Chapter 2 The Problem: Fewer Salmon and Steelhead in the Central Valley

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Fewer salmon and steelhead are in the watersheds of California's Central Valley today than in the 1940s and 1950s. This is due in part to large dams built in that era, Shasta (1944) and Keswick (1950) on the Sacramento River and Friant (1942) on the San Joaquin River. Federal and State resource agencies have listed several populations of Central Valley salmon and steelhead as threatened or endangered. In listing these fish, the resource agencies have cited the loss of historical spawning and rearing habitat that are upstream of large, impassable dams as a primary factor contributing to the fish decline and a threat to their continued existence. Other structures contributing to their decline include road crossings, bridges, culverts, flood control channels, erosion control structures, canal and pipeline crossings, and gravel mining pits.

For current listing information on Pacific salmonids, visit the NMFS web page at http://www.nwr.noaa.gov/1salmon/salmesa/index.htm

The Sacramento River winter-run is currently listed as “endangered.” The central California coast and Central Valley steelhead, and Central Valley spring-run are currently listed as “threatened.” The California Central Valley fall-run and late-fall run Chinook salmon are currently listed as “species of special concern.”

Many of the principal waterways in California’s Central Valley and the San Joaquin Valley contain large dams (referred to as “rim dams”) that prevent fish passage to formerly used habitat. It has been previously noted and is well documented that rim dams such as Shasta, Oroville, Folsom, etc., have been a major factor resulting in population declines of salmonids. Between 80 and 90 percent of historical anadromous fish habitat has been lost because of construction of rim dams, resulting in significant population declines and subsequent State and federal listings of several salmonid populations. However, the geographic scope of the Fish Passage Improvement Program is limited to the geographic scope of the Ecosystem Restoration Program; and until the scope of the Ecosystem Restoration Program extends upstream of rim dams, the focus of the fish passage program will be on providing fish passage at man-made structures downstream of rim dams[1].

This chapter describes the historical and current distribution of salmon and steelhead listed as threatened or endangered and their critical habitat in the Central Valley. In April 2002, a federal court vacated the rule designating critical habitat for the Central Valley spring-run evolutionarily significant unit and the Central Valley steelhead ESU. The National Marine Fisheries Service is currently reviewing the status of these ESUs; therefore, designations may change in the future. The chapter also shows the distribution of ESUs of salmon and steelhead in the Central Valley, the distribution of critical habitat for endangered or threatened Chinook salmon and steelhead, and the distribution of essential fish habitat for winter-, fall-, and late-fall Chinook salmon runs (figures 2-1 to 2-7). More information about these designations is in Appendix D.

Figure 2-1 Location of steelhead trout (*Oncorhynchus mykiss*) evolutionarily significant unit

Figure 2-2 Location of Chinook salmon (*Oncorhynchus tshawytscha*) evolutionarily significant unit

Figure 2-3 Critical habitat for winter-run Chinook

Figure 2-4 Essential fish habitat for spring-run Chinook salmon in the Central Valley of California

Figure 2-5 Essential fish habitat for winter-run Chinook salmon in the Central Valley of California

Figure 2-6 Essential fish habitat for fall-run Chinook salmon in the Central Valley of California

Figure 2-7 Essential fish habitat for late-fall run Chinook salmon in the Central Valley of California

Appendix D

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[1] Appendix E contains information on a portion of the San Francisco Bay Area and Delta anadromous fish-bearing streams with fish passage issues.

Chinook Salmon in the Central Valley

There are four runs of Chinook salmon in the Central Valley. Each run is named according to the season when adult fish migrate upstream and spawn and the periods of juvenile residency and smolt migration (Vogel and Marine 1991, Fisher 1994).

Central Valley Spring-run

Figures 2-8 and 2-9 show the historical and current distribution of spring-run Chinook salmon (DFG 1998). Figure 2-9 also displays known structures within the present range of spring-run Chinook salmon. Spring-run salmon require adequate summer flows and summer holding habitat—cold pools. Streams suitable for the spring-run occur at elevations of at least 1,500 feet in the Sacramento River drainage and higher in the San Joaquin River drainage (Yoshiyama and others 1996). Streams originating at 1,500 feet and higher or those receiving substantial water from cold springs have cooler summer water, adequate summer flows, and pools for oversummering.

Figure 2-8 Historical range and distribution of spring-run Chinook salmon in the Central Valley of California

Figure 2-9 Known structures within the present range of spring-run Chinook salmon in the Central Valley of California

According to the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS 1999), the five-year average in the late 1990s was 8,500 spring-run fish, compared with 40,000 fish in the 1940s. Between 80 and 90 percent of the spring-run Chinook's spawning and rearing habitat has been lost due to water system developments. Water diversion and hydroelectric dams have limited or prevented access to upstream summer holding habitat historically utilized by spring-run. As a result, spring-run and fall-run are no longer separated spatially and temporally, increasing hybridization potential. This is evident in the main stem Sacramento River and the Feather River. However, populations in Mill, Deer, and Antelope creeks remain separated both spatially and temporally. In Butte and Clear creeks, efforts are being made to create or maintain a spatial separation between spring-run and fall-run at strategic locations that will benefit both runs (Aceituno 2004 pers comm). In the case of Butte Creek, the entire population occurs below elevation 1,000 feet due to operation of the PG&E DeSalba-Centerville Project. The PG&E DeSalba-Centerville Project imports cold water from the West Branch Feather River to support summer holding habitat at the lower elevations.

Sacramento River Winter-run

Until completion of Shasta Dam in 1944, winter-run salmon were in the upper Sacramento River system, in the Little Sacramento, Pit, McCloud, Fall rivers and others, ascending far up the drainages to the headwaters (Hallock and Rectenwald 1990; Fisher, unpublished data referenced in Yoshiyama and others 1996). Battle Creek is the only remaining tributary stream downstream of Shasta Dam that has accessible winter-run habitat and that supports a winter-run population.

Figure 2-10 Historical range and distribution of winter-run Chinook salmon in the Central Valley of California

Figure 2-11 Known structures within the present range of winter-run Chinook salmon in the Central Valley of California

Winter-run streams are fed by cool, constant springs that provide the flows and low temperatures required for spawning, incubation, and rearing in summer (Slater 1963). Figures 2-10 and 2-11 show the historical and current distribution of winter-run Chinook salmon based on Yoshiyama and others (1996). Figure 2-11 also displays known structures within the present range of winter-run Chinook salmon. From 1974 to 1984, winter-run salmon were occasionally documented on the Calaveras River, east of Stockton (DFG 1993). There is considerable debate whether the river, with its headwaters at a relatively low elevation, once had a winter-run or whether recent sightings of winter-run fish were strays. Thus, Figure 2-11 does not include the Calaveras River.

Central Valley Fall-run and Late-fall Runs

Figures 2-12 and 2-13 show the historical and current distribution of fall-run Chinook salmon based on Yoshiyama and others (1996). Figure 2-13 also displays known structures within the present range of fall-run Chinook salmon. Historically, fall-run salmon were in all Central Valley streams that had enough water during the fall, even if the streams were intermittent during other times of the year. Fall-run salmon generally spawned in streams on the valley floor and in foothill reaches below 500-feet elevation (Rutter 1904; Yoshiyama and others 1996).

Figure 2-12 Historical range and distribution of fall-run Chinook salmon in the Central Valley of California

Figure 2-13 Known structures within the present range of fall-run Chinook salmon in the Central Valley of California

Late-fall run fish require similar conditions to those of the winter-run. Juveniles rear in fresh water and require cold water in summer (Fisher 1994) from either springs or late snowmelt. Figures 2-14 and 2-15 show the historical and current distribution of late-fall run Chinook salmon based on Yoshiyama and others (1996). Figure 2-15 also displays known structures within the present range of late-fall run Chinook salmon.

Figure 2-14 Historical range and distribution late-fall run Chinook salmon in the Central Valley of California

Figure 2-15 Known structures within the present range of late-fall run Chinook salmon in the Central Valley of California

There is still suitable habitat for fall-run and late-fall run Chinook salmon spawning and rearing in lower foothill and Central Valley streams that had historical runs or host these runs today. There are many man-made barriers in these reaches that can delay spawning or prevent access.

Declining Habitat

Today, all four runs are primarily restricted to lower foothill and Central Valley stream reaches, primarily because of construction of flood control, water storage and debris control reservoirs on rivers such as the Feather, Mokelumne, Yuba, and American, on Stony Creek, and on tributaries of the upper Sacramento River. Spring-run Chinook still go up Mill Creek, Deer Creek, and occasionally Beegum Creek off of Cottonwood Creek, all of which exist above what is generally considered Sierra and Coast Range foothills (Hamilton 2004 pers comm). Spring-run salmon have been extirpated from the San Joaquin River drainage.

Based on large streams in the Central Valley and excluding the Sacramento-San Joaquin Delta, Yoshiyama and others (1996) estimated that 1,014 miles of Central Valley streams remain available to Chinook salmon compared to the 2,113 miles that were available historically (a 48 percent loss). This includes lengths of streams available to salmon as migration corridors, such as the lower Sacramento and San Joaquin rivers, as well as upstream holding and spawning habitat. Further, when excluding stream lengths used strictly as migration corridors, Yoshiyama and others (1996) estimated that 82 percent of original spawning and holding habitat for all salmon runs in the Central Valley was no longer available. The loss of spawning habitat is a larger portion of the total habitat loss because the spawning areas lie in stream reaches now cut off by dams (Yoshiyama and others 1996).

Of the total length of stream courses accessible today, less than a third in the San Joaquin River drainage and less than half in the Sacramento River drainage are suitable as spawning habitat. Less than 300 miles out of 6,000 miles of historical spawning habitat are available for salmon and steelhead in the Central Valley (a 95 percent loss) (DFG 1993). This is similar to the estimate made by Yoshiyama and others (1996).

Steelhead in the Central Valley and San Francisco Bay Area

Before intensive water development during the last century, steelhead were more common in the Central Valley than they are today.

Adult steelhead normally migrate during high flows between September and March (DFG 1996). In July, adults generally begin moving upstream through the main stem of the Sacramento River. Upstream movement peaks in late September-October but continues though February and March (Moyle 2002). Most spawning occurs from December to April. No historical information is available for San Joaquin River steelhead. Figure 2-16 shows the historical and current distribution of steelhead trout (*Oncorhynchus mykiss*) in drainages flowing into the Central Valley.

Figure 2-16 Current and historical distribution of California Central Valley steelhead trout (*Oncorhynchus mykiss*)

Both natural and hatchery-maintained steelhead have declined in the Sacramento River system. In 1996, about 10 to 30 percent of adults returning to spawn were of natural origin (DFG 1996), down from an average 88 percent for the 1953–1954 and 1958–1959 seasons (Hallock and others 1961). The size of the steelhead run in the American River in the 1971–1972 and 1973–1974 seasons was 19,583 and 12,274, respectively (Staley 1976). Run sizes of 300, 1,500, and 250 were estimated for the 1990–1991 through 1992–1993 seasons, respectively (DFG 1996).

Dams and other structures have blocked steelhead access to miles of spawning and rearing habitat. Low-elevation stream reaches downstream of dams typically do not provide suitable habitat conditions for steelhead because existing flow regimes and spawning and rearing habitat features may be insufficient to support viable populations. Additionally, summer rearing temperatures may be too high downstream of dams. However, it is important to note that large dams may actually assist in providing available cold water to stream reaches in low elevations throughout the year.

Mill Creek and Deer Creek, tributaries of the Sacramento River, may represent the best spawning and rearing habitat available to steelhead in the Central Valley. In addition, Cow, Battle, Clear, and Cottonwood creeks have incidental reports of steelhead and offer good opportunities for restoration of native steelhead populations for the Upper Sacramento River.

The California Department of Fish and Game (1996) identified several Central Valley streams with steelhead habitat and has recommended ways to improve fish access to upstream reaches or provide adequate flows for steelhead spawning and rearing. The streams with potential for self-sustaining wild runs are Clear, Big Chico, Cow, Cottonwood, Battle, Mill, Deer, Antelope, and Butte Creeks, and the Yuba River. Since the publication of "Steelhead restoration and management plan for California" (DFG 1996), there have been few published records of steelhead distribution and abundance (Aceituno 2003 pers comm). However, they have been seen in streams not previously considered to have adequate habitat such as Dry Creek in Roseville (Placer County). The lack of monitoring and updating of information make it difficult to fully describe the fish passage barriers affecting steelhead today.

There is little history regarding steelhead distribution in the San Joaquin River system. Based on historical documentation of known Chinook salmon distribution in the drainage, there were steelhead from at least the Kings River headwaters north (McEwan 2001). Today, a small but active steelhead sport fishery exists on the Tuolumne River (McEwan 2000 pers comm).

Steelhead numbers in many streams emptying into San Francisco Bay have declined. Most of those streams flow through heavily urbanized areas, so the streams have been modified into flood control channels. They have lost their riparian vegetation, and water quality has deteriorated. The headwaters have also been affected by erosion and siltation from housing development and grazing cattle (Leidy 1984).

Figure 2-17 shows the historical and 1984 distribution of central California coast steelhead trout based on Leidy (1984). Steelhead are documented in a variety of watersheds around the bay including San Pablo Creek in Contra Costa County; San Francisquito, Corte Madera, San Antonio, Campbell, Guadalupe, Coyote, Arroyo Honda, Smith, and Isabel creeks in Santa Clara County; San Leandro and Alameda Creeks in Alameda County; creeks and rivers of the Napa River and Sonoma Creek drainages in Napa and Sonoma counties; and Corte Madera and Miller creeks in Marin County (Leidy 1984).

Figure 2-17 Current and historical distribution of central California coast steelhead trout *(Oncorhynchus mykiss)* within ERP geographic scope

How Structures in Rivers and Streams Contribute to the Problem

Since the 19th century when the first dams were built in California's Central Valley, salmon and steelhead habitat has declined from 6,000 miles of rivers and streams to 300 miles—a 95 percent loss (DFG 1993). This decline in habitat relates to a corresponding decline in salmon and steelhead populations.

Salmon and steelhead were not only abundant in stream communities but they also provided food and energy for other native fishes (Moyle and Randall 1998). Populations of bald eagles and other animals that depend on migrating salmon for food may decrease dramatically if the salmon are eliminated (Spencer and others 1991). Water quality and nutrient cycling can also be impacted by loss of key faunal components. Salmon release nutrients when they die after spawning, affecting algal biomass and primary production (Kline and others 1990) as well as secondary insect consumers (Schuldt and Hershey 1995). The nutrient release is considered essential for maintaining productivity of nursery areas for future salmon stocks (Mathisen

1972). When dams or other obstructions block salmonid migration routes, patterns of nutrient cycling in entire river and stream ecosystems can be altered.

In California, as in most temperate and arid regions of the world, aquatic biodiversity is declining because aquatic ecosystems have been severely altered by human activity (Moyle and Williams 1990; Moyle and Leidy 1992; Jensen and others 1993; Leidy and Moyle 1998). A well established body of literature documents the widespread occurrence of dams and their profound physical, chemical, and biological effects on riverine ecosystems (Baxter 1977; Petts 1984; Dynesius and Nilsson 1994; Collier and others 2000; Graf 1999; Rosenberg and others 2000).

Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead trout (*O. mykiss*) were once important parts of aquatic ecosystems at low to middle elevations in western Sierra Nevada streams from the Kings River north. However, dams and other obstructions have excluded these species from much of their former habitat. Migratory fish, particularly salmon, are frequently the species most impacted by dams (Shuman 1995). The exclusion has significantly altered the stream communities of which salmon and steelhead were once part (Moyle and Randall 1998).

Stream ecosystems evolved as continuous features of the landscape. Man-made structures can fragment streams and their ecosystems. Road crossings, dams, diversions, severe pollution, or land management practices alter the geomorphology, hydrologic regime, and hydrologic connectivity of streams. Fragmentation of aquatic ecosystems results in altered nutrient cycling patterns, streamflow, sediment transport, channel morphology, species composition, and genetic diversity. The fragmentation and alteration of streams by humans can have dramatic effects on ecosystem integrity and biological diversity (Holden 1979; Petts 1979; Krapu and others 1984; Sullivan and others 1987; Grams 1991; Stevens and Ayers 1993; Bauer and others 1994; Middleton and Liittschwager 1994; Pringle 1997; Levin and Schiewe 2001).

Some aquatic ecologists believe that environmental degradation, including fragmentation of streams and rivers by dams and other structures, underlies the demise of the 106 salmon populations now considered extinct along the west coast of North America (Levin and Schiewe 2001). Bank erosion is the most important source of spawning gravel in the Sacramento River; riprap bank stabilization reduces the amount of gravel that is available for salmon spawning habitat in this system (Shields 1991). Also, Buer and others (1984) identified riprap bank stabilization as a contributing cause of declining salmon populations in the Sacramento River.

Over the past 75 years, dams in Southern California have caused considerable loss of steelhead freshwater habitat (McEwan and Jackson 1996). Habitat fragmentation and population decline increases the chances for inbreeding, loss of rare alleles, and genetic drift, impacting species' ability to respond to environmental changes over the long-term and remain viable. Research to determine the level of genetic diversity of rainbow trout populations from Big Pico Creek south to Pauma Creek in Southern

California was conducted (Nielsen and others 1997). It was determined rainbow trout that retained access to the ocean had significantly higher levels of genetic diversity than those whose migrations were blocked by dams.

Sustained unnatural flows downstream of dams cause loss of breeding and rearing habitat for amphibians, such as the arroyo southwestern toad of Southern California (Sweet 1992, USFWS 1994), and other aquatic fauna. Habitat loss affects larval, newly metamorphosed and adult life stages of aquatic fauna, causing high mortality (Sweet 1992). Extreme alterations in habitat conditions have been documented downstream of large dams such as Glenn Canyon Dam on the Colorado River. Cold water releases from the dam and trapped sediments have altered downstream habitat conditions and have been related to declining populations of endangered Humpback Chub, a native minnow of the lower Colorado River (Coggins and Walters 2001).

For more information on Colorado River research, see http://www.gcmrc.gov/

Types of Structural Fish Passage Barriers

Obstructions to fish passage include dams, culverts, bridges, flood control channels, erosion control structures, canal and pipeline crossings, and gravel mining pits, as well as natural features such as beaver dams and log jams, and geomorphic features such as waterfalls. Dams are the most obvious and visible of these obstructions. There is limited information available regarding sturgeon passage, as a majority of the literature regarding fish passage is geared toward salmon.

Dams

Dams provide water storage for flood control and navigation, debris containment, electrical power generation, recreation, and fish and wildlife habitat and can improve water quality (Collier and others 2000). In the early years of dam building, environmental effects were seldom considered. Since then, impacts of dams on migrating fish, natural geomorphic processes in streams such as sediment transport, and flows and temperatures of river systems have become evident. With declines of many fish populations in California and listing of some salmonids under the federal Endangered Species Act, alterations of dams and other structures are being considered in restoration and recovery efforts.

Dams can affect migrating fish in several ways. Migration can be blocked at large dams (often referred to as rim dams) when it is not possible to build fishways (due to economic, engineering, social, or environmental issues). Downstream migrants can be lost in large reservoirs and through turbines (Bell 1990). To the fish accustomed to rivers, a lack of current in reservoirs causes them to wander upstream and downstream in search of an exit from the reservoir. Wandering can be fatal to fish because of the energy they expend and their susceptibility to predation (Bell 1990). Dams that are as small as a foot high may prevent fish passage when there is insufficient streamflow or the downstream face or footing of the dam is too long or shallow for fish to overcome. Downstream-migrating juvenile salmonids face stress, injury, and death by passing over the tops of dams and landing on concrete or rocks below, becoming caught in recirculating hydraulics at the base of dams, or becoming prey to piscivorous fish that congregate at dams or ladders.

In addition, sustained unnatural flows and flow manipulations downstream of dams confuse fish when high flow releases occur at non-migratory periods, attracting fish at the wrong times or into channels where flows are not sustained, stranding or killing fish as a result.

Fish passage over smaller types of dams, such as low head dams or flashboard dams, may be accomplished with the use of fish ladders, step pools, and other modifications. Passage over these types of dams is simple compared to the obstacles faced when attempting fish passage over rim dams. However, new technologies and practices are now used to allow fish passage over rim dams.

Methods to move fish over rim dams are being implemented in the Pacific Northwest, namely on the Snake and Columbia rivers, and are being considered elsewhere, including the Feather River at Lake Oroville. A goal of any fish passage system is to limit the number of fish handling events. Each time a fish is handled increases the likelihood of stress which can directly or indirectly lead to fish casualties.

Moving fish over rim dams often requires a multistage process. The initial stage in fish passage often uses a mechanical lifting device (fish elevators/lifts, fish locks, navigation locks) or a fish ladder where appropriate (different designs utilized depending on height and stream conditions) (DWR 2004). There is also a sorting phase where fish that are not part of the fish passage program or fish not of proper criteria (that is, size) are removed (DWR 2004). Sorting may be done manually or by using an automated system. Prior to transportation, the fish are often held in tanks, pools or ponds that are regulated for temperature, dissolved oxygen, pH, and other biotic and abiotic constituents (DWR 2004). The method used to transport the adult fish varies depending on fish passage goals, terrain and available funds. Transportation of the adult fish may be done by using specially equipped tank trucks, barges, trains or helicopters (DWR 2004). Once the adult fish are moved upstream of the dams and reservoirs, they will be released in streams with suitable spawning habitat (DWR 2004).

If spawning and rearing are successful, the next phase in fish passage is getting out-migrating juveniles past the large dams or rim dams. This involves collecting, sorting, holding, transporting, and releasing the juvenile salmonids downstream of the dam so they can continue their ocean migration (DWR 2004). Juvenile collection often uses fish screens, surface collectors, or gulpers that are specially designed to limit mortality and can be done in the reservoir or within the stream reaches (DWR 2004). Depending on the fish passage goals and finances, juveniles may be sorted or tagged (DWR 2004). Once the juveniles have been collected, they will be held in climate-controlled pens or raceways to prepare for transportation and release (DWR 2004). Depending on location and logistics, the fish may be transported to their release location by truck, barge, train, or helicopter (DWR 2004). The final step in the passage of the juvenile salmonids would their release into the appropriate waterway. Depending on the fish passage goals, logistics, and river characteristics, the juveniles may be released just downstream of the dam, in further downstream reaches, or closer to ocean waters.

Gravel Pits

Instream gravel mining activities—including the use of temporary culverts and bridges, gravel skimming, pits, and associated large ponds left after gravel mining operations are complete—can provide warm or slack water habitat for fish that prey on juvenile salmonids and other barriers to fish passage. Warm-water predators include non-natives such as striped bass, largemouth bass, and smallmouth bass, or natives such as the northern pike minnow. Juvenile salmonids migrating downstream can become disoriented in the slow waters of a pond and become more vulnerable to predation. Many of these ponds lack adequate cover for juvenile salmonids trying to avoid predators. Demko (1998) noted the occurrence of predation on juvenile salmonids by striped bass in instream gravel pit ponds at the Oakdale Recreation Area on the Stanislaus River. The warm water in the ponds may be deadly for juvenile salmonids that are acclimated to the colder water of their spawning areas. Warm-water stress can also make them susceptible to predators. Instream ponds trap large quantities of sand and silt that high flows mobilize and carry downstream, potentially covering downstream spawning areas. In addition, when river flows spill over into offstream ponds close to the river, fish can be trapped and stranded once flows recede. Many of these problems have been observed anecdotally by biologists and anglers but await further study to describe the extent of these impacts (Mesick 2002 pers comm).

Roads and Infrastructure

Depending on streamflow, horizontal distance, and depth of water over the structure, roads and other infrastructure built across streams have been recognized as potential barriers to fish migration (for example, fords, pipelines, bridge footings, and energy dissipaters) (Robison and others 2000). Recent surveys and investigations have documented the significance of road construction impacts to migratory paths of anadromous salmonids in the Pacific Northwest alone (GAO 2001; R. Taylor 2000, 2001; NMFS 2002 in prep.). Culverts may become perched by downstream scouring or erosion, making them too high for adult or juvenile fish to access under low streamflow. Fish can become injured when they land on riprap or concrete placed downstream an outlet to control erosion. At high flows, the force of the water flowing through a culvert may create velocity barriers that can overwhelm migrating fish. As part of the effort to recover declining populations of listed salmonids and other fishes, culverts at stream road crossings have come under intense scrutiny nationwide. These efforts have received significant State and federal funding.

Channel modifications for flood control include clearing vegetation, riprapping, widening, deepening, realigning, and lining. These modifications remove ecologically valuable features such as stream meanders, oxbows and sloughs, spawning substrate, streamside riparian cover, and instream vegetation; decrease stream length; increase gradient and velocity; dewater adjacent lands; change basic physicochemical regimes; and alter nutrient inputs (USFWS 1982). Flood control structures such as concrete-lined or riprapped stream channels can impede upstream migration if there are no places for fish to rest as they work against high velocity water. Drop structures also impede fish migration if fish cannot move past them. Channelized or dewatered stream reaches create adverse habitat conditions, such as warm water that exceeds tolerance limits, or lack of cover that limits shading, food production, predator avoidance capacity and ultimately survival and growth of migrating juveniles. Areas downstream of channelized reaches can experience adverse streamflow conditions resulting in degraded stream quality.

Existing Fish Passage Features

Existing fish ladders and other fishways should be inventoried to determine their functionality. Passage structures that are old, deteriorated, less than optimal, or otherwise do not meet fish passage criteria of the California Department of Fish and Game or National Marine Fisheries Service, can act as partial or complete barriers to fish migration and should be removed or replaced.

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