SECTION 6.0

SPECIES MANAGED UNDER THE PACIFIC COAST SALMON FISHERIES MANAGEMENT PLAN

Although EFH pertains to all Pacific Coast salmon, fall-/late fall-run Chinook salmon and their associated habitat requirements are the species discussed in this section because: 1) spring-run Chinook salmon and their critical habitat were discussed in Section 5.0 of the Applicant-Prepared Draft BA (Status of the Species) and evaluated in the Draft BA because of their status as a threatened species under the federal ESA; and 2) species other than spring-run and fall-/late fall-run Chinook salmon requiring EFH evaluation do not occur in the Action Area (e.g., lower Yuba River). The discussions in Section 5.0 of the Applicant-Prepared Draft BA addressed: 1) listing status and critical habitat designation; 2) a review of available information; 3) life history and habitat requirements; 4) limiting factors and threats (e.g., historical and current pressures, limiting factors for recovery within the ESU and within the Action Area); 5) viability of the Central Valley ESU and Yuba River populations; and 6) recovery plan implementation.

To supplement the information on Chinook salmon presented in Section 5.0 of the Applicant-Prepared Draft BA, general life history information and habitat requirements for fall- and late fall-run Chinook salmon are presented here. Further detailed information on the spring-run and fall-/late fall-run Chinook salmon ESUs are available in NMFS' Technical Memorandum NMFS-NWFSC-35 – Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California (Myers et al. 1998), NMFS' Technical Memorandum NMFS-NWFSC-66 – Updated Status of federally Listed ESUs of West Coast Salmon and Steelhead (Good et al. 2005), and NMFS' Technical Memorandum NOAA-TM-NMFS-SWFSC-564 – Viability Assessment for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Southwest (Williams et al. 2016).

6.1 Central Valley Fall-/Late Fall-run Chinook Salmon ESU

Central Valley fall- and late fall-run Chinook salmon are considered by NMFS to be the same ESU (64 FR 50394). NMFS determined that listing this ESU as a threatened species was not warranted (64 FR 50394), but subsequently classified this ESU as a federal Species of Concern because of specific risk factors, including population size and hatchery influence (69 FR 19975). Central Valley late fall-run Chinook salmon are also listed as a state Species of Special Concern (CDFG 2011a). The ESU includes all naturally spawned populations of fall-run Chinook salmon in the Sacramento and San Joaquin river basins and their tributaries east of Carquinez Strait, California.

Chinook salmon are the largest of the Pacific salmon and are highly prized by commercial, sport, and subsistence fishers (NMFS 2009a). 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). Chinook salmon stocks located off the coasts of Washington, Oregon, and California are managed by the PFMC under the Pacific Coast Salmon FMP. Approximately 80 percent of the California catch comes from fish from the Central Valley as opposed to fish from the Klamath River system, although as much as 90 percent of the caught fish may be of hatchery origin (Barnett-Johnson et al. 2007). These stocks include fall- and late fall-run Chinook salmon from the Klamath and Central Valley systems (Reclamation 2008).

6.1.1 General Life History and Habitat Requirements

This section presents a general overview of lifestage-specific information (e.g., adult immigration and holding, adult spawning, embryo incubation, juvenile rearing and downstream movement) for the ESU. Then, this section specifically focuses and provides information on lifestage-specific temporal and spatial distributions for fall-/late fall-run Chinook salmon in the lower Yuba River. The lower Yuba River is utilized by two principal Chinook salmon runs (i.e., spring-run and fall-run Chinook salmon). Although late fall-run Chinook salmon populations occur primarily in the Sacramento River (CDFG Website 2007 as cited in RMT 2010a), incidental observations of late fall-run Chinook salmon have been reported to occur in the lower Yuba River (D. Massa, CDFG, pers. comm. 2009; M. Tucker, NMFS, pers. comm. 2009). Although reported, there have been only occasional episodic incidences of late fall-run Chinook salmon straying from the Sacramento River system into the lower Yuba River. For example, six Chinook salmon adults were recovered during the late-winter and early-spring portion of the 2008 escapement surveys with Coded Wire Tags demonstrating that these fish were late fall-run fish from the Coleman National Fish Hatchery located on Battle Creek (YCWA 2009). This Applicant-Prepared Draft EFH Assessment addresses the Central Valley fall- and late fall-run Chinook salmon ESU as defined by NMFS, but the assessment focuses on fall-run Chinook salmon lifestages that have the potential to be affected by the Proposed Action.

The RMT developed representative temporal distributions for specific fall-run Chinook salmon lifestages through review of previously conducted studies, as well as recent and ongoing data collection activities of the M&E Program. The resultant lifestage periodicities encompass the majority of activity for a particular lifestage, and are not intended to be inclusive of every individual in the population (RMT 2013a). The lifestage-specific periodicities for fall-run Chinook salmon are summarized in Table 6.1-1 and discussed below.

Table 6.1-1. Lifestage-specific periodicities for fall-run Chinook salmon in the lower Yuba River.

Lifestage	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Fall-run Chinook Salmon																								
Adult Immigration & Staging													■	■	■	■	■	■	■	■	■	■	■	■
Spawning																			■	■	■	■	■	■
Embryo Incubation	■	■	■	■	■	■													■	■	■	■	■	■
Fry Rearing	■	■	■	■	■	■	■	■																■
Juvenile Rearing		■	■	■	■	■	■	■	■	■	■	■												
Juvenile Downstream Movement	■	■	■	■	■	■	■	■	■	■	■	■												■

Source: RMT 2013a

6.1.1.1 Adult Immigration and Staging

Adult fall-run Chinook salmon have been reported to enter the Sacramento and San Joaquin rivers from July through December, and to spawn from October through December (Reclamation 2008). Unlike spring-run Chinook salmon, adult fall-run Chinook salmon do not exhibit an extended over-summer holding period in the lower Yuba River (RMT 2010b). Rather, it is believed that they stage for a relatively short period of time prior to spawning. This conventional belief is supported by the recent evaluation by the RMT of the acoustic telemetry monitoring data and the VAKI Riverwatcher™ data (RMT 2013a).

Adult fall-run Chinook salmon immigration and staging has been reported to generally occur in the lower Yuba River from August through November (CALFED and YCWA 2005), and immigration generally peaks in November, with typically greater than 90 percent of the run having entered the river by the end of November (CDFG 1992; CDFG 1995, both as cited in RMT 2010b). The RMT's review of available data indicates that fall-run Chinook salmon immigration generally extends from July through December. As indicated by the eight years of available data of fish passing through the VAKI Riverwatcher™ systems located in both ladders at Daguerre Point Dam, the average date associated with the median of adult fall-run Chinook salmon passing Daguerre Point Dam was October 14, and the average date by which 90 percent of the annual runs had passed the dam was November 17 (RMT 2013a).

In general, a minimal amount of effort was expended by the RMT to differentiate between fall- and spring-run Chinook when acoustically-tagging adult immigrating Chinook salmon (RMT 2013a). A total of eight individuals were acoustically-tagged below Daguerre Point Dam during October 2011. By contrast to phenotypic adult spring-run Chinook salmon, which exhibited extended periods of holding downstream of Daguerre Point Dam, the acoustically-tagged fall-run adult Chinook salmon held for an average of only about 3 days downstream of Daguerre Point Dam prior to passing upstream through the fish ladders. These data tend to generally confirm the understanding that adult fall-run Chinook salmon spends relatively short periods of time staging prior to migrating to spawning areas and commencing spawning activities (RMT 2013a).

RMT (2013a) identified an upper tolerable water temperature index (WTI) value of 68°F for the fall-run Chinook salmon adult immigration and staging lifestage.

6.1.1.2 Adult Spawning

The lower Yuba River fall-run Chinook salmon spawning period has been reported to extend from October through December (CALFED and YCWA 2005). Preliminary data from the recently conducted redd surveys, and back-calculations from previous and recent carcass surveys generally confirm this temporal distribution (RMT 2013a).

According to RMT (2010b), fall-run Chinook salmon are primarily observed spawning during October in the upper reaches of the lower Yuba River upstream of Daguerre Point Dam. Spawning fall-run Chinook salmon begin expanding their spatial distribution further downstream in later fall months as suitable temperatures become available near or downstream of Daguerre

Point Dam (RMT 2010b). Recent analyses of available redd distribution and water temperature data confirm these previous characterizations (RMT 2013a).

According to RMT (2013a), for the periods analyzed from October through December (the fall-run Chinook salmon spawning period), the measure of central tendency of redd distribution continues to move downstream as the spawning season progresses from October through December. Also, redds were distributed farther downstream as water temperatures became cooler in late October, compared to early October (RMT 2013a).

Fall-run Chinook salmon spawning activity appeared to be associated with water temperature. RMT (2013a) identified an upper tolerable WTI value of 58°F for fall-run Chinook salmon spawning. For all Chinook salmon redds newly-constructed in the lower Yuba River during October through December of 2009 and 2010, about 97 percent were observed at locations where concurrent water temperature measurements were at or below the upper tolerable WTI value of 58°F (RMT 2013).

6.1.1.3 Embryo Incubation

The fall-run Chinook salmon embryo incubation period has been reported to extend from October through March (YCWA et al. 2007). Based upon consideration of accumulated thermal units from the time of egg deposition through hatching and alevin incubation, the RMT (2010b) therefore considered the fall-run Chinook salmon embryo incubation period to extend from October through March. This time period is consistent with observed trends in Chinook salmon fry captures in the RSTs, as previously described in RMT (2013a). Review of recently available data and information, including updated fall-run Chinook salmon spawning spatial and temporal distributions, and recent water temperature monitoring information, confirms the general characterization of the fall-run Chinook salmon embryo incubation period as extending from October through March in the lower Yuba River (RMT 2013a). RMT (2013a) identified an upper tolerable WTI value of 58°F for the fall-run Chinook salmon embryo incubation lifestage.

6.1.1.4 Fry Rearing

Fall-run Chinook salmon fry rearing in the lower Yuba River is reported to extend from mid-December through April (RMT 2013a). In the Central Valley, fall-run Chinook salmon fry emergence generally occurs from late-December through March (Moyle 2002). In the Feather River, fall-run Chinook salmon fry emergence has been reported to occur as early as November (Seesholtz et al. 2003). Chinook salmon fry are typically 33-36 mm in length when they emerge, though there is considerable variation among populations, and size at emergence is determined in part by egg size (PFMC 2014). Upon emergence from spawning beds, juvenile salmonid fry begin foraging for food and seek cover in areas of reduced flow or move downstream (Healy 1991). A large downstream movement of Chinook salmon fry shortly after emergence is typical of most fall-run Chinook salmon populations in the Central Valley (Moyle 2000). Larger fry tend to be the most likely to disperse from redds earliest. Movement occurs mostly at night and tends to cease after a few weeks, when fry settle into rearing habitat in streams (DWR 2003). Water temperatures reported to be optimal for rearing of Chinook salmon fry and juveniles are reported to be between 45°F and 65°F (NMFS 2002a; Rich 1987; Seymour 1956).

In the lower Yuba River, most fall-run Chinook salmon reportedly exhibit downstream movement as fry shortly after emergence from gravels, although some individuals rear in the river for a period of up to several months and move downstream as juveniles (RMT 2010b). According to RMT (2010b), in past years CDFW employed the run identification methodology to identify fall-run Chinook salmon juveniles captured in the RSTs. Based on CDFW's examination of run-specific determinations, the majority (81.1 percent) of fall-run Chinook salmon in the lower Yuba River move past the Hallwood Boulevard RST from December through March, with decreasing numbers captured during April (8.9 percent), May (6.6 percent), June (3.2 percent), and July (0.2 percent) (RMT 2010b, as cited in RMT 2013a). Most of the fish captured from December through March were post-emergent fry (< 50 mm FL), while nearly all juvenile fall-run Chinook salmon captured from May through July were larger (≥ 50 mm FL) (YCWA et al. 2007). Based upon estimation of initial emergence in consideration of the accumulated thermal units (ATUs) required for embryo incubation to hatching, and upon size-at-time of juvenile Chinook salmon in the RSTs as previously discussed, the phenotypic fall-run Chinook salmon fry rearing period generally extends from mid-December through April (RMT 2013a).

6.1.1.5 Juvenile Rearing and Downstream Movement

Fall-run Chinook salmon juvenile rearing in the lower Yuba River has been reported to primarily occur from December through June (CALFED and YCWA 2005). The RMT has reviewed available data to further refine juvenile fall-run Chinook salmon lifestage periodicities. Based upon size-at-time of juvenile Chinook salmon in the RSTs as previously discussed, the phenotypic fall-run Chinook salmon juvenile rearing lifestage extends from mid-January through June (RMT 2013a). Juvenile downstream movement, which includes both fry and larger juveniles as indicated by captures in the Hallwood Boulevard RSTs, generally occurs from mid-December through June (RMT 2013a). RMT (2013a) identified an upper tolerable WTI value of 68°F for the fall-run Chinook salmon juvenile rearing and downstream movement lifestage.

6.1.1.6 Ocean Distribution

According to Reclamation (2008), Pacific salmon *Oncorhynchus spp*. tagged with coded-wire tags (CWTs) since 1981 have been recovered in commercial fisheries and research programs in the North Pacific Ocean, Gulf of Alaska, and Bering Sea-Aleutian Islands (Celewycz et al. 2007 in Reclamation 2008). The known range of North American Chinook salmon, as shown by tagging experiments, extends across almost the entire Bering Sea, north to 60°03'N and west to 172°12'E. In the North Pacific, the known ocean range of North American Chinook salmon extends north from about 40°N (in the coastal waters just off California) and west to the waters just south of Adak Island in the central Aleutians (176°34'W, 51°29'N) (Celewycz et al. 2007 in Reclamation 2008).

Pacific salmon spend most of their life cycles in the nutrient-rich North Pacific Ocean. Along the California coast, adult Chinook salmon are key predators, responding in their distribution and abundance to availability of food resources (Adams 2001 as cited in Reclamation 2008). Fall-run Chinook salmon normally spend 2 to 4 years in the ocean, although Feather River salmon normally have a 4 to 5 year ocean residency (Moyle 2002). Available data suggest that, while in the ocean, fall-run Chinook salmon primarily remain in the coastal waters off California (NMFS 1997 as cited in Reclamation 2008). Chinook salmon typically move into the Gulf of the Farallones in February and March, and are generally found off the Golden Gate from Bolinas Point in the north to Point San Pedro in the south (Reclamation 2008). Their diets consist of Pacific herring (recently emigrated from the San Francisco Bay after November to February spawning) and anchovies. Herring are particularly vulnerable to Chinook salmon predation as they are weakened from spawning. Chinook salmon may move offshore again in April to June to feed on euphausiid shrimp *Thysanoessa spinifera* (i.e., krill), crab larvae, and juvenile rockfish and, then return to the near-shore in July to forage exclusively on anchovy. The distribution of adult Chinook salmon and their stomach contents strongly relate to the availability and composition of food resources, such as anchovy, and the availability of those food resources is related to climatic and ocean conditions (Reclamation 2008).

During February and March, anchovies begin to gather in near-shore waters before their migration into the San Francisco Bay, which occurs during April and represents the transition time in Chinook salmon near-shore and offshore feeding habits. Euphausiids are taken as prey by Chinook salmon during April and May (Adams 2001 as cited in Reclamation 2008). Dungeness crab (C*ancer magister)* megalopa larvae dominate the diets of Chinook salmon for a short time period, during their last pelagic phase in early April. In May and June, Chinook salmon move further offshore and start feeding on euphausiids and juvenile rockfish (Reclamation 2008). In years when juvenile rockfish are abundant, they are the preferred prey and dominate the Chinook salmon diet, whereas in low abundance years, Chinook salmon feed mainly on euphausiids (Reclamation 2008). Later in the summer, the Gulf water warms due to the absence of upwelling, and anchovies simultaneously move out of the San Francisco Bay and into the Gulf of the Farallones. This is coupled with a seasonal disappearance of juvenile rockfish, causing the salmon to return to the near-shore and capitalize on the feeding opportunity presented by the anchovies. Diet information has confirmed the salmon’s dependence on aggregations of prey, and the prevalence of opportunistic feeding (Adams 2001 in Reclamation 2008). This natural concentration of Chinook salmon makes them susceptible to increased angling take (Reclamation 2008). However, the dependence on these traditional prey complexes may be disrupted during strong El Niños or other changes to ocean conditions. When prey aggregations fail to occur, the condition (length-to-weight relationship) may decrease similar to what was recorded during California’s commercial salmon catch in El Niño years (Reclamation 2008).

Ocean conditions are likely an important cause of density-independent mortality and interannual fluctuations in escapement sizes. Most mortality experienced by salmonids during the marine phase occurs soon after ocean entry (Pearcy 1992, Mantua et al. 1997 both as cited in SJRRP 2009). Adult Chinook salmon are also prey for killer whales off the Pacific Coast of the United States.

6.1.2 Historical Distribution and Abundance

Historically, fall-run Chinook salmon were one of the more abundant salmon runs in the Central Valley, and used the major rivers and their 21 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 as cited in Reclamation 2008). Late fall-run Chinook salmon probably used the Sacramento River and tributaries above Shasta Dam (Moyle et al. 1995). Counts of adult salmon as they passed over the Anderson-Cottonwood Irrigation District (ACID) Dam were obtained as early as 1937, but complete estimates of fall-run Chinook salmon abundance in the Sacramento River and its major tributaries were not made until 1953 (USFWS 1995). The late fall-run was identified as separate from the fall-run in the Sacramento River after the Red Bluff Diversion Dam (RBDD) was constructed in 1966 and fish counts could be more accurately made at the RBDD fish ladder (Reclamation 2008).

According to Yoshiyama et al. (2001), fall-run Chinook salmon historically spawned primarily in the mainstem Feather River downstream of Oroville Reservoir, and Fry (1961) reported fall-run Chinook salmon escapement estimates of 10,000 to 86,000 between 1940 and 1959. Reclamation (2008) reports that Feather River fall-run Chinook salmon population trends continue to show annual variability, but are more stable than before Oroville Dam was completed. Pre-dam escapement levels in the Feather River averaged about 41,000 fish compared to about 46,000 thereafter, although this increase appears to be a result of hatchery production in the system (Reclamation 2008).

Annual run sizes of fall- and late fall-run Chinook salmon are reported in “GrandTab", a database administered by CDFW for the Central Valley that includes reported run size estimates from 1952 through 2010 for fall-run Chinook salmon and from 1970 through 2010 for late fall-run Chinook salmon. The Central Valley fall-/late fall-run Chinook salmon ESU has displayed broad fluctuations in adult abundance. Between 1959 and 1970, escapement of fall-run Chinook salmon in the mainstem Sacramento River exceeded 100,000 fish every year except for one year (1967). Since 1970, escapement generally has not exceeded 100,000 (Reclamation 2008). More recent estimates of fall-run Chinook salmon in the Sacramento River and its tributaries (not including the lower Yuba and Feather rivers because GrandTab does not distinguish between fall-run and spring-run Chinook salmon in-river spawners, and not including the FRFH) have ranged from 30,128 in 2009 to 685,179 in 2002.

The average abundance for the Sacramento River and its tributaries (excluding the lower Yuba and Feather rivers – see above) was 134,694 for the period extending from 1970 through 1979, 155,282 for the period 1980 through 1989, 177,994 for the period 1990 through 1999, and 252,614 for the period 2000 through 2010.

Although fall-run Chinook salmon is an important commercial and recreational fish species, recent declines in populations of this species have resulted in harvest management restrictions. Due to very low returns of fall-run Chinook salmon to the Central Valley in 2007 and 2008, there was a complete closure of the commercial and recreational ocean Chinook salmon fishery in 2008 and 2009 (Lindley et al. 2009). Only 66,000 spawners are estimated to have returned to natural areas and hatcheries in 2008 (Lindley et al. 2009). In April 2009, the PFMC and NMFS adopted a closure of all commercial ocean salmon fishing through April 30, 2010, and placed restrictions on inland salmon fisheries (CDFG 2009). As shown in Table 6.1-2, abundance estimates of fall-run Chinook salmon in 2010 were greater than 2009 estimates for all California Central Valley watersheds that monitor fall-run Chinook salmon. Fishing in 2010 was also constrained for the same reasons as in the previous two years (CDFG 2011b).

Table 6.1-2. Fall-run Chinook salmon escapement estimates from 1994-2015 for rivers in the California Central Valley (CDFW 2016).

Year	Sacramento River Mainstem	Battle Creek	Clear Creek	Cottonwood Creek	Cow Creek	Bear Creek	Mill Creek	Deer Creek	Butte Creek	Feather River	Yuba River	American River	Consumnes River	Mokulumne River	Stanislaus River	Tuolumne River	Merced River
1994	58,546	24,274	2,546				1,081	307		38,382	10,890	33,598		1,238	1,031	506	2,646
1995	63,934	56,515	9,298						445	59,912	14237*	70,618		2,194	619	827	2,320
1996	84,086	52,409	5,922						500	57,170	27,900	69,745		4,038	168	4,362	3,291
1997	119,296	50,744	8,569				478	1,203	800	50,547	25,948	47,195		3,681	5,588	7,146	2,714
1998	6,318	53,957	4,259				546	270	500		31,090	50,457	300	4,122	3,087	8,910	3,292
1999	161,192	92,929	8,003								24,230	55,339	229	2,183	4,349	8,232	3,129
2000	96,688	53,447	6,687							114,717	14,995	100,852	460	1,973	8,498	17,873	11,130
2001	75,296	100,604	10,865						4,433	178,645	23,392	135,384		2,307	7,033	8,782	9,181
2002	65,690	397,149	16,071				2,611		3,665	105,163	24,051	124,252	1,350	2,840	7,787	7,173	8,866
2003	89,229	64,764	9,475				2,426		3,492	89,946	28,316	163,742	122	2,122	5,902	2,163	2,530
2004	43,604	23,861	6,365				1,192	300	2,516	54,171	15,269	99,230	1,208	1,588	4,015	1,984	3,270
2005	57,012	20,520	14,824				2,426	963	4,255	49,160	17,630	62,679	370	10,406	1,427	668	1,942
2006	55,468	19,493	8,422		4,209		1,403	1,905	1,920	76,414	8,121	24,540	530	1,732	1,923	562	1,429
2007	17,061	9,904	4,157	1,250	2,044	140	851	563	1,225	21,909	2,604	10,120	77	470	443	224	485
2008	24,743	4,286	7,677	510	478	19	218	194	275	5,939	3,508	2,514	15	173	865	388	389
2009	5,827	3,047	3,228	1,055	261	6	102	58	306	4,847	4,635	5,297	-	680	595	124	358
2010	16,372	6,631	7,192	1,137	536		144	166	370	44,914	14,375	14,688	740	1,920	1,086	540	651
2011	11,957	12,513	4,841	2,144	1,810		1,231	662	416	47,289	8,928	25,626	53	2,674	1,309	893	1,571
2012	28,701	31,554	7,631	2,556	1,488		890	873	813	63,649	7,668	38,328	1,071	5,471	4,006	783	2,011
2013	40,084	30,834	13,337	2,774	3,011		2,197	1,026	2,200	151,209	14,880	58,228	-	7,071	2,845	1,926	2,826
2014	34,876	27,064	15,794	1,940	3,535		2,488	849	1,412	61,200	11,615	26,475	373	3,297	3,060	438	922
2015	28,664	3,643	8,809	604	591	5	1,033	612	82	20,566	6,507	15,732	204	4,581	6,136	113	1,247

* Survey method not compatible. Estimate includes assumed 15.5% contribution to annual escapement from Rose Bar to SR20 Bridge.

In 2011, both CDFW and PFMC approved reopening the commercial and recreational fishing season based on scientific information suggesting that the Sacramento River fall-run Chinook salmon ocean population size was more than 700,000 fish – almost triple the 2010 forecast (CDFG 2011b). CDFG (2011b) reported that "…[CDFG and PFMC] *are cautiously optimistic that Sacramento River salmon stocks have recovered to the point that fisheries this year — our California sport and commercial ocean fisheries as well as river fisheries — can be sustained while still being confident that enough fish will return to natural spawning grounds and hatcheries to reproduce next fall*."

Recently, California has experienced well below average precipitation during each of the past 4 water years (2012, 2013, 2014, and 2015), record high surface air temperatures during the past 2 water years (2014 and 2015), and record low snowpack in 2015. Some paleoclimate reconstructions suggest that the current 4-year drought is the most extreme in the past 500 or perhaps more than 1,000 years. Anomalously high surface temperatures have made this a "hot drought", in which high surface temperatures substantially amplified annual water deficits during the period of below average precipitation. NMFS further recognizes that "*four consecutive years of drought (2012−2015) and the past two years (2014−2015) of exceptionally high air, stream, and upper ocean temperatures have together likely had negative impacts for many populations of Chinook salmon*" (Williams et al. 2016).

The 2015 fall-run Chinook salmon escapement data indicate an overall large decline in fall-run Chinook salmon populations in the Sacramento River Basin in comparison to 2012, 2013 and 2014, possibly as a result of the recent drought. The full effects of the drought (2010-2016) have yet to be seen in the returning Central Valley fall-run Chinook salmon.

Historically, the Yuba River watershed reportedly was one of the most productive habitats for runs of Chinook salmon (Yoshiyama et al. 1996). Although it is not possible to estimate the numbers of spawning fish from historical data, CDFG (1993) suggested that the Yuba River "*historically supported up to 15 percent of the annual run of fall-run Chinook salmon in the Sacramento River system*" (Yoshiyama et al. 1996).

Historic trends in distribution and abundance of Yuba River Chinook salmon during three periods: (1) pre-dam period (pre-1904); (2) dam construction period (1906-1969); and (3) post-Yuba River Development Project (post-1970) are summarized below.

During the pre-dam period, Chinook salmon had access to much of their historic spawning and rearing habitat and, based on anecdotal accounts, ascended considerable distances up the South, Middle, and North Forks of the Yuba River (Yoshiyama et al. 1996). Although trends in fish abundance during this period were not documented, significant declines in Chinook salmon abundance probably occurred as a result of extensive habitat destruction resulting from hydraulic mining during the mid-to-late 1800s (SWRI et al. 2000). The massive influx of sediment caused profound changes in the channel and floodplain of the lower Yuba River, which has continued to adversely affect fishery resources to the present day.

During the dam construction period, the California Debris Commission constructed a series of dams in the lower Yuba River to capture hydraulic mining debris and prevent its transport to navigable river reaches on the valley floor. These dams resulted in severe, long-term impacts on Chinook salmon populations in the Yuba River by forming complete or partial barriers to migration and eliminating access to much of the historic spawning and rearing habitat. Englebright Dam, completed in 1941, blocked spawning runs of Chinook salmon to upper portions of the mainstem Yuba River and its tributaries. Fall-run Chinook salmon were adversely affected, but population declines were probably less severe than those of spring-run Chinook salmon because a significant portion of fall-run Chinook salmon historic spawning and rearing habitat remained accessible below the dams.

CDFW began making annual estimates of fall-run Chinook salmon spawning escapement (the number of salmon that "escape" the commercial and sport fisheries in the Pacific Ocean and return to spawn in the lower Yuba River) in 1953. From 1953 to 1971, these estimates ranged from 1,000 fish in 1957 to 37,000 fish in 1963 and averaged 12,906 fish (YCWA et al. 2007). Since 1970, operation of New Bullards Bar Dam on the North Fork of the Yuba River has modified the seasonal flow and temperature patterns in the lower Yuba River below Englebright Dam (SWRI et al. 2000). Compared to pre-New Bullards Bar Dam conditions, flows have generally decreased in the spring, increased in the summer and fall, and remained the same in the winter. These changes have been accompanied by a general increase in water temperatures in the spring, a decrease in the summer and fall, and little or no change in the winter. A multiple-level outlet was installed at the dam during construction to control the temperatures of downstream discharges (SWRI et al. 2000) although by agreement with Cal Fish and Wildlife, YCWA uses the lower level outlet exclusively.

Grandtab (CDFW 2016a) estimates of fall-run Chinook salmon escapement to the lower Yuba River extend from 1975 to 2015. From 1975 through 2002 (when the VAKI Riverwatcher™ system was first implemented), the annual average run of Chinook salmon was 15,501 fish. It is important to note that a direct comparison between survey years is complicated by inconsistent experimental methodologies. For example, early CDFW studies often covered a limited portion of the spawning area or spawning period. Since 1953, mark-recapture carcass surveys have been conducted on the lower Yuba River to estimate escapement (or abundance), although methods have varied considerably (RMT 2010c). Historical reports list non-uniform sampling procedures including differing survey reach demarcations, varying survey duration and sampling areas. Different mark-recapture models were used for escapement estimation (i.e., Petersen, Jolly-Seber, modified-Schaefer) over the years. Standardized mark and recapture (Schaefer) methods were not utilized until about 1978 (J. Nelson, CDFG, 2006, pers. comm.), and it is difficult to determine the specific methods utilized to expand direct observations during the earlier studies (YCWA et al. 2007). Additionally, the lower Yuba River from the Narrows Pool downstream to the State Route 20 (SR20) Bridge (also referred to as the Blue Point Mine Reach or Rose Bar Reach) was not surveyed from 1973-1993 (Nelson and Hill 1995 as cited in RMT 2010c). Surveys were frequently attempted on this reach, but seldom were completed due to inclement weather, inaccessibility or turbid storm flows. As a result, most escapement estimates from this survey section have been rejected due to low statistical confidence. In lieu of data-driven estimates, CDFW applied a 15.5 percent expansion to the total lower Yuba River estimate (SR20-Feather River confluence) to produce escapement estimates above SR20 from 1973-1993 (Nelson and Hill 1995 as cited in RMT 2010c). Recent surveys (1994 and 1996-present) have been more consistent in both duration and area of survey (RMT 2010c).

From about 1953 to 2000, Yuba River fall-run Chinook salmon escapement has been sustained and, in recent years has increased to levels exceeding those that occurred prior to the operation of New Bullards Bar Reservoir (SWRI et al. 2000). The fall-run Chinook salmon population in the Yuba River was substantially reduced before the 1950s by extensive mining, agriculture, urbanization, and commercial fishing (YCWA et al. 2007). Since 1950, natural production of fall-run Chinook salmon in the lower Yuba River has sustained or slightly increased the average population levels despite continued and increasing out-of-basin stressors that have acted to further limit survival of Chinook salmon in the lower Sacramento River, Delta and Pacific Ocean (YCWA et al. 2007).

6.1.3 Population Status and Trends

6.1.3.1 Central Valley

In the Central Valley, fall-run Chinook salmon are the most numerous of the four salmon runs, and continue to support commercial and recreational fisheries of significant economic importance. Fall-run Chinook salmon are currently the largest run of Chinook salmon utilizing the Sacramento River system. The Feather and Yuba rivers and San Joaquin River tributaries also support runs of fall-run Chinook salmon. Central Valley-wide fall- and late fall-run Chinook salmon abundance estimates are available through GrandTab (CDFW 2016a). Fall-run Chinook salmon abundance from 1996 through 2015 in the Sacramento River system is presented in Table 6.1-3. Since 1983, in-river estimates for the lower Feather River have not been included in the system-wide estimates, although FRFH estimates are provided separately. Additionally, spring-run Chinook salmon are not estimated in GrandTab for the lower Yuba River, and all lower Yuba River Chinook salmon escapement estimates are reported as fall-run Chinook salmon. For the Sacramento River system (not including the FRFH or Nimbus Hatchery) since 1996, fall-run Chinook salmon run size estimates have ranged from a high of

738,652 in 2002 to a low of 28,669 in 2009. The abundance of in-river spawning Central Valley fall-run Chinook salmon steadily declined from 2002 through 2009, gradually increased from 2010 through 2013, and declined during 2014 and 2015, with a total abundance of 187,463 fish, and 86,854 fish, respectively, in the past two years.

Table 6.1-3. Fall-run Chinook salmon abundance from 1996 through 2015 in the Sacramento River system.

Year	FALL-RUN CHINOOK SALMON IN THE SACRAMENTO RIVER SYSTEM					
	Keswick Dam to Red Bluff Diversion Dam		Red Bluff Diversion Dam to Princeton Ferry		Princeton Ferry to Sacramento	
	Sacramento River Mainstem	Sacramento River Tributaries(1)	Sacramento River Mainstem	Sacramento River Tributaries(2)	Sacramento River Mainstem	Sacramento River Tributaries(3)
1996	71,725	58,331	12,361		—	155,315
1997	98,765	59,313	20,531	1,681	—	124,490
1998	5,718	58,216	600	816	—	82,047
1999	133,365	100,932	27,827		—	79,569
2000	87,793	60,134	8,895		—	230,564
2001	57,920	111,469	17,376		—	341,854
2002	45,552	413,220	20,138	2,611	—	257,131
2003	66,485	74,239	22,744	2,426	—	285,496
2004	34,050	30,226	9,554	1,492	—	171,186
2005	44,950	35,344	12,062	3,389	—	133,724
2006	46,568	32,124	8,900	3,308	—	110,995
2007	14,097	17,495	2,964	1,414	—	35,858
2008	23,134	12,970	1,609	412	—	12,236
2009	5,311	7,597	516	160	—	15,085
2010	13,824	15,497	2,548	310	—	74,347
2011	10,623	21,308	1,334	1,893	—	82,259
2012	22,435	43,229	6,266	1,763	—	110,458
2013	32,515	50,131	7,569	3,223	—	226,517
2014	29,966	48,405	4,910	3,480	—	100,702
2015	21,770	13,652	6,894	1,651	—	42,887

(1) Tributaries include Battle Creek, Clear Creek, Cottonwood Creek, Cow Creek and Bear Creek.
(2) Tributaries include Mill Creek and Deer Creek.
(3) Tributaries include Butte Creek, Feather River, Yuba River and American River.

Overall, progress in achieving the Chinook salmon production targets called for in the Central Valley Project Improvement Act (CVPIA) has become increasingly difficult since 2000 (USDOI 2010). In 2000, 44 percent of the watersheds that were monitored exceeded their Anadromous Fish Restoration Program (AFRP) production target, whereas only 8 percent of the monitored watersheds exceeded their AFRP target by 2009 (USDOI 2010). As discussed in USDOI (2010), the causal factors for the recent decline in the abundance of fall-run Chinook salmon from the Central Valley have been the subject of substantial debate and analysis. The historical and current factors affecting the runs have been described by several authors (e.g., Yoshiyama et al. 1998; Moyle 2002; NMFS 2009c). These factors (in no particular order) include, but are not limited to:

- The construction of dams and water diversion infrastructure, which have eliminated historical salmon spawning areas or altered hydrologic conditions.
- Harvest of adult salmon in the ocean and natal watersheds.
- Entrainment of juvenile salmon by water diversion infrastructure.
- Loss of juvenile salmon floodplain and estuarine rearing habitat through diking and draining of habitat.

- Enhanced predation of juvenile salmon, particularly by non-native fish species.
- A variety of effects relating to the hatchery production of juvenile salmon (e.g., changes in the genetic diversity of a native salmon stock due to introgression with hatchery-produced salmon).
- Elevated incidents of diseases that may affect adult and juvenile salmon.
- Pollution.
- Losses of riparian cover that lead to elevated temperature regimes in the areas where adult and juvenile salmon could occur.
- Siltation of spawning areas where juvenile salmon hatch or rear.
- Introduced species that change the processes and function in the ecosystem where salmon occur.
- Factors that include long periods of drought, extreme flood events, and periods of low ocean productivity.

In a comprehensive review, Lindley et al. (2009) identified specific factors that were probably responsible for the large decline in the numbers of adult fall-run Chinook salmon that returned to the Central Valley in 2007 and 2008. The proximate cause for the decline probably consisted of anomalous conditions in the coastal portion of the Pacific Ocean in 2005 and 2006, which then resulted in unusually poor survival of the 2004 and 2005 broods of juvenile fall-run Chinook salmon that had migrated to the ocean (USDOI 2010). Some of the anomalous conditions in the ocean that may have caused the poor survival of juvenile Chinook salmon entering the Pacific Ocean include weak upwelling of ocean water, which resulted in low primary productivity, warm sea surface temperatures that may have led to a general reduction in fish health, and low densities of the prey items that juvenile salmon consume (USDOI 2010). Lindley et al. (2009) also suggest other factors likely compounded the problems created by unusual ocean conditions. These include, in descending order of importance:

- The ongoing degradation of freshwater and estuarine habitats that juvenile salmon depend upon for rearing and growth.
- The production of juvenile fall-run Chinook salmon at five fish hatcheries in the Central Valley that have contributed to the loss of genetic diversity in, and therefore the fitness of, native salmon populations.
- Inaccurate forecasts of the number of adult salmon that were projected to return to the Central Valley to spawn, and the subsequent establishment of harvest levels that overestimated the number of adult salmon that could be harvested on a sustainable basis.

According to USDOI (2010), some of the factors responsible for reductions in Chinook salmon populations can be minimized through restoration actions conducted pursuant to the CVPIA. For example, adverse effects related to changes in the quality of gravel substrates where salmon eggs are laid, hydrologic conditions, entrainment of juvenile salmon, and the loss of juvenile salmon rearing habitat can be minimized by management actions (e.g., Spawning Gravel Program, Dedicated Project Yield Program, Anadromous Fish Screen Program, and AFRP). It is not clear, however, if the cumulative benefits created by these restoration programs and other programs administered by entities such as the CDFW or NMFS can successfully offset conditions in the ocean where salmon spend approximately two-thirds of their lives (USDOI 2010).

In summary, Central Valley Chinook salmon constitute the majority of salmon produced in California and at times have accounted for 70 percent or more of the State-wide commercial harvest (Yoshiyama et al. 2001). According to NMFS (2009a), fall-run Chinook salmon on the mainstem Sacramento River have shown a steady decline in abundance since 1999. This long-term trend is partly attributed to operating Shasta Dam releases for temperature control and ramp downs in the fall to conserve storage. Shasta Dam releases are typically reduced in the fall to conserve storage after the irrigation season, and this reduction in fall flows can strand and dewater Chinook salmon redds that are located in shallow riffle areas in the upper Sacramento River (Red Bluff Diversion Dam to Keswick Dam). More recently, the decline in fall-run Chinook salmon is consistent with Central Valley-wide declines attributed to poor ocean conditions and recent drought conditions (NMFS 2007; CDFW 2016b).

Fall-run Chinook salmon from the Yuba River are classified as “rebuilding” (Reclamation 2008). In 2010, eight watersheds, including the Yuba River, were classified as experiencing an increase in the average natural production of fall-run Chinook salmon over time (USDOI 2010).

6.1.3.2 Lower Yuba River

Since 2003, infrared-imaging technology has been used to monitor fish passage at Daguerre Point Dam in the lower Yuba River using VAKI Riverwatcher™ systems to document specific observations addressing VSP parameters of adult Chinook salmon abundance and diversity. The VAKI Riverwatcher™ system records both silhouettes and electronic images of each fish passage event. By capturing silhouettes and images, fish passage can be accurately monitored even under turbid conditions.

In the lower Yuba River, fall-run Chinook salmon was differentiated from spring-run Chinook salmon utilizing VAKI Riverwatcher™ data counts of Chinook salmon passing upstream of Daguerre Point Dam and an analysis of temporal modality applied to the annual distributions of the daily number of Chinook salmon passing upstream of Daguerre Point Dam that resulted from the reduction of the VAKI Riverwatcher™ hourly counts.

Table 6.1-4 displays the results of the above calculations for the 2004-2015 run sizes of lower Yuba River Chinook salmon, and the spring-run and fall-run Chinook salmon in-river spawners reported by GrandTab for the Sacramento River system (RMT 2013a).

Table 6.1-4. Estimated number of phenotypic spring-run and fall-run Chinook salmon spawning in the lower Yuba River from 2004 through 2015, and corresponding spring-run and fall-run Chinook salmon spawners reported in GrandTab for Sacramento River system.

Year	Yuba River Chinook Salmon Escapement			Sacramento River System Chinook Salmon Escapement	
	GrandTab[1] (No. of Fish)	Spring-run[2] (No. of Fish)	Fall-run[3] (No. of Fish)	Spring-run[4] (No. of Fish)	Fall-run[5] (No. of Fish)
2004	15,269	738	14,531	17,150	348,108
2005	17,630	3,592	14,038	23,093	399,266
2006	8,121	1,326	6,795	12,906	274,368
2007	2,604	372	2,232	11,144	91,735
2008	3,508	521	2,987	13,387	65,638
2009	4,635	723	3,912	4,429	44,938
2010	14,375	2,886	11,489	4,623	138,456
2011	8,928	1,159	7,769	7,774	195,877
2012	7,668	1,046	6,622	22,426	312,189
2013	14,880	3,130	11,750	23,696	411,794
2014	11,615	2,336	9,279	9,901	226,745
2015	6,507	184	6,323	5,635	124,565

1 In-river Chinook salmon escapement reported in GrandTab (4/11/2016). GrandTab reports all escapement to the Yuba River as fall-run Chinook salmon.
2 Estimated number of spring-run Chinook salmon passing upstream of Daguerre Point Dam from VAKI Riverwatcher™ data, as reported in Table 5.1-3 (see Section 5.0 of this Applicant-Prepared Draft EFH Assessment).
3 Number of fall-run Chinook salmon escapement to the Yuba River estimated by subtracting the spring-run estimates from the escapement reported in GrandTab, assuming that spring-run Chinook salmon spawn upstream of Daguerre Point Dam.
4 Spring-run Chinook salmon escapement as reported in GrandTab (4/11/2016) for the Sacramento River mainstem and tributaries including Battle Creek, Clear Creek, Cottonwood Creek, Antelope Creek, Mill Creek, Thomes Creek, Big Chico Creek and Butte Creek, and for the Feather River Hatchery.
5 Fall-run Chinook salmon escapement as reported in GrandTab (4/11/2016) for the Sacramento River mainstem and tributaries including Battle Creek, Clear Creek, Cottonwood Creek, Paynes Creek, Cow Creek, Bear Creek, Mill Creek, Deer Creek and Butte Creek, the Feather River and American River, and for the Coleman National Fish Hatchery, Feather River Hatchery and Nimbus Hatchery.

It is recognized that this approach to separate the annual GrandTab run sizes of lower Yuba River Chinook salmon spawners into spring-run and fall-run annual estimates is rather simplistic and results in only crude estimates. The existence of unavoidable differences in accuracy and precision between the estimates generated from the carcass surveys and the VAKI Riverwatcher™ counts may affect the accuracy and precision of the resulting estimates of phenotypic spring-run Chinook salmon that spawn in the lower Yuba River. These estimates based on GrandTab data were developed only to obtain a more equitable basis of comparison with the Sacramento River system.

The estimated numbers of lower Yuba River fall-run Chinook salmon spawners in Table 6.1-4 were used to evaluate their percent contribution to the in-river spawning population of fall-run Chinook salmon in the Sacramento River system (i.e., the fall-run Chinook salmon reported by GrandTab for the Sacramento River mainstem and tributaries) during the period of 2004-2015. The lowest contribution of lower Yuba River fall-run Chinook salmon to the Sacramento River system occurred in 2012 (2.1 percent). The lower Yuba River percent contribution increased each year from 2007 through 2009, reaching its maximum percent contribution during 2009 (8 percent). From 2010 through 2015, the percent contribution of the lower Yuba River ranged between 7.7 percent and 2.1 percent, respectively.

6.2 Limiting Factors, Threats and Stressors

Section 5.0 of the Applicant-Prepared Draft BA addresses limiting factors and threats for the spring-run Chinook salmon ESU, and their specific geographic influences – including the Sacramento River and the Delta – are also generally applicable to the fall-/late fall-run Chinook salmon ESU. Stressors that are unique to fall-run Chinook salmon EFH in the lower Yuba River, or substantially differ in the severity from the stressors previously described in Section 5.0 of the Applicant-Prepared Draft BA, are described below.

6.2.1 Pacific Coast Salmon

PFMC (1999) states that to maintain or restore habitat necessary for a sustainable salmon fishery requires the biophysical processes producing properly functioning habitat be maintained or restored. However, because watersheds and rivers differ in their characteristics (e.g., flow, water temperature, sedimentation, nutrient levels, physical structure, biological components), specific habitat requirements of salmonids differ among species, and change with seasonality and lifestage. Table 6.2-1 presents the general major habitat requirements and habitat concerns during each lifestage of Chinook salmon. According to PFMC (1999), salmonid habitat requirements should be met by maintaining habitat features within the natural range of patterns and processes that define the properly functioning habitat conditions within which salmon can exist.

Under the MSA, NMFS and PFMC have more recently identified non-fishing activities that may adversely affect EFH, as well as actions to encourage the conservation and enhancement of EFH, including recommended options to avoid, minimize, or mitigate for the adverse effects identified in the FMP. Amendment 14 includes 21 such activities and conservation measures, and 10 additional non-fishing threats (Table 6.2-2) were identified by NMFS and PFMC (2011) during the 5-Year EFH Review. Each of the non-fishing-related activities in Table 6.2-2 may directly, indirectly, or cumulatively, temporarily or permanently, threaten the physical, chemical, and biological properties of the habitat utilized by salmonid species and/or their prey. The direct results of these threats is that salmonid EFH may be eliminated, diminished or disrupted (PFMC 1999).

Table 6.2-1. Lifestage-specific habitat concerns associated with Pacific Coast salmon EFH (PFMC 1999).

ADULT IMMIGRATION PATHWAYS	
Passage blockage (e.g., culverts, dams)	Reduced frequency of holding pools
Water quality (high temperatures, pollutants)	Lack of cover, reduced depth of holding pool
High flows/low flows/water diversions	Reduced cold-water refugia
Channel modification/simplification	Increased predation resulting from habitat modification
SPAWNING AND EMBYRO INCUBATION	
Availability of spawning gravel of suitable size	Redd dewatering
Siltation of spawning gravels	Temperature/water quality problems
Redd scour caused by high flows	Redd disturbance from trampling (human, animal)
JUVENILE REARING HABITAT	
Diminished pool frequency, area, or depth	Low water flows/high water flows
Temperature/water quality problems	Nutrient availability
Diminished prey/competition for prey	Diminished channel complexity and cover
Blockage of access to habitat (upstream or down)	Predation caused by habitat simplification or loss of cover
Loss of off-channel areas, wetlands	
JUVENILE AND SMOLT EMIGRATION PATHWAYS	
Water quality	Passage blockage/diversion away from stream
Low water flows/high water flows	Increased predation as a result of habitat simplification or modification
Altered timing/quantity of water flows	
ESTUARINE HABITAT	
Water quality	Loss of channels, eel grass beds, woody debris
Altered timing/quantity of fresh water in-flow	Diminished prey/competition for prey
Loss of habitat resulting from diking dredging, filling	Increased predation as a result of habitat simplification or modification
Diminished habitat complexity	
MARINE HABITAT	
Water quality	Diminished prey/competition for prey
Increased predation	Altered timing/quantity/composition of river water plumes

Table 6.2-2. Non-fishing threats to Pacific Coast salmon EFH. Newly identified threats appear in the right column. Detailed information on the threats identified in the first column can be found in Amendment 14.

Threats Identified in Amendment 14 (1999)	New Threats Identified During the EFH 5-Year Review (2011)
Agriculture	Pile Driving
Artificial Propagation of Fish and Shellfish	Over-Water Structures
Bank Stabilization	Alternative Energy Development
Beaver Removal and Habitat Alteration	Liquefied Natural Gas Projects
Construction/Urbanization	Desalination
Dam Construction/Operation	Power Plant Intakes
Dredging and Dredged Spoil Disposal	Pesticide Use
Estuarine Alteration	Flood Control Maintenance
Forestry	Culvert Construction
Grazing	Climate Change
Habitat Restoration Projects	
Irrigation/Water Management	
Mineral Mining	
Introduction/Spread of Nonnative Species	
Offshore Oil and Gas Drilling	
Road Building and Maintenance	
Sand and Gravel Mining	
Vessel Operation	

Table 6.2-2. (continued)

Threats Identified in Amendment 14 (1999)	New Threats Identified During the EFH 5-Year Review (2011)
Wastewater/Pollutant Discharge	
Wetland and Floodplain Alteration	
Woody Debris/Structure Removal	

Conservation measures to address the 31 non-fishing threats were developed as part of Amendment 18 to the Pacific Coast Salmon FMP. Each of the 31 threats, including potential conservation measures and management alternatives for each threat are described in Appendix A to the Pacific Coast Salmon FMP, as modified by Amendment 18 to the Pacific Coast Salmon Plan (PFMC 2014).

Dams and reservoirs influence water temperatures through storage, diversion, and irrigation return flows, and changes in water temperatures can have significant implications for anadromous fish survival. Elevated water temperatures can stress all lifestages of anadromous fish, increase the risk of disease and mortality, affect toxicological responses to pollutants, and can cause migrating adult salmon to stop or delay their migrations. Warm water temperatures also increase the foraging rate of predatory fish thereby increasing the consumption of smolts (NMFS 2008).

Chinook salmon survival through migration corridors generally declines with distance traveled, whether due to natural hazards (including predation), mortality due to passage facilities, or other factors associated with development (e.g., water quality) (NMFS 2008). According to NMFS (2008), increased travel time (i.e., migration delay) presents an array of potential survival hazards to migrating juvenile Chinook salmon, including: 1) increased exposure to potential mortality vectors (e.g. predation, disease, thermal stress); 2) disruption of arrival timing to the Delta (which likely affects predator/prey relationships); 3) depletion of energy reserves; 4) potential metabolic problems associated with smoltification; and 5) increased contribution to residualism (i.e., loss of migratory behavior).

6.2.2 Central Valley Chinook Salmon

In the EFH assessment prepared by Reclamation (2008) and in the resultant EFH conservation recommendations in NMFS (2009), it was concluded that the projected impacts of CVP/SWP system-wide operations are expected to eliminate, diminish, and/or disrupt many EFH habitat functions for the fall-/late fall-run Chinook salmon ESU throughout the Central Valley, as described below.

Opportunities to avoid or minimize adverse affects to EFH in a specific project area may be constrained, and the potential for substantive habitat gains in these areas is minimal (NMFS 2009a). Yoshiyama et al. (2001) noted that the primary cause in the reduction of instream habitat for Chinook salmon has been the construction of dams and other barriers. Many of the direct adverse impacts to fall- and late-fall run Chinook salmon EFH, or the indirect impacts caused by these runs to the EFH of other Chinook runs, could be alleviated if fish passage were provided (NMFS 2009a). In Central Valley watersheds, dams block 95 percent of historic salmonid spawning habitat (NMFM 2009a). Additionally, non-federal FERC-licensed dams account for approximately 40 percent of all surface water storage in the Central Valley. As a result, Chinook salmon have been extirpated from approximately 5,700 mi of their historic habitat in the Central Valley. In most cases, the habitat remaining is restricted to the valley floor where it was historically limited to seasonal migration use only. Remnant populations below these dams are now subject to intensive river regulation and to further direct and indirect impacts of hydroelectric operations (NMFS 2009a).

The Sacramento River is constrained by levees along much of the lower reaches. Stressors identified in the Sacramento River include high water temperatures, a modified hydrograph, simplified instream habitat, diversion dams, predation, and harvest. Water temperatures and flow fluctuations are the main short-term factors affected by the ongoing operation of the CVP and SWP water projects (Reclamation 2008). According to NMFS (2009a), fall-/late fall-run Chinook salmon spawning in the upper Sacramento River is adversely affected in all years when flows are kept high for agricultural demand (i.e., rice decomposition) and then decreased in the fall to conserve water in Shasta Reservoir. Large numbers of fall-run Chinook salmon redds have been dewatered in the upper Sacramento River when flows are lowered after the rice decomposition program is completed and Shasta Dam releases decrease. Consequently, it is anticipated that some redd dewatering will continue in the future (NMFS 2009a).

According to NMFS (2009a), CVP/SWP system-wide operations in the Central Valley reduce adult reproductive success and increase mortality of early lifestage (egg through smolt) fall- and late fall-run Chinook salmon. NMFS (2009a) considered the net effects of CVP/SWP project operations and hatchery production in the short-term, and also separately considered the long-term effects of hatchery production on fall-run Chinook salmon, determining that hatchery practices could diminish the productivity, distribution and diversity of non-listed stocks (e.g., fall-run Chinook salmon) over the long-term. NMFS (2009a) evaluated the potential changes in freshwater mortality sources for Central Valley fall-/late fall-run Chinook salmon attributed to CVP/SWP operations. Mortality sources included elevated water temperatures, low flows upstream, and direct entrainment in the Delta. Other effects of CVP/SWP project operations on fall-/late fall-run Chinook salmon or its habitat included fish stranding, redd dewatering and predation (NMFS 2009a).

Hatchery practices, as well as spatial and temporal overlaps of habitat use and spawning activity between spring-run and fall-run fish have led to the hybridization and homogenization of some subpopulations (CDFG 1998). As early as the 1960s, Slater (1963) observed that spring-run and early fall-run were competing for spawning sites in the Sacramento River below Keswick Dam, and speculated that the two runs may have hybridized. Spring-run from the FRFH have been documented as straying throughout the Central Valley for many years (CDFG 1998), and in many cases, have been recovered from the spawning grounds of fall-run, an indication that FRFH spring-run may exhibit fall-run life history characteristics. Although the degree of hybridization has not been comprehensively determined, it is clear that the populations of spring-run spawning Chinook salmon in the Feather River and counted at RBDD contain hybridized fish (NMFS 2009).

Outmigrating Chinook salmon juveniles are also subjected to potential entrainment from water diversions located along the Sacramento River — of the 879 diversions only 91 (11 percent) currently have fish screens (Calfish database and AFSP 2009 annual report, as cited in NMFS 2009a). These diversions adversely affect EFH by disrupting migration, diverting juveniles into unsuitable rearing habitat, and killing fish outright. The RPA described in NMFS (2009) assures that continued funding of fish screens will continue through the AFRP to reduce entrainment at unscreened diversions (NMFS 2009a).

Juvenile fall- and late-run Chinook salmon typically migrate down the Sacramento River through the highly productive feeding grounds of the Delta, to the San Francisco Estuary and towards the Pacific Ocean. Based on the mainly ocean-type life history observed (i.e., fall-run), MacFarlane and Norton (2002) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry (NMFS 2009). Nevertheless, Chinook salmon may encounter numerous stressors during the juvenile rearing and downstream movement, and smolt outmigration lifestages.

Factors limiting salmon populations in the Delta include periodic reversed flows due to high water exports (drawing juveniles into large diversion pumps), loss of fish into unscreened agricultural diversions, predation by introduced species, and reduction in the quality and quantity of rearing habitat due to channelization, pollution, and riprapping (Dettman et al. 1987; California Advisory Committee on Salmon and Steelhead Trout 1988; Kondolf et al. 1996a, 1996b). The suitability of the Delta migration corridor as part of juvenile salmon rearing EFH is reduced by various aspects of CVP/SWP operations (NMFS 2009a). Adverse impacts to EFH may complicate customary habitat functions by extending migration routes (i.e., complex channel configurations make it difficult for salmon to find their way to the ocean), increasing water temperatures, increasing susceptibility to predators, and adding direct mortality from salvage and entrainment operations (NMFS 2009a).

Sacramento River flows, and many juvenile Chinook salmon, enter the Delta Cross Channel (when the gates are open) and Georgiana Slough, and subsequently the central Delta, especially during periods of increased water export pumping from the Delta. The mortality of juvenile salmon entering the central Delta is higher than for those continuing downstream in the Sacramento River. This difference in mortality could be caused by a combination of factors, including: 1) the longer migration route through the central Delta to the western Delta; 2) exposure to higher water temperatures; 3) higher predation rates; 4) exposure to seasonal agricultural diversions; 5) water quality impairments due to agricultural and municipal discharges; and 6) a more complex channel configuration that makes it more difficult for salmon to successfully migrate to the western Delta and the ocean (Reclamation 2008).

Estimated fall-run Chinook salmon smolt survival through the Delta was calculated by Kjelson and Brandes (1989) using estimated historic flow patterns under four different Central Valley water development scenarios, by water year type (WYT). Their results indicate that reduced inflows into the Delta caused by water development in the Sacramento Valley has reduced fall-run Chinook salmon smolt survival substantially (i.e., about 30 percent from about 1940-1990) (Kjelson and Brandes 1989). According to NMFS (2009), these estimates are considered minimal estimates of survival decline, because greater survival per unit flow would have occurred prior to the operations of the Delta Cross Channel (DCC) in the 1950s. Due to the increased demands in the Central Valley over the intervening 20+ years, Reclamation (2008) suggest that smolt survival is more than likely less under current conditions, compared to when the 1990 level of development estimates were used by Kjelson and Brandes (1989). Additionally, factors affecting salmon populations in Suisun Bay include heavy industrialization within its watershed and discharge of wastewater effluents into the bay. Loss of wetland habitat along the fringes of the bay also has reduced juvenile rearing habitat and diminished the functional processes that wetlands provide for the bay ecosystem (Reclamation 2008).

When juvenile salmon are in the vicinity of the CVP/SWP water export diversion facilities, they are more likely to be drawn into these facilities during water diversion operations. With exports increasing in the future due to CVP/SWP operations, and assuming that entrainment is directly proportional to the amount of water exported, the potential exists for these diversions to adversely affect the ability of outmigrating fall-/late fall-run Chinook salmon to utilize the habitat as they normally would (NMFS 2009).

Overall, NMFS (2009a) state that, based on the available evidence, CVP/SWP system-wide operations are expected to adversely impact Sacramento River fall-/late fall-run Chinook salmon EFH through continuing degradation of spawning and rearing habitat, water temperature-related impacts, reduced flows, and entrainment at unscreened water diversions. According to NMFS (2009a), increased level of water demands through 2030, reduced diversions from the Trinity River, and future climate change are anticipated to exacerbate water temperature-related impacts to EFH. However, many actions within the RPA described in NMFS (2009) will generally improve EFH for naturally spawning fall- and late-fall run Chinook salmon by improving adult fish passage at RBDD, increasing juvenile survival (i.e., reducing predation, and entrainment at diversions), reducing water temperature related impacts, increasing reservoir storage, and restoring EFH in tributary spawning areas (NMFS 2009a).

In developing its EFH conservation recommendations for CVP/SWP system-wide operations, NMFS (2009a) recognized that the appropriate and practicable steps to avoid adverse effects to EFH and measures to minimize remaining adverse affects are constrained due to the existing CVP/SWP operational conditions that have transpired over the time span in which water in the Central Valley has been managed. Consequently, available opportunities to avoid and minimize adverse effects may be limited. In addition, NMFS (2009a) states that its highest priority is to fulfill its conservation mandates for protecting winter-run and spring-run Chinook salmon and steelhead listed under the ESA, and in some instances, this priority may take precedent over protecting the EFH of fall and late-fall run Chinook salmon for particular locations. Due to these limitations to avoid and minimize EFH impacts, NMFS (2009a) believes that available conservation measures may be insufficient to offset the expected further deterioration of EFH habitat functions in parts of the CVP/SWP Project area. Generally, however, actions to protect listed anadromous fish species will provide benefits to non-listed salmonids (e.g., fall- and late fall-run Chinook salmon) because they share similar habitats and respond to environmental impacts in a comparable fashion (NMFS 2009a).

6.2.3 Yuba River Chinook Salmon

The Yuba River spring-run Chinook salmon population is exposed and subject to the myriad limiting factors, threats and stressors described for the Central Valley ESU in Section 5.0 of the

Applicant-Prepared Draft BA. Although no recovery plan has been developed for the fall-/late fall-run Chinook salmon ESU because the ESU is not listed under the ESA, many of the key threats and stressors identified for spring-run Chinook salmon in the NMFS Recovery Plan (NMFS 2014b) and those described in Section 5.0 of the Applicant-Prepared Draft BA also generally are applicable to fall-run Chinook salmon and EFH.

The previous discussions in this Applicant-Prepared Draft EFH Assessment addressing Central Valley fall-/late-fall run Chinook salmon general life history and habitat requirements that also pertain to spring-run Chinook salmon are not repeated in this section of the Applicant-Prepared Draft EFH Assessment. Additionally, general life history and habitat requirements, population status and trends, limiting factors, threats and stressors to spring-run Chinook salmon are fully described in the Applicant-Prepared Draft BA, and are not repeated here.

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