A.20 Central Valley Fall-/Late Fall-Run Chinook Salmon (*Oncorhynchus tshawytscha*)

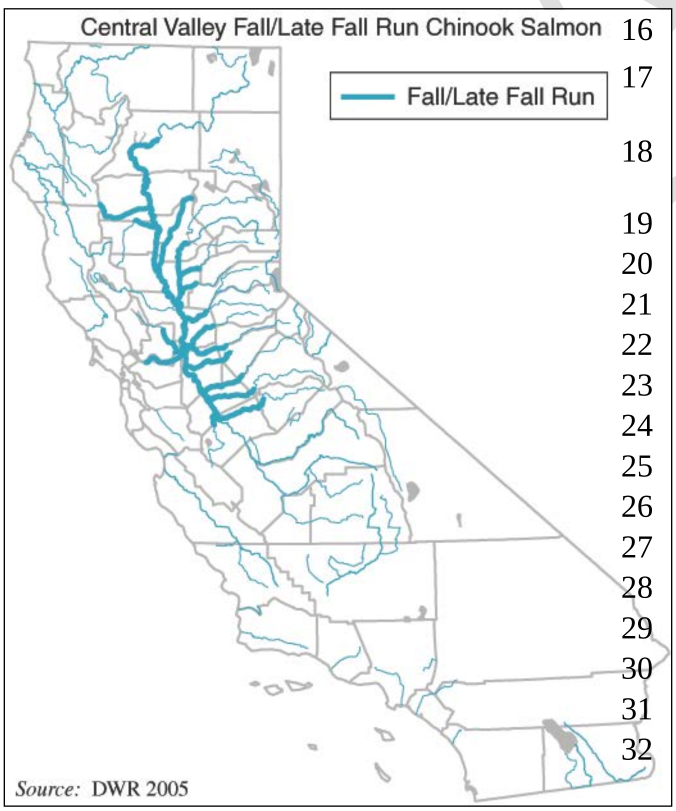
illustration by Joseph Tomelleri

A.20.1 Legal and Other Status

The Central Valley fall-/late fall-run Chinook salmon Evolutionarily Significant Unit (ESU)[1] comprises two runs: fall and late fall. The National Marine Fisheries Service (NMFS) has identified five ESUs of Chinook salmon populations in California: Sacramento River winter-run, Central Valley spring-run, Central Valley fall-run, Southern Oregon and California Coastal, and Upper Klamath and Trinity River. This account focuses on the Central Valley fall-/late fall-run Chinook salmon ESU, which occurs in the BRCP Plan Area.

The fall-/late fall-run ESU was designated as a candidate for listing on September 16, 1999 (NMFS 1999). However, the 2006 status review (USFWS 2006) did not include it as a candidate.

The Sacramento River late fall-run Chinook salmon is a California Species of Special Concern (Moyle et al. 1995).



Source: DWR 2005

A.20.2 Species Distribution and Status

A.20.2.1 Range and Status

Fall-/late fall-run Chinook salmon can be found in the ocean along the west coast of North America from south of Monterey, California, to Alaska, but the southern extent of spawning is in the San Joaquin and Kings rivers (Moyle 2002). Historically, fall-run Chinook salmon used rivers and their tributaries in the Central Valley from the Kings River in the south to the Pit and McCloud rivers in the north (Schick et al. 2005). Late fall-run Chinook salmon probably used the Sacramento River and tributaries above Shasta Dam (Moyle et al. 1995). The late

[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).

fall-run was identified as separate from the fall-run in the Sacramento River after the Red Bluff Diversion Dam was constructed in 1966 and fish counts could be more accurately made at the fish ladder there.

Fall-run, as well as some late fall-run Chinook salmon in the Sacramento River have been artificially propagated in hatcheries and released into the rivers and bays since 1872 (BRT 1997). In the last 50 years, 1.6 billion fall-run fish have been released from hatcheries into Central Valley waterways. State hatcheries on the American and Feather rivers now transport young fish to salt water to avoid mortality in the Delta, but it is thought that this increases straying of adults when they return to spawn.

Fall-run Chinook salmon are the most abundant run in the Central Valley (Moyle 2002). From 1981 to 2010, in-river (non-hatchery) adult escapement averaged 240,971 per year (CDFG 2011). Escapement peaked in 2002 (766,668 individuals) and declined to historical lows in 2009 (30,426 individuals). In 2010, in-river adult escapement was estimated at 111,455 fish (CDFG 2011) and predictions based on grilse (precocious adults that return early) suggest escapement will be higher for the 2011 spawning season.

Late fall-run in-river adult escapement averaged 9,824 individuals between 1980/81 and 2009/10 spawning seasons (CDFG 2011). Escapement of in-river adults was 0 in 1996/97 but peaked at 39,340 individuals in 1997/98. Escapement during 2010/11 spawning season was 4,390 individuals, which is approximately half of the average escapement over the past 30 years.

A.20.2.2 Distribution and Status in the Plan Area

Although no California Natural Diversity Database (CNDDB) occurrences of Central Valley fall/late fall-run Chinook salmon have been reported from Butte County (see Figure A-20), fall-run Chinook salmon are thought to use the Feather River to Oroville, Butte Creek, Big Chico Creek, Little Chico Creek, Rock Creek, Mud Creek, and the Sacramento River (Maslin et al. 1997, GIC 1999, NMFS 1999) (Figure A-20). The length of historical stream habitat was 6.8 kilometers (km) in Big Chico Creek and 25.7 km in Butte Creek. Fall-run Chinook salmon population size in Big Chico Creek was estimated at 50 fish in 1957, but removal of a barrier in 1958 opened 15 miles (24 km) of spawning habitat (Fry 1961). However, no adults have returned to Big Chico Creek since 1985. Butte Creek has had consistent returns of 2,000-5,000 fall-run adults between 2001 and 2005, but returns have declined to fewer than 400 individuals during the past three years (2008-2010) (DFG 2011).

A.20.3 Habitat Requirements and Special Considerations

Fall-/late fall-run Chinook salmon require gravel and cobble areas, primarily in moderately shallow riffles, with water flow through the substrate for spawning. Gravel and cobble sizes can range from 0.1 to 6 inches (SWRI 2003). Preferred water velocity for spawning is 1.2 to 3.8 feet per second (ft/sec). The gravel needs to be clean, loose, and stable for the duration of the larval stage.

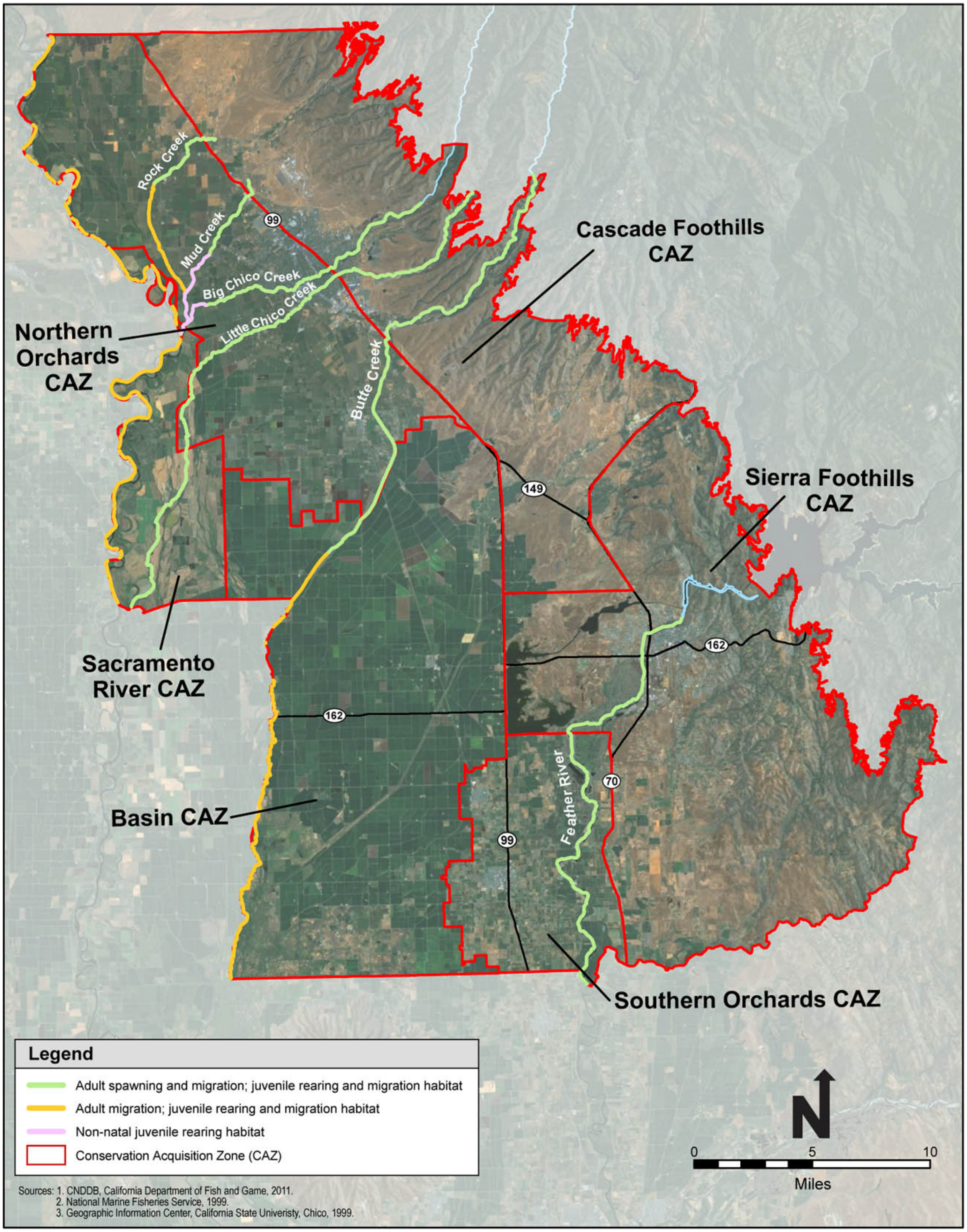


Figure A-20. Central Valley Fall-/Late Fall-Run Chinook Salmon Modeled Habitat

Adults tolerate water temperatures between 51 and 67ºF (10.6 and 19.4ºC), while juveniles tolerate temperatures of 32 to 75.2ºF (0 to 24ºC). Juvenile rearing habitat optimally contains space (a large enough area to allow growth), instream and overhead cover, and an adequate food supply (aquatic and terrestrial invertebrates) with suitable water velocities and depth (SWRI 2003). The optimal dissolved oxygen concentration is above 9 milligrams per liter (mg/l), and pH is optimal between 6.8 and 8.0.

Low turbidity is preferred, although both juveniles and adults can tolerate turbidity up to 1,000 and 4,000 parts per million, respectively (SWRI 2003). Migratory routes must be free of barriers that can impede or prevent movement upstream and downstream.

A.20.4 Life History

Chinook salmon are anadromous, migrating from the ocean up rivers and streams to spawning grounds. Adult fall-run Chinook salmon migrate upstream from July through December and spawn from October through December. Peak spawning occurs during October and November. Late fall-run adults migrate upstream from October through April and spawn one to three months later during January between April. Peak spawning occurs in February and March. During spawning, females dig a shallow depression (or redd) in gravel to lay their eggs, and the males fertilize the eggs. A single female in the Sacramento River can produce up to 5,800 eggs (Moyle 2002). Late fall-run Chinook salmon do not eat during their migration to spawning areas or during holding before spawning (Moyle et al. 1995). The eggs hatch in 3 to 4 months, and the larvae remain in the gravel for another 2 to 3 weeks before emerging. Fry emergence typically occurs at night. Newly emerged fry seek streamside habitat with riparian habitat that provides food (aquatic and terrestrial invertebrates), cover from predators, and slower water velocity (NMFS 1996).

Fall-run Chinook salmon fry typically emerge between December and March, with emigration to the ocean occurring December through June. Peak downstream migration trends appears to be correlated with high winter flows. Late fall-run Chinook salmon fry generally emerge from April through June and rear from April until the following April.

Central Valley Chinook salmon enter the ocean near the Gulf of the Farrallones and then distribute north and south along the continental shelf mostly between Point Conception and Washington (Healey 1991). Chinook salmon grow rapidly in the ocean for 2 to 5 years. Fall-run Chinook salmon mature in the ocean before returning to freshwater to spawn. Late fall-run Chinook salmon may return to freshwater as immature adults as indicated by a 1- to 3-month delay in spawning once reaching the spawning grounds.

A.20.5 Threats

Access to the upper extent of the historical upstream spawning habitat for fall-/late fall-run Chinook salmon has been eliminated or degraded by man-made structures (e.g., dams and weirs) associated with water storage and conveyance, flood control, and diversions and exports for municipal, industrial, agricultural, and hydropower purposes (Yoshiyama et al. 1998). Over 80 percent of salmon holding and spawning habitat is no longer accessible (Moyle 2002).

Upstream diversions and dams have decreased downstream flows and altered the seasonal hydrologic patterns. These factors have been identified as contributing to delays in upstream migration by adults, increased mortality of out-migrating juveniles, and responsible for making some streams uninhabitable by fall-run Chinook salmon (Yoshiyama et al. 1998). Unscreened or poorly screened diversions are also responsible for entrainment of salmon fry and juveniles.

Much of the migration corridors for fall- and late fall-run Chinook salmon has been leveed, channelized, and modified with riprap for thereby reducing and degrading the quality and availability of natural habitat for rearing and emigrating juvenile Chinook salmon (Brandes and McLain 2001).

Predation on juvenile salmon by nonnative fish has been identified as an important threat to fall- and late fall-run Chinook salmon in areas with high densities of non-native fish (e.g., small and large mouth bass, striped bass, and catfish) that prey on out-migrating juvenile salmon (Lindley and Mohr 2003). Upstream gravel pits and flooded ponds attract nonnative predators because of their depth and lack of cover for juvenile salmon (DWR 2005).

Coastal marine waters offshore of San Francisco Bay are a mixed stock fishery comprised of both wild and hatchery-produced salmon. Commercial and recreational harvest, therefore, targets both hatchery and wild salmon. It is believed that harvest is having detrimental effects to wild spawners in this mixed stock fishery, although few data are available. Naturally reproducing Chinook salmon populations are less able to withstand high harvest rates compared to hatchery-based stocks due to differences in population size (Knudsen et al. 1999).

Artificial propagation programs (hatchery production) for fall-/late fall-run Chinook salmon in the Central Valley present multiple threats to wild (in-river spawning) Chinook salmon populations, including genetic introgression by hatchery origin fish that spawn naturally and interbreed with local wild populations (USFWS 2001, Reclamation 2004, Goodman 2005). It is now recognized that Central Valley hatcheries are a significant and persistent threat to wild Chinook salmon and steelhead populations and fisheries (NMFS 2009a). Interbreeding with hatchery fish contributes directly to reduced genetic diversity and introduces maladaptive genetic changes to the wild population (DFG 1995, CALFED 2004, Myers et al. 2004, Araki et al. 2007). In addition, releasing hatchery smolts downstream of hatcheries has resulted in an increase in straying rates, further reducing genetic diversity among populations (Williamson and May 2005).

The loss of fish to entrainment mortality at the State Water Project and Central Valley Project diversion in the south Delta has been identified as an impact to Chinook salmon populations (Kjelson and Brandes 1989). In addition, unscreened and poorly screened diversions found throughout the freshwater range of fall- and late-fall run Chinook salmon (Herren and Kawasaki 2001) contribute to entrainment mortality of juvenile salmon

Concern regarding exposure of Chinook salmon to toxic substances, including mercury, selenium, copper, pyrethroids, and endocrine disruptors, includes waterborne chronic and acute exposure, as well as bioaccumulation and chronic dietary exposure. Sublethal concentrations of toxins may interact with other stressors to cause adverse effects to salmonids, such as increasing their vulnerability to mortality as a result of exposure to seasonally elevated water temperatures, predation, or disease (Werner 2007). For example, Clifford et al. (2005) found in a laboratory setting that juvenile fall-run Chinook salmon exposed to sublethal levels of a common parathyroid, esfenvalerate, were more susceptible to infectious hematopoietic necrosis virus than those not exposed to esfenvalerate.

A.20.6 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 2009b) 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 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 fall-/late fall-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 fall-/late fall-run Chinook salmon.

The Bay Delta Conservation Plan is under development to contribute to the recovery of Central Valley fall-/late fall-run Chinook salmon and other fish species. Proposed conservation measures under the plan that would benefit fall-/late fall-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.20.7 Species Habitat Suitability Model

Fall-/late fall-run Chinook salmon habitats are defined as fall-/late fall-run Chinook salmon habitats delineated by CNDDB (2007), NMFS (1999), GIC (1999), and C. Garmin (pers. comm.).

Adult Migration and Holding, Spawning, and Juvenile Rearing and Migration Habitats. Fall-/late fall-run Chinook salmon migrate, hold, spawn, and rear throughout the entire reaches of Butte, Big Chico, and Little Chico creeks within the Plan Area. Fall-/late fall-run Chinook salmon also migrate, hold, spawn, and rear in the Feather River upstream to the Fish Diversion Dam, which serves as a barrier to movement further upstream. Nonnatal juvenile rearing occurs in lower portions of Mud Creek and Big Chico Creek (Maslin et al. 1997)

Assumptions. Data from DFG (CNDDB 2007) and NMFS (1999) were used for this model because these agencies are the state and federal agencies, respectively, responsible for managing fall-/late fall-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 DFG (CNDDB 2007) and NMFS (1999) GIS databases were augmented with information from Chico State University's Geographic Information Center and C. Garmin (pers. comm.).

A.20.8 Recovery Plan Goals

A recovery plan has not been prepared and recovery plan goals have not been established for Central Valley fall-/late fall-run Chinook salmon because it is not federally listed as threatened or endangered.

A.20.9 References

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