UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

Klamath River Renewal Corporation
PacifiCorp

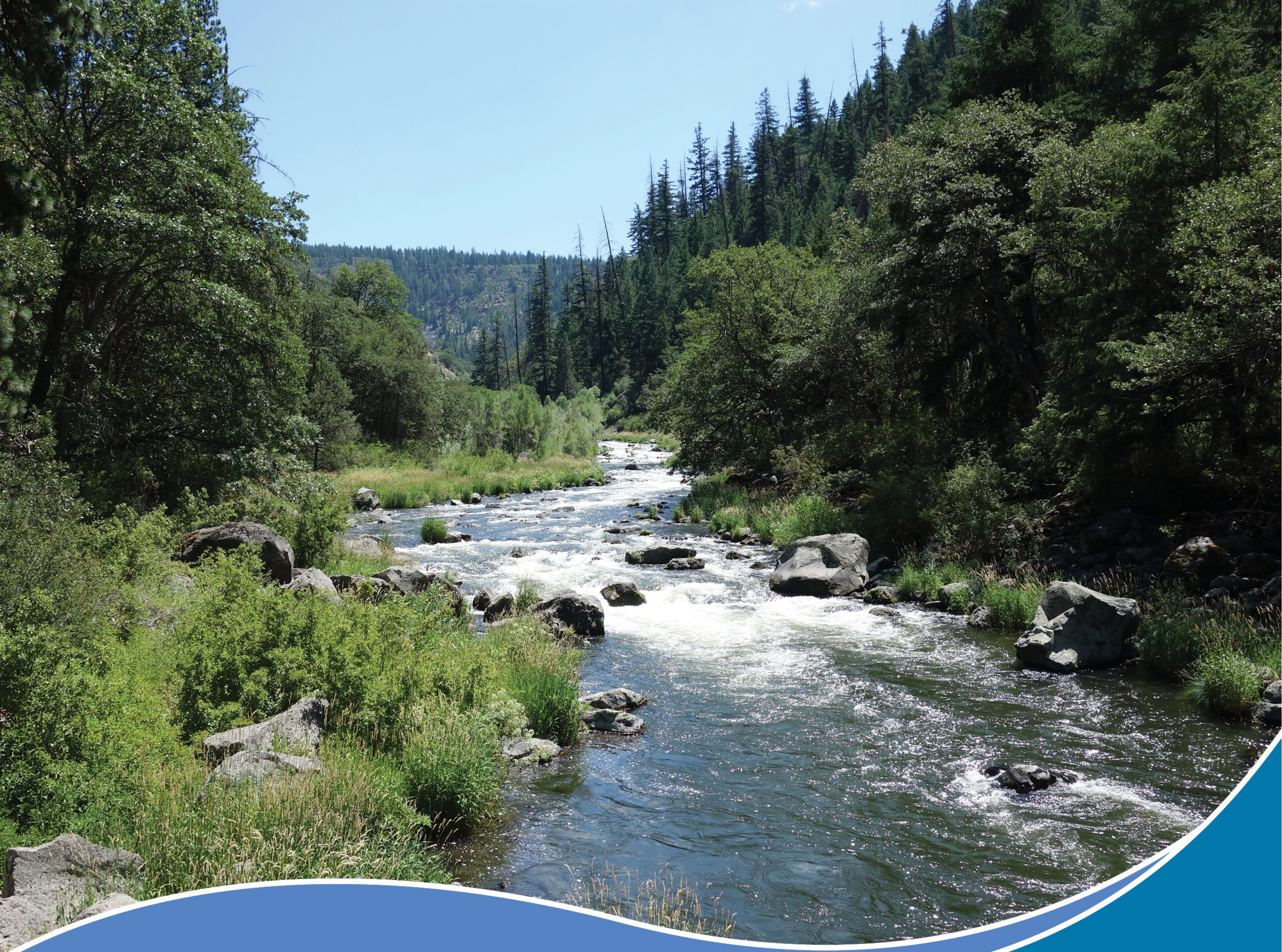
Project Nos. 14803-001;
2082-063

AMENDED APPLICATION FOR SURRENDER OF LICENSE FOR MAJOR PROJECT AND REMOVAL OF PROJECT WORKS

Attachment A-11

Lower Klamath Project Biological Assessment

Appendix J
(Klamath River Chinook Salmon Analysis)



Biological Assessment

Appendix J – Klamath River Chinook Salmon Analysis

KLAMATH RIVER RENEWAL CORPORATION

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J. KLAMATH RIVER CHINOOK SALMON ANALYSIS

This appendix describes the status of the Chinook salmon populations in the Klamath Basin and anticipated effects of the Proposed Action on fall-run Chinook salmon. Anticipated short-term effects are related to water quality conditions during reservoir drawdown, and include high suspended sediment concentrations (SSCs), low dissolved oxygen, and habitat impairment due to bedload deposition. Long-term effects include the influence of Chinook life history diversity, reduced hatchery production and hatchery effects, hydrologic and water quality changes, restored access to historical spawning and rearing habitat, and reduced disease prevalence.

References cited in this appendix are listed in Chapter 8 of the BA.

J.1 Klamath River Chinook Salmon Populations

The following section is adopted directly from SWRCB (2020a).

Two Chinook salmon ESUs currently occur in the Klamath Basin downstream of Iron Gate Dam—the Southern Oregon and Northern California Coastal ESUs, which include all naturally spawned Chinook salmon in the Lower Klamath River downstream of its confluence with the Trinity River, and the Upper Klamath and Trinity Rivers ESU, which includes all naturally spawned populations of Chinook salmon in the Klamath and Trinity rivers upstream of the confluence of the two rivers. A status review in 1999 determined that neither ESU warranted listing under the federal ESA (NMFS 1999b). The Upper Klamath and Trinity Rivers ESU is listed as a CDFW Species of Special Concern and a USDA Forest Service Sensitive Species.

Another petition to list Chinook salmon in the Upper Klamath and Trinity Rivers ESU under the ESA was submitted to NMFS in January 2011 (CBD et al. 2011). In the petition, NMFS was asked to consider one of three alternatives for the listing of Chinook salmon in the Upper Klamath and Trinity River ESU: (1) list spring-run only as a separate ESU; (2) list spring-run as a DPS within the Upper Klamath and Trinity River Chinook Salmon ESU; or (3) list the entire Chinook salmon Upper Klamath and Trinity River ESU, including both spring-run and fall-run populations. In April 2011, NMFS announced that the petition contained substantial scientific information warranting federal review as to whether Chinook salmon in the Upper Klamath and Trinity River ESU should be listed as threatened or endangered. As a result, NMFS formed a Biological Review Team (BRT) to assess the biological status of the species and determine if listing under the ESA is necessary. The BRT (Williams et al. 2011b) found that recent spawner abundance estimates of both fall-run and spring-run Chinook salmon returning to spawn in natural areas are generally low compared to historical estimates of abundance; however, the majority of populations have not declined in spawner abundance over the past 30 years (i.e., from the late 1970s and early 1980s to 2016) except for the Scott and Shasta rivers, where there have been modest declines (Williams et al. 2011b). In addition, Williams et al. (2011b) found that hatchery returns did not track escapement to natural spawning areas, and they concluded that there has been little change in the abundance levels, trends in abundance, or population growth rates since the review conducted by Myers et al. (1998). The BRT also noted that recent abundance levels of some populations are low, especially in the context of historical abundance estimates. This was most evident with two of the three spring-run population units that were evaluated (Salmon River and South Fork Trinity River). The BRT concluded that although current levels of abundance are low when compared to historical estimates of abundance, the current abundance levels did not constitute a major risk in terms of ESU extinction.

The BRT also concluded that spring-run Chinook salmon did not warrant designation as a separate ESU or DPS within the Upper Klamath and Trinity River ESU. This finding was based in part on genetic evidence that indicates that spring-run and fall-run life histories have evolved on multiple occasions across different coastal watersheds north and south of the Klamath River. Kinziger et al. (2008) found that there are four genetically distinct and geographically separated groups of Chinook salmon populations in the Upper Klamath and Trinity River basins; and that spring-run and fall-run Chinook salmon life histories have evolved independently, but in parallel, in both the Salmon and Trinity rivers. In addition, spring-run and fall-run populations in the Salmon River were nearly genetically indistinguishable, and spring-run and fall-run populations in the South Fork Trinity River were extremely similar to each other and to Trinity River hatchery stocks. Williams et al. (2011b) concluded that spring-run and fall-run Chinook salmon in the Upper Klamath and Trinity river basins are genetically similar to each other, and that the two runs are not substantially reproductively isolated from each other. In addition, ocean type (ocean entry in early spring within a few months of emergence) and stream type (ocean entry during spring of their second year of life) life history strategies are exhibited by both run types, further suggesting that spring-run Chinook salmon in the Upper Klamath and Trinity river basins do not represent an important component in the evolutionary legacy of the species.

However, recently published research by Prince et al. (2017) questions the basis of treating the fall-run and spring-run Chinook salmon in the Upper Klamath and Trinity River ESU as a single ESU, which was based on overall genetic structure that is primarily defined by geography. The genomic results of Price et al. indicate that premature migration observed in spring-run Chinook salmon is defined by a single genetic variation, questioning the basis of conventional ESU designations, which assume that genetic structure is primarily defined by geography.

In response to new information from Prince et al. (2017) and the overall decline of spring-run Chinook salmon, in November 2017, the Karuk Tribe and the Salmon River Watershed Council submitted a petition to NMFS to list the Upper Klamath and Trinity Rivers ESU as threatened or endangered; or alternatively, create a new ESU to describe Klamath spring-run Chinook salmon, and list the new ESU as threatened or endangered under the ESA. In February 2018, NMFS announced a 90-day finding on this petition (NMFS 2018a). NMFS found that the petition presents substantial scientific information indicating the petitioned actions may be warranted. NMFS will conduct a status review of the Chinook salmon in the Upper Klamath and Trinity rivers to determine if the petitioned actions are warranted. No final decision has been published to date.

Regardless of the status of a determination on whether spring-run and fall-run Chinook salmon comprise a single ESU, these two runs have different life history strategies (NRC 2004), and therefore are considered distinct in this analysis. A more detailed discussion of the two run types is described below.

J.1.1 Fall-Run Chinook Salmon

Fall-run Chinook salmon are currently distributed throughout the Klamath River downstream of Iron Gate Dam. Upstream adult migration through the estuary and Lower Klamath River peaks in early September and continues through late October (Moyle 2002, FERC 2007, Strange 2008). Spawning peaks in late October and early November, and fry begin emerging from early February through early April (Stillwater Sciences 2009a), although timing may vary somewhat depending on temperatures in different years and tributaries.

Fall-run Chinook salmon in the Klamath Basin exhibit three juvenile life-history types: Type I (ocean entry at age-0 in early spring within a few months of emergence); Type II (ocean entry at age-0 in fall or early winter); and Type III (ocean entry at age-1 in spring) (Sullivan 1989). Based on outmigrant trapping at Big Bar on the Klamath River from 1997 to 2000, 63 percent of natural Chinook salmon outmigrants are Type I, 37 percent are Type II, and less than 1 percent are Type III (Scheiff et al. 2001). Although trapping efforts are not equal among seasons, the results are consistent with scale analysis of adult returns by Sullivan (1989).

Critical stressors on fall-run Chinook salmon in the basin include water quality and quantity in the mainstem and in spawning tributaries. Downstream from Iron Gate Dam, the mainstem Klamath River undergoes seasonal changes in flows, water temperature, dissolved oxygen, and nutrients, as well occasional blooms of *Microcystis aeruginosa* (a blue-green algae species that is potentially toxic to fish). During outmigration, juvenile Chinook salmon are vulnerable to contracting disease from pathogens, including the bacterium *Flavobacterium columnare*, and myxozoan parasites *Parvicapsula minibicornis* and *Ceratonova shasta*.

J.1.2 Spring-Run Chinook Salmon

Spring-run Chinook salmon in the Klamath Basin are distributed mostly in the Salmon and Trinity rivers and in the mainstem Klamath River downstream of these tributaries during migratory periods, although a few fish are occasionally observed in other areas (Stillwater Sciences 2009a). Based on data from 2005 to 2014 (CDFW 2015b), the Salmon River contributions to the overall escapement of spring-run Chinook salmon ranged from 1 to 12 percent of the total escapement, and from 1 to 20 percent of the natural escapement.

To date, no spring-run Chinook salmon spawning has been observed in the mainstem Klamath River (Shaw et al. 1997). As described above, the BRT (Williams et al. 2011b) concluded that although current abundance is low compared with historical abundance, the Chinook salmon population (which includes hatchery fish) appears to have been fairly stable for the past 30 years. However, the BRT noted, as did Myers et al. (1998), that the recent spawner abundance levels of two of the three spring-run population components (Salmon River and South Fork Trinity River) are very low compared to historical abundance (less than 2,000 fish and 1,000 fish, respectively). The BRT was concerned about the relatively few populations of spring-run Chinook salmon and the low numbers of spawners within those populations (Williams et al. 2011b).

The BRT (Williams et al. 2011b) found the decline in spring-run salmon especially troubling, given that historically the spring-run population may have been equal to, if not larger than the fall-run (Barnhart 1994). Huntington (2006) reasoned that spring-run Chinook salmon likely accounted for the majority of the Upper Klamath Basin's actual salmon production under historical conditions. Spring-run Chinook salmon spawned in the tributaries of the Upper Klamath Basin (Moyle 2002, Hamilton et al. 2005, Hamilton et al. 2016), with large numbers of spring-run Chinook salmon spawning in the basin upstream of Upper Klamath Lake in the Williamson, Sprague, and Wood rivers (Snyder 1931). Large runs of spring-run Chinook salmon also historically returned to the Shasta, Scott, and Salmon rivers (Moyle et al. 1995). The runs in the Upper Klamath Basin are thought to have been in substantial decline by the early 1900s and were eliminated by the construction of Copco No. 1 Dam in 1912. The cause of the decline of the Klamath River spring-run Chinook salmon prior to Copco No. 1 Dam has been attributed to dams, overfishing, and irrigation; but largely to commercial hydraulic mining operations (Snyder 1931, Coots 1962). These large- scale mining operations occurred primarily in the late 1800s, and along with overfishing, left spring-run Chinook salmon little chance to recover prior to dam construction in the early 1900s. Dams (e.g., Link River Dam, Iron Gate Dam, Lewiston Dam) have eliminated access to much of the historical spring-run spawning and rearing habitat, and are partly responsible for the extirpation of at least seven spring-run populations from the Klamath-Trinity River system (Myers et al. 1998). For example, the construction of Dwinnell Dam on the Shasta River in 1926 was soon followed by the disappearance of the spring-run Chinook salmon run in that tributary (Moyle et al. 1995).

Wild spring-run Chinook salmon from the Salmon River appear to primarily express a Type II life history, based on scale analyses of adults returning from 1990 to 1994 in the Salmon River (Olson 1996), as well as otolith analyses of Salmon River fry and adults (Sartori 2006). A small number of fish employ the Type III life history, although it does not appear to be nearly as prevalent as Type II.

Spring-run Chinook salmon upstream migration is observed during two time periods: spring (April through June) and summer (July through August) (Strange 2008). Snyder (1931) also describes a run of Chinook salmon occurring in the Klamath River during July and August under historical water quality and temperature conditions. Adults spawn from mid-September to late October in the Salmon River, and from September through early November in the South Fork Trinity River (Stillwater Sciences 2009a). Emergence begins in March and continues until early June (West et al. 1990). Age-0 juveniles rearing in the Salmon River emigrate at various times of the year, with one of the peaks of outmigration occurring in April through May (Olson 1996), which would be considered Type I life history. Based on outmigrant trapping from April to November in 1991 at three locations in the South Fork Salmon River, Olson (1996) reported that the greatest peak in outmigration of age-0 juveniles (69 percent) was in mid-October, which would be considered Type II life history. Sullivan (1989) reported that outmigration of Type II age-0 juveniles can occur as late in the year as early winter. On the South Fork Trinity River, outmigration occurs in late April and May, with a peak in May (Dean 1994, 1995), although it is not possible to differentiate between spring- and fall-run juveniles, so the spring run may have different run timing. Age-1 juveniles (Type III) have been found to outmigrate from the South Fork Trinity River during the following spring (Dean 1994, 1995).

Stressors on spring-run Chinook salmon related to water quality and quantity are similar to those for fall-run Chinook salmon in the mainstem Klamath River. Although water quality tends to improve in the mainstem downstream of the confluence with the Salmon River (the upstream-most spawning tributary), degradation of water quality (especially temperature and dissolved oxygen) can create critically stressful conditions for spring-run Chinook salmon adults and juveniles for much of the summer (June through September). Production in the Salmon River is primarily controlled by high water temperatures that reduce adult holding and summer rearing habitat in the mainstem Salmon River, while increased fine sediment input in the watershed reduces spawning and rearing habitat quality in some locations (Elder et al. 2002).

J.2 Klamath River Chinook Salmon Abundance

Fall-run Chinook numbers have declined drastically since the early 1900s when Copco No. 1 Dam was constructed on the Klamath River. The total estimated catch and escapement of all Chinook salmon in the Klamath River between 1915 and 1928 averaged between 300,000 and 400,000 fish annually. From 1981 to 2018, the average number of returning adult Chinook salmon was 110,126 fish, with minimum and maximum values of 24,600 fish and 295,300 fish, respectively (PFMC 2019). From 1981 to 2018, natural-origin Chinook salmon accounted for 66 percent of the adult spawners in the Klamath Basin (KRTT 2019).

USFWS found the number of natural area spawners between Iron Gate Dam and the Shasta River confluence trended downward between 2001 and 2018, perhaps related to decreased survival of juvenile Chinook salmon due to *C. shasta* mortality (USFWS 2019). From 1981 to 2018, 3-year-old and 4-year-old Chinook salmon made up 47 percent and 36 percent of the spawning run, respectively (PFMC 2019).

Between 2004 and 2018, adult Chinook salmon escapement in the mainstem Klamath River averaged 30 percent of natural spawning in the Klamath River (without Trinity River production), 18 percent of total natural spawner escapement, and 12 percent of total spawner escapement (CDFW 2018a).

J.3 Chinook Salmon as a Southern Resident Killer Whale Food Resource

Resident killer whales, which primarily occupy coastal waters, are salmonid predators that show strong selectivity for Chinook salmon (Ford et al. 2010). Whales prey on Chinook salmon, which have the highest energy content of any salmon, and the whales selectively prey on the largest Chinook salmon (Ford et al. 1998; Ohlberger et al. 2019). Killer whales consumed more Chinook salmon biomass between 1975 and 2015, compared to the Chinook salmon consumption of all other categories of marine mammals combined. Killer whale consumption of Chinook salmon increased from 5 million to 31.5 million individual Chinook salmon over the 40-year period (Ohlberger et al. 2019). Food limitation may be one of the factors responsible for the recent decline in the abundance of the Southern Resident killer whales, the only population of fish-eating killer whales in the northeast Pacific Ocean that is not thriving (Ohlberger et al. 2019).

The correspondence between changes in Chinook salmon abundance and mortality of Southern Resident killer whales suggests that prey limitation was an important factor in recent population declines (Ford et al. 2010). Klamath River Chinook salmon distribution in the Pacific Ocean overlaps with Southern Resident killer whale range in the winter and spring. Compared to other stocks, Klamath River Chinook salmon are of lesser importance as a Southern Resident killer whale food source relative to other stocks that have greater spatial and temporal overlap with the whales, such as Chinook salmon stocks from the Salish Sea and Puget Sound (NMFS and WDFW 2018).

In summary, Klamath River Chinook salmon are a prey resource for Southern Resident killer whales during the winter and spring when the whales migrate south from the Salish Sea region. Chinook salmon are a valuable food resource that is selectively consumed by Southern Resident killer whales. Therefore, evaluating Proposed Action effects on Klamath River Chinook salmon is necessary to determine the potential effect of the Proposed Action on Southern Resident killer whales.

J.4 Short-Term Effects on Klamath River Chinook Salmon

J.4.1 Suspended Sediment Concentrations

A detailed description of the SSC analysis is provided for coho salmon (see Appendix H); a similar process was followed for Chinook salmon.

SSCs derived from the 1D flow and sediment transport model (USBR 2011b) were used to assess Proposed Action effects on adult and juvenile Klamath River Chinook salmon in the Klamath River. The sediment transport model predicts daily SSC as a continuous time series from October 1 of the year before drawdown to September 30 of Year 2. The time series includes background conditions and SSCs associated with pre-drawdown activities, the drawdown, and the post-drawdown. Modeled flows and SSC values are reported for each of three water quality stations that are represented by existing USGS stream gauge stations, as shown in Figures J-1 through J-3. The water quality stations also represent different geographic reaches of the Klamath River with each reach influenced by tributary inflows. Figure J-4 shows screw trap locations and water and suspended sediment modeling stations.

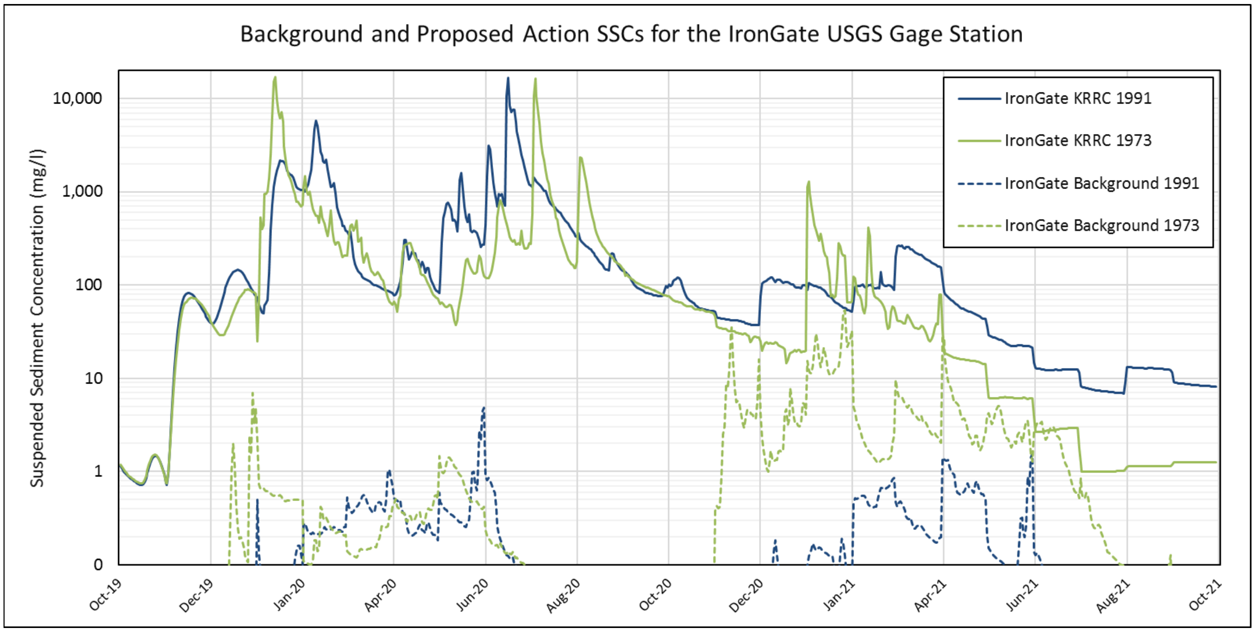

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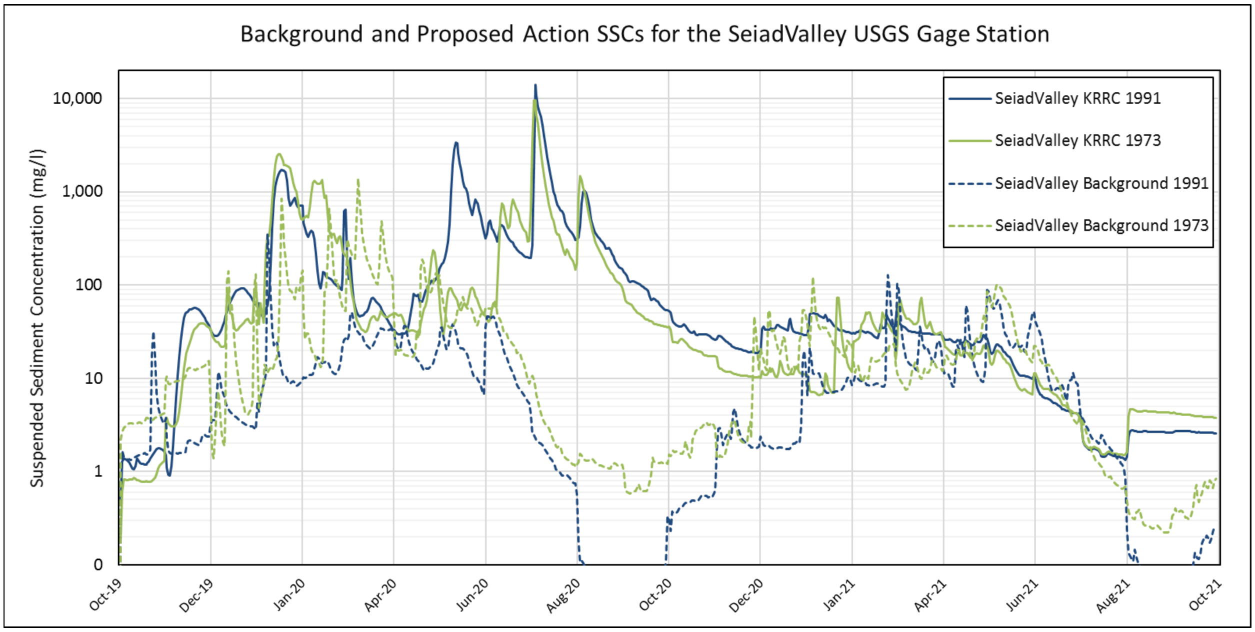
Figure J-1: Comparison of modeled daily SSCs at the Iron Gate Station (RM 193.1) for the Chinook Salmon Median Impact Year (1991) and Severe Impact Year (1973) scenarios under Background Conditions and the Proposed Action, based on SRH-1D Model described in Appendix I of the BA



Klamath River Renewal Corporation, Klamath River Renewal Project

Figure J-2: Comparison of modeled daily SSCs at the Seiad Valley Station (RM 129.4) for the Chinook Salmon Median Impact Year (1991) and Severe Impact Year (1973) scenarios under Background Conditions and the Proposed Action, based on SRH-1D Model described in Appendix I of the BA

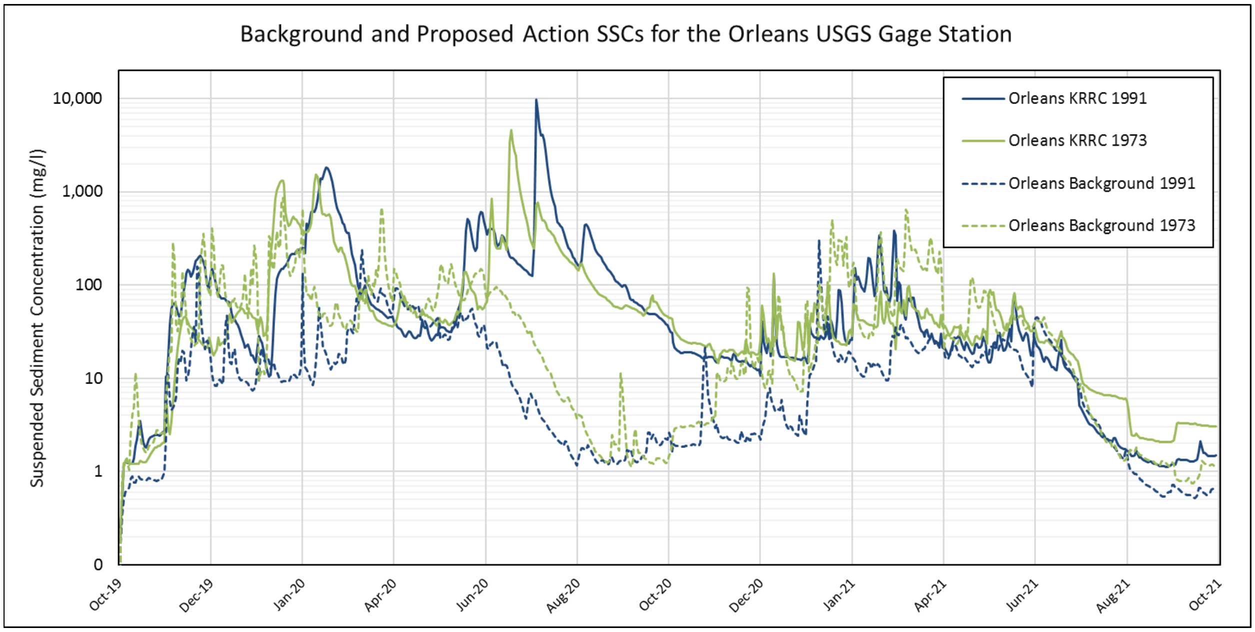


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Figure J-3: Comparison of modeled daily SSCs at the Orleans Station (RM 59) for the Chinook Salmon Median Impact Year (1991) and Severe Impact Year (1973) scenarios under Background Conditions and the Proposed Action, based on SRH-1D Model described in Appendix I of the BA

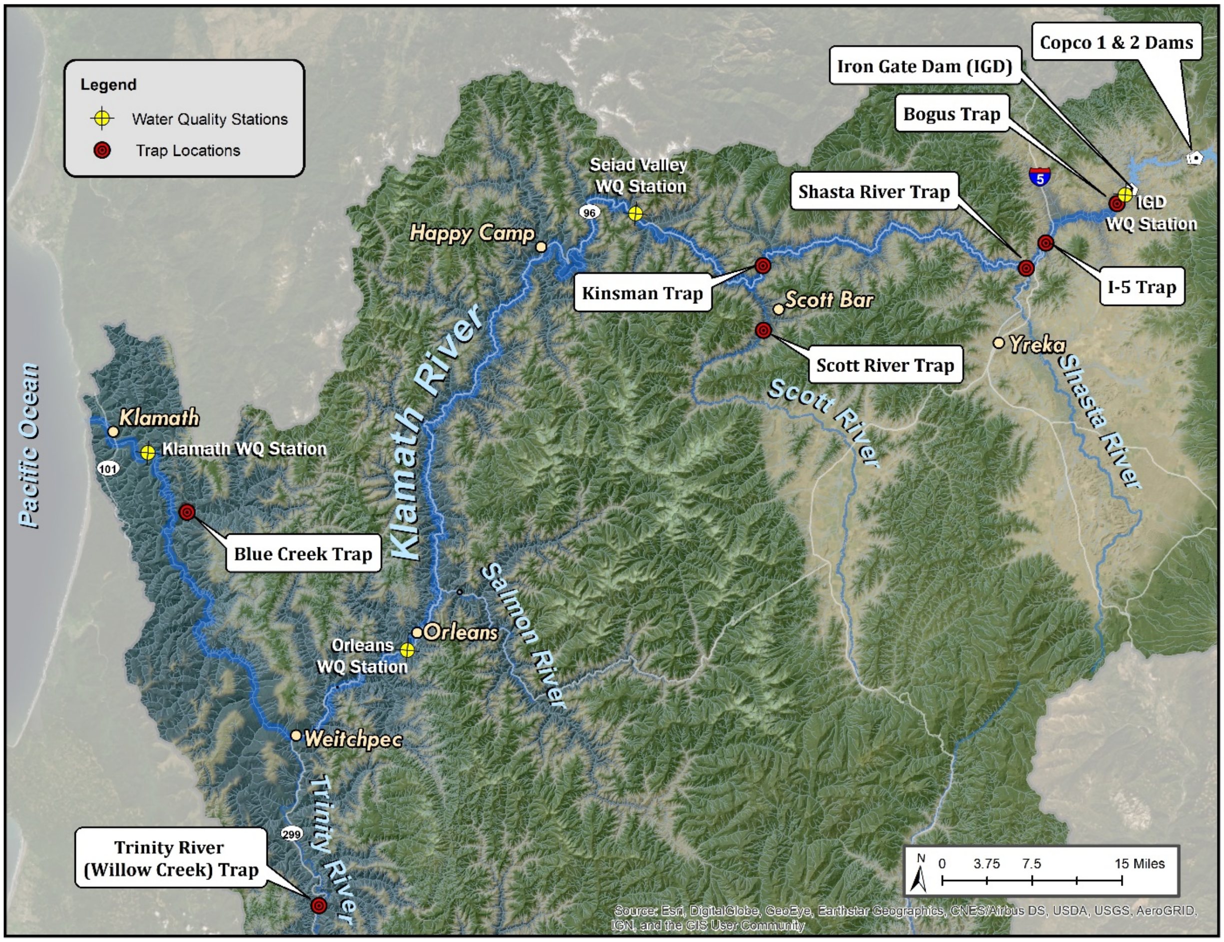

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Figure J-4: SSC Modeling Result Stations and Select Trap Locations Used in Determining Suspended Sediment Effects to Chinook Salmon.

The Klamath River Chinook salmon analysis employed the same methodology as the coho analysis, although SSC effects were determined for age-0+ Chinook salmon, rather than age-0+ coho salmon. The effects analysis reports median and severe SSC scenarios and the anticipated physiological and behavioral effects of associated SSC levels on outmigrating age-0+ Chinook salmon.

The Renewal Corporation used a 20-day outmigration period, or 9.6 miles/day outmigration rate, for the juvenile Chinook salmon SSC exposure analysis. This migration rate was based on work by Foott et al. (2009) and Wallace (2004). Foott et al. (2009) reported median outmigration travel times for radio-tagged juvenile Chinook salmon released from Iron Gate Hatchery (IGH) to Klamath Glen (approximately 185 river miles) of 10.2 days. Median travel rates through the upper reaches of the Klamath River (Ager Bridge and Shasta River reaches) were greater than 2.7 miles/hour, nearly twice as fast as migration rates through downstream reaches. Travel rate differences were in part explained by release timing, because fish released at night moved immediately following release, whereas fish released during the day delayed outmigration

(Foott et al. 2009). Water temperature and fish size also influenced outmigration rates. Wallace (2004) reported annual median travel times for coded-wire tagged juvenile Chinook salmon from IGH to the estuary of 26 days to 52 days, with a range from 13 days to 109 days from a study completed between 1998 and 2002. The travel times equate to median values of 3.7 miles/day to 7.4 miles/day, with a range from 1.8 miles/day to 14.8 miles/day).

The following sections provide a description of anticipated SSC effects to Chinook salmon age classes.

Adult Migration and Spawning (July 15 – November 30)

Fall-run Chinook salmon begin returning to the Klamath River by mid-July and migrate to spawning grounds through late October. Spawning occurs from mid-October through the end of November. Adult Chinook salmon migrating and spawning the year prior to drawdown will be minimally affected by the Proposed Action as pre-drawdown activities could release minimal amounts of turbid water. With the onset of drawdown activities on January 1 of Year 1, SSCs will rapidly rise downstream of Iron Gate Dam. Approximately 18 percent of natural spawning Klamath Basin Chinook salmon spawn in the mainstem Klamath River between Iron Gate Dam and the Shasta River confluence. Redds in this reach are expected to experience high mortality rates due to sediment burial during drawdown. Downstream mainstem redds are also expected to experience high mortality rates due to sediment deposition and low dissolved oxygen.

Table J-1 includes a comparison of severity of ill effects values (SEVs) and adult Chinook salmon behavioral responses for the background and Proposed Action under median and severe impact year scenarios. The median impact year is represented by the 1991 water year hydrology and the severe impact year is represented by the 1973 water year hydrology. Data are presented for the three USGS water quality stations, Iron Gate, Seiad Valley, and Orleans. Adult Chinook salmon will experience sublethal conditions in Year 1 and Year 2. The severe impact year conditions during drawdown will result in the highest SEV values. Values are most severe at the Iron Gate station, and slightly decline at the Seiad Valley and Orleans stations. Median and severe impact year conditions for the Proposed Action are similar in Year 2, and greater than the background condition SEV values for the same period.

Table J-1: Adult Chinook Salmon Response to 14-day Exposure to Proposed Action and Median Impact Year and Severe Impact Year Scenario SSCs during Migration and Spawning in Year 1 (Drawdown) and Year 2.

Scenario	Water Quality Station	Year 1 (Drawdown) Severity of Effects and Response with 14- day Exposure		Year 2 Severity of Effects and Response with 14-day Exposure	
		Migration (Oct 1 – Oct 31)[1]	Spawning (Oct 15 – Nov 30)	Migration (July 15 – Oct 31)	Spawning (Oct 15 – Nov 30)
Background Median Impact Year	Iron Gate	SEV 0 to 2: No effect to Abandonment of cover	SEV 0 to 2: No effect to Abandonment of cover	SEV 0: No effect	SEV 0: No effect
	Seiad	SEV 2 to 5: Abandonment of cover to Minor physiological stress	SEV 4 to 5: Short-term reduction in feeding rates to Minor physiological stress	SEV 2 to 3: Abandonment of cover to Avoidance response	SEV 3: Avoidance response
	Orleans	SEV 4 to 5: Short-term reduction in feeding rates to Minor physiological stress	SEV 4 to 5: Short-term reduction in feeding rates to Minor physiological stress	SEV 3: Avoidance response	SEV 3: Avoidance response
Background Severe Impact Year	Iron Gate	SEV 1 to 2: Alarm reaction to Abandonment of cover	SEV 1 to 6: Alarm reaction to Moderate physiological stress	SEV 1 to 2: Alarm reaction to Abandonment of cover	SEV 2: Abandonment of cover
	Seiad	SEV 3 to 5: Avoidance response to Minor physiological stress	SEV 5 to 8: Minor physiological stress to Indications of major physiological stress	SEV 4 to 5: Short-term reduction in feeding rates to Minor physiological stress	SEV 5: Minor physiological stress
	Orleans	SEV 4 to 6: Short-term reduction in feeding rates to Moderate physiological stress	SEV 5 to 8: Minor physiological stress to Indications of major physiological stress	SEV 5: Minor physiological stress	SEV 5: Minor physiological stress
Proposed Action Median Impact Year	Iron Gate	SEV 8 to 9: Indications of major physiological stress to Reduced growth rate	SEV 7 to 8: Impaired homing to Indications of major physiological stress	SEV 6: Moderate physiological stress	SEV 6: Moderate physiological stress
	Seiad	SEV 7 to 9: Impaired homing to Reduced growth rate	SEV 7 to 8: Impaired homing to Indications of major physiological stress	SEV 5 to 6: Minor physiological stress to Moderate physiological stress	SEV 6: Moderate physiological stress
	Orleans	SEV 7: Impaired homing	SEV 7 to 8: Impaired homing to Indications of major physiological stress	SEV 5 to 6: Minor physiological stress to Moderate physiological stress	SEV 6: Moderate physiological stress

Scenario	Water Quality Station	Year 1 (Drawdown) Severity of Effects and Response with 14- day Exposure		Year 2 Severity of Effects and Response with 14-day Exposure	
		Migration (Oct 1 – Oct 31)[1]	Spawning (Oct 15 – Nov 30)	Migration (July 15 – Oct 31)	Spawning (Oct 15 – Nov 30)
Proposed Action Severe Impact Year	Iron Gate	SEV 8 to 9: Indications of major physiological stress to Reduced growth rate	SEV 7 to 8: Impaired homing to Indications of major physiological stress	SEV 5: Minor physiological stress	SEV 5: Minor physiological stress
	Seiad	SEV 7 to 9: Impaired homing to Reduced growth rate	SEV 7: Impaired homing	SEV 5: Minor physiological stress	SEV 5: Minor physiological stress
	Orleans	SEV 7 to 9: Impaired homing to Reduced growth rate	SEV 7: Impaired homing	SEV 5: Minor physiological stress	SEV 5: Minor physiological stress

1. Suspended sediment concentration data set begins on October 1 of the year before drawdown.

Juvenile Outmigration - Upper Klamath River Populations

The Iron Gate Dam water quality station was used to evaluate SSC effects to Chinook salmon in Upper Klamath River populations. Screw trap data collected on the Klamath River downstream of the Bogus Creek confluence, on the Klamath River downstream of Interstate 5, and on the Shasta River near the Shasta River-Klamath River confluence were used to estimate juvenile Chinook salmon outmigration timing and abundance. Fifty percent of the outmigrating age-0+ Chinook salmon pass the Bogus Creek, I-5, and Shasta River traps by the first week of April, mid-April, and the first week of March, respectively. Juvenile Chinook salmon outmigrate earliest from the Shasta River due to the warmer water temperatures in the groundwater-dominated system.

Under the background conditions, age-0+ Chinook salmon entering the mainstem Klamath River during the spring outmigration period are exposed to 20-day median SSCs downstream of Iron Gate Dam that are less than 2 mg/L for both the median impact year and severe impact year scenarios.

Under the Proposed Action, median SSCs are expected to peak in the period between February 1 and February 20 and again in the period between June 20 and July 9. Median SSCs decline to moderate levels between the two peaks. Because juvenile Chinook salmon are not expected to enter the mainstem Klamath River in the vicinity of the Bogus Creek RST until after the middle of February, Bogus Creek fish are not expected to experience the first peak SSC event. Most of the Bogus Creek fish outmigrate between February 22 and May 15, before the second peak SSC event. Median SEV values are sublethal under the median impact year and exceed lethal values during three periods under the severe impact year scenario. Under the severe impact year scenario, potentially 13 percent of the Bogus Creek run could experience mortality (Table J-2).

Table J-2: Age-0+ Chinook Salmon Outmigrating from the Upper Klamath River at the Bogus Creek RST by 20-day Exposure Period to 20-day Median SSCs at the USGS Iron Gate Station and Associated Predicted Mortality for Year 1.

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % Outmigrants[1]	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
1	2/1	2/20	0.0%	1449	10.3	0%	901	9.9	0%
2	2/21	3/11	11.7%	473	9.4	0%	1433	10.3	2%
3	3/12	3/31	36.3%	187	8.8	0%	84	8.2	0%
4	4/1	4/20	34.7%	97	8.3	0%	845	9.9	7%
5	4/21	5/10	14.9%	72	8.1	0%	516	9.5	3%
6	5/11	5/30	2.2%	267	9.1	0%	509	9.5	<1%
7	5/31	6/19	0.2%	322	9.2	0%	1162	10.1	<1%
8	6/20	7/9	0.0%	1545	10.3	0%	1298	10.2	0%
9	7/10	7/29	0.0%	429	9.4	0%	581	9.6	0%
10	7/30	8/18	0.0%	302	9.1	0%	209	8.9	0%
Potential Mortality to Age-0+ Chinook Salmon Outmigrants				**Median Impact Year**			**Severe Impact Year**		
				0%			**13%**		

1. Population data from Bogus Creek RST data.

Juvenile Chinook salmon pass the I-5 trap over a broader time period than they do at the Bogus Creek trap location. Similar to the Bogus Creek trap, juvenile Chinook will begin entering the reach by early March when SSCs remain at high levels. Based on the percentage of outmigrating fish and the anticipated SSCs, potentially 1 percent of the run may experience mortality in the median impact year and potentially 17 percent of the run may experience mortality in the severe impact year (Table J-3).

Table J-3: Age-0+ Chinook Salmon Outmigrating from the Upper Klamath River at the I-5 RST by 20-day Exposure Period to 20-day Median SSCs at the USGS Iron Gate Station and Associated Predicted Mortality for Year 1.

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % of Outmigrants[1]	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
1	2/1	2/20	0.0%	1449	10.3	0%	901	9.9	0%
2	2/21	3/11	7.4%	473	9.4	0%	1433	10.3	1%
3	3/12	3/31	16.9%	187	8.8	0%	84	8.2	0%
4	4/1	4/20	24.2%	97	8.3	0%	845	9.9	5%
5	4/21	5/10	20.9%	72	8.1	0%	516	9.5	4%
6	5/11	5/30	19.5%	267	9.1	0%	509	9.5	4%
7	5/31	6/19	4.4%	322	9.2	0%	1162	10.1	1%

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % of Outmigrants[1]	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
8	6/20	7/9	3.0%	1545	10.3	1%	1298	10.2	1%
9	7/10	7/29	3.8%	429	9.4	0%	581	9.6	1%
10	7/30	8/18	0.0%	302	9.1	0%	209	8.9	0%
Potential Mortality to Age-0+ Chinook Salmon Outmigrants				**Median Impact Year**			**Severe Impact Year**		
				1%			**17%**		

1. Population data from I-5 RST data.

Juvenile Chinook salmon pass the Shasta River trap a short distance upstream from the Shasta River confluence with the Klamath River. Juvenile Chinook salmon outmigrate earlier in the year relative to fish passing the Bogus Creek and I-5 trap locations. Approximately 60 percent of the run typically enters the Klamath River by the last week of March. Based on anticipated median SSCs, potentially 3 percent and 15 percent of the run could experience mortality during median and severe impact year conditions, respectively (Table J-4).

Table J-4: Age-0+ Chinook Salmon Outmigrating from the Upper Klamath River at the Shasta River RST by 20-day Exposure Period to 20-day Median SSCs at the USGS Iron Gate Station and Associated Predicted Mortality for Year 1.

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % of Outmigrants[1]	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
1	2/1	2/20	12.8%	1449	10.3	3%	901	9.9	3%
2	2/21	3/11	28.8%	473	9.4	0%	1433	10.3	6%
3	3/12	3/31	27.0%	187	8.8	0%	84	8.2	0%
4	4/1	4/20	16.0%	97	8.3	0%	845	9.9	3%
5	4/21	5/10	8.1%	72	8.1	0%	516	9.5	2%
6	5/11	5/30	5.6%	267	9.1	0%	509	9.5	1%
7	5/31	6/19	1.5%	322	9.2	0%	1162	10.1	0%
8	6/20	7/9	0.1%	1545	10.3	<1%	1298	10.2	<1%
9	7/10	7/29	0.0%	429	9.4	0%	581	9.6	<1%
10	7/30	8/18	0.0%	302	9.1	0%	209	8.9	0%
Potential Mortality to Age-0+ Chinook Salmon Outmigrants				**Median Impact Year**			**Severe Impact Year**		
				3%			**15%**		

1. Population data from Shasta RST data.

Juvenile Outmigration - Middle Klamath Populations

Tributary inputs between the Shasta River and Scott River dilute SSCs in the Klamath River, reducing the SSC-related mortality potential downstream of the Shasta River confluence. The Seiad Valley water quality station was used to assess SSCs in the Middle Klamath. USFWS manages the Kinsman RST on the Klamath River upstream from the Scott River confluence. The Kinsman trap samples juvenile anadromous fish originating in the mainstem Klamath River, and tributaries from Iron Gate Dam downstream to above the Scott River confluence. CDFW operates the Scott River RST near the Scott River confluence with the Klamath River. Scott River trap estimates represent fish entering the Klamath River from the Scott River, one of the largest tributaries in the Middle Klamath. Screw trap data for the Kinsman trap and the Scott River trap were used to assess age-0+ Chinook salmon migration timing and abundance to predict SSC effects to juvenile Chinook salmon.

Juvenile Chinook salmon pass the Kinsman trap at the end of February, and peak during mid-April. Potentially 1 percent and 9 percent of the run could experience mortality during median impact year and severe impact year conditions, respectively (Table J-5.

Table J-5: Age-0+ Chinook salmon Outmigrating from the Middle Klamath River at the Kinsman RST by 20-day Exposure Period to 20-day Median SSCs at the USGS Seiad Valley Station and Associated Predicted Mortality for Year 1.

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % of Outmigrants[1]	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
1	2/1	2/20	0.0%	808	9.9	0%	692	9.7	0%
2	2/21	3/11	8.5%	224	8.9	0%	1103	10.1	2%
3	3/12	3/31	20.7%	102	8.4	0%	68	8.1	0%
4	4/1	4/20	25.0%	59	8.0	0%	562	9.6	5%
5	4/21	5/10	17.3%	47	7.8	0%	313	9.2	0%
6	5/11	5/30	14.8%	128	8.5	0%	280	9.1	0%
7	5/31	6/19	8.1%	106	8.4	0%	589	9.6	2%
8	6/20	7/9	4.9%	1148	10.1	1%	1059	10.0	1%
9	7/10	7/29	0.7%	311	9.2	0%	491	9.5	0%
10	7/30	8/18	0.0%	246	9.0	0%	162	8.7	0%
Potential Mortality to Age-0+ Chinook Salmon Outmigrants				**Median Impact Year**			**Severe Impact Year**		
				1%			**9%**		

1. Population data from Kinsman RST data.

Juvenile Chinook salmon pass the Scott River trap on the lower Scott River beginning in mid-February, and peak during mid-April. Over 90 percent of the run typically enters the Klamath River by mid-June, prior to the expected second SSC peak. Potentially 2 percent and 11 percent of the run could experience mortality during median impact year and severe impact year conditions, respectively (Table J-6).

Table J-6: Age-0+ Chinook Salmon Outmigrating from the Middle Klamath River at the Scott River by 20-day Exposure Period to 20-day Median SSCs at the USGS Seiad Valley Station and Associated Predicted Mortality for Year 1.

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % of Outmigrants[1]	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
1	2/1	2/20	1.8%	808	9.9	<1%	692	9.7	<1%
2	2/21	3/11	6.1%	224	8.9	0%	1103	10.1	1%
3	3/12	3/31	14.4%	102	8.4	0%	68	8.1	0%
4	4/1	4/20	26.6%	59	8.0	0%	562	9.6	5%
5	4/21	5/10	16.9%	47	7.8	0%	313	9.2	0%
6	5/11	5/30	11.2%	128	8.5	0%	280	9.1	0%
7	5/31	6/19	16.1%	106	8.4	0%	589	9.6	3%
8	6/20	7/9	6.8%	1148	10.1	1%	1059	10.0	1%
9	7/10	7/29	0.0%	311	9.2	0%	491	9.5	0%
10	7/30	8/18	0.0%	246	9.0	0%	162	8.7	0%
Potential Mortality to Age-0+ Chinook Salmon Outmigrants				**Median Impact Year**			**Severe Impact Year**		
				2%			**11%**		

1. Population data from Scott River RST data.

Juvenile Outmigration - Lower Klamath River Populations

Tributary inputs between the Scott River and the Trinity River confluence further dilute SSCs in the Lower Klamath River, reducing the SSC-related mortality potential. The Orleans water quality station, which is downstream of the Salmon River confluence, but upstream of the Trinity River, was used to assess SSCs in the Lower Klamath. Because the Orleans water quality station is upstream of the Trinity River confluence, modeled SSC levels would be higher than those likely to be experienced by age-0+ Chinook salmon entering the Lower Klamath River because the Trinity River and other tributary inputs would dilute SSC levels.

CDFW manages the Trinity River–Willow Creek RST, and the Karuk Tribe manages the Blue Creek RST. Because these two screw traps sample juvenile Chinook salmon entering the Lower Klamath River, the Renewal Corporation used the trap population estimates to assess age-0+ Chinook salmon migration timing and abundance to predict SSC effects to juvenile Chinook salmon in the Lower Klamath River.

Juvenile Chinook salmon pass the Trinity River–Willow Creek trap beginning early March, and the outmigration peaks during end of June. Potentially 5 percent of the run could experience mortality during median impact year and severe impact year conditions (Table J-7). Potential mortality is associated with the second SSC peak in late June to early August.

Table J-7: Age-0+ Chinook Salmon Outmigrating from the Lower Klamath River at the Trinity River-Willow Creek RST by 20-day Exposure Period to 20-day Median SSCs at the USGS Orleans Station and Associated Predicted Mortality for Year 1.

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % of Outmigrants[1]	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
1	2/1	2/20	0.0%	298	9.1	0%	379	9.3	0%
2	2/21	3/11	0.1%	117	8.5	0%	543	9.6	<1%
3	3/12	3/31	4.0%	53	7.9	0%	45	7.8	0%
4	4/1	4/20	4.5%	27	7.4	0%	253	9.0	0%
5	4/21	5/10	13.3%	39	7.7	0%	146	8.6	0%
6	5/11	5/30	12.9%	62	8.0	0%	145	8.6	0%
7	5/31	6/19	26.5%	50	7.9	0%	264	9.1	0%
8	6/20	7/9	25.3%	650	9.7	5%	707	9.8	5%
9	7/10	7/29	11.7%	173	8.7	0%	276	9.1	0%
10	7/30	8/18	1.4%	167	8.7	0%	114	8.4	0%
Potential Mortality to Age-0+ Chinook Salmon Outmigrants				**Median Impact Year**			**Severe Impact Year**		
				5%			**5%**		

1. Population data from Trinity River- Willow Creek RST data.

Juvenile Chinook salmon pass the Blue Creek trap on lower Blue Creek beginning in early April, and peak in late May. Potentially 2 percent of the run could experience mortality during median impact year and severe impact year conditions (Table J-8). Potential mortality is associated with the second SSC peak in late June to early August.

Table J-8: Age-0+ Chinook Salmon Outmigrating from the Lower Klamath River at the Blue Creek RST by 20-day Exposure Period to 20-day Median SSCs at the USGS Orleans Station and Associated Predicted Mortality for Year 1.

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % of Outmigrants[1]	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
1	2/1	2/20	0.0%	298	9.1	0%	379	9.3	0%
2	2/21	3/11	0.0%	117	8.5	0%	543	9.6	0%
3	3/12	3/31	0.0%	53	7.9	0%	45	7.8	0%
4	4/1	4/20	11.2%	27	7.4	0%	253	9.0	0%
5	4/21	5/10	31.2%	39	7.7	0%	146	8.6	0%
6	5/11	5/30	28.1%	62	8.0	0%	145	8.6	0%
7	5/31	6/19	11.6%	50	7.9	0%	264	9.1	0%
8	6/20	7/9	8.2%	650	9.7	2%	707	9.8	2%

Exposure Period Year 1				Median Impact Year			Severe Impact Year		
Exposure Period	Start	End	Estimated % of Outmigrants[1]	Median SSC	Median SEV	Estimated % Mortality	Median SSC	Median SEV	Estimated % Mortality
9	7/10	7/29	5.9%	173	8.7	0%	276	9.1	0%
10	7/30	8/18	2.3%	167	8.7	0%	114	8.4	0%
Potential Mortality to Age-0+ Chinook Salmon Outmigrants				**Median Impact Year**			**Severe Impact Year**		
				2%			**2%**		

1. Population data from Blue Creek RST data.

SSCs remain elevated through fall of Year 1 under both the median impact year and the severe impact year scenarios at the three stations. Under the median impact year, SSCs remain above 100 mg/L through the last week of September under the median impact year, and through mid-August under the severe impact year. Proposed Action SSC values remain above background values through Year 2 under both median and severe impact year conditions at the Iron Gate Station. Proposed Action SSCs at the Seiad Valley station are similar to, or less than, background values under both the median and severe impact year scenarios in Year 2. Modeling results suggest a similar pattern at the Orleans station. While SSCs remain elevated at the three stations in Year 2, SEV values are sublethal and no population level mortality is expected. *C. shasta* effects are also likely to be diminished as annelid worm (invertebrate host) colonies are scoured and/or buried by released sediment.

Suspended sediment effects are anticipated to primarily affect Type I Chinook salmon that outmigrate in the spring. Lower SSCs, cooling water temperatures, and lower disease levels are anticipated to have minor physiological effect on the Type II life-history juvenile Chinook salmon that emigrate from tributaries to the Klamath River in the fall. Type III juvenile Chinook salmon compose less than 1 percent of all production (Sullivan 1989), but the larger size of outmigrating Type III smolts is linked to an outsized portion of escapement (Sullivan 1989). The larger Type III smolts account for up to 4 percent of escapement, and therefore, these fish represent a small but important life- history strategy.

In summary, the severity of suspended sediment effects model developed by Newcombe and Jensen (1996) was applied to juvenile Chinook salmon in the Klamath River during reservoir drawdown and dam removal. The flow and sediment transport model results were used to assess potential mortality of juvenile Chinook salmon over 20-day exposure periods during the course of juvenile outmigration. Juvenile Chinook salmon outmigrating during the reservoir drawdown and dam removal will experience variable conditions from Iron Gate Dam to the Klamath River estuary. The Renewal Corporation expects Chinook salmon redds between Iron Gate Dam and the Shasta River will experience 100 percent mortality due to sediment burial during Year 1 and potentially during Year 2 depending on sediment deposition. Juvenile Chinook salmon entering the Klamath River between Iron Gate Dam and the Shasta River in February and March and in mid- to late-June will experience severe conditions due to high SSC levels. Fish entering between the peak SSC periods will be subjected to sublethal SSC levels. Fish entering the middle and lower Klamath River later in the spring may experience severe conditions associated with the second peak SSC event. Nevertheless, SSC-related mortality is anticipated to impact less than 10 percent of the affected juvenile Chinook salmon outmigrating during the spring in Year 1 under the median impact year conditions, and up to 17 percent of outmigrating juvenile Chinook salmon under the severe impact year conditions (Table J-9).

Table J-9: Summary of Predicted Age-0+ Chinook Salmon Mortality Related to Spring Outmigration in Year 1.

Population/Trap Location	Estimated Mortality as Proportion of Population	
	Median Impact Year	Severe Impact Year
Bogus Creek	0%	13%
Upper Klamath River (I-5 trap)	1%	17%
Shasta River	3%	15%
Middle Klamath River (Kinsman trap)	1%	9%
Scott River	2%	11%
Lower Klamath River (Trinity River trap)	5%	5%
Lower Klamath River (Blue Creek)	2%	2%

SSC effects are expected to be greatest for eggs and alevins reared in spawning redds in the Iron Gate Dam to Shasta River reach due to burial and suffocation caused by fine sediment released during reservoir drawdown. Age-0+ Chinook salmon emigrating from tributaries to the Klamath River will be exposed to high SSCs during an average 20-day migration to the ocean. Due to the high SSC exposure, juvenile Chinook salmon that outmigrate in Year 1 will experience the most severe effects, while subsequent brood years will experience lesser effects as mainstem habitat conditions improve over time. SSCs will remain elevated relative to background conditions through Year 2 at the Iron Gate water quality station, but Proposed Action and background SSC levels begin to converge between winter of Year 1 and spring of Year 2 at the Seiad Valley and Orleans stations. Under median impact year conditions, Proposed Action and background SSCs converge between January and February in Year 2 at the Seiad Valley and Orleans stations. For the severe impact year conditions, Proposed Action and background SSCs converge by November of Year 1 at the two stations.

J.4.2 Dissolved Oxygen Concentrations

An existing dissolved oxygen spreadsheet model (Stillwater Sciences 2011) was updated with hydrology and suspended sediment concentration (SSC) data from the SRH-1D flow and sediment model (USBR 2011, Appendix I of the BA) to assess dissolved oxygen conditions downstream of Iron Gate Dam during reservoir drawdown. Because the model is sensitive to initial dissolved oxygen saturation, the Renewal Corporation used two initial dissolved oxygen saturation levels for the model boundary condition (see Section 5.1.1.2) for additional model details).

Chinook Salmon High Dissolved Oxygen Saturation Scenario

Table J-11 includes the dissolved oxygen model output for the median year and severe year scenarios associated with an 80 percent initial dissolved oxygen saturation. Under the median year scenario, dissolved oxygen levels decline to 0.2 mg/L and 0.0 mg/L during the mid-January and mid-June peak SSC events. The mid-January event occurs as the reservoirs are drawn down, reservoir outflow exceeds inflow, and stored sediments are mobilized. During this event, minimum dissolved oxygen levels occur 1.2 miles downstream of Iron Gate Dam and recover to 7 mg/L and 5 mg/L at RM 131.8 and RM 148.6, respectively, due to reaeration and tributary inputs (the Scott River confluence is located at RM 145.1). Depleted dissolved oxygen conditions at Iron Gate Dam persist for 6 consecutive days relative to the 7 mg/L threshold, and 3 consecutive days relative to the 5 mg/L threshold. The distance and magnitude of depleted oxygen conditions downstream of Iron Gate Dam varies daily depending on SSC concentrations, water temperatures, and initial dissolved oxygen saturation. Juvenile Chinook salmon from the Upper Klamath River, Shasta River, and Scott River that overwinter in the mainstem Klamath River or that are emigrate from tributary streams to the mainstem Klamath River in mid to late January may experience high SSCs and diminished dissolved oxygen conditions that may result in sublethal or lethal effects. Dissolved oxygen concentrations generally recover to levels greater than 7 mg/L in all reaches by late January under the median impact year scenario.

The mid-June event is caused by the Copco No. 1 historical cofferdam breach and the mobilization of stored sediment from upstream of the cofferdam. Minimum dissolved oxygen levels occur 0.6 miles downstream of Iron Gate Dam and recover to 7 mg/L and 5 mg/L at RM 161.6 and RM 177.8, respectively (the Shasta River confluence is located at RM 179.3). Depleted dissolved oxygen conditions at Iron Gate Dam persist for 47 consecutive days relative to the 7 mg/L threshold, and for 9 days relative to the 5 mg/L threshold. The distance of depleted oxygen conditions downstream of Iron Gate Dam varies daily depending on SSC concentrations, water temperatures, and initial dissolved oxygen saturation. Depleted dissolved oxygen conditions (less than 7 mg/L) in close proximity to Iron Gate Dam may persist for 1-2 months primarily due to the low initial dissolved oxygen conditions associated with high SSCs, and elevated water temperatures in Iron Gate Reservoir.

Under the severe year (1973) scenario, reservoir inflows exceed the capacity of the Iron Gate Dam outlet tunnel and less stored sediment is mobilized during the initial drawdown. Dissolved oxygen levels decline to 0.0 mg/L during a mid-June SSC event. During this event, minimum dissolved oxygen levels occur 0.6 miles downstream of Iron Gate Dam and recover to 7 mg/L and 5 mg/L at RM 152.9 and RM 166.0, respectively. Depleted dissolved oxygen conditions at Iron Gate Dam persist for 90 consecutive days relative to the 7 mg/L threshold, and 9 consecutive days relative to the 5 mg/L threshold. The distance of depleted oxygen conditions downstream of Iron Gate Dam varies daily depending on SSC concentrations, water temperatures, and dissolved oxygen saturation. Juvenile Chinook salmon in the upper mainstem Klamath River or emigrating from tributaries between Iron Gate Dam and Shasta River confluence, are expected to experience sublethal effects associated with diminished dissolved oxygen concentrations.

Table J-10: Estimated Location of Minimum Dissolved Oxygen and Location at which Dissolved Oxygen will Return to 7 mg/L and 5 mg/L Downstream of Iron Gate Dam due to High Short-Term SSC under the Proposed Action Chinook Salmon Median Impact Year and Severe Impact Year Scenarios with 80 percent initial dissolved oxygen saturation.

Date[1]	Boundary conditions at Iron Gate Dam			Spreadsheet model output			
	Initial dissolved oxygen (at 80% saturation)[2] (mg/L)	IOD (mg/L)	BOD (mg/L)	Minimum dissolved oxygen (mg/L)	Location of minimum dissolved oxygen[3]	Location at which dissolved oxygen returns to 7 mg/L[4] RM	Location at which dissolved oxygen returns to 5 mg/L[4] RM
Chinook Median Impact Year (WY 1991 Conditions)							
10/27/2022	8.0	0.0	0.0	8.0	0.0	-	-
11/24/2022	8.9	0.0	0.2	8.9	0.0	-	-
12/31/2022	9.9	0.0	0.2	9.9	0.0	-	-
1/13/2023	10.3	10.2	57.1	0.2	1.2	131.8	148.6
2/1/2023	10.0	2.4	13.5	7.7	0.6	-	-
3/1/2023	9.4	0.3	1.7	9.2	0.6	-	-
4/2/2023	8.6	0.1	0.5	8.6	0.6	-	-
5/15/2023	7.9	0.4	2.2	7.6	0.6	-	-
6/17/2023	7.1	7.8	43.7	0.0	0.6	161.6	177.8
7/1/2023	6.7	0.8	4.7	5.9	0.6	186.5	-
8/2/2023	6.8	0.3	1.7	6.6	0.6	189.0	-
9/17/2023	7.2	0.2	0.9	7.1	0.6	-	-
Chinook Severe Impact Year (WY 1973 Conditions)							
10/24/2022	8.0	0.0	0.0	8.0	0.0	-	-
11/15/2022	8.9	0.1	0.3	8.9	0.0	-	-
12/22/2022	9.9	0.1	0.5	9.9	0.6	-	-
1/14/2023	10.3	0.3	1.8	10.0	1.2	-	-
2/20/2023	10.0	2.8	15.7	7.3	1.2	-	-
3/1/2023	9.4	0.9	5.2	8.5	1.2	-	-
4/7/2023	8.6	1.7	9.2	7.0	1.2	-	-
5/5/2023	7.9	1.1	6.0	6.9	0.6	190.2	-
6/16/2023	7.1	10.8	60.2	0.0	0.6	152.9	166.0
7/7/2023	6.7	0.8	4.4	6.0	0.6	187.1	-
8/2/2023	6.8	0.2	1.3	6.7	0.6	189.6	-
9/1/2023	7.2	0.1	0.5	7.2	0.0	-	-

1. Year values updated from 2012 BA to reflect 2023 reservoir drawdown.
2. Initial dissolved oxygen downstream of Iron Gate Dam calculated for 80 percent saturation using average monthly water temperature, salinity = 0 ppt, and elevation = 707 meters (2,320 feet). An initial dissolved oxygen at 80 percent saturation was used based on typical existing conditions below Iron Gate Dam.
3. Location is in miles downstream of Iron Gate Dam.
4. Minimum acceptable dissolved oxygen concentration for salmonids. WY = water year

Chinook Salmon Low Dissolved Oxygen Saturation Scenario

Table J-12 includes the dissolved oxygen model output for the median year and severe year scenarios associated with a 0 percent initial dissolved oxygen saturation. Under both scenarios, initial dissolved oxygen concentrations are input as 0.0 mg/L at Iron Gate Dam in all months to represent uncertainty in water quality conditions within Iron Gate Reservoir due to drawdown of the Hydroelectric Reach reservoirs. Under the median impact year, the greatest distance of depleted dissolved oxygen occurs in mid-January when SSCs peak at 16,226 mg/L. Dissolved oxygen levels recover to 7 mg/L and 5 mg/L at RM 88.3 and RM 113.2, respectively, during the mid-January event. For reference, Indian Creek is located at RM 108.3, and the Salmon River is located at RM 66.3. The mid-January event occurs as the reservoirs are drawn down, reservoir outflow exceeds inflow, and stored sediments are mobilized. In the other months, depleted dissolved oxygen levels recover to 7 mg/L and 5 mg/L by RM 153.6 and RM 164.1, respectively.

Based on the model inputs, 0 mg/L serves as the model boundary condition under the Low Dissolved Oxygen Scenario and therefore, dissolved oxygen at Iron Gate Dam does not increase above 0 mg/L over the course of the model period. The distance of depleted oxygen conditions downstream of Iron Gate Dam varies daily depending on SSC concentrations, water temperatures, and dissolved oxygen saturation influenced by tributary inputs and turbulence. Juvenile Chinook salmon from the Upper Klamath River, Shasta River, and Scott River populations that are emigrating from tributary streams in mid to late January may experience high SSCs and diminished dissolved oxygen conditions that may result in sublethal or lethal effects. A second peak SSC event in mid-June (12,423 mg/L) also depletes dissolved oxygen levels downstream of Iron Gate Dam, although dissolved oxygen levels recover to 7 mg/L by RM 154.2 and to 5 mg/L by RM 164.7.

Under the severe year (1973) scenario, depleted oxygen downstream of Iron Gate Dam varies daily depending on SSC concentrations, flows, and water temperatures. Moderate SSC levels (523 mg/L) in mid-January result in depleted dissolved oxygen levels beginning at Iron Gate Dam. Dissolved oxygen levels recover to 7 mg/L by RM 107.0 and to 5 mg/L by RM 136.8. Dissolved oxygen levels remain depleted downstream of Iron Gate Dam through the spring and summer, recovering, on average between February and May, to 7 mg/L by RM 138.6 and to 5 mg/L by RM 153.4. The peak SSC event (17,109 mg/L) in mid-June results in a comparable distance of dissolved oxygen depletion with dissolved oxygen levels recovering to 7 mg/L by RM 147.3 and 5 mg/L by 155.4, respectively. In short, juvenile Chinook salmon rearing in the Klamath River or emigrating from tributaries to the Klamath River under the Low Dissolved Oxygen Scenario during extreme year conditions, would experience depleted dissolved oxygen levels from Iron Gate Dam approximately 40 miles downstream to the vicinity of the Scott River confluence (5 mg/L recovery at RM 153.4 in spring, Scott River confluence is at RM 145.1).

Table J-11: Estimated Location of Minimum Dissolved Oxygen and Location at which Dissolved Oxygen will Return to 7 mg/L and 5 mg/L Downstream of Iron Gate Dam due to High Short-Term SSC under the Proposed Action Chinook Salmon Median Impact Year and Severe Impact Year Scenarios with 0 percent initial dissolved oxygen saturation.

Date[1]	Boundary conditions at Iron Gate Dam			Spreadsheet model output			
	Initial dissolved oxygen (at 0% saturation)[2] (mg/L)	IOD (mg/L)	BOD (mg/L)	Minimum dissolved oxygen (mg/L)	Location of minimum dissolved oxygen[3]	Location at which dissolved oxygen returns to 7 mg/L[4] RM	Location at which dissolved oxygen returns to 5 mg/L[4] RM
Chinook Median Impact Year (WY 1991 Conditions)							
10/27/2022	0.0	0.0	0.0	0.0	0.0	170.3	179.7
11/24/2022	0.0	0.0	0.2	0.0	0.0	171.0	179.7
12/31/2022	0.0	0.0	0.2	0.0	0.0	170.3	179.0
1/13/2023	0.0	10.2	57.1	0.0	0.0	88.3	113.2
2/1/2023	0.0	2.4	13.5	0.0	0.0	153.6	164.1
3/1/2023	0.0	0.3	1.7	0.0	0.0	169.1	179.0
4/2/2023	0.0	0.1	0.5	0.0	0.0	166.6	177.8
5/15/2023	0.0	0.4	2.2	0.0	0.0	167.8	179.0
6/17/2023	0.0	7.8	43.7	0.0	0.0	154.2	164.7
7/1/2023	0.0	0.8	4.7	0.0	0.0	172.8	182.1
8/2/2023	0.0	0.3	1.7	0.0	0.0	170.3	180.3
9/17/2023	0.0	0.2	0.9	0.0	0.0	170.3	180.3
Chinook Severe Impact Year (WY 1973 Conditions)							
10/24/2022	0.0	0.0	0.0	0.0	0.0	166.6	178.4
11/15/2022	0.0	0.1	0.3	0.0	0.0	163.5	175.3
12/22/2022	0.0	0.1	0.5	0.0	0.0	161.0	173.4
1/14/2023	0.0	0.3	1.8	0.0	0.0	107.0	136.8
2/20/2023	0.0	2.8	15.7	0.0	0.0	125.0	142.4
3/1/2023	0.0	0.9	5.2	0.0	0.0	137.4	152.3
4/7/2023	0.0	1.7	9.2	0.0	0.0	139.3	153.6
5/5/2023	0.0	1.1	6.0	0.0	0.0	151.7	165.4
6/16/2023	0.0	10.8	60.2	0.0	0.0	147.3	155.4
7/7/2023	0.0	0.8	4.4	0.0	0.0	176.5	183.4
8/2/2023	0.0	0.2	1.3	0.0	0.0	172.2	181.5
9/1/2023	0.0	0.1	0.5	0.0	0.0	172.2	181.5

1. Year values updated from 2012 BA to reflect 2023 reservoir drawdown.
2. An initial dissolved oxygen at 0 percent saturation was used based on uncertainty of water quality conditions in Iron Gate Reservoir due to reservoir drawdown.
3. Location is miles downstream of Iron Gate Dam.
4. Minimum acceptable dissolved oxygen concentration for salmonids. WY = water year

Summary

The Renewal Corporation updated an existing dissolved oxygen model to evaluate potential effects to age-0+ Chinook salmon during the drawdown year. The model incorporated observed and predicted values for input variables including flow, SSC, immediate and biological oxygen demand, average temperature, and initial dissolved oxygen concentration based on 80 percent and 0 percent saturation. Conditions associated with the peak SSC each month from October of the pre-drawdown year through September of the drawdown year were used for the model boundary conditions. This approach therefore followed a conservative process for assessing potential drawdown effects on dissolved oxygen and age-0+ Chinook salmon.

Under the High Dissolved Oxygen Saturation Scenario, depleted dissolved oxygen conditions during the January SSC event will affect the Klamath River from Iron Gate Dam downstream to RM 148.5 (5 mg/L threshold) near the Scott River confluence (RM 145.1). This event will occur before juvenile Chinook salmon migrate from tributaries to the mainstem, although a small number of yearling Chinook salmon may be rearing in the mainstem and may be affected. The mid-June depleted dissolved oxygen event under the median and severe impact years could affect late downstream migrants before dissolved oxygen levels recover to 5 mg/L at RM 177.8 and RM 166.0, respectively. Table J-13 includes the percentage of age-0+ Chinook salmon outmigrants sampled at radial screw trap locations on the mainstem Klamath River (Bogus Creek, I-5, and Kinsman) and on the Shasta River in mid-June.

Age-0+ Chinook salmon originating in the Upper Klamath River largely pass the rotary screw traps between late February and early June and would be downstream of the low dissolved oxygen reach prior to the depleted dissolved oxygen event in mid-June. However, approximately 11 percent of the outmigrants from the Upper Klamath River and the Middle Klamath River pass through the reach upstream of the Shasta River after May 31 (the start of the 20-day analysis period that includes the mid-June depleted dissolved oxygen event). Age-0+ Chinook salmon originating in the Shasta River typically outmigrate by mid-June and only 1.6% of the outmigrants would be exposed when they enter the Klamath River by mid-June. In summary, under the High Dissolved Oxygen Saturation scenario, in both the median and severe impact years, depleted dissolved oxygen does not recover to the 7 mg/L and 5 mg/L thresholds until downstream of the Shasta River. Low dissolve oxygen levels coupled with high SSCs may have sub-lethal and lethal effects on late outmigrating age-0+ Chinook salmon.

Table J-12: Percentages of Age-0+ Chinook Salmon Populations Outmigrating from the Klamath River Based on Rotary Screw Trap Locations between Bogus Creek and the Shasta River. Affected Percentages are Based on mid-June Outmigrants. Dissolved Oxygen Levels are Anticipated to Return to 7 mg/L in the Median Impact year by RM 177.8 and RM 166.0 in the Severe Impact Year.

Chinook Salmon Natal Reaches	Estimated % Outmigrants in mid-June Low Dissolved Oxygen Period	Rotary Screw Trap Location
Upper Klamath River	0.2%	Bogus Creek (RM 192.6)
Upper Klamath River	11.2%	I-5 (RM 182.1)
Shasta River	1.6%	Shasta River (RM 179.3)
Middle Klamath River	13.0%	Kinsman (RM 147.6)

Under the Low Dissolved Oxygen Saturation Scenario in a median impact year, depleted dissolved oxygen conditions will affect the Klamath River from Iron Gate Dam downstream to between the Humbug Creek (RM 173.9, 7 mg/L recovery) and Beaver Creek (RM 163.3, 5 mg/L recovery), on average, from February to June. In the approximate 25 river miles between Iron Gate Dam and the downstream dissolved oxygen recovery zone, outmigrating age-0+ Chinook salmon will experience depleted dissolved oxygen and high SSCs. Low dissolved oxygen levels may amplify high SSC effects resulting in additional sublethal and lethal effects to age-0+ Chinook salmon. The furthest downstream recovery of dissolved oxygen to the 7 mg/L threshold is RM 88.3 (between Seiad Valley and the Salmon River) in mid-January in the median impact year. However, few age-0+ Chinook salmon are anticipated to be in the mainstem Klamath River during this time.

Under the Low Dissolved Oxygen Saturation Scenario in a severe impact year, depleted dissolved oxygen conditions will affect the Klamath River from Iron Gate Dam downstream to between O'Neil Creek (RM 139.1, 7 mg/L recovery) and Horse Creek (RM 149.5, 5 mg/L recovery), during the primary juvenile outmigration between February and mid-June. In the approximate 45 river miles between Iron Gate Dam and the downstream dissolved oxygen recovery zone (to 5 mg/L), outmigrating age-0+ Chinook salmon will experience depleted dissolved oxygen and high SSCs between February and mid-June. The furthest downstream recovery of dissolved oxygen to the 7 mg/L and 5 mg/L thresholds in mid-January are RM 107.0 (Indian Creek) and RM 136.8, respectively.

The High and Low Dissolved Oxygen Saturation Scenarios bracket the anticipated dissolved oxygen effects to rearing and outmigrating age-0+ Chinook salmon during the drawdown year. Dissolved oxygen concentrations are influenced by initial dissolved oxygen saturation, flow, water temperature, and biological oxygen demand and immediate oxygen demand. Tributary inputs reaerate mainstem water and dissolved oxygen levels in the Klamath River recover to target dissolved oxygen levels. The actual dissolved oxygen conditions that occur during reservoir drawdown are likely to fall between the High and Low Dissolved Oxygen Saturation Scenarios.

Salmonid mortality begins to occur when dissolved oxygen concentrations are below 3 mg/L for periods longer than 3.5 days (USEPA 1986). A summary of various field study results by WDOE (2002) reports that significant mortality occurs in natural waters when dissolved oxygen concentrations fluctuate in the range of 2.5 - 3 mg/L. Long-term (20 - 30 days) constant exposure to mean dissolved oxygen concentrations below 3 - 3.3 mg/L is likely to result in 50% mortality of juvenile salmonids (WDOE 2002). However, coho salmon have been found consistently utilizing off-channel habitat with dissolved oxygen as low as 1 mg/l in the lower Klamath River basin, but water temperatures were generally 15 °C or less (Beesley and Fiori, 2014).

Depleted dissolved oxygen levels and hypoxia will be an additive stressor to the high SSCs age-0+ Chinook salmon will encounter during outmigration, potentially increasing age-0+ Chinook salmon mortality during the drawdown year.

Implementation of AR-2 Actions 2 and 3 will be implemented to reduce the impacts to fish rearing in the mainstem Klamath River or emigrating from tributaries to the mainstem Klamath between January 1 and May 31.

J.4.3 Bedload Deposition

The Renewal Corporation analyzed SRH-1D bed sediment and bedload modeling output, provided by USBR, to assess bedload sediment transport and deposition associated with the Proposed Action. Updated modeling output reflects the Proposed Action's revised reservoir drawdown scenario that differs from the reservoir drawdown and dam removal approach proposed by USBR in the Detailed Plan (USBR 2012a). The Proposed Action includes a revised drawdown approach and schedule that results in a slower average drawdown rate and later reservoir sediment evacuation in the Hydroelectric Reach reservoirs. The bedload deposition analysis approach and results are presented in Section 5.1.1.3. The following summary is based on the potential bedload deposition effects to Chinook salmon.

The reservoir drawdown and dam removal were simulated over a two-year period beginning on October 1 of the pre-drawdown year. Modeling results predict reservoir sediments will coarsen over the two years as flows winnow fine sediments and the Klamath River channel erodes to its historical pre-dam elevation. Two sediment wedges, one upstream (Figure 5-14) and one downstream (Figure 5-15) of Iron Gate Dam, increase the channel bed elevation and affect channel morphology and habitat between the downstream end of Iron Gate Reservoir and Willow Creek (Figure 5-16). Since the sediment wedges are building at the end of the simulation period, wedge longevity is unknown.

Over the 2-year simulation period and for some number of years past the simulation period (because the simulation period did not extend to sediment equilibrium), the two sediment wedges may affect Chinook salmon downstream of the Iron Gate Dam site through pool filling and redd burial. The bedload deposition model output indicates bed deposition will occur from Iron Gate Dam downstream to the Willow Creek confluence. From 2001 – 2019, the median number of Chinook salmon carcasses from immediately below Iron Gate Dam to Willow Creek was approximately 100 carcasses per kilometer in the 6.5-kilometer reach, or approximately 650 adult carcasses (Gough et al. 2020). This compares to the long-term (2001-2019) median escapement value for fall-run Chinook salmon in the Klamath River of 4,880 fish (4,469 – 5,309 median 95 percent confidence limit values). Therefore, sediment deposition in the Iron Gate Dam to Willow Creek reach could affect approximately 13 percent of Chinook salmon spawning escapement in the Klamath River.

Additionally, bedload deposition has the potential to affect a minimum of two years of Chinook spawning downstream of Iron Gate Dam. A minor amount of sediment will mobilize during reservoir drawdown and deposit downstream of the Iron Gate Dam site. Depending on the channel bed material, hyporheic (intergravel) flow, and cover habitat, adult Chinook salmon could spawn in the recently deposited material. Subsequent stored sediment mobilization during winter would bury redds. Based on the model simulations, a similar process would be repeated in the post-drawdown year. Further, because the sediment wedges are in an aggrading state at the end of the model simulations, redd burial could occur in subsequent years. Depending on the rate of sediment wedge erosion, the two sediment wedges could also impact upstream passage of Chinook salmon through the former Iron Gate Dame site.

Over time (5 years to 50 years), the sediment wedges will disperse, and bed elevations will adjust to a new sediment equilibrium, which will include a restored sediment supply from upstream tributaries that was formerly trapped by the Hydroelectric Reach dams. The deposition of the sediment wedge downstream of Iron Gate Dam will occur over a bed that has, in all likelihood, been degraded over the past 60 years due to the elimination of bedload replenishment. As a result, bed elevations may remain elevated relative to current conditions as sediment processes return to pre-dam conditions.

J.5 Changes in Klamath River Hatchery Production

NOAA-Fisheries (NMFS 2021) completed an analysis to evaluate potential changes in Chinook salmon ocean abundance in the context of Chinook salmon prey availability for Southern Resident killer whales and ocean harvest following changes in Chinook salmon hatchery production associated with the closure of IGH and the transition to lower production levels at the new Fall Creek Hatchery (FCH). FCH production levels will be 41 percent lower for sub-yearling Chinook salmon (IGH production goal of 5.1 million sub-yearlings versus FCH goal of 3.0 million sub-yearlings), and there will be a 72 percent reduction in yearling Chinook salmon production (IGH production goal of 900,000 yearlings versus FCH goal of 250,000 yearlings). The analysis only accounted for changes in hatchery production and did not incorporate other short-term or long-term effects of the dam removal project.

NMFS (2021) used cohort reconstruction models developed for the Klamath River Fall Chinook (KRFC) fisheries (Mohr 2006), to extract estimated ocean abundance and the total ocean harvest of ages 3, 4, and 5 Chinook salmon for IGH sub-yearling and yearling releases between 1996 and 2014. NMFS compared the ocean abundances and ocean harvest associated with the existing IGH and proposed FCH production levels. Reduced production effects were averaged for the three age classes over the three brood years.

If all other conditions remain the same and the change in hatchery production levels is the only variable affecting ocean abundance and ocean harvest, the proposed reduced hatchery production would result in a mean annual reduction of 36,545 ocean adults (ages 3-5) and a mean annual reduction of 2,620 fish available for ocean harvest (ages 3-5, commercial and recreational harvest) (NMFS 2021). As these are average values, individual years may experience higher or lower effects to ocean abundance and ocean harvest. Reduced hatchery production effects would be greater in years when juvenile survival is high, and lower in years when juvenile survival and recruitment into the adult population is low (NMFS 2021).

For 2020, the Pacific Fishery Management Council (PFMC) forecasted 1,607,400 adult Chinook salmon in the U.S. Economic Exclusion Zone (EEZ) - South of Cape Falcon (PFMC 2020a). An estimated 34,346 adult fish of the 36,545 adult Chinook salmon that would not be produced under revised hatchery production, would be in South of Cape Falcon waters according to the distribution model (Shelton et al. 2019) adopted by the PFMC's Southern Resident Killer Whale Work Group (SRKWWG). The reduction of 34,346 adult fish equates to 2.1 percent of the 2020 forecast for South of Cape Falcon (NMFS 2021). The 2000-2016 mean South of Cape Falcon ocean abundance calculated by SRKWWG (PFMC 2020b) was 2,354,701 and ranged from 984,668 to 3,796,994. Reduced hatchery production would account for 1.5 percent of the long-term average ocean abundance in South of Cape Falcon waters. Coastwide, the 36,545 adult Chinook salmon reduction would equate to 1,403 fewer Chinook salmon contributing towards the current North of Falcon adult Chinook salmon abundance threshold of 966,000 adult fish established for SRKW protection (NMFS

2021). The 1,403 fewer Chinook salmon equates to a 0.15 percent loss relative to the SRKW salmon abundance threshold target.

A projected reduction of 2,620 adult fish for ocean harvest compares to a 2000-2018 mean combined California and Oregon ocean commercial and recreational catch of 418,099 (PFMC 2020c), or a 0.6 percent reduction due to the reduced hatchery production (NMFS 2021). Fewer adult Chinook salmon available for harvest would differentially affect commercial and recreational fishermen depending on port locations (NMFS 2021). Tables J-14 through J-17 include ocean abundance and ocean harvest summaries for sub-yearling and yearling Chinook salmon hatchery production under existing IGH and proposed FCH management (data provided by NMFS 2020).

Table J-13: Adult Chinook Salmon Ocean Abundance by Age Class Based on Chinook Salmon Sub-yearling Production at IGH, and the Mean Reduction in Adult Chinook Salmon Ocean Abundance Related to Reduced FCH Hatchery Production

Age Classes	IGH Production – Ocean Abundance (# Adult Chinook)	Mean Reduction Associated with Lower FCH Production (# Adult Chinook)
Age-3 Ave (Min-Max), 1 SD	44,080 (1,794 – 166,759), 48,682	-18,151
Age-4 Ave (Min-Max), 1 SD	8,466 (179 – 29,044), 8,734	-3,478
Age-5 Ave (Min-Max), 1 SD	237 (0 – 845), 298	–98

Table J-14: Adult Chinook Salmon Ocean Harvest by Age Class Based on Chinook Salmon Sub-yearling Production at IGH, and the Mean Reduction in Adult Chinook Salmon Ocean Harvest Related to Reduced FCH Hatchery Sub-yearling Production

Age Classes	IGH Production – Ocean Harvest (# Adult Chinook)	Mean Reduction in Ocean Harvest Associated with Lower FCH Production (# Adult Chinook)
Age-3 Ave (Min-Max), 1 SD	2,369 (0 – 14,196), 3,541	-975
Age-4 Ave (Min-Max), 1 SD	1,360 (0 – 5,913), 1,821	-560
Age-5 Ave (Min-Max), 1 SD	54 (0 – 341), 103	–22

Table J-15: Adult Chinook Salmon Ocean Abundance by Age Class Based on Chinook Salmon Yearling Production at IGH, and the Mean Reduction in Adult Chinook Salmon Ocean Abundance Related to Reduced FCH Hatchery Production

Age Classes	IGH Production – Ocean Abundance (# Adult Chinook)	Mean Reduction Associated with Lower FCH Production (# Adult Chinook)
Age-3 Ave (Min-Max), 1 SD	14,564 (446 – 41,526), 11,263	-10,518
Age-4 Ave (Min-Max), 1 SD	5,742 (103 – 18,469), 4,859	-4,147
Age-5 Ave (Min-Max), 1 SD	213 (0 – 787), 266	-154

Table J-16: Adult Chinook Salmon Ocean Harvest by Age Class Based on Chinook Salmon Yearling Production at IGH, and the Mean Reduction in Adult Chinook Salmon Ocean Harvest Related to Reduced FCH Hatchery Yearling Production

Age Classes	IGH Production – Ocean Harvest (# Adult Chinook)	Mean Reduction in Ocean Harvest Associated with Lower FCH Production (# Adult Chinook)
Age-3 Ave (Min-Max), 1 SD	367 (0 – 3,212), 796	-265
Age-4 Ave (Min-Max), 1 SD	1,017 (0 – 5,119), 1,357	-735
Age-5 Ave (Min-Max), 1 SD	87 (0 – 451), 132	- 63

In summary, NMFS (2021) modeled potential changes to adult Chinook salmon ocean abundance and ocean harvest based on reduced hatchery production associated with lower FCH production targets compared to historical IGH production targets. Reduced hatchery production is anticipated to result in an annual reduction of 36,545 adult Chinook salmon, equating to a 1.5 percent reduction in the long-term adult fish abundance in the South of Cape Falcon EEZ, and a 0.15 percent annual reduction in adult Chinook salmon contributing to the SRKW salmon abundance threshold target in the North of Cape Falcon EEZ. Reduced hatchery production would also equate to an annual ocean harvest reduction of 0.6 percent.