natural History***

14 Delta smelt spawn in the freshwater reaches of the San Francisco estuary, primarily in  
15 the Delta. Adult delta smelt spawn during the late winter and spring months, with most  
16 spawning occurring during April through mid-May (Moyle 2002:229). After hatching,  
17 larvae disperse into low salinity habitats, generally moving into Suisun Bay, Montezuma  
18 Slough, and the lower Sacramento River below Rio Vista as they mature (Grimaldo  
19 et al. 1998:27). In general, delta smelt prefer to rear in or just above the region of the  
20 estuary where fresh water and brackish water mix as a result of tidal and river currents;  
21 this region is typically in Suisun Bay (Bennett 2005:11).

### 22 ***D.2.2.4 Threats***

23 Because of their short life span (one or two years), low fecundity, current low  
24 abundance and limited geographic range, changes in the Delta have influenced the  
25 distribution and abundance of delta smelt in complex and synergistic ways. Delta smelt  
26 have been affected by loss of habitat and reductions in the quality of their habitat,  
27 largely as a result of changes in Delta inflows that affect salinity and human activities  
28 such as wetland and floodplain reclamation. The amount of spawning habitat may have  
29 been reduced as a result of reclamation, channelization, and riprapping of historical  
30 intertidal and shallow subtidal wetlands.

31 Delta smelt are lost to entrainment in the CVP and SWP water export facilities, various  
32 smaller facilities, and agricultural diversions in the Delta, most of which are unscreened  
33 or inadequately screened (Herren and Kawasaki 2001:343). The risk of entrainment to  
34 delta smelt varies seasonally and among years. Modeling has shown that up to 25% of  
35 larval or juvenile smelt and as much as 50% of the adult population may be entrained by  
36 increased pumping activities during high export years (Kimmerer 2008). In addition, the  
37 CVP and SWP water export facilities and other diversions export phytoplankton,  
38 zooplankton, nutrients, and organic material that would otherwise support the base of  
39 the food web in the Delta, thus reducing food availability for delta smelt (Jassby and  
40 Cloern 2000:345; Resources Agency 2007:21).

41 The introduction and invasion of nonnative species has also contributed to adversely  
42 affecting delta smelt. Introduced clams have reduced phytoplankton and zooplankton  
43 abundance throughout the region (Thompson 2007, slide 8) and altered the abundance

1 and species composition of the zooplankton (Jassby et al. 2002:699). Changes in the  
2 zooplankton species composition have affected the quality of food resources available  
3 to delta smelt because some of the nonnative zooplankton species are less suitable as  
4 a food resource than the native species (Resources Agency 2007:16). Delta Smelt are  
5 likely not particularly susceptible to predation due to their low abundances and habitat  
6 requirements which are not favored by predators. While Largemouth Bass will consume  
7 Delta Smelt in aquaculture (Ferrari et al. 2014), there is limited habitat overlap and like  
8 many other potential predators for Delta Smelt, their ambush predatory tactics and  
9 generalist diet makes them a low risk for the rare smelt (Moyle et al. 2016). Mississippi  
10 silverside (*Menidia beryllina*) is a more likely predator for smelt eggs and larvae as their  
11 abundances are high in habitats and areas where Delta Smelt may spawn (Bennett  
12 2005, Baerwald et al. 2012).

13 Brazilian waterweed and water hyacinth (both introduced plants) grow in dense  
14 aggregations and can indirectly affect delta smelt by reducing dissolved oxygen levels,  
15 suspended sediment concentrations and turbidity within the water column. Reduced  
16 turbidity as a result of these plants and filter feeding by the introduced clams may  
17 reduce foraging efficiency and increase the vulnerability of delta smelt to predation.  
18 Because of the structure and shade they provide, these aquatic plants also create  
19 excellent habitat for bass and sunfish, nonnative predators of delta smelt.

20 Numerous toxic chemicals including agricultural pesticides, herbicides, heavy metals,  
21 and other agricultural and urban product can enter delta smelt habitat from a variety of  
22 sources. Chemicals, such as pesticides, herbicides, endocrine disrupting compounds,  
23 and metals may have lethal and sublethal effects on delta smelt that make them more  
24 vulnerable to other sources of mortality (Werner 2007).

### 25 **D.2.2.5 Relevant Conservation Efforts and Guidance**

26 Current conservation efforts and guidance for Delta smelt are provided primarily by  
27 USFWS in its 2019 Biological Opinion for the Reinitiation of the Long-term Operation of  
28 the Project CVP and SWP (USFWS 2019). The 1996 Delta Native Fishes Recovery  
29 Plan provided initial guidance on recovery of delta smelt; however, that document is out  
30 of date and currently under revision by USFWS.

## 31 **D.2.3 Green Sturgeon**

### 32 **D.2.3.1 Legal Status**

33 The southern DPS of green sturgeon is federally listed as Threatened. Critical habitat  
34 for this green sturgeon DPS has been designated and includes the Sacramento River,  
35 lower Feather River, and lower Yuba River in California; and the Sacramento-San  
36 Joaquin Delta and Suisun, San Pablo, and San Francisco bays in California (74 FR  
37 52300).

### 38 **D.2.3.2 Distribution**

39 In the Pacific Ocean, green sturgeon range from the Bering Sea, Alaska, to Ensenada,  
40 Mexico. Green sturgeon occupy freshwater rivers from the Sacramento River up  
41 through British Columbia (Moyle 2002:110), but spawning has been confirmed in only

1 three rivers: the Rogue River in Oregon and the Klamath and Sacramento rivers in  
2 California. Based on genetic analyses and spawning site fidelity (Adams et al. 2002:12;  
3 Israel et al. 2004:926), NMFS determined that are at least two distinct population  
4 segments of green sturgeon. Green sturgeon in the Delta and Sacramento River Basin  
5 belong to the southern DPS, consisting of populations originating from coastal  
6 watersheds south of the Eel River (“Southern DPS”). Spawning of Southern DPS Green  
7 Sturgeon primarily occurs in the mainstem Sacramento River although a spawning  
8 event was documented in 2011 in the lower Feather River at the Thermalito Afterbay  
9 Outlet (Seesholtz et al. 2012).Relevant Natural History

10 Green sturgeon spend a large portion of their lives in coastal marine waters as  
11 subadults and adults. Subadult male and female green sturgeon spend at least  
12 approximately 6 and 10 years at sea, respectively, before reaching reproductive  
13 maturity and returning to freshwater to spawn for the first time (Nakamoto et al. 1995:iv,  
14 14). Adult green sturgeon spend as many as 2 to 4 years at sea between spawning  
15 events (70 FR 17386, April 6, 2005; Erickson and Webb 2007:264). Adults typically  
16 begin their upstream spawning migration in the spring and either migrate downstream  
17 after spawning, or reside within the river over the summer (Erickson et al. 2002:568;  
18 Benson et al. 2007:10-12). Subadults may also migrate upstream, but for unknown  
19 purposes. Adults and subadults occupy the San Francisco Bay, San Pablo Bay, Suisun  
20 Bay, and the Delta adjacent to the Sacramento River. Adults and subadults primarily  
21 inhabit the Delta and bays during summer months, most likely for feeding and growth  
22 (Kelly et al. 2007:292).

### 23 **D.2.3.3 Threats**

24 Like the anadromous salmonids, access to historical spawning habitat for green  
25 sturgeon has been reduced by construction of migration barriers, such as major dams,  
26 that block or impede access. The locks at the end of the Sacramento River Deep Water  
27 Ship Channel at the connection with the Sacramento River block migration of fish from  
28 the deep water ship channel back to the Sacramento River (DWR 2005:3-49). In  
29 addition, green sturgeon are attracted by high floodwater flows into the Yolo Bypass  
30 basin and then concentrate behind Fremont Weir, which blocks passage and may  
31 strand sturgeon when flood flows recede (DWR 2005:4-16). Larval and juvenile  
32 sturgeon are susceptible to entrainment in multiple diversions along the Sacramento  
33 and Feather rivers.

34 Reclamation of wetlands and islands have reduced and degraded the availability of  
35 rearing habitat for green sturgeon. The impacts of channelization and riprapping are  
36 thought to affect all life stages. Dredging operations to maintain commercial and  
37 recreational vessel passage in the Sacramento and San Joaquin rivers, and the  
38 navigation channels within the Delta, and Suisun, San Pablo, and San Francisco bays  
39 pose risks to bottom dwelling fish such as green sturgeon through entrainment. In  
40 addition, dredging operations can decrease the abundance of locally available prey  
41 species, contribute to resuspension of toxics such as ammonia, hydrogen sulfide, and  
42 copper during dredging and dredge spoil disposal, and alter bathymetry and water  
43 movement patterns.

1 Green sturgeon are vulnerable to recreational sport fishing within the Bay-Delta estuary  
2 and Sacramento River. Regulations require the release of green sturgeon caught  
3 incidentally, but illegal harvest may still occur. High water temperatures in the Feather  
4 River and San Joaquin River may affect sturgeon migration, spawning, and egg  
5 development. Water temperatures in the Sacramento River may no longer be a major  
6 concern for green sturgeon because temperatures in the upper Sacramento River are  
7 actively managed for Sacramento River winter-run Chinook salmon. Juvenile sturgeon  
8 are also exposed to increased water temperatures in the Delta during the late spring  
9 and summer due to the loss of riparian shading and by thermal inputs from municipal,  
10 industrial, and agricultural discharges.

11 Subadults and adults feeding in bays and estuaries may be exposed to contaminants  
12 that may affect their growth and reproduction (Fairey et al. 1997:1063 Table 2;  
13 Greenfield et al. 2005:33 Table 2). Studies on white sturgeon in estuaries indicate that  
14 the bioaccumulation of pesticides and other contaminants adversely affects growth and  
15 reproductive development and may result in decreased reproductive success (Kruse  
16 and Scarnecchia 2002:437; Feist et al. 2005:1681). Green sturgeon are believed to  
17 experience similar risks from contaminants (70 FR 17386, April 6, 2005). Because  
18 green sturgeon spend more time in marine waters than white sturgeon, they may have  
19 less exposure to contaminants in estuaries compared to white sturgeon. However,  
20 green sturgeon may be more sensitive than white sturgeon to certain contaminants  
21 found in coastal estuaries, including methylmercury and selenium, that affect their  
22 routine and active metabolic rates, swimming performance, and ability to avoid  
23 predators (Kaufman et al. 2008, slide 20).

#### 24 ***D.2.3.4 Relevant Conservation Efforts and Guidance***

25 Current conservation efforts and guidance for green sturgeon are provided primarily by  
26 National Marine Fisheries Service (NMFS) in its 2019 Biological Opinion for the  
27 Reinitiation of the Long-term Operation of the CVP and SWP (NMFS 2019).

## 28 **D.2.4 Longfin Smelt**

### 29 ***D.2.4.1 Legal Status***

30 Longfin smelt are listed as Threatened by the State of California. In 2009, the USFWS  
31 issued a 12-month finding concluding that the Delta population of longfin smelt did not  
32 meet the definition of a distinct population segment, and therefore did not qualify for  
33 listing under the federal ESA. Shortly thereafter, the Center for Biological Diversity and  
34 The Bay Institute filed a lawsuit challenging the Service's decision. On February 2,  
35 2011, the United States District Court for the Northern District of California approved a  
36 settlement agreement between the USFWS, the Center for Biological Diversity, and The  
37 Bay Institute, obligating the USFWS to reconsider the status of the longfin smelt,  
38 including the San Francisco Bay-Delta population. Under the terms of the settlement,  
39 the USFWS must conduct a rangewide review of the species and issue a new listing  
40 determination by September 30, 2011. No critical habitat for this species has been  
41 designated.



#### 1 **D.2.4.2 Distribution**

2 The historical and current range of the longfin smelt is from Alaska southward to the  
3 San Francisco Bay-Delta in California (77 FR 19756). In California, longfin smelt are  
4 known from the Klamath River, Humboldt Bay and its tributaries, the Eel River, the Van  
5 Duzen River, the Russian River, and the San Francisco Bay-Delta (Moyle 2002:235-  
6 236). During its life cycle, the longfin smelt uses the entire estuary from the freshwater  
7 Sacramento-San Joaquin Delta downstream to South San Francisco Bay and out into  
8 coastal marine waters (Baxter 1999:180; Moyle 2002:236; Rosenfield and Baxter  
9 2007:1590). Longfin smelt are dispersed broadly in the San Francisco Bay-Delta  
10 estuary by high outflows and currents, which could transport larvae or small juveniles  
11 long distances before they mature and start living near the bottom of the water column  
12 (77 FR 19756).

#### 13 **D.2.4.3 Relevant Natural History**

14 The longfin smelt is a euryhaline (tolerant of variable salinities) pelagic fish that inhabits  
15 various depths of the water column depending on the individual's life stage. Longfin  
16 smelt reportedly cannot tolerate water temperatures greater than 68 °F (20 °C) (Moyle  
17 2002:236), and will move farther downstream (west) during the summer months when  
18 water temperatures in the Delta are higher. Longfin smelt have been found throughout  
19 the year in fresh and brackish waters with salinities ranging from 14 to 28 parts per  
20 thousand (ppt) (DFG 2001:477).

21 Longfin smelt may spawn as early as November and as late as June, although  
22 spawning typically occurs from February to April (Moyle 2002:236). However, longfin  
23 smelt at various life stages are detected in the San Francisco Bay estuary trawl surveys  
24 in numerous months of the year (Rosenfield and Baxter 2007:1587), suggesting that the  
25 spawning period may not be restricted to November to June or that growth and  
26 development between individuals varies. Spawning occurs in areas of relatively low  
27 salinity, which are considered essential nursery habitat for estuarine organisms.  
28 Spawning usually occurs over rocky or gravelly substrates and aquatic plants (Moyle  
29 2002:236). Newly hatched embryos are transported in the upper portion of the water  
30 column downstream (west) into more brackish parts of the San Francisco Bay-Delta  
31 system (Moyle 2002:236). Longfin smelt usually live for 2 years, although some  
32 individuals may spawn as 1- or 3-year-old fish, and die soon after spawning (Moyle  
33 2002:236).

34 Longfin smelt first begin feeding on copepods and cladocerans. With subsequent  
35 growth, their diet expands to include mysids and amphipods among a variety of lesser  
36 food items (Slater 2008:418). Longfin smelt are preyed upon by fishes, birds, and  
37 mammals (Barnhart et al. 1992:44). A composite index of predatory fish density in  
38 Central Bay and San Pablo Bay was found to be negatively associated with trends in  
39 Longfin Smelt abundance in population dynamics modeling by Maunder et al. (2015).

#### 40 **D.2.4.4 Threats**

41 Due to their similarity in habitat use, longfin smelt are subject to many of the same  
42 stressors and population threats as delta smelt (see discussion above).

1 Additionally, Jeffries et al. (2016) examined physiological performance in larval/young  
2 juvenile Longfin Smelt in relation to water temperature in a laboratory study and  
3 concluded that Longfin Smelt may be more susceptible than Delta Smelt to increases in  
4 temperature, and therefore Longfin Smelt may have little tolerance for future warming in  
5 California under climate change. By comparison to Delta Smelt (Brown et al. 2013,  
6 2016), climate change could result in detrimental effects on Longfin Smelt ecology  
7 related to factors such as maturation and spawning season length and timing, as well as  
8 reduction in habitat extent.

#### 9 ***D.2.4.5 Relevant Conservation Efforts and Guidance***

10 Longfin smelt are being managed through a protective State regulation that governs  
11 SWP and CVP operations in the south Sacramento-San Joaquin Delta, research and  
12 monitoring, local water diversions and the State water Project North Bay Aqueduct,  
13 dredging, and sand mining.

### 14 **D.2.5 Sacramento Splittail**

#### 15 ***D.2.5.1 Legal Status***

16 Sacramento splittail are not listed under the State (CESA) or federal ESA, but are  
17 considered a California species of special concern.

#### 18 ***D.2.5.2 Distribution***

19 Adult splittail spawn within the mainstem rivers and major tributaries to the Delta  
20 upstream in the Extended Planning Area. Adult splittail spawn on inundated floodplains  
21 of the Yolo Bypass and Cosumnes River. Collection of larvae and young juveniles  
22 indicates that inundation of terrestrial habitat within the levees of the San Joaquin River  
23 also provides suitable spawning habitat (Moyle et al. 2004). Larvae and young juveniles  
24 begin their migration downstream through the Delta with rising water temperatures  
25 during the spring; such migrations often occur in late-April, May, or even June of high  
26 flow years (Moyle et al. 2004). In low flow years, juvenile splittail are most abundant in  
27 the northern and western regions of the Delta; in high flow years, their distribution is  
28 more even throughout the Delta (Sommer et al. 2009). Most late stage juveniles and  
29 non-reproductive adults inhabit moderately shallow (<4 m) brackish and freshwater tidal  
30 sloughs and shoals, such as those found in Suisun Marsh and the margins of the lower  
31 Sacramento River (Moyle et al. 2004).

#### 32 ***D.2.5.3 Relevant Natural History***

33 The Adult splittail begin a gradual upstream migration towards spawning areas  
34 sometime between late November and late January. The relationship between  
35 migrations and river flows is poorly understood, but it is likely that splittail have a  
36 positive behavioral response to increases in flows. Feeding in flooded riparian areas in  
37 the weeks just prior to spawning may be important for later success of spawning and for  
38 post-spawning survival. Evidence of splittail spawning on floodplains has been found on  
39 both the San Joaquin and Sacramento Rivers. In the San Joaquin River drainage,  
40 spawning has apparently taken place in wet years in the region where the San Joaquin  
41 River is joined by the Tuolumne and Merced Rivers. Spawning has also been  
42 documented on flooded areas along the lower Cosumnes River (Crain et al. 2004).

1 Spawning may take place elsewhere in the Delta (e.g., on mid-channel islands) but it  
2 has not been documented.

## 3 **D.2.6 Pacific Lamprey and River Lamprey**

### 4 ***D.2.6.1 Legal Status***

5 The river lamprey and pacific lamprey are not listed under the federal or State ESA.  
6 River lamprey is considered a species of special concern by the State of California.  
7 Pacific Lamprey is considered a Federal species of concern.

### 8 ***D.2.6.2 Distribution***

9 In the Central Valley, river lamprey are found in the lower Sacramento and San Joaquin  
10 River drainages, including the Stanislaus and Tuolumne Rivers. They may exist in other  
11 tributaries of these rivers, but are easily overlooked and have been the subject of few  
12 targeted sampling efforts (Moyle 2002). The species appears to be more abundant in  
13 the lower Sacramento-San Joaquin River system than in other streams in California.

### 14 ***D.2.6.3 Relevant Natural History***

15 The Pacific lamprey are anadromous, beginning their migration into freshwater towards  
16 upstream spawning areas primarily between early March and late June (Moyle 2002).  
17 Most upstream migration occurs at night and occurs in pulses. Spawning habitat  
18 requirements are thought to be similar to those of salmonids. There is some evidence  
19 that lamprey in larger river systems, such as the Klamath and Eel Rivers, have distinct  
20 runs similar to Chinook salmon (Moyle 2002). Both sexes contribute to nest construction  
21 by removing larger stones from a gravelly substrate, creating a shallow depression.  
22 These simple nests occur in gravelly substrata with moderately swift current, water  
23 temperatures typically of 12-18 degrees Celsius, and at a depth of 30-150 centimeters  
24 (Moyle 2002). External fertilization of eggs occurs just in front of the nest and are then  
25 washed into the nest. Fecundity is unknown. Spawning is repeated until both individuals  
26 are spent. Adults typically die after spawning. The eggs hatch into ammocoetes after  
27 approximately 19 days at 15 degrees Celsius, spend a short time in the nest, and then  
28 drift downstream to suitable area in sand or mud (Moyle 2002).

29 Ammocoetes remain in freshwater for approximately 5 to 7 years, where they bury into silt  
30 and mud and feed on algae, organic material, and microorganisms. Ammocoetes change  
31 locations during this stage. Ammocoetes begin metamorphosis into macrophthalmia  
32 (juveniles) when they reach 14-16 centimeters TL. Individuals develop external features  
33 (eyes, oral disc, and color changes) and experience internal and physiological changes  
34 that prepare them for their predatory life stage in the ocean (McPhail and Lindsey  
35 1970). Downstream migration begins upon completion of this metamorphosis, generally  
36 coinciding with high flow events in winter and spring (Moyle 2002).

37 Adults spend 3-4 years in the ocean in British Columbia, but this length is thought to be  
38 shorter in more southern areas (Moyle 2002). Adult remain close to the mouths of the  
39 rivers from which they came, likely because their prey is most abundant in estuaries and  
40 other coastal areas (Moyle 2002). Individuals attack a wide variety of fishes, include  
41 salmon, Pacific herring, and flatfishes, in the ocean (Beamish 1980). Pacific lamprey are

1 thought to be preyed upon in the ocean by sharks, other fish, otters, seals, and sea  
2 lions (Moyle 2002).

#### 3 **D.2.6.4 Threats**

4 Artificial barriers, including dams, culverts, water diversions, tidal gates, and other  
5 barriers, can impede or completely block the upstream migration of adults to spawning  
6 grounds, resulting in impacts to the distribution and abundance of lamprey (Luzier et al.  
7 2009). Lamprey adults may have difficulty passing over barriers using ladders and other  
8 passage structures designed for salmonids, possibly due to high water velocity, sharp  
9 angles, culverts with drop-offs, or insufficient resting areas (Kostow 2002).

10 Artificial barriers, including dams, culverts, water diversions, tidal gates, and other  
11 barriers, can impede or completely block the downstream migration of ammocoetes and  
12 macrophthalmia towards the ocean, resulting in impacts to the distribution and  
13 abundance of lamprey (Luzier et al. 2009). Pacific lamprey populations cannot persist  
14 for more than a few years above impassable barriers (Beamish and Northcote 1989).

#### 15 **D.2.6.5 Relevant Conservation Efforts and Guidance**

16 Along with several tribes, state and federal agencies are increasingly incorporating of  
17 Pacific lamprey into management and monitoring plans to increase the state of  
18 knowledge and conserve the species.

### 19 **D.2.7 Hardhead**

#### 20 **D.2.7.1 Legal Status**

21 Hardhead are not listed under the State or federal ESA, but are considered a California  
22 species of special concern.

#### 23 **D.2.7.2 Distribution**

24 Hardhead is a native species that is widely distributed in low to mid-elevation streams in  
25 the Sacramento and San Joaquin drainages.

#### 26 **D.2.7.3 Relevant Natural History**

27 Stream dwelling juvenile (<150 mm SL) hardhead are often found in small aggregations  
28 in pools and runs during the day, actively feeding at the water's surface, holding in  
29 moving water to feed on drifting material, or browsing from the benthos (Moyle 2002).  
30 Adults tend to school in the deepest part of pools, cruising about slowly during the day.  
31 They are most active when feeding, in early morning and evening (Moyle 2002). In  
32 small streams, they seldom move more than one kilometer away from home pools,  
33 except when spawning.

34 Hardhead mature following their second year and spawn in the spring, mainly in April  
35 and May (Moyle 2002) judging by the upstream migrations of adults into smaller  
36 tributary streams during this time of the year. Estimates based on juvenile recruitment  
37 suggest that hardhead spawn by April-June in Central Valley streams, although the  
38 spawning season may occasionally extend into August in the foothill streams of the  
39 Sacramento-San Joaquin drainage.

#### 1 **D.2.7.4 Threats**

2 The apparent ongoing declines in hardhead distribution and abundance are a result of  
3 synergistic impacts from habitat loss, decline in water quality, and invasions of alien  
4 species (Moyle 2002). The principal threats to hardhead include: (1) dams and  
5 diversions, (2) agriculture, (3) urbanization, (4) instream mining, (5) stream modification  
6 for transportation, (6) fisheries management ('harvest' associated with past eradication  
7 of 'rough fishes' to benefit recreational fisheries), and (7) alien species.

### 8 **D.2.8 Riffle Sculpin**

#### 9 **D.2.8.1 Legal Status**

10 Riffle Sculpin is considered a Federal species of concern.

#### 11 **D.2.8.2 Distribution**

12 Riffle sculpin are found in many increasingly isolated watersheds in the Central Valley  
13 drainage and the central coast. In tributaries to the San Joaquin River, they are present  
14 from the Mokelumne River south to the Kaweah River. They are mostly present in mid-  
15 elevation reaches, although they are present below dams with coldwater releases. In  
16 the Sacramento River drainage, they are present in Putah Creek on the west side and  
17 most tributaries on the east side, from the American River north to the upper  
18 Sacramento and McCloud rivers.

#### 19 **D.2.8.3 Relevant Natural History**

20 Riffle sculpin are found exclusively in permanent cold-water streams. Riffle sculpins eat  
21 mainly benthic invertebrates, primarily active insect larvae such as those of caddisflies,  
22 stoneflies, and mayflies (Moyle 2002). However, they will consume other prey that is  
23 readily available, such as amphipods and small fish, including other sculpins. Riffle  
24 sculpins live in permanent, cool, headwater streams where riffles and rocky substrates  
25 predominate.

### 26 **D.2.9 Sacramento Hitch**

#### 27 **D.2.9.1 Legal Status**

28 Hardhead are not listed under the State or federal ESA, but are considered a California  
29 species of special concern.

#### 30 **D.2.9.2 Distribution**

31 Hitch were once found throughout the Sacramento and San Joaquin valleys in low  
32 elevation streams and rivers, as well as in the Delta. Today they are absent from the  
33 San Joaquin River and the lower reaches of its tributaries from Friant Dam down to the  
34 Merced River. In the Sacramento River, hitch appear to be spread across much of their  
35 native range, up to and including Shasta Reservoir.

#### 36 **D.2.9.3 Relevant Natural History**

37 Sacramento hitch are omnivorous and feed upon zooplankton and insects, usually in  
38 open waters or at the surface of streams (Moyle 2002). In streams, they feed on

1 filamentous algae, aquatic insects and terrestrial insects. Sacramento hitch inhabit  
 2 warm, lowland, waters including clear streams, turbid sloughs, lakes and reservoirs. In  
 3 streams they are generally found in pools or runs among aquatic vegetation, although  
 4 small individuals will also use riffles.

#### 5 **D.2.9.4 Threats**

6 The Sacramento hitch occur in the lowland reaches of rivers and streams most  
 7 impacted by human use, as well as in some reservoirs. Given that they persist in some  
 8 urban streams, it appears hitch are capable of surviving in highly altered habitats  
 9 although their abundance in such extreme environments is likely limited. Best evidence  
 10 indicates that their populations are localized and fragmented today which, in turn,  
 11 suggests that they may be particularly susceptible to a combination of anthropogenic  
 12 stressors, including dams, polluted run-off from agricultural lands, rural and urban  
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