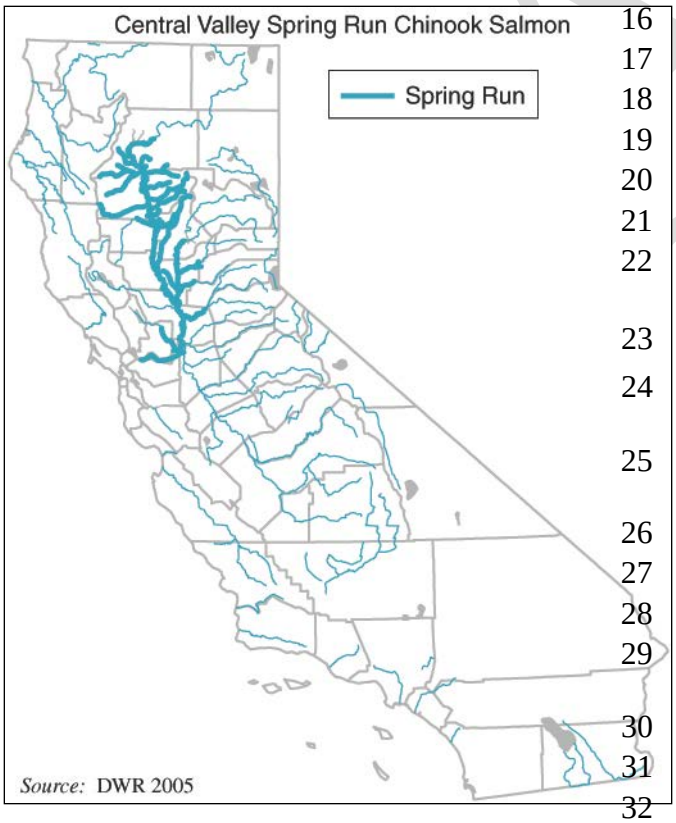
A.19 CENTRAL VALLEY SPRING-RUN CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*)

illustration by Joseph Tomelleri

A.19.1 Legal and Other Status

Central Valley Chinook salmon are composed of several genetically distinct races, or evolutionarily significant units (ESU)[1]. This account focuses on the Central Valley spring-run Chinook salmon ESU, which occurs in the BRCP Plan Area.

The Central Valley spring-run Chinook salmon ESU was listed as a threatened species under the ESA on September 16, 1999, and the threatened status was affirmed on June 28, 2005 (NOAA 1999, 2005a). In the 2005 decision, the ESU included all naturally spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries in California, including the Feather River, as well as the Feather River Hatchery spring-run Chinook salmon program (NOAA 2005a). Before this decision, Feather River Hatchery spring-run Chinook salmon were not included in the ESU, despite fish from the hatchery being genetically distinct from other populations in Mill, Deer, and Butte creeks.



Critical habitat was established on September 2, 2005, and became effective on January 2, 2006 (NOAA 2005b) (see Figure A-19 for critical habitat within the Plan Area). Spring-run Chinook salmon was listed as a threatened species under the California ESA on February 5, 1999.

A.19.2 Species Distribution and Status

A.19.2.1 Range and Status

The distribution and status information below was taken from the California Department of Fish and Game (1995) unless otherwise noted.

Spring-run Chinook salmon can be found in rivers throughout Alaska, British Columbia, Washington, Idaho, Oregon,

[1] An ESU is defined as "a population that 1) is substantially reproductively isolated from conspecific populations and 2) represents an important component in the evolutionary legacy of the species" (Johnson et al. 1994).

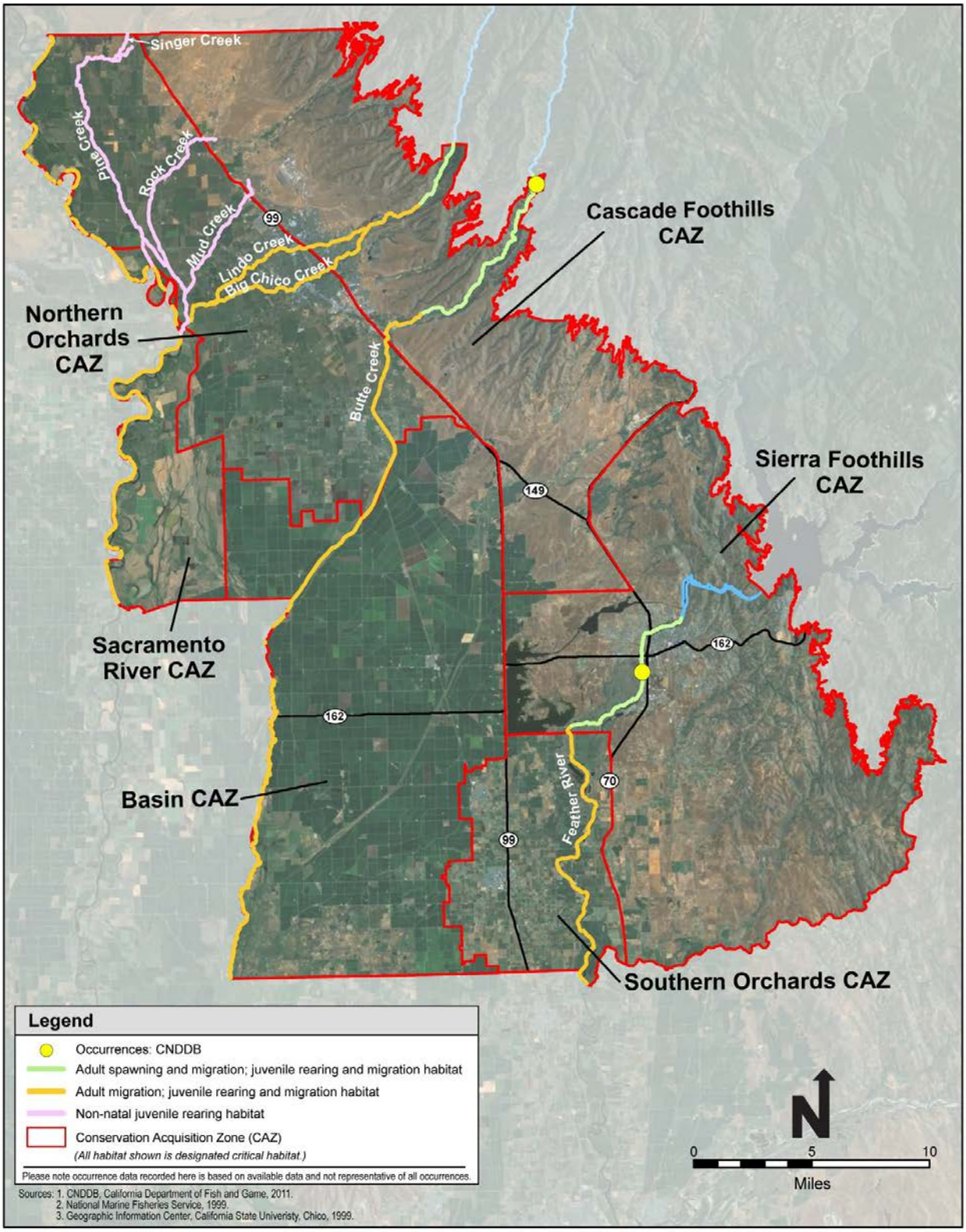


Figure A-19. Central Valley Spring-Run Chinook Salmon Modeled Habitat and Recorded Occurrences

and California, but have depleted populations throughout this range. In the Sacramento-San Joaquin drainage, the principal holding and spawning areas were historically in the middle reaches of the San Joaquin, American, Yuba, Feather, Upper Sacramento, McCloud, and Pit rivers, presumably with smaller populations in most other tributaries that were large and cold enough to support the salmon through the summer. The main populations were all extirpated with the construction of dams, primarily in the 1940s and 1950s, which blocked access to holding areas (DFG 1995). Currently, the most consistent self-sustaining, wild populations reside in Deer and Mill Creeks, Tehama County, and a few fish are present in Antelope, Battle, Big Chico, Clear, Cottonwood, and Beegum creeks and the Feather and Yuba rivers (DFG 1995, 2001). Substantial numbers of spring-run Chinook salmon are also located in Butte Creek with high variability (10 to 20, 259 fish between 1979 and 2006) (DFG 2007).

Historically, spring-run Chinook salmon were one of the largest runs on the Pacific coast. In 1885, commercial fisheries harvested over 600,000 fish in the Central Valley. The population was never estimated historically, but in 1955 the San Joaquin drainage was estimated by the DFG to sustain 210,000 wild Chinook salmon per year with proper management. In 1945, a total of 56,000 fish migrated up the San Joaquin River; this would be the last large run for the species. After the construction of Friant Dam in 1948 and the resulting loss of habitat, the spring-run Chinook salmon population in the San Joaquin River was locally extirpated, leaving those from the Sacramento River watershed as the primary stock for the run.

Spring-run Chinook salmon populations in the Sacramento drainage were drastically reduced following construction of barrier dams. Historical estimates of run size for the Sacramento River and its tributaries averaged over 15,000 fish in the McCloud River, Pit River, Little Sacramento River above Shasta Dam; 8,000 to 20,000 fish in the Feather River above Oroville Dam; 6,000 to 10,000 fish in the Yuba River above Englebright Dam; and over 10,000 fish in the American River above Folsom Dam (DFG 1995). The entire Sacramento River drainage supported an estimate exceeding 100,000 fish in many years between the late 1800s and 1940s, which was possibly low by a factor of 3 or 4 (DFG 1995).

Currently, the only waterways that support viable spring-run populations are Butte, Deer, and Mill creeks (DFG 1998). In addition, adult spring-run return to the Feather River Hatchery on the Feather River. Preliminary 2010 Butte Creek snorkel survey data indicate that there were 1,160 adult spring-run Chinook salmon in Butte Creek (GrandTab 2011). Population size estimates have declined every year since 2005, in which 10,625 adults were observed in snorkel surveys. Preliminary population estimates of spring-run during 2010 in Mill and Deer creeks were 482 and 262 individuals, respectively. Population numbers have generally declined since 2005-2006 in both of these creeks. The preliminary population estimate of spring-run during 2010 in the Feather River, all of which were hatchery fish, was 1,661 individuals. Population size has generally declined since 2003, during which 8,662 adults returned.

A.19.3 Distribution and Status in the Plan Area

Spring-run Chinook salmon have been recorded in three main drainages in Butte County, including Big Chico Creek, Butte Creek, and the Feather River (CNDDB 2006), as shown in Figure A-19.

Along Big Chico Creek, individuals have been observed from Bidwell Park, 6 miles (9.65 kilometers [km]) west-northwest of Paradise, to Higgings Hole 0.5 mile (0.8 km) upstream of Ponderosa Way Crossing. Along Butte Creek, individuals have been found from the Parrot-Phelan diversion dam upstream to the Centerville diversion dam west of De Sabla. Along the Feather River, individuals have been observed from the Thermalito Afterbay outlet to the fish barrier at the Feather River Hatchery upstream.

A.19.4 Habitat Requirements and Special Considerations

The success of immigration and spawning is dependent on water movement and velocity, water depth, substrate composition, and temperature (Resources Agency et al. 1998). Spawning takes place in swift, moderately shallow riffles or in areas along fast moving banks with plentiful, gravelly substrate. The gravel needs to be clean, loose, and stable for the duration of the larval stage. Pre-spawning activity of Chinook salmon requires a territory of 200 to 650 square feet (18.6 to 60.4 square meters) depending on the density of the population. The female will dig a redd, or nest, in the gravel with an average size of 165 square feet (15.3 square meters), and she will deposit several packets of eggs and bury them after they have been fertilized by the male.

Spawning locations have a particular balance of water velocity and depth. Water velocity is more critical to the viability of the habitat than water depth. Incubating embryos buried in the gravel require sufficient water flow through the gravel for the supply of oxygen and removal of metabolic wastes. This water flow is governed by the velocity of the water. Water velocity in Chinook salmon spawning areas ranges from 1.0 to 3.5 feet per second (fps) and the optimum velocity is 1.5 fps. Overly high water velocity may lead to redd scour, in which spawning gravels or eggs become mobilized. Spawning depths fall between 1 to 5 feet (0.3 to 1.5 meter) with a maximum depth observed of 20 feet. A depth shallower than 6 inches can be restrictive to Chinook salmon movement.

Substrate composition has other key implications in spawning success. The embryos and alevins (newly hatched fish with the yolk sacs still attached) require adequate water movement through the substrate. This movement can be inhibited by the accumulation of fines and sand. Higher amounts of sand and fines may prohibit successful embryo incubation and emergence of alevins from the substrate. Generally, the redd should contain less than 5 percent fines (The Resources Agency et al. 1998).

The water temperature is also critical for immigration and spawning of Chinook salmon. This species prefers well-oxygenated water within a range of 57ºF to 67ºF (8.3ºC to 13.9ºC) for upstream

migration and between 42ºF and 56ºF (5.6ºC and 13.3ºC) for spawning (The Resources Agency et al. 1998). Typically, a temperature of 52ºF (11.1ºC) is preferred for spawning. Temperatures outside of these thresholds decrease reproductive success.

A.19.5 Life History

The runs of Chinook salmon in California are distinguished by several physical and temporal properties, including the maturity of fish entering fresh water, time of spawning migrations and holding periods, spawning areas, incubation times, incubation temperature requirements, and migration timing of juveniles (DFG 1995).

Spring-run Chinook salmon migrate great distances to spawning habitat. The spring-run Chinook salmon leave the ocean and enter the rivers between late January and September during the spring snow-melt runoff (DFG 1998). The majority of the immigrating fish is 3 years old, but can range from 2 to 5 years of age. During the migration to their natal streams, adults will spend their time in suitable holding habitat of deep pools with clean water through the summer. Spawning occurs in mid-August to early October (DFG 1995, The Resources Agency et al. 1998, Moyle 2002). The embryos incubate for 5 to 6 months, November through March, and once they hatch, the alevins remain in the gravel substrate for 2 to 3 weeks until the yolk sac is fully absorbed (DFG 1995). Emigration of fry and smolts generally occurs during late November through April; however, emigration timing is variable among and within creeks (NMFS 2009). Juveniles can move downstream just after hatching or they can remain until the following fall. They may also hold in the Sacramento River or San Francisco Bay estuary and increase their size before reaching the ocean. Most spring-run salmon smolts have presumably left the system by mid-May (DFG 1995).

Historically, spawning adults consisted of mostly larger fish that were likely 4 or 5 years of age. However, recently, these individuals are far less abundant due to intense ocean fishing of the largest fish within the population (DFG 1995). Thus, the most prevalent spawning fish are younger and average 3 years old, based on size.

A.19.6 Threats

The three major threats to spring-run Chinook salmon include loss of historical spawning habitat, degradation of remaining habitat, and genetic threats from Feather River hatchery practices (Good et al. 2005, NMFS 2009).

A.19.6.1 Spawning Habitat Loss

The construction of dams and water diversions for agriculture, flood control, and domestic and hydropower purposes along migratory streams has blocked the passage to many natal tributaries for spring-run Chinook salmon and has resulted in a reduction in the number of natural spawning populations from an estimated 17 to three (Good et al. 2005). Suitable summer water

temperatures for spring-run Chinook salmon are found at elevations between 492 to 1,640 feet (150 to 500 meters); however, most of the waterways are currently blocked by impassible dams.

A.19.6.2 Habitat Degradation

Existing suitable habitat is limited to a small number of tributaries on the Sacramento River, but has been further degraded by elevated water temperatures and agricultural and municipal diversions, entrainment into unscreened or poorly screened diversions, predation by nonnative species, and restricted and regulated flows. Dam-regulated low flow periods and alterations in river flows are other limiting factors for salmon migration and reproduction. During times of low or no flows, fish are unable to reach natal spawning habitat or become disconnected and isolated from flowing water. In dry years, some individuals may be blocked from their streams and forced to remain in main rivers where breeding habitat is marginal.

A.19.6.3 Loss of Genetic Diversity

Interbreeding of wild spring-run Chinook salmon with both wild and hatchery fall-run Chinook salmon has the potential to dilute and eventually eliminate the adaptive genetic distinctiveness of the few remaining naturally reproducing populations (DFG 1995). Spring and fall runs of Chinook salmon were historically isolated in time and space in the past; however, the construction of dams has eliminated access to historical spawning areas of spring-run fish in the upper tributaries and streams. This forces spring-run fish to spawn in lower elevation areas also used by fall-run fish, likely resulting in hybridization of the two races. Further, the Feather River Hatchery spring-run salmon program releases their fish far downstream of the hatchery (San Pablo Bay), which increases the rate of straying adults migrating back upstream (DFG 2001). Recent efforts by DFG, however, have reduced straying, and, therefore, the potential for hybridization (McReynolds et al. 2006). Half of the production fish are now released in the Feather River at Live Oak.

A.19.7 Relevant Conservation Efforts

Many conservation efforts have arisen from management actions meant to minimize the potential effects of State Water Project and Central Valley Project water diversions in the Delta. Section 7 Biological Opinions and Reasonable and Prudent Alternatives (RPAs) (e.g., NMFS 2009) and other federal projects have led to the establishment of large programs to conserve Central Valley salmonids. In 1992, an amendment to the authority of the CVP through the Central Valley Project Improvement Act (CVPIA) was enacted and gave rise to the Anadromous Fish Restoration Program (AFRP). The AFRP has been engaged in monitoring, education, and funding restoration projects towards the goal of doubling the natural populations of select anadromous fish species in the Central Valley. Restoration projects funded through the AFRP include fish passage, fish screening, riparian easement and land acquisition, development of watershed planning groups, instream and riparian habitat improvement, and gravel replenishment.

Several actions have addressed habitat issues with Central Valley salmonids through ESA section 7 Reasonable and Prudent Alternatives addressing temperature, flow, and operations of the CVP and SWP; actions by EPA to minimize acid mine runoff from Iron Mountain Mine; and Central Valley Regional Water Quality Control Board decisions to require compliance with Sacramento River water quality objectives, which resulted in the installation of the Shasta Temperature Control Device in 1998.

DWR's Delta Fish Agreement Program has provided approximately $49 million for projects that benefit salmon and steelhead production in the Sacramento-San Joaquin basins and Delta since 1986. Delta Fish Agreement projects that benefit Central Valley spring-run Chinook salmon include water exchange programs on Mill and Deer creeks; enhanced law enforcement efforts from San Francisco Estuary upstream to the Sacramento and San Joaquin rivers and their tributaries; design and construction of fish screens and ladders on Butte Creek; and, screening of diversions in Suisun Marsh and San Joaquin River tributaries. The Spring-Run Salmon Increased Protection Project provides overtime wages for DFG wardens to focus on reducing illegal take and illegal water diversions on upper Sacramento River tributaries and adult holding areas, where the fish are vulnerable to poaching. This project covers Mill, Deer, Antelope, Butte, Big Chico, Cottonwood, and Battle creeks, and has been in effect since 1996.

The CALFED Ecosystem Restoration Program (ERP) has conducted restoration actions that include installation of fish screens, modification of barriers to improve fish passage, habitat acquisition, and instream habitat restoration. A major CALFED ERP action currently underway is the Battle Creek Salmon and Steelhead Restoration Project. This project will restore 77 km (48 miles) of habitat in Battle Creek to support steelhead and Chinook salmon spawning and juvenile rearing at a cost of more than $90 million. The project includes removal of five small hydropower diversion dams, construction of new fish screens and ladders on another three dams, and construction of several hydropower facility modifications to ensure continued hydropower operations. This restoration effort is believed to be the largest cold water restoration project to date in North America.

The Feather River Fish Hatchery is making efforts to segregate spring-run from fall-run Chinook salmon to enhance and restore the spring-run Chinook salmon genotype in the Feather River, including changing release locations of juveniles and developing a Hatchery and Genetic Management Plan (DFG 2001, McReynolds et al. 2006).

The Fish Passage Improvement Project at the Red Bluff Diversion Dam is building a pumping facility to provide reliable water supply for high-valued crops in Tehama, Glenn, Colusa, and northern Yolo counties while providing year-round unimpeded fish passage. Gate closures at the dam have historically interrupted the passage of spring-run Chinook salmon and other migratory species.

Seasonal constraints on sport and commercial fisheries south of Point Arena and in-river constraints on sport fishing by DFG, as well as enhanced enforcement efforts to reduce illegal harvest, have reduced harvest on spring-run Chinook salmon.

The Bay Delta Conservation Plan is under development to contribute to the recovery of Central Valley spring-run Chinook salmon. Proposed conservation measures under the plan that would benefit spring-run Chinook salmon include restoring up to 65,000 acres of tidal wetland, 10,000 acres of floodplain, and 10 linear miles of channel margin habitat; reductions in predation; improvements in dissolved oxygen levels in the Stockton Deep Water Ship Channel; reducing illegal harvest; improving fisheries in the Yolo Bypass; and contributing to hatchery and genetic management plans at Central Valley hatcheries.

Many smaller tributaries to the Sacramento and San Joaquin rivers have local watershed conservancies with master plans to contribute to conservation and recovery of salmonids.

A.19.8 Species Habitat Suitability Model

Spring-run Chinook salmon migration, holding, spawning, and rearing habitats are defined as migration, holding, spawning, and rearing habitats delineated by CNDDB (2007), NMFS (2005), GIC (1999), and C. Garmin (pers. comm.) (Figure A-19).

Spawning and Holding Habitat. Spring-run Chinook salmon spawning and holding has been recorded in three main drainages in the Plan Area, including Big Chico Creek, Butte Creek, and the Feather River. Spawning habitat occurs in Big Chico Creek from River Mile (RM) 13 to Bidwell Park, in Butte Creek from RM 44 to outside the Plan Area (RM 22), and in the Feather River from the Thermalito Afterbay Outlet to the Fish Barrier Dam.

Adult Migration Habitat. Adult migration habitat of spring-run Chinook salmon is located in waterways within of spawning habitat in Big Chico and Butte Creeks, Feather River, and on the mainstem Sacramento River.

Juvenile Migration Habitat. Spring-run Chinook salmon juveniles migrate downstream towards the Pacific Ocean throughout all spawning and adult migration habitat in the Plan Area.

Juvenile Rearing Habitat. Juvenile rearing habitat consists of all adult spawning and juvenile/adult migration habitat discussed above, but can also include nonnatal streams in Big Chico Creek, such as Mud, Rock, Pine, and Singer Creeks to rear.

Assumptions. Data from DFG (CNDDB 2007) and NMFS (2005) were used for this model because these agencies are the state and federal agencies, respectively, responsible for managing spring-run Chinook salmon and, as such, are considered to be the authorities on the distribution of the species and its habitat. Data gaps in the CNDDB (2007) and NMFS (2005) GIS databases were augmented with information from Chico State University's Geographic Information Center (1999) and C. Garmin (pers. comm.).

A.19.9 Recovery Plan Goals

The Public Draft Recovery Plan for Central Valley salmonids, including spring-run Chinook salmon, was released by NMFS on October 19, 2009. Although not final, the overarching goal in the public draft is the removal of, among other listed salmonids, spring-run Chinook salmon from the federal list of Endangered and Threatened Wildlife (NMFS 2009b). Several objectives and related criteria represent the components of the recovery goal, including the establishment of at least two viable populations within each historical diversity group, as well as other measurable biological criteria.

A.19.10 References

Literature Cited

CNDDB (California Natural Diversity Database). 2006. Sacramento: California Department of Fish and Game.

CNDDB (California Natural Diversity Database). 2007. Natural Heritage Division. California Department of Fish and Game, State of California.

DFG (California Department of Fish and Game). 1995. Fish Species of Special Concern in California, Spring-Run Chinook Salmon. Habitat Conservation Planning Branch. Website: http://www.dfg.ca.gov/hcpb/species/ssc/sscfish/sprngrnchnok.htm. Accessed October 2006.

DFG (California Department of Fish and Game). 2008. Report to the Fish and Game Commission: A Status Review of the Spring-Run Chinook Salmon (*Onchorhynchus tshawytscha*) in the Sacramento River Drainage. Candida eSpecies Status Report 98-01. Sacramento, CA.

DFG (California Department of Fish and Game). 2000a. The Status of Rare, Threatened, and Endangered Animals and Plants of California, Spring-Run Chinook Salmon. http://www.dfg.ca.gov/hcpb/cgi-bin/read_one.asp?specy=fish&idNum=52.

DFG (California Department of Fish and Game). 2000b. The Status of Rare, Threatened, and Endangered Animals and Plants of California, Winter-Run Chinook Salmon. http://www.dfg.ca.gov/hcpb/cgi-bin/read_one.asp?specy=fish&idNum=54.

DFG (California Department of Fish and Game). 2001. Final report on anadromous salmonid fish hatcheries in California. Technical report, California Department of Fish and Game and National Marine Fisheries Service, Southwest Region. Accessed May 2007 from http://swr.nmfs.noaa.gov/ HatcheryReviewPublicDraft2.pdf .

DFG (California Department of Fish and Game). 2004. Sacramento River Spring-run Chinook Salmon, 2002-2003 Biennial Report. Habitat Conservation Division, Native Anadromous Fish and Watershed Branch. Accessed May 2007 from http://www.dfg.ca.gov/nafwb/pubs/2004/ChinookSR0203.pdf.

DFG (California Department of Fish and Game). 2011. GrandTab, maintained by DFG Fisheries Branch. Updated 2/1/2011. http://www.calfish.org/Programs/AdditionalPrograms/DFGFisheriesBranch/tabid/104/Default.aspx.

DWR (California Department of Water Resources). 2005. Fish Passage Improvement, An Element of CALFED's Ecosystem Restoration Program website: http://www.watershedrestoration.water.ca.gov/fishpassage/b250/content.html. Accessed March 2007

GIC (Geographic Information Center). 1999. California State University, Chico.

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

Hallock, R. J. and F. W. Fisher. 1985. Status of Winter-Run Chinook Salmon, *Oncorhynchus tshawytscha*, in the Sacramento River. Anadromous Fisheries Branch, California Department of Fish and Game. January 25.

Hayes, J. M., and C. E. Lindquist. 1967. Appendix C: Fish and Wildlife. Pp. 177-293 in Sacramento Valley Eastside Investigation: a Study of Surface Water Development Opportunities in Eastern Tehama and Western Butte Counties. Preliminary Edition, August. California Department of Water Resources Bulletin 137. California Department of Water Resources, Sacramento.

McReynolds, T. R., C. E. Garman, P. D. Ward, and S. L. Plemons. 2006. Butte and Big Chico Creeks Spring-Run Chinook Salmon, *Oncorhynchus tshawytscha*, Life History Investigation 2004-2005. Department of Fish and Game, Inland Fisheries Administrative Report No. 2006-4.

NMFS (National Marine Fisheries Service). 2009. Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento River Winter-Run Chinook Salmon and Central Valley Spring-Run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead. Sacramento Protected Resources Division. October.

NMFS (National Marine Fisheries Service). 2005. http://swr.nmfs.noaa.gov/salmon/layers/finalgis.htm.

NMFS (National Marine Fisheries Service). 1999. Endangered and Threatened Species; Threatened Status for Two Chinook Salmon Evolutionarily Significant Units (ESUs) in California. Federal Register 64(179):50394. September 16.

NMFS (National Marine Fisheries Service). 1997. Endangered and Threatened Species: Listing of Several Evolutionary Significant Units (ESUs) of West Coast Steelhead. Final Rule. *Federal Register* 62(159): 43937-43954.

NMFS (National Marine Fisheries Service). 1997. Proposed Recovery Plan for the Sacramento River Winter-run Chinook Salmon August 1997. Southwest Regional Office. http://swr.nmfs.noaa.gov/hcd/recweb.htm.

NMFS (National Marine Fisheries Service). 1994. Endangered and Threatened Wildlife and Plants; Emergency Listing of the Sacramento River Winter-run Chinook Salmon. *Federal Register* 55 (67): 12631-12632. April 6, 1990.

NMFS (National Marine Fisheries Service). 1993. Designated Critical Habitat; Sacramento River Winter-Run Chinook Salmon. *Federal Register* 58 (114): 33212. June 16.

NOAA (National Oceanic and Atmospheric Administration). 2005a. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. *Federal Register* 70(123):37160. June 28, 2005.

NOAA (National Oceanic and Atmospheric Administration). 2005b. Endangered and Threatened Species; Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California. Federal Register 70(170):52488. September 2, 2005.

The Resources Agency, State of California, California State Water Resources Control Board, and U.S. Fish and Wildlife Service. 1998. Deer Creek Watershed Management Plan, Existing Conditions Report. Prepared by the Deer Creek Watershed Conservancy. June.

Titus, R. G., D. C. Erman, and W. M. Snider. 2003. History and Status of Steelhead in California Coastal Drainages South of San Francisco Bay. *Hilgardia* 138-268 (In preparation).

Vogel, D. A. 1987. Estimation of the 1986 Spring Chinook Salmon Run in Deer Creek, California. Report No. FR1/FAO-87-3, Fisheries Assistance Office, U.S. Fish and Wildlife Service, Red Bluff, CA.

Personal Communication

Garmin, C. 2007. Fisheries Biologist, DFG. Phone call with Rick Wilder on November 6 regarding salmonid habitat in Butte County.

This page intentionally left blank.