3.3 Aquatic Resources

This section describes the effects that the Proposed Action and alternatives would have on aquatic resources, and specifically fish, freshwater mussels, and aquatic macroinvertebrates.

3.3.1 Areas of Analysis

This section of the Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (EIS/EIR) analyzes impacts on fish populations, fish species recovery, and changes to habitat in the Klamath River watershed, excluding the Lost River watershed, Tule Lake watershed, and most of the Trinity River. However, because the lower quarter-to-half mile of the Trinity River could be used as a refuge by Klamath River fish attempting to avoid exposure to sediment pulses that would result from dam removal, this use of the Trinity River was considered in the analysis.

The Lead Agencies assessed potential impacts within and across five study reaches of the Klamath Basin separated by changes in physiography (e.g., Upper and Lower Klamath Basins), the presence of Klamath Hydroelectric Project facilities, and degree of marine influence (Figure 3.3-1). The five study reaches with the area of analysis are as follows:

1. Upper Klamath River: upstream of the influence of J.C. Boyle Reservoir, including the following:
    a. Upper Klamath Lake, Agency Lake, Keno Impoundment/Lake Ewauna, and Tule Lake
    b. Tributaries to Upper Klamath Lake (Sycan, Wood, and Williamson Rivers)
    c. Bureau of Reclamation (Reclamation) Klamath Project facilities (e.g., Link River Dam)
2. Hydroelectric Reach: from the upstream end of J.C. Boyle Reservoir to Iron Gate Dam, including the following:
    a. Tributaries to the Klamath River (examples include Jenny, Spencer, Slate, Shovel, and Fall Creeks)
    b. J.C. Boyle, Copco 1, Copco 2, and Iron Gate Reservoirs
    c. J.C. Boyle Bypass and Peaking Reaches
    d. Klamath downstream of the Copco 2 tailrace
3. Lower Klamath River: downstream of Iron Gate Dam, including the following:
    a. Major tributaries to the Klamath River (Shasta, Scott, and Salmon Rivers)
    b. Minor tributaries to the Klamath River (examples include Bogus, Beaver, Humbug, and Cottonwood Creeks)
    c. The lower portion of the Trinity River
4. Klamath River estuary
5. Pacific Ocean nearshore environment

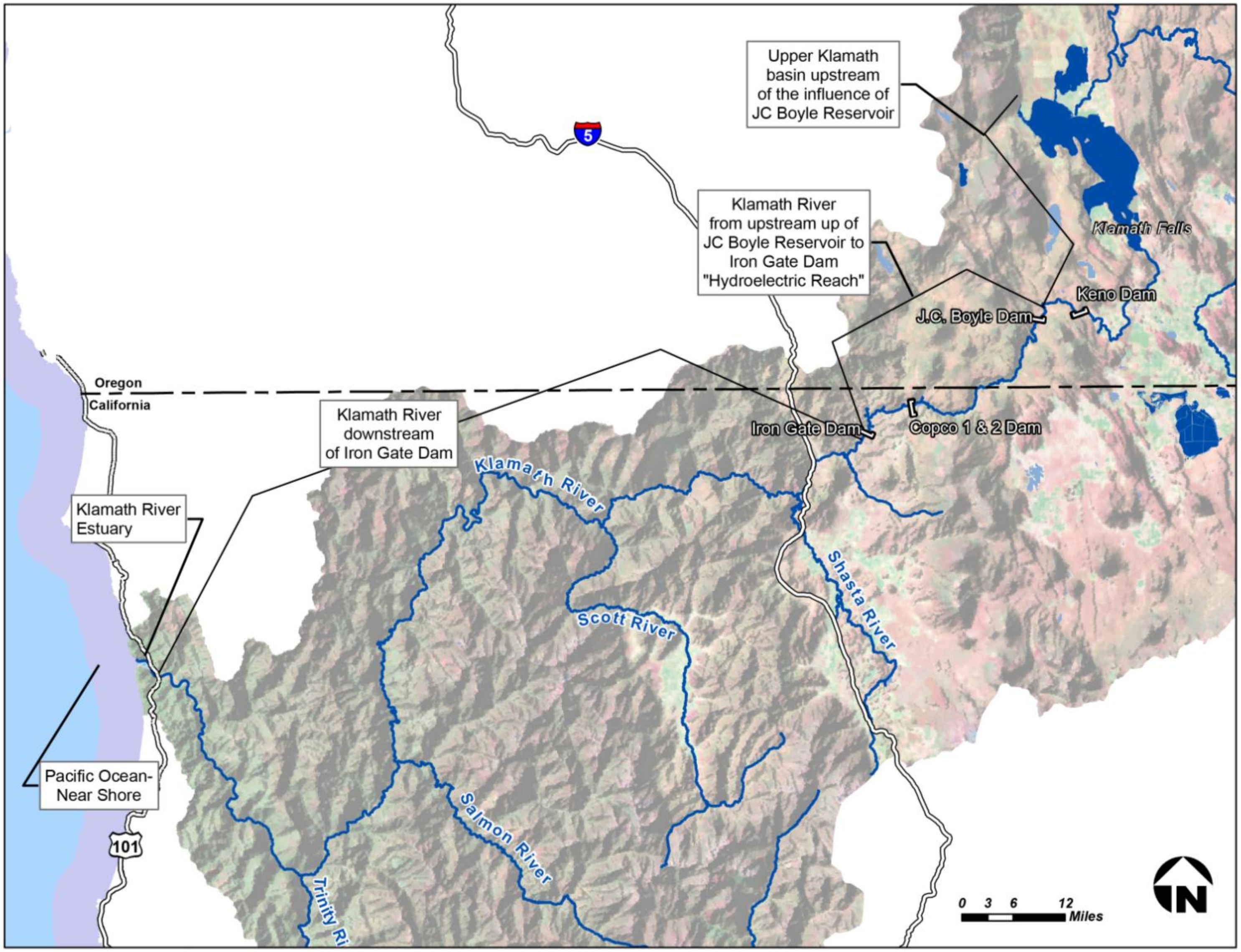

Figure 3.3-1. Five Study Reaches within the Area of Analysis for the Aquatic Resources Analysis

The Klamath Basin has traditionally been divided into the Upper and Lower Klamath Basins at Iron Gate Dam (Natural Resources Council [NRC] 2004, 2008). For purposes of this evaluation, the Upper Basin was subdivided into two reaches at the upstream influence of J.C. Boyle Reservoir. The area upstream of the influence of J.C. Boyle Reservoir could experience some changes in flow in riverine reaches or water surface elevation in lakes and reservoirs due to changes in Reclamation's Klamath Project operations under some of the alternatives, but the physical structure of the habitat would remain similar to existing conditions. The Hydroelectric Reach encompasses the four dams proposed for removal. Under several of the alternatives, the physical structure of some or all reservoir habitat within the Hydroelectric Reach would be changed from lacustrine (lake) to riverine habitat. The Lower Klamath River: downstream of Iron Gate Dam corresponds to the traditional "Lower Basin" designation.

3.3.2 Regulatory Framework

Aquatic species within the area of analysis are regulated by several federal and state laws and regulations, which are listed below.

3.3.2.1 Federal Authorities and Regulations

- Federal Endangered Species Act
- Fish and Wildlife Coordination Act
- Magnuson-Stevens Fishery Conservation and Management Act
- Marine Mammal Protection Act
- Wild and Scenic Rivers Act
- Federal Power Act
- Coastal Zone Management Act

3.3.2.2 State Authorities and Regulations

- California Endangered Species Act
- California Fish and Game Code
- Oregon Endangered Species Act
- Oregon Removal-Fill Law
- Oregon Statewide Planning Program

3.3.2.3 Local Authorities and Regulations

- Klamath Act

The regulation and protection of water quality as related to beneficial uses and aquatic species is discussed in Section 3.2, Water Quality.

3.3.3 Existing Conditions/Affected Environment

This section describes existing conditions in the area of analysis, including discussion of aquatic species (Section 3.3.3.1); physical habitat, water bodies within the different regions for the analysis (Section 3.3.3.2); and important factors affecting aquatic resources that the Lead Agencies anticipate would likely change if the Proposed Action or the alternatives are implemented (Section 3.3.3.3).

The species descriptions include a brief account of the current and historical distribution, life-history patterns, and habitat requirements of aquatic species. This section is subdivided into anadromous fish, native riverine fish, introduced species, estuarine species, and listed species. The last category includes species that would otherwise be included in the anadromous, riverine, or estuarine species.

The description of physical habitat provides information on the physical structure of the habitat. It contains a brief description of the water quality and other factors that may limit fish production in those water bodies, and describes the species that occur in these water bodies. This section also describes Endangered Species Act (ESA) critical habitat and Magnuson-Stevens Fishery Conservation Management Act Essential Fish Habitat (EFH) occurring within the area of analysis.

Section 3.3.3.3, *Factors Expected to be Affected by the Project*, provides a more detailed description of existing conditions for factors that are thought to have a major influence on aquatic resources. These factors form the basis for the effects evaluation in Section 3.3.4.

3.3.3.1 Aquatic Species

Fish

Numerous fish species use the Klamath Basin during all or some portion of their lives, including salmonids, lamprey, sturgeon, suckers, minnows, and sculpin. Many other species are present in the estuary. Species that have been introduced into the basin include yellow perch, largemouth bass, spotted bass, sunfish, and catfish. The species include introduced resident species, estuarine species, and species listed under the federal or state ESAs. The number of species prohibits evaluation of each species. To address the impacts and benefits of the Proposed Action, target species have been selected for analysis based on their legal status or importance for tribal, commercial or recreational fisheries, and based on adequate data to conduct analysis. These target species are discussed below.

Anadromous Fish Species

The Klamath Basin provides habitat for many species of anadromous fish, many of which are salmonids, but which also include green sturgeon (*Acipenser medirostris* Ayres), Pacific lamprey, and American shad (non-native). Anadromous fish within the Klamath River watershed are nearly all in decline (Table 3.3-1). Green sturgeon appear to be in less decline than other fish species. Van Eenennaam et al. (2006) carefully suggests that the Klamath River green sturgeon population appears strong and stable, while cautioning against conclusions based on short time frames relative to their life history.

Table 3.3-1. Declines in Klamath River Anadromous Fish

Species	Historical Level	Percent Reduction from Historical Levels (estimates of individual runs)	Source
Pacific Lamprey	Unknown	98% (Represents reduction in tribal catch per effort)	Petersen Lewis 2009
Steelhead	400,000[(1)]	67% (130,000)	Leidy and Leidy 1984; Busby et al. 1994
Coho salmon	15,400-20,000	52% to 95% (760 to 9,550)	Moyle et al. 1995; Ackerman et al. 2006
Fall-run Chinook salmon	500,000[(3)]	92% to 96% (20,000-40,000)	Moyle 2002
Shasta River Chinook salmon[(4)]	20,000-80,000	88% to 95% (A few hundred to a few thousand)	Moyle 2002
Spring-run Chinook salmon	100,000	98% (2,000)[(2)]	Moyle 2002

(1) This estimate is from 1960. Anadromous fish numbers were already in decline in the early 20th century (Snyder 1931)
(2) Includes Klamath River and Trinity River Chinook salmon
(3) Excludes hatchery influenced escapement
(4) Shasta River is a subset of the overall Klamath River Chinook salmon population

Anadromous salmonids in the Klamath River include fall- (including late-fall) and spring-run Chinook salmon; coho salmon; fall-, winter-, and summer-run steelhead; and coastal cutthroat trout. Anadromous salmonids share many similar life-history traits, but the timing of their upstream migrations, habitat preferences, and distributions differ. All anadromous salmonids spawn in gravel or cobble substrates that are relatively free of fine sediment with suitable surface and subsurface flow to carry oxygen to the eggs and carry metabolic waste away from the eggs. Once suitable spawning habitat is found, the adult female digs one or more nests and deposits up to 3,000 eggs. Her mate(s) will simultaneously fertilize the eggs and fend off other males and egg-eating predators. The female continues digging upstream of the nest, which forms a distinctive pit just upstream and a protective mound of gravel and cobble over the eggs. The female will continue the mound-building process and defend her nest location until her demise. Steelhead and coastal cutthroat trout have similar life histories, but may survive spawning, re-enter the ocean, and return to spawn the following year(s). The eggs hatch several weeks or months later, depending on species and water temperature. The resulting yolk-sac fry, also referred to as alevins, reside in the gravel for several more weeks until their yolk sac is depleted. The fry then emerge from the redd and seek slow shallow areas near shoreline or vegetative cover, gradually moving into deeper and faster water as they grow. Anadromous salmonids are generally considered "juveniles" when they have grown to a size of approximately 55 mm. Juveniles feed and grow on their way downstream and may also rear for some time in the estuary prior to entering the ocean, but before entering brackish or salt water, they must undergo a physiological process called smoltification. After entering the ocean, smolts range up and down the coast as they grow to adulthood. Most adult salmonids return to spawn in the stream where they were born, although some straying does occur. Specific details of life history and distribution are described for each run of anadromous salmonid in the following section.

Chinook Salmon

Two Chinook salmon Evolutionarily Significant Units (ESUs) occur in the Klamath Basin—the Southern Oregon and Northern California Coastal ESU, which includes all naturally spawned Chinook salmon in the lower Klamath River downstream from 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 Klamath and Trinity Rivers. A status review in 1999 determined that neither ESU warranted listing (National Oceanic and Atmospheric Administration (NOAA) Fisheries Service 1999a). A petition to list the Upper Klamath and Trinity Rivers ESU was submitted to the NOAA Fisheries Service in January 2011 (CBD et al. 2011); in April, NOAA Fisheries Service announced that the petition contained substantial scientific information warranting federal review and that a finding as to whether they should be listed as threatened or endangered will be made by January 28, 2012 (http://www.noaanews.noaa.gov/stories2011/20110411_chinook.html). Two races of Chinook salmon occur in the Klamath River: fall-run and spring-run. Although wild spring-run Chinook salmon in the Klamath River system differs from fall-run Chinook salmon genetically, as well as in terms of life history and habitat requirements (NRC 2004), both runs are included within these ESUs (Myers et al. 1998). Both races are described below.

Fall-Run Chinook Salmon Fall-run Chinook salmon (*Oncorhynchus tshawystcha*) are distributed throughout the Klamath River downstream of Iron Gate Dam. Historical records reviewed by Hamilton et al. (2005) and genetic information obtained from archaeological sites analyzed by Butler et al (2010) indicate that prior to the construction of Copco 1 Dam, Chinook salmon spawned in the tributaries upstream of Upper Klamath Lake, including the Sprague, Williamson, and Wood Rivers.

Adult upstream migration through the estuary and lower Klamath River peaks in early September and continues through late October (Moyle 2002; Federal Energy Regulatory Commission [FERC] 2007; Strange 2009). 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[1] 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).

[1] A fish emerging in spring is designated as age 0 until January 1st of the following year, when it is designated as age 1 until January 1st of the next year, when it is designated age 2.

Critical stressors on fall-run Chinook salmon in the basin include water quality and quantity in the mainstem and within spawning tributaries. Downstream of 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*. During outmigration, juvenile Chinook salmon are vulnerable to contracting disease from pathogens, including the bacterium *Flavobacterium columnare*, and myxozoan parasites *Parvicapsula minibicornis* and *Ceratomyxa shasta*.

Spring-Run Chinook Salmon Spring-run Chinook salmon in the Klamath Basin are distributed mostly in the Salmon and Trinity Rivers and on the mainstem below these tributaries during migratory periods, although a few fish are occasionally observed in other areas (Stillwater Sciences 2009a). Based on data from 1992 to 2001 (California Department of Fish and Game [CDFG], unpublished data 2004), the Salmon River contributions to the overall escapement ranged from 1 to 20 percent of the total escapement, and from 2 to 35 percent of the natural escapement. No spawning has been observed in the mainstem Klamath River (Shaw et al. 1997). Historically, the spring run may have been as abundant as the fall run (Moyle 2002). Large numbers of Chinook salmon once spawned in the basin above Klamath Lake in the Williamson, Sprague, and Wood Rivers, but the completion of Copco Dam in 1917 eliminated these runs (Snyder 1931, as cited in NRC 2004). It is believed that spring Chinook salmon spawned in the tributaries of the upper basin (Moyle 2002; Hamilton et al. 2005; Butler et al. 2010). Large runs of spring Chinook salmon also returned to the Shasta, Scott, and Salmon rivers. The construction of Dwinnell Dam on the Shasta River in 1926 was soon followed by the disappearance of the spring Chinook salmon run in that tributary.

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 apparently not nearly as prevalent as the 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 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 takes place from 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. Scale circuli patterns of adults with an identified Type II life history were consistent with those from juveniles outmigrating in mid-October. 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 race juveniles and 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).

It is unclear how much time outmigrating age-0+ juveniles spend in the Klamath River mainstem and estuary before entering the ocean. Sartori (2006) did identify a period of increased growth (estimated mean of 24 days) just prior to reaching an estuarine environment based on otolith analyses of returning adults to the Salmon River, but this period was never clearly linked to mainstem residence. From March to May, there were fair numbers of age-1 juvenile outmigrants captured in the Klamath River estuary (Wallace 2004). Most were identified to be hatchery age-1 juvenile fall-run Chinook salmon, but nearly half were identified to be of natural origin, based on tag expansions.

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 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 reduces spawning and rearing habitat quality (Elder et al. 2002).

<u>Steelhead</u>
Klamath Basin summer steelhead and winter steelhead (*O. mykiss irideus*) populations both belong to the Klamath Mountain Province ESU. NOAA Fisheries Service (2001) status review found that this ESU was not in danger of extinction or likely to become so in the foreseeable future, based on estimated populations for the ESU and lower estimates of genetic risk from naturally spawning hatchery fish than estimated in previous reviews, and consideration of existing conservation efforts that are benefiting steelhead in the ESU (NOAA Fisheries Service 2001).

Summer Steelhead Summer steelhead are distributed throughout the Klamath River downstream of Iron Gate Dam and in its tributaries, and genetic information obtained from archaeological sites analyzed by Butler et al (2010) suggests that steelhead historically used habitat upstream of Upper Klamath Lake prior to the construction of Copco 1 Dam. Based on available escapement data, approximately 55 percent of summer steelhead spawn in the Trinity River and other lower-elevation tributaries. Most remaining summer steelhead are believed to spawn in tributaries between the Trinity River (River Mile [RM] 43) and Seiad Creek (RM 129), with high water temperatures limiting their use of tributaries farther upstream (NRC 2004). The mainstem Klamath River is used primarily as a migration corridor for adult summer steelhead to access holding and spawning habitat in tributaries to the Klamath River.

Summer steelhead adults enter and migrate up the Klamath River from March through June while sexually immature (Hopelain 1998), then hold in cooler tributary habitat until spawning begins in December (United States Fish and Wildlife Service [USFWS] 1998). Forty to 64 percent of summer steelhead in the Klamath River exhibit repeat spawning, with adults observed to migrate downstream to the ocean after spawning (also known as "runbacks") (Hopelain 1998). Summer steelhead in the basin also have a "half-pounder" life-history pattern, in which an immature fish emigrates to the ocean in the spring, returns to the river in the fall, spends the winter in the river, then emigrates to the ocean again the following spring (Busby et al. 1994; Moyle 2002).

Juvenile summer steelhead in the Klamath Basin may rear in freshwater for up to 3 years before outmigrating. Although many juveniles migrate downstream at age 1+ (Scheiff et al. 2001), those that outmigrate to the ocean at age 2+ appear to have the highest survival (Hopelain 1998). Juveniles outmigrating from tributaries at age 0+ and age 1+ may rear in the mainstem or in non-natal tributaries (particularly during periods of poor water quality) for 1 or more years before reaching an appropriate size for smolting. Age-0 juvenile steelhead have been observed migrating upstream into tributaries, off-channel ponds, and other winter refuge habitat in the lower Klamath River (Stillwater Sciences 2010b). Juvenile outmigration can occur from the spring through fall. Smolts are captured in the mainstem and estuary throughout the fall and winter (Wallace 2004), but peak smolt outmigration normally occurs from April through June, based on estuary captures (Wallace 2004). Temperatures in the mainstem are generally suitable for juvenile steelhead, except during periods of the summer, especially upstream of Seiad Valley (for more species information see USFWS 1998; Moyle 2002; NRC 2004; and Stillwater Sciences 2009a). Critical limiting factors for summer steelhead are believed to include degraded habitats, fish passage, predation, and competition (Moyle et al. 2008).

Winter Steelhead Moyle (2002) describes steelhead in the Klamath Basin as having a summer- and winter-run. Some divide the winter-run into fall and winter runs (Barnhart 1994; Hopelain 1998; USFWS 1998; Papa et al. 2007). In this report "winter steelhead" refers to both fall and winter runs except in cases when the distinction is pertinent to the discussion. Effects on winter-and fall-run steelhead were differentiated wherever data was sufficient to analyze them separately.

Winter steelhead are widely distributed throughout the Klamath River and its tributaries downstream of Iron Gate Dam, and are believed to have historically used habitat upstream of Upper Klamath Lake (Butler et al. 2010). The Trinity, Scott, Shasta, and Salmon Rivers are the most important spawning streams for winter steelhead. Winter steelhead adults generally enter the Klamath River from July through October (fall run) and from November through March (winter run) (USFWS 1998; Stillwater Sciences 2010b). Winter steelhead primarily spawn in tributaries from January through April (USFWS 1998), with peak spawn timing in February and March (ranging from January to April) (NRC 2004). Adults may repeat spawning in subsequent years after returning to the ocean. Half-pounders typically utilize the mainstem Klamath River until leaving the following March (NRC 2004), although they also utilize larger tributaries such as the Trinity River (Dean 1994, 1995).

Fry emerge in spring (NRC 2004), with fry observed in outmigrant traps in Bogus Creek and Shasta River from March through mid-June (Dean 1994). Age-0+ and 1+ juveniles have been captured in outmigrant traps in spring and summer in tributaries to the Klamath River above Seiad Creek (CDFG 1990a, 1990b, as cited in USFWS 1998). These fish are likely rearing in the mainstem or non-natal tributaries before leaving as age-2+ outmigrants.

Juvenile outmigration appears to primarily occur between May and September with peaks between April and June, although smolts are captured in the estuary as early as March and as late as October (Wallace 2004). Most adult returns (86 percent) originate from fish that smolt at age 2+, representing 86 percent of adult returns; in comparison with only 10 percent for age-1 juveniles and 4 percent for age 3+ juveniles (Hopelain 1998).

Similar limiting factors listed for summer steelhead also affect winter steelhead populations, including degraded habitats, decreased habitat access, fish passage, predation, and competition (for more species information see USFWS 1998; NRC 2004; Wallace 2004; and Stillwater Sciences 2009a).

<u>Coastal Cutthroat Trout</u>

Klamath River coastal cutthroat trout (*Oncorhynchus clarki clarki)* belong to the Southern Oregon California Coasts ESU. In a 1999 status review, NOAA Fisheries Service determined that the Southern Oregon California Coasts ESU did not warrant ESA listing (Johnson et al. 1999). Coastal cutthroat trout are distributed primarily within smaller tributaries to the lower 22 miles of the Klamath River mainstem above the estuary (NRC 2004), but also within tributaries to the Trinity River (Moyle et al. 1995).

Cutthroat trout have not been extensively studied in the Klamath basin, but it has been noted that their life history is similar to fall and winter steelhead in the Klamath River (NRC 2004). Both resident and anadromous life histories are observed in the Klamath Basin. Anadromous adults enter the river to spawn in the fall. Generally, spawning of anadromous and resident coastal cutthroat trout may occur from September to April (Moyle 2002). Sea-run adults may either return in summer to feed, or return in September or October to spawn and/or possibly overwinter (NRC 2004). Moyle (2002) noted that upstream migration in northern California spawning streams tends to occur from August to October after the first substantial rain.

Juveniles may spend anywhere from one to three years in freshwater to rear. Juveniles outmigrate during April through June, at the same time as Chinook salmon juvenile downstream migration (Hayden and Gale 1999, as cited in NRC 2004; Moyle 2002). Juveniles also appear to spend at least some time rearing in the estuary. Wallace (2004) found that estuary residence time ranged from 5 to 89 days, with mean of 27 days, based on a mark-recapture study.

<u>Pacific Lamprey</u>

Pacific lamprey are the only anadromous lamprey species in the basin. It is not clear whether residual populations of this species still exist above Iron Gate Dam. Pacific lamprey, along with three other lamprey species, was petitioned for ESA listing in 2003 (Nawa 2003). Although the USFWS halted species status review in December 2004 due to inadequate information (NOAA Fisheries Service 2004), efforts to list Pacific lamprey are anticipated to resume as more information is obtained. No current status assessments are available for any Klamath lampreys and little is known of their biology or sensitivity to environmental changes in the Klamath drainage (Hamilton et al. 2011).

Pacific lamprey are found in Pacific coast streams from Alaska to Baja California. They occur throughout the mainstem Klamath River downstream of Iron Gate Dam and its major tributaries: the Trinity, Salmon, Shasta, and Scott River Basins (Stillwater Sciences 2009a). The extent of their historical upstream distribution is uncertain due to the occurrence of several resident species of lamprey in the upper parts of the Klamath Basin (FERC 2007). Pacific lamprey are capable of migrating long distances, and show similar distributions to anadromous salmon and steelhead (Hamilton et al. 2005). Preliminary results of radio telemetry studies by the Yurok Tribe show an extended period of time for adult presence in the river (Yurok Tribe 2011, unpublished data).

Pacific lamprey are anadromous nest builders that die shortly after spawning. They enter the Klamath River during all months of the year, with peak upstream migration occurring from December through June (Stillwater Sciences 2009a). Spawning occurs at the upstream edge of riffles in sandy gravel from mid-March through mid-June (Stillwater Sciences 2009a). After lamprey eggs hatch, the larvae (ammocoetes) drift downstream to backwater areas and burrow into the substrate, feeding on algae and detritus (FERC 2007). Based on observations and available habitat, most ammocoete rearing likely occurs in the Salmon, Scott, and Trinity Rivers, as well as in the mainstem Klamath River. The Klamath River upstream of the Shasta River appears to have less available spawning and rearing habitat, and Pacific lamprey are not regularly observed there. Juveniles remain in freshwater for 5 to 7 years before they migrate to the ocean and transform into adults (Moyle 2002). They spend 1 to 3 years in the marine environment, where they parasitize a wide variety of ocean fishes, including Pacific salmon, flatfish, rockfish, and pollock. For more species information see Close et al. 2010; Stillwater Sciences 2009a; and PacifiCorp 2004a.

Major factors believed to be affecting their populations include barriers to upstream migration at dams, dewatering of larval habitat through flow regulation, stranding due to rapid downramping, reducing larval habitat by increasing water velocity and/or reducing sediment deposition areas, and mortality due to exposure to contaminants in the larval stage (Close et al. 2002, as cited in Hamilton et al. 2011).

Green Sturgeon

Green sturgeon (*Acipenser medirostris Ayres*) are an anadromous species that occurs in coastal marine waters from Mexico to the Bering Sea. NOAA Fisheries Service has identified two distinct population segments (DPSs): the Northern Green Sturgeon DPS, which includes populations spawning in coastal watersheds from the Eel River north, which is not listed as threatened or endangered but is on NOAA Fisheries Service' Species of Concern list, and the Southern Green Sturgeon DPS, encompassing coastal or Central Valley populations spawning in watersheds south of the Eel River, which is listed as threatened under the federal ESA (NOAA Fisheries Service 2006a). Although the Southern DPS is considered a separate population from the Northern DPS based on genetic data and spawning locations, their ranges outside of the spawning season tend to overlap (CDFG 2002b; Israel et al. 2004; Moser and Lindley 2007). The Klamath Basin may support most of the spawning population of green sturgeon (Adams et al. 2002). Although Southern DPS green sturgeon may enter west coast estuaries to feed in the summer and fall, but there has been no evidence of them entering the Klamath River estuary (Reclamation 2010). Northern DPS green sturgeon in the Klamath River sampled during their spawning migration ranged in age from 16 to 40 years (Van Eenennaam et al. 2006). It is believed that in general green sturgeon have a life span of at least 50 years, and spawn every 4 years on average after around age-16, for a total of around eight spawning efforts in a lifetime (Klimley et al 2007). Green sturgeon enter the Klamath River to spawn from March through July. Green sturgeon spawn primarily in the lower 67 miles of the mainstem Klamath River (downstream of Ishi Pishi Falls), in the Trinity River, and occasionally in the lower Salmon River (Klamath River Basin Fisheries Task Force [KRBFTF] 1991; Adams et al. 2002; Benson et al. 2007). Most green sturgeon spawning occurs from the middle of April to the middle of June (NRC 2004). After spawning, around 25 percent of green sturgeon migrate directly back to the ocean (Benson et al. 2007), and the remainder hold in mainstem pools in the Klamath River from river mile (RM) 13 to 65 through November. During the onset of fall rainstorms and increased river flow, adult sturgeon move downstream and leave the river system (Benson et al. 2007). Juvenile green sturgeon may rear for 1 to 3 years in the Klamath River system before they migrate to the estuary and ocean (NRC 2004; FERC 2007; CALFED 2007), usually during summer and fall (Emmett et al. 1991, as cited in CALFED 2007; CH2M Hill 1985; Hardy and Addley 2001).

Resident Riverine Fish Species

Rainbow and Redband Trout

Rainbow trout (*Oncorhynchus mykiss*) exhibit a wide range of life-history strategies, including anadromous forms (steelhead, described above) and resident forms, described here. The Klamath Basin has two subspecies of rainbow trout. Behnke (1992) identifies the inland form as the Upper Klamath redband trout, *Oncorhynchus mykiss newberrii*, but considers steelhead and resident rainbow trout downstream of Upper Klamath Lake to be primarily coastal rainbow trout, *Oncorhynchus mykiss irideus*. Since construction of Copco 1 Dam and Iron Gate Dam, resident trout upstream of Iron Gate Dam are considered redband trout, and resident trout downstream of Iron Gate Dam are considered coastal rainbow trout (FERC 2007). Behnke (2002) indicates that two distinct groups of redband trout may be in the upper basin: one that is adapted to lakes and another that is adapted to streams. The area upstream of Iron Gate Dam, and particularly Upper Klamath Lake, support populations of redband trout. These fish support a substantial recreational fishery.

The Upper Klamath Lake Basin supports the largest and most functional adfluvial redband trout population of Oregon’s interior basins (Hamilton et al. 2011). Adfluvial adult redband trout migrate from lake habitats into tributaries to spawn. Peak spawning occurs in December and January, but redband trout in Spring Creek have been documented to spawn nearly year-round, in all months from October through August. Their progeny typically spend one year rearing in tributaries before migrating back to the lake. In the Hydroelectric Reach, most redband trout spawning is thought to occur in Spencer and Shovel Creeks. Redband trout need to migrate among habitats, mainstem, tributaries, and reservoirs to meet their life-history requirements. Redband trout are not susceptible to *C. shasta* or other diseases potentially brought upstream by anadromous fishes (Hamilton et al. 2011). For more species information, see USFWS (1998); USFWS (2000); Behnke (2002); Moyle (2002); NRC (2004); PacifiCorp (2004a); Starcevich et al. (2006); Messmer and Smith (2007); and Stillwater Sciences (2009a).

Resident Lampreys

In addition to the anadromous Pacific lamprey, described above, at least five or six resident species are present in the Klamath Basin (PacifiCorp 2006; Hamilton et al. 2011):

- Pit-Klamath brook lamprey (*Entosphenus lethophagus*)
- Modoc brook lamprey (*Entosphenus folletti*)
- Western brook lamprey (*Lampetra richardsoni*)
- Klamath River lamprey (*Entosphenus similis*)
- Miller Lake lamprey (*Entosphenus minima*)
- “Klamath Lake lamprey,” an undescribed, parasitic species

All lamprey species have a similar early life history where ammocoetes drift downstream to areas of low velocity with silt or sand substrate and proceed to burrow into the stream bottom and live as filter feeders (USFWS 2004). After they transform into adults, the non-parasitic species do not feed, while the parasitic species feed on a variety of fish species (FERC 2007).

Klamath River lamprey are found both upstream and downstream of Iron Gate Dam, from Spencer Creek downstream, and are common in the lower Klamath River and the low-gradient tributaries there (NRC 2004). They are also found in the Trinity River, and in the Link River of the Upper Klamath Basin (Lorion et al. 2000, as cited by Close et al. 2010). “Klamath Lake lamprey,” an as yet undescribed species, reside in Upper Klamath Lake and migrate upstream in the Sprague River to spawn (Close et al. 2010). Klamath Lake lamprey ammocoetes are reported to metamorphose in the fall, spend 12 to 15 months in Upper Klamath Lake parasitizing fish, and then spawn in the spring in the Sprague River (FERC 2007).

Cyprinids

The blue chub (*Gila coerulea)* and tui chub (*Gila bicolor*) are both found in the Klamath Basin. These species prefer habitat with quiet water, well-developed beds of aquatic plants, and fine sediment or sand bottoms. Although chubs can withstand a variety of conditions including cold, clear lake water, and can also tolerate low dissolved oxygen levels, they are most often found in habitats with summer water temperatures higher than 20°C. These fish are omnivores and can play an important role in nutrient cycling. Chub spawning takes place from April through July, in shallow rocky areas in temperatures of 15 to 18°C (Moyle 2002).

Sculpin

Several sculpin (*Cottidae*) species are found in coastal streams and rivers from Alaska to southern California. At least 7 species of sculpin are known to occur in the Klamath River or its estuary, including Pacific staghorn, prickly, slender, sharpnose, coastrange, marbled, and Klamath Lake sculpin. Mainstem river habitat may be important to sculpin populations as it can provide an important migration corridor (White and Harvey 1999). Pacific staghorn sculpin are found predominantly in brackish waters of the estuary. Coastal populations of prickly and coastrange sculpin are generally assumed to be estuary-dependent for part of their early life history (White and Harvey 1999). The marbled sculpin (*Cottus klamathensis*) is a relatively wide-ranging species found in a variety of habitats in northern California and southern Oregon (Daniels and Moyle 1984). Marbled sculpin are found mainly in low gradient, spring-fed streams and rivers where the water temperature is less than 20°C in the summer and in habitat with fine substrate that can support beds of aquatic plants. They are typically found in 60 to 70 cm of water and are in velocities around 23 cm/sec (Moyle 2002).

Smallscale sucker

The Klamath smallscale sucker (*Catostomus rimiculus*) is common and widely distributed in the Klamath River and its tributaries below the city of Klamath Falls, Oregon, and in the Rogue River (Moyle 2002). They tend to inhabit deep, quiet pools in mainstem rivers and slower-moving reaches in tributaries; however, they can be found in faster-flowing habitats when feeding or breeding (Moyle 2002). McGinnis (1984) reported that this species spawns in small tributaries to the Klamath and Trinity Rivers. Spawning in tributaries to Copco Reservoir has been observed from mid-March to late April (Knudsen and Mills 1980, as cited in Moyle 2002). Juveniles are most commonly found in the streams that are used for spawning. This species does not achieve a large size and is relatively long-lived. Fish measuring 45 cm have been aged through scale analysis as being 15 years old (Scoppetone 1988, as cited in Moyle (2002). Moyle (2002) speculated that dams and diversions have benefitted this species by increasing the availability of its preferred warmer, low-velocity habitat.

Electrofishing by PacifiCorp and Oregon Department of Fish and Wildlife (ODFW) in the J.C. Boyle Peaking Reach revealed the existence of a good population of smallscale suckers in moderate velocity habitat—smallscale sucker dominated the fish assemblage in most samples (W. Tinniswood, 2011, pers. comm.). The dams have increased reservoir habitat that does not appear to be conducive to a riverine sucker species such as smallscale suckers. The J.C. Boyle Dam blocks the migration of suckers to spawning habitat in Spencer Creek. Spawning now occurs in the mainstem Klamath River where smallscale suckers are exposed to flow fluctuations that can displace their broadcast eggs or dessicated them during power peaking (Dunsmoor 2006). Electrofishing in Jenny Creek revealed adult smallscale suckers occupying deep, moderate-velocity habitat among boulders (W. Tinniswood, 2011, pers. comm.). The reservoirs themselves do not appear to provide habitat for smallscale sucker.

Non-native Fish Species

Goldfish

Goldfish (*Carassius auratus)* are abundant in J.C. Boyle Reservoir and Keno Impoundment; in September 2010, they were the most abundant species captured during ODFW electrofishing surveys.

Yellow Perch

Yellow perch (*Perca flavescens*) prefer weedy rivers and shallow lakes. They are found in reservoirs and ponds along the Klamath River. Optimal temperature for growth is 22–27°C but yellow perch can survive in temperatures up to 30–32°C. They can survive low levels of dissolved oxygen (less than 1 milligram per liter [mg/L]) but are most abundant in areas with high water quality, as they are visual feeders. Larval and juvenile yellow perch feed on zooplankton; adults are opportunistic predators that may feed on larger invertebrates and small fish (Knight et al. 1984). The preferred habitat of the yellow perch includes large beds of aquatic plants for spawning and foraging. Their spawning takes place in 7 to 19°C water in April and May and usually occurs in their second year (Moyle 2002).

Bass and Sunfish

Several species of bass (*Micropterus* spp.) and sunfish (*Lepomis* spp.) have been introduced into the Klamath Basin, including largemouth bass, spotted bass, white and black crappie, bluegill, pumpkinseed and green sunfish. Largemouth bass and sunfish (*Centrarchidae*) prefer lakes, ponds, or low-velocity habitat in rivers. They prefer habitats with aquatic vegetation and will spawn in a variety of substrates. They prefer water temperatures above 27ºC. Juvenile and adult largemouth bass tend to feed on larger invertebrates and fish (Moyle 2002). Smaller members of the family, such as sunfish, are opportunistic feeders and eat a variety of aquatic insects, fish eggs, and planktonic crustaceans (Moyle 2002).

Sacramento Perch

Sacramento Perch (*Archoplites interruptus)* occur in J.C. Boyle Reservoir and Keno Impoundment. The species is native to the Sacramento-San Joaquin watershed of California's Central Valley, from which they were extirpated.

Catfish

Several species of catfish have been introduced into the Klamath Basin, including black, brown, and channel catfish, and yellow bullhead (Logan and Markle 1993; NRC 2004). Catfish prefer slow moving, warm water habitat. Brown bullhead (*Ameiurus nebulosus*) can tolerate a wide range of salinities and live at temperatures of 0 to 37°C, but their optimum temperature range is 20 to 33°C. Brown bullhead are most active at night and form feeding aggregations. Catfish are opportunistic omnivores and scavenge off the bottom of their habitat (Moyle 2002).

Trout

Brook trout (*Salvelinus fontinalis)* is an introduced species in the Upper Klamath Basin (FERC 2007) found in clear, cold lake and stream habitats. They prefer temperatures between 14 and 19°C but can survive in temperatures ranging from 1 to 26°C. Brook trout feed predominantly on terrestrial insects and aquatic insect larvae, though they may also opportunistically feed on other types of prey such as crustaceans, mollusks, and other small fish. Brook trout spawn in the fall and prefer habitats with small-sized gravel and nearby cover (Moyle 2002).

Brown trout (*Salmo trutta*) has also been introduced to the Klamath River and are found in both the Upper and Lower Basin. Brown trout prefer clear, cold water and can utilize both lake and stream habitats. Like brook trout, they spawn in the fall in streams with areas of clean gravel. Brown trout become piscivorous (fish eaters) once they reach a size where their gape can accommodate small fish available as prey.

Kokanee

Kokanee are landlocked sockeye salmon *(Oncorhynchus nerka)* that have been found in Upper Klamath Lake and Fourmile Creek.

American Shad

American shad (*Alosa sapidissima*) are an introduced, anadromous fish species that enjoys some popularity as a sport fish.

Fathead Minnow

Fathead minnow (*Pimephales promelas*) are an introduced bait fish widely distributed in the Upper Klamath Basin; however, it is thought that their introduction into the upper Klamath lakes may be a result of their use for pollution bioassays (Simon and Markle 1997, Moyle 2002).

Estuarine Species

The estuary is the mixing zone for freshwater and ocean water. The balance of fresh and saltwater changes over the course of the day with tides and is also strongly influenced by river flows. Because of this, both marine and freshwater species can often be found in different portions of the estuary at different times. All anadromous fish pass through the estuary during their migrations from freshwater to the sea and back again, and juvenile salmonids may rear in the estuary for varying periods of time, prior to moving into the ocean. CDFG surveys in the freshwater portion of the estuary commonly find Klamath speckled dace, Klamath smallscale sucker, prickly sculpin, and Pacific staghorn sculpin. Other fairly common species include northern anchovy, saddleback gunnel, and bay pipefish. Other species in the estuary include federally listed eulachon, state listed longfin smelt (described under listed species), silversides, surf smelt, stickleback, and several gobies. Impacts to the estuarine species were assessed based on effects on essential fish habitat for groundfish and pelagic fish, as described in subsequent sections.

Freshwater Mollusks

Four species of native freshwater mussels have been observed within the Klamath Basin (FERC 2007; Westover 2010). PacifiCorp surveys in 2002 and 2003 found Oregon floater (*Anodonta oregonensis*), California floater (*A. californiensis*) and western ridged mussel (*Gonidia angulata*) along Klamath River reaches from the Keno Impoundment/Lake Ewauna to the confluence of the Klamath and Shasta Rivers.

Westover (2010) found western pearlshell mussel (*Margaritifera falcata*) in addition to these species along the Klamath River from Iron Gate Dam to the confluence of the Klamath and Trinity Rivers.

Anodonta spp. are habitat generalists, more tolerant of lentic conditions than other native species (Nedeau et al. 2005). *Anodonta* spp. are also more tolerant of siltier substrates, as their thin shells allow individuals to "float," or rest on top of silt-dominated streambeds (these species are commonly referred to as "floaters"). *G. angulata* is the largest and most common type of freshwater mussel found within the Klamath Basin, although little is known about their life history or habitat preferences (Nedeau et al. 2005). *G. angulata* is known to prefer cold, clean water, but can tolerate seasonal turbidity, and can be found in aggrading, or depositional areas as it can partially bury itself within bed sediments without affecting filter feeding (Vannote and Minshall 1982; Westover 2010). *M. falcata* has also been observed within the Klamath Basin downstream of Iron Gate Dam, though in lesser abundance than other species (Westover 2010). *M. falcata* occupies low shear stress habitats (e.g., pools and near banks) and interstices within bedrock and cobble (Howard and Cuffey 2003).

Adult freshwater mussels are generally found wedged into gravel, rock substrate or partially buried in finer substrates, using a muscular foot to maintain position. Freshwater mussels filter feed on plankton and other organic material suspended in the water column.

While life history traits of individual species of freshwater mussels have not been fully studied, the general life cycle is as follows. Eggs within female freshwater mussels are fertilized by sperm that is brought into the body cavity. From April through July thousands of tiny larvae, called glochidia, are released into the water where they must encounter a host fish for attachment within hours, otherwise they perish (Haley et al. 2007). Most juvenile freshwater mussels from these species drop off the fish hosts to settle from June to early August. They may spend an undetermined amount of time buried in the sediment where they grow to the point where they can maintain themselves at or below the substrate surface in conditions that are optimal for filter feeding (Nedeau et al. 2009). Freshwater mussels are fed upon by muskrats, river otters, and sturgeon (Nedeau et al. 2009). They were also a food of cultural significance for the Karuk Tribe (Westover 2010) and The Klamath Tribes.

Seven to eight species of fingernail clams and peaclams (Family: Sphaeriidae) were also found in the Hydroelectric Reach and from Iron Gate Dam to Shasta River during re-licensing surveys. One of the clam species, the montane peaclam (*Pisidium ultramontanum)*, has special status as a federal species of concern and a United States Forest Service (USFS) sensitive species. The montane peaclam is generally found on sand-gravel substrates in spring-influenced streams and lakes, and occasionally in large spring pools. The original range included the Klamath and Pit Rivers in Oregon and California, as well as some of the larger lakes (Upper Klamath, Tule, Eagle, and possibly, lower Klamath lakes). On USFS lands they are currently present or suspected in streams and lakes of Lassen and Shasta-Trinity National Forests. Fingernail clams and peaclams are relatively short-lived (1 to 3 years) compared to freshwater mussels (10 to 15 years or

100 plus years for some species). These small clams live on the surface or buried in the substrate in lakes, ponds or streams. They bear small numbers of live young several times throughout the spring and summer (Thorp and Covich 2001).

There are also many species of freshwater snails, some of which are endemic to the Klamath Basin and have restricted ranges, often associated with cold-water springs. Several of these have recently been petitioned for listing. However, based on their restricted distribution outside of any areas that could be affected by the Proposed Action they were considered, but not included in any additional analysis.

Benthic Macroinvertebrates

Benthic macroinvertebrates include immature, aquatic stages of insects such as midges, mayflies, caddisflies, stoneflies, dragonflies, and damselflies. They also include immature and adult stages of aquatic beetles; crayfish, amphipods and isopods (crustaceans); clams and snails; aquatic worms and other major invertebrate groups. Many benthic macroinvertebrates (BMIs) are the primary consumers in riverine food webs, feeding on primary producers—algae, aquatic plants, phytoplankton, bacteria, as well as leaves and other materials from terrestrial plants, and detritus. By converting organic material into biomass available to a wide variety of consumers, these organisms form an important component of the aquatic food web. Some BMIs are secondary consumers, feeding on the primary consumers. Together the BMIs are the primary food source for most fish species, and changes in abundance, distribution, or community structure can negatively affect fish populations. BMIs are also used as general indicators of water quality in indices of biological integrity based upon the richness or diversity of pollution tolerant and resistant species. BMIs are also particularly sensitive to changes in fine and coarse sediment load, which could occur under the Proposed Action and alternatives. Food supply can limit growth of salmonids, and this is especially true at higher temperatures; i.e., as water warms, a fish needs more food to sustain growth (Brett 1971; Elliott 1981; McCullough 1999). Growth is critical to juvenile salmonids because a larger size often confers a survival advantage during the overwintering period, smolt outmigration, or ocean residence. If fish are chronically exposed to warmer temperatures and food availability is low, growth may cease, fish may experience physiological stress, and mortality from disease, parasites, and predation may increase. But in a productive system with high densities of macroinvertebrates or forage fish, a high rate of growth can be sustained at temperatures higher than would be considered optimal under conditions where food is limiting.

Relicensing studies evaluated BMIs from Link River Dam to the Shasta River and on Fall Creek in 2002 and 2003 (FERC 2007). These studies show that macroinvertebrates are abundant, with densities of 4,000 to 8,000 individuals per square meter.

Macroinvertebrate densities in fall of 2002 ranged from a low of 4,000 per square meter below the powerhouse on the Klamath River to 21,000 per square meter below Keno Dam (PacifiCorp 2004b). Abundance of macroinvertebrates in the peaking reach of the Klamath River was as low as 500 per square meter in the spring of 2003. Dominant species in the riverine areas were caddisflies, blackflies, midges, beetles, and mayflies.

The reservoirs had high abundance of invertebrates but low diversity, and were dominated by species tolerant of impaired water quality conditions.

Listed Species

Coho Salmon

The Southern Oregon/Northern California Coast (SONCC) coho salmon (*O. kisutch*) ESU is listed as federally threatened (NOAA Fisheries Service 1997a). This ESU includes all naturally spawning populations between Punta Gorda, California and Cape Blanco, Oregon, which encompasses the Trinity and Klamath Basins (NOAA Fisheries Service 1997a). Three artificial propagation programs are considered to be part of the ESU: the Cole Rivers Hatchery, Trinity River Hatchery, and Iron Gate Hatchery coho salmon programs. NOAA Fisheries Service has determined that these artificially propagated stocks are no more than moderately diverged from the local natural populations. In addition, coho salmon in the Klamath Basin have been listed by the California Fish and Game Commission as threatened under the California Endangered Species Act (CESA) (CDFG 2002a).

Williams et al. (2006) described nine historical coho salmon populations within the Klamath Basin, including the upper Klamath River, Shasta River, Scott River, Salmon River, mid-Klamath River, lower Klamath River, and three population units within the Trinity River watershed (upper Trinity River, lower Trinity River, and South Fork Trinity River).

Coho salmon are currently widely distributed in the Klamath River downstream of Iron Gate Dam (RM 190), which blocks the upstream migration of coho salmon to historically available habitat in the upper watershed. Before the construction of the dams, coho salmon were apparently common and widely distributed throughout the watershed, probably in both mainstem and tributary reaches up to and including Spencer Creek at RM 228 (NRC 2004, as cited in NOAA Fisheries Service 2007; Hamilton et al. 2005). Coho salmon utilize the mainstem Klamath River for some or all of their life history stages (spawning, rearing and migration). However, the majority of returning adult coho salmon spawn in the tributaries to the mainstem (Magneson and Gough 2006, NOAA Fisheries Service 2010a).

Coho salmon adults in the Klamath Basin migrate upstream from September through late December, peaking in October and November. Spawning occurs mainly in November and December, with fry emerging from the gravel in the spring, 3 to 4 months after spawning (Trihey and Associates 1996; NRC 2004).

Some fry and age-0+ juveniles enter the mainstem in the spring and summer following emergence (Chesney et al. 2009). Large numbers of age-0 juveniles from tributaries in the mid-Klamath River move into the mainstem in the fall (October through November) (Soto et al. 2009; Hillemeier et al. 2009). Juvenile coho salmon have been observed to move into non-natal rearing streams, off-channel ponds, the lower Klamath River, and the estuary for overwintering (Soto et al. 2009; Hillemeier et al. 2009). Some proportion of juveniles generally remain in their natal tributaries to rear.

Age 1+ coho salmon migrate from tributaries into the mainstem Klamath River from February through mid-June with a peak in April and May, which often coincides with the descending limb of the spring hydrograph (NRC 2004; Chesney and Yokel 2003; Scheiff et al. 2001). Once in the mainstem, smolts appear to move downstream rather quickly; Wallace (2004) reported that numbers of coho salmon smolts in the Klamath River estuary peaked in May, the same month as peak outmigration from the tributaries.

The major activities identified as responsible for the decline of coho salmon in Oregon and California and/or degradation of their habitat included logging, road building, grazing, mining, urbanization, stream channelization, dams, wetland loss, beaver trapping, artificial propagation, overfishing, water withdrawals, and unscreened diversions for irrigation (NOAA Fisheries Service 1997a). In 2007, NOAA Fisheries Service published a Klamath River Coho Salmon Recovery Plan to comply with Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 (not equivalent to recovery plans under ESA), including the following actions identified as high priority for recovery:

- Complete and implement the NOAA Fisheries Service recovery plan for the SONCC coho salmon under the ESA.
- Restore access for coho salmon to the Upper Klamath Basin by providing passage beyond existing mainstem dams.
- Fully implement the Trinity River Restoration Program.
- Provide incentives for private landowners and water users to cooperate in (1) restoring access to tributary streams that are important for coho spawning and rearing; and (2) enhancing mainstem and tributary flows to improve instream habitat conditions.
- Continue to improve the protective measures already in place to address forestry practices and road building/maintenance activities that compromise the quality of coho salmon habitat.
- Implement restorative measures identified through fish disease research results to improve the health of Klamath River coho salmon populations.

Eulachon

Eulachon (*Thaleichthys pacificus*) is an anadromous fish that occurs in the lower portions of certain rivers draining into the northeastern Pacific Ocean, ranging from northern California to the southeastern Bering Sea in Bristol Bay, Alaska (Hubbs 1925; Schultz and DeLacy 1935; McAllister 1963; Scott and Crossman 1973; Willson et al. 2006, as cited in BRT 2010). The southern population of Pacific eulachon consists of populations spawning in rivers south of the Nass River in British Columbia, Canada, to and including the Mad River in California (NOAA Fisheries Service 2009a). On March 18, 2010, NOAA Fisheries Service listed the southern DPS of eulachon as threatened under the ESA (NOAA Fisheries Service 2010b). The Klamath River is near the southern limit of the range of eulachon (Hubbs 1925, Schultz and DeLacy 1935, both as cited in BRT 2010). Large spawning aggregations of eulachon historically occurred regularly in the Klamath River (Fry 1979), and occasionally in the Mad River (Moyle et al. 1995; Moyle 2002) and Redwood Creek (Ridenhour and Hofstra 1994; Moyle et al. 1995). CDFG sampled in the Klamath River from 1989 to 2003 with no eulachon captures (Wallace, pers. comm., 2011). The Yurok Tribe sampled extensively for eulachon in early 2011 and, although they did not capture eulachon from the Klamath River itself, tribal fishermen did recover eulachon from the surf zone at the mouth of the river (M. Belchik, pers. comm. 2011). The Tribe will be sampling for eulachon in the lower Klamath River again next winter.

Historically, eulachon runs in northern California were said to start as early as December and January and peak in abundance during March and April. Historically, large numbers of eulachon migrated upstream in March and April to spawn, but they rarely moved more than 8 miles inland (NRC 2004). Spawning occurs in gravel riffles, with hatching about a month later. The larvae generally move downstream to the estuary following hatching.

Southern DPS Green Sturgeon

The Southern Green Sturgeon DPS is listed as threatened under the federal ESA (NOAA Fisheries Service 2006a). Juvenile and adult Southern Green Sturgeon enter many estuaries along the West Coast during the summer months to forage, but their use of the Klamath River estuary is unknown. The Yurok Tribe has tagged many Green Sturgeon of the Southern DPS with acoustic tags. They have been detected immediately offshore (~1/2 mile) on marine ultrasonic receivers, but there have been no detections within the estuary despite the fact that there are receivers there (M. Belchik, pers. comm., 2011). They are not known to use areas of the Klamath River upstream of the estuary, and they have not been observed to spawn in the Klamath River.

Lost River and Shortnose Suckers

Lost River (*Deltistes luxatus*) and shortnose (*Chasmistes brevirostris*) suckers are endemic to the Upper Klamath Basin of southern Oregon and northern California (Moyle 2002). These species are listed as endangered under the ESA (USFWS 1988), and are endangered under CESA, as well as fully protected species under California Fish and Game code section 5515(a)(3)(b)(4) and (6), respectively; thus any take of these species is prohibited. Threats to the population include: the damming of rivers, instream flow diversions, hybridization, competition and predation by exotic species, dredging and draining of marshes, water quality problems associated with timber harvest, the removal of riparian vegetation, livestock grazing, agricultural practices, and low lake elevations, particularly in drought years. Reduction and degradation of lake and stream habitats in the upper Klamath Basin is considered by USFWS to be the most important factor in the decline of both species (USFWS 1993)

The Lost River sucker historically occurred in Upper Klamath Lake (Williams et al. 1985) and its tributaries and the Lost River watershed, Tule Lake, Lower Klamath Lake, and Sheepy Lake (Moyle 1976). Shortnose suckers historically occurred throughout Upper Klamath Lake and its tributaries (Williams et al. 1985; Miller and Smith 1981). The present distribution of both species includes Upper Klamath Lake and its tributaries (Buettner and Scoppettone 1990), Clear Lake Reservoir and its tributaries (USFWS 1993), Tule Lake and the Lost River up to Anderson-Rose Dam (USFWS 1993), and the Klamath River downstream to Copco Reservoir (Beak Consultants 1987) and probably to

Iron Gate Reservoir (USFWS 1993). Shortnose sucker occur in Gerber Reservoir and its tributaries, but Lost River sucker do not.

Lost River and shortnose suckers are lake-dwelling, but spawn in tributary streams or springs (USFWS 1988). They spawn from February through May, depending on water depth and stream temperature (Buettner and Scoppettone 1990; Andreasen 1975, USFWS 2008). When spawning occurs over cobble and armored substrate, eggs fall between crevices or are swept downstream (Buettner and Scoppettone 1990). Larval Lost River and shortnose suckers spend relatively little time in tributary streams, migrating back to the lake shortly after emergence, typically in May and early June (Buettner and Scoppettone 1990). Adults return to Upper Klamath Lake soon after spawning. Lake fringe emergent vegetation is the primary habitat used by larval suckers. Juvenile suckers utilize a wide variety of near-shore habitat including emergent vegetation, non-vegetated areas and off-shore habitat (Hamilton et al. 2011). Refugial areas of relatively good water quality are important for fish in Upper Klamath Lake during the summer and early fall, when dissolved oxygen and pH levels can be stressful or lethal in much of the lake (Coleman and McGie 1988). A recovery plan for Lost River and shortnose suckers was completed in 1994. A new recovery plan is currently in development and is expected to be published in 2011 (Sada, pers. comm., 2011), along with proposed critical habitat. More detailed information for this species can be found in USFWS (2008).

Bull Trout

Bull trout (*Salvelinus confluentus*) are listed as threatened under the ESA in 1999 (USFWS 1999), and a recovery plan for the Klamath River Bull Trout DPS was published in 2002 (USFWS 2002). Historically, bull trout occurred throughout the Klamath Basin in Oregon. Currently bull trout are found in two streams in the Upper Klamath Lake watershed (Sun and Threemile creeks), six streams in the Sprague River watershed (Deming, Brownsworth, Leonard, Boulder, Dixon, North Fork Sprague), and one stream in the Sycan River watershed (Long Creek).

The distribution and numbers of bull trout are believed to have declined in the Klamath Basin due to habitat isolation, loss of migratory corridors, poor water quality, and the introduction of nonnative species. The geographic isolation of the Klamath populations places them at greater risk of genetic effects and extirpation (NRC 2004). Bull trout exhibit two basic life-history strategies: resident and migratory. Migratory bull trout live in larger river and lake systems and migrate to small stream headwaters to spawn. In general, migratory fish are larger than resident fish. Research indicates that various types of bull trout interbreed at times, which helped maintain viable populations throughout the fish's range (Rieman and McIntyre 1993).

Bull trout reach sexual maturity in 5 to 7 years and spawn from the end of August through November. Spawning may occur annually for some populations, and every other year for the rest. Bull trout require particularly clean gravel substrates for spawning. High sediment levels suffocate eggs by reducing dissolved oxygen (Rieman and McIntyre 1996). Bull trout eggs incubate over the winter and hatch in the late winter or early spring. Emergence usually requires an incubation period of 120 to 200 days.

Juvenile bull trout migrate upstream from spawning areas to grow and take advantage of cool headwater temperatures. Bull trout less than 1 year old are generally found in areas along stream margins and inside channels. Most migratory juvenile bull trout remain in headwater tributaries for 1 to 3 years before emigrating downstream to larger stream reaches. Emigration usually takes place from June to August (Rieman and McIntyre 1996).

Southern Resident Killer Whale

The Southern Resident Killer Whale (*Orcinus orca*) DPS is designated as endangered under the ESA (NOAA Fisheries Service 2005). This DPS primarily occurs in the inland waters of Washington State and southern Vancouver Island, particularly during the spring, summer, and fall, although individuals from this population have been observed off coastal California in Monterey Bay, near the Farallon Islands, and off Point Reyes (Heimlich-Boran 1988; Felleman et al. 1991; Olson 1998; Osborne 1999; NOAA Fisheries Service 2005). Southern Resident Killer Whale survival and fecundity are correlated with Chinook salmon abundance (Ward et al. 2009; Ford et al. 2009). Southern Resident Killer Whales could potentially be affected by changes in salmon populations in the Klamath River caused by the Proposed Action (food abundance is one of the elements of their critical habitat, as described in the Critical Habitat Section). Hanson et al. (2010) found that Southern Resident Killer Whale stomach contents included several different ESUs of salmon, including Central Valley fall-run Chinook salmon.

Longfin Smelt

Longfin smelt (*Spirinchus thaleichthys*) are a state-listed threatened species throughout their range in California (CDFG 2009), but the USFWS denied the petition for federal listing because the population in California (and specifically San Francisco Bay) was not believed to be sufficiently genetically isolated from other populations (USFWS 2009). This species generally has a 2 year lifespan, although 3-year-old fish have been observed (Moyle 2002). They typically live in bays, estuaries and have sometimes been observed in the nearshore ocean from San Francisco Bay to Prince William Sound, Alaska, including the Klamath River. They prefer salinities of 15 to 30 ppt, although they can tolerate salinities from freshwater to full seawater. They prefer temperatures of 16 to 18°C and generally avoid temperatures higher than 20°C. Longfin smelt may occur in the Klamath River throughout the year. They would only be expected to use the estuary and the lowest reaches of the river. Longfin smelt spawning occurs primarily from January to March, but may extend from November into June, in fresh or slightly brackish water over sandy or gravel substrates. Temperatures during spawning in the San Francisco estuary are 7 to 14.5ºC. Embryos hatch in 40 days in 7ºC water temperature (25 days in 10.6ºC water) and are quickly swept downstream by the current to more brackish areas. The importance of ocean rearing is unknown. Little is known about longfin smelt populations in the Klamath River, except that they are presumably small.

3.3.3.2 Physical Habitat Descriptions

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir

Aquatic habitat in the Upper Klamath Basin includes both lacustrine and riverine habitats, and also includes large, thermally stable coldwater springs. The upper Klamath River upstream of Iron Gate Dam once supported large populations of anadromous salmon and steelhead by providing spawning and rearing habitat (Hamilton et al. 2005). Further, Butler et al. (2010) documented fish remains from six archaeological sites located upstream of Upper Klamath Lake to provide an independent record of Chinook salmon and steelhead in the Upper Basin.

Upper Klamath Lake is the most prominent feature in this part of the basin, although other lakes and reservoirs are also present. Lake Ewauna, another lake on the Klamath River mainstem, is connected to Upper Klamath Lake via the Link River. The Keno Impoundment/Lake Ewauna is formed by Keno Dam, which regulates water surface elevations in the impoundment to facilitate agricultural diversions. Implementation of the Klamath Hydroelectric Settlement Agreement (KHSA) and the Klamath Basin Restoration Agreement (KBRA) would result in the reintroduction of anadromous fish into these lakes and their tributary streams. The KBRA has substantial funding designated to improve water quality above Keno Dam.

Lower Klamath Lake, Tule Lake, Clear Lake and Gerber Reservoir in the Upper Basin could be affected by changes in water management associated with the Proposed Action and alternatives. The KBRA includes provisions for specific water allocations and delivery obligations for the Lower Klamath Lake and Tule Lake National Wildlife Refuges, which will increase availability and reliability of water supplies above historical refuge use in most years (Hetrick et al. 2010). These two refuges contain important habitat for Pacific Flyway waterfowl and waders (see Section 3.5). Tule Lake, Clear Lake, and Gerber Reservoir support populations of shortnose and Lost River suckers (FERC 2007; USFWS 2007a, b; NRC 2008).

Upper Klamath Lake and Lake Ewauna are affected by poor water quality conditions as described in Section 3.2, Water Quality. Each summer these water bodies exhibit high pH, broad daily shifts in dissolved oxygen, and high ammonia (Hamilton et al. 2011). In Upper Klamath Lake several incidents of mass adult mortality of shortnose and Lost River sucker have been associated with low dissolved oxygen levels (Buchanan et al. 2011a). Instances of pH levels above 10 and extended periods of pH levels greater than 9 lasting for several weeks have been associated with large algal blooms occurring in the lake (Kann 2010). On a diel basis, algal photosynthesis can elevate pH levels during the day, with changes exceeding 2 pH units over a 24-hour period. During November–April (non-growing season) pH levels in Upper Klamath Lake are near neutral (Aquatic Scientific Resources 2005).

Fish passage over Link Dam is provided by a ladder. This ladder is designed to modern standards to allow the passage of shortnose and Lost River suckers, salmonids and other migratory fish, including anadromous salmonids and Pacific lamprey, if present. Keno Dam is equipped with a 24-pool weir and orifice type fish ladder, which rises 19 feet over a distance of 350 feet, designed to pass trout and other resident fish species (FERC 2006). The fishway at Keno Dam currently complies with passage criteria for salmonid fish, but plans are being developed to have the fishway rebuilt to criteria for lamprey and for greater anadromous salmonid runs if the Keno facility is transferred to the government as part of settlement (T. Hepler, Reclamation, pers. comm., as cited in Hamilton et al. 2011). Although suckers have been observed to use the Keno Dam fish ladder, the ladder was not designed for sucker passage and is considered generally inadequate for sucker passage (Reclamation 2002).

The Williamson and Wood Rivers are the largest tributaries to Upper Klamath Lake, with the Williamson River being the largest tributary. The Sprague River is tributary to the Williamson River, and the Sycan River is tributary to the Sprague River (Hamilton et al. 2011). These tributaries currently provide habitat for redband trout, bull trout, shortnose sucker and Lost River sucker, as well as other species. Historically these tributaries provided substantial habitat for Chinook salmon and steelhead (Hamilton et al. 2005, 2011). Substantial flow contributions from springs into these tributaries provide cool summer baseflows with water temperatures and dissolved oxygen (DO) levels generally adequate to support coldwater fish habitat requirements (Hamilton et al. 2011); though these tributaries suffer from some water quality impairments as described in Section 3.2, Water Quality.

In addition to redband trout, shortnose and Lost River sucker, the Upper Basin supports many other fish species. Resident fishes include several species of minnow, sucker, sculpin, and salmonids. At least 18 species have been introduced into the Upper Klamath Basin including several species of minnow, catfish, sunfish, largemouth bass, and spotted bass, as well as yellow perch.

Hydroelectric Reach: J.C. Boyle Reservoir Downstream to Iron Gate Dam

The hydroelectric reach, from the upstream extent of J.C. Boyle Reservoir to Iron Gate Dam, includes four reservoirs (J.C. Boyle, Copco 1, Copco 2, and Iron Gate) and two riverine reaches. Several coolwater tributaries enter the Klamath River and reservoirs in this reach. The reservoirs are productive and nutrient rich. They tend to be warm during the summer months, with mean daily temperatures sometimes reaching 23ºC (FERC 2007). Water quality in the Copco 1 and Iron Gate Reservoirs during the summer is generally quite poor due to warm surface waters and annual blooms of the *Anabaena flos-aquae* and *M. aeruginosa* (see Section 3.2). These algae produce toxins that are harmful to fish and other animals and humans. Tests for the *A. flos-aquae* toxin have not been routinely performed, because adequate testing protocols have not been available (Anderson, pers. comm., 2011). *M. aeruginosa* produces a compound known to cause liver failure. Samples taken from areas frequented by recreational users of the reservoirs contained cell counts up to 4,000 times greater than what the World Health Organization considers a moderate health risk (see Section 3.4). This has resulted in the reservoirs being posted by local health officials during each summer since 2005.

The 22 miles long riverine reach between J.C. Boyle and Copco 1 Reservoirs, is divided into two reaches: a 4-mile long bypass reach, which receives bypass flows from J.C. Boyle Dam, and a 17-mile long “peaking reach,” which receives variable flow from hydroelectric operations. The downstream 6.2 miles is designated by CDFG as a Wild Trout Area with the whole reach managed for wild trout (FERC 2007) and the reach from the J.C. Boyle Powerhouse to the California-Oregon border is designated as a National Wild and Scenic River. Approximately 100 cfs is released from J.C. Boyle Dam through a minimum flow outlet and the ladder. This is augmented by inflows from Big Springs of about 220 to 250 cfs (FERC 2007, more recent estimates indicate this inflow is about 285 cfs). In the peaking reach, this flow is provided by flows from the powerhouse, which can range from 0 to over 3,000 cfs, depending on water availability (FERC 2007). Depending on water availability, power demands and whitewater boating needs, peaking operations can occur daily, or cycles may extend over several days. The 1.5 mile long Copco 2 Bypass Reach, has flows of about 5 cfs provided below Copco 2 Dam. Both of these riverine reaches provide complex habitat suitable for salmonid spawning and rearing.

A number of tributary streams come into this reach, including Spencer, Shovel, Fall, Spring, and Camp Creeks. These streams provide suitable coldwater spawning and rearing habitat for riverine fish.

The reservoirs currently provide a recreational fishery for non-native fishes including largemouth bass, trout, catfish, crappie, and sunfish (Hamilton et al. 2011). Fishing is popular in Copco 1 and Iron Gate Reservoirs, especially for yellow perch, this area is known locally as the best yellow perch fishery in California (Hamilton et al. 2011). These reservoirs also support the native shortnose and Lost River suckers in small numbers that are believed to be individuals that have migrated down from the upstream reservoirs and are not thought to be self-sustaining populations or to be contributing to populations in upstream areas (Hamilton et al. 2011). Fish collections by Oregon State University in Copco 1 Reservoir during 1998 and 1999 found about 13 percent of all adult fish caught were listed suckers, primarily shortnose sucker. One percent of the adult fish in Iron Gate Reservoir were listed sucker, and those were only shortnose sucker. Riverine sections between reservoirs support populations of speckled dace, marbled sculpin, tui chub, and rainbow and redband trout. This area historically supported anadromous fish populations, including Chinook and coho salmon, steelhead, and Pacific lamprey. These fish can no longer access this area because of the dams.

Klamath River from Iron Gate Dam Downstream to Estuary

The lower Klamath River flows unobstructed for 190 miles downstream of Iron Gate Dam before entering the Pacific Ocean. Downstream of Iron Gate Dam, the Klamath River has a gradient of approximately 0.0025 and four major tributaries enter this reach: the Shasta, Scott, Salmon, and Trinity Rivers.

The river basin downstream of Iron Gate Dam supports anadromous fish, including fall-run and spring-run Chinook salmon, coho salmon, steelhead, green sturgeon, American shad, and Pacific lamprey. Most of the anadromous salmonid species spawn primarily in the tributary streams, although fall-run Chinook salmon and coho salmon do spawn on the mainstem. The mainstem also serves as a migratory corridor and as rearing habitat for juveniles of many salmonid species (FERC 2007). The amount of time spent on the mainstem varies with species, run, temperature and hydrologic conditions in the mainstem and the tributaries. Pacific lamprey are also found throughout the mainstem Klamath River and its major tributaries downstream of Iron Gate Dam. Green sturgeon (belonging to the Northern Green Sturgeon DPS) spawn and rear in the Klamath River downstream of Ishi Pishi Falls, and in the Salmon and Trinity Rivers. Tributaries to the Klamath River provide hundreds of miles of suitable habitat for anadromous fish. Stocks of anadromous fish stocks have declined substantially from historical levels (NRC 2004, FERC 2007). The ability of the mainstem Klamath River to support the rearing and migration of anadromous species is reduced by periodic high water temperatures during summer, poor water quality (low DO and high pH; see Sections 3.2.3.5 and 3.2.3.6), and disease outbreaks during spring. Habitat quality in the tributaries is also affected by high temperatures. The Shasta and Scott Rivers also are impaired by low flows, high water temperatures, stream diversions, non-native species, and degraded spawning habitat (Hardy and Addley 2001; FERC 2007; North Coast Regional Water Quality Control Board [NCRWQCB] 2010). In the Salmon River, past and present high severity fires and logging roads in the basin contribute to high sediment yields, and continued placer mining has disturbed spawning and holding habitat (NRC 2004).

The Trinity River (RM 42.8) is not expected to be directly affected by conditions in the mainstem Klamath River, but the lower one-quarter to one-half mile of the river may be used by fish as refuge during the drawdown. Fish populations in the Trinity River are expected to be directly affected by the Proposed Action while migrating along the mainstem Klamath River, and indirectly affected by potential changes in salmonid escapement to the basin.

Klamath River Estuary and Pacific Ocean Nearshore

Wallace (1998) surveyed the Klamath River Estuary, and noted formation of a sand berm at the river mouth each year in the late summer or early fall, raising the water level in the estuary, reducing tidal fluctuation, and restricting saltwater inflow. The surveys found brackish water layer along the bottom of the estuary may be extremely important to rearing juvenile salmonids, as they appeared to be more abundant near the freshwater/saltwater interface. Juvenile Chinook salmon may also use the cooler brackish water layer as a thermal refuge.

The Klamath River Estuary supports a wide array of fish species and may also serve as breeding and foraging habitat for marine and estuarine species. These species include, but are not limited to all of the anadromous fish listed previously, federally threatened Southern DPS green sturgeon, Pacific herring, surf smelt, longfin smelt, eulachon, top smelt, starry flounder and other flatfish, Klamath speckled dace, Klamath smallscale sucker, prickly sculpin, and Pacific staghorn sculpin, northern anchovy, saddleback gunnel, and bay pipefish.

3.3.3.3 Habitat Attributes Expected to be Affected by the Project

The action alternatives would affect the physical, chemical, and biological components of habitat throughout the Klamath River watershed, from the tributaries to Upper Klamath Lake downstream to the Pacific Ocean. These effects would result from changes in suspended sediment, bedload sediment, water quality, water temperature, disease and parasites, and flow related habitat. As described in the following sections, these changes would act in both beneficial and harmful ways on species, critical habitat, and EFH. Appendices E and F provide more detailed technical descriptions of suspended sediment and bedload sediment. Changes in water quality are discussed in greater detail in Section 3.2, Water Quality and its associated appendices, and a description of the effects of the action alternatives on algae is found in Section 3.4, Algae. A description of these parameters, water temperature, and disease and parasites under existing conditions is provided in the following sections.

Suspended Sediment

Lower Klamath River: Downstream of Iron Gate Dam

The downstream transport of suspended sediment can affect species through elevated suspended sediment concentrations (SSCs) that may clog or abrade the gills of fish, or reduce foraging efficiency and as the material settles on the stream bed during declining flows, it can reduce the survival of incubating eggs and developing alevins in salmonid redds by impeding intergravel flow as well as the emergence of fry. SSCs under existing conditions in the Klamath River upstream and downstream of Iron Gate Dam are summarized in Section 3.2.3, Water Quality. In general, the data indicate that suspended sediment downstream of Iron Gate Dam ranges from less than 5 mg/L during summer low flows to greater than 5,000 mg/L during winter high flows (see Section 3.2.3.3). During large winter storms or following landslides in the Klamath Basin, extremely high SSCs have been observed in the Klamath River mainstem and tributaries. Appendix E provides a detailed analysis of the effects of suspended sediment on aquatic species downstream of Iron Gate Dam under existing conditions. To provide a reliable basis for a relative comparison of SSCs to the alternatives, SSCs under existing conditions were calculated using the SRH-1D model (Reclamation 2011) based on hydrology data from 1961 to present. SSCs were developed for two conditions meant to represent the existing range of variability under existing conditions, defined as follows:

- **Normal conditions:** suspended sediment concentrations and durations with a 50 percent exceedance probability for the mainstem Klamath River downstream of Iron Gate Dam (i.e., the probability of these concentrations and durations being equaled or exceeded in any one year is 50 percent). Exceedance probabilities were based on modeling SSC for all water years subsequent to 1961 with facilities in place. To assess “normal conditions” the median (50 percent) suspended sediment concentration and duration from these results was estimated (Figure 3.3-2).

- **Extreme conditions:** suspended sediment concentrations and durations with a 10 percent exceedance probability (i.e., the probability of these concentrations and durations being equaled or exceeded in any 1 year is 10 percent). This represents an extreme condition (Figure 3.3-3).

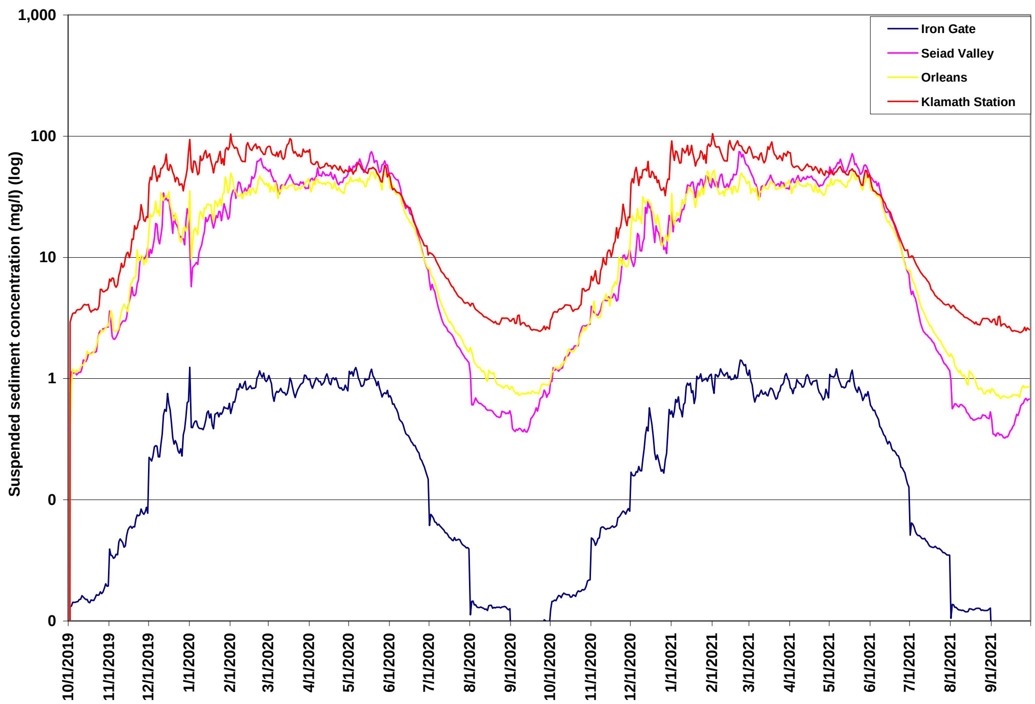

Figure 3.3-2. Normal conditions (50 Percent Exceedance Probability) SSCs for Three Locations Downstream of Iron Gate Dam under Existing Conditions, as Predicted Using the SRH-1D Model.

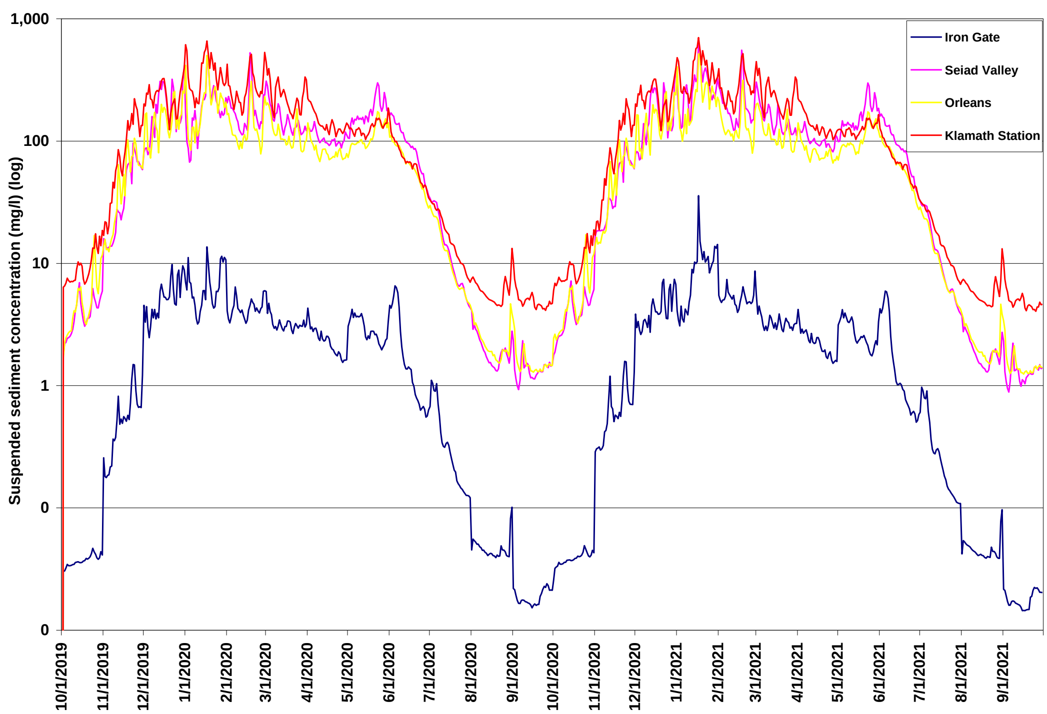

Figure 3.3-3. Extreme conditions (10 Percent Exceedance Probability) SSCs for Three Locations Downstream of Iron Gate Dam under Existing Conditions, as Predicted Using the SRH-1D Model.

Under both normal and extreme conditions, SSCs of the magnitude and duration modeled are expected to cause major stress to migrating adult and juvenile salmonids primarily during winter (Newcombe and Jenson 1996, Appendix E). SSC generally increases in a downstream direction from the contribution of tributaries, and since Iron Gate Dam currently effectively traps most suspended sediment.

Klamath River Estuary

Under existing conditions SSCs within the Klamath River Estuary is relatively high. As described in Section 3.2.4.3.1.2, the lower Klamath River downstream of the Trinity River confluence to the estuary mouth is currently listed as sediment impaired under Section 303(d) of the Clean Water Act, as related to protection of the cold freshwater habitat beneficial use associated with salmonids (NCRWQCB 2010). Modeling in the Klamath River (from Seiad Valley at approximately RM 128 downstream to the Klamath Station at RM 5) under normal conditions indicates that SSCs are generally less than 100 mg/L year-round (Figure 3.3-2), and under extreme conditions are less than 100mg/L in summer and fall but can spike to well over 100 mg/L during winter and spring (Figure 3.3-3).

Pacific Ocean Nearshore Environment

Under existing conditions a "plume" exists within the nearshore environment in the Klamath River vicinity that is subject to strong land runoff effects following winter rainfall events. These effects include low-salinity, high levels of suspended particles, high sedimentation, and low light (and potential exposure to land-derived contaminants). The extent and shape of the plume is variable, and influenced by wind patterns, upwelling effects, shoreline topography (especially Point Saint George), and longshore currents. High SSCs events contribute to the plume, especially during floods. In a recent study of the Eel River nearshore sediment plume, located approximately 80 miles to the south of the Klamath River, *in situ* measurements of plume characteristics indicated no relationship with SSCs, turbulent-kinetic-energy, time from river mouth, wind speed, wave height, or discharge. A relationship apparently did exist between effective settling velocity (bulk mean settling velocity) of plume sediments and wind speed/direction, as well as with tides (Curran et al. 2002).

<u>Bedload</u>

Appendix F describes current habitat conditions and assesses the changes to bedload sediment within the analysis area for existing conditions, and under each Klamath River EIS/EIR alternative. The sections below provide a brief summary of the analysis provided in Appendix F.

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir

For all practical purposes, the amount of sediment supplied to the Klamath River from the Klamath Basin upstream of Keno Dam is negligible (Reclamation 2011). Upper Klamath Lake, with its large surface area, traps nearly all sediment delivered from upstream tributaries, although some finer material may be transported through the lake during high runoff events. All fluvial sediment supplied to reaches downstream of Iron Gate Dam is delivered to the Klamath River between Keno Dam and Iron Gate Dam. Sources within this reach supply 24,160 tons/year of coarse sediment (1.3 percent of the cumulative average annual basin wide coarse sediment delivery) (Stillwater Sciences 2010a).

Hydroelectric Reach: Klamath River from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam

The Project reservoirs are the dominant feature in this 38-mile reach, with a 22-mile riverine section between J.C. Boyle Dam and Copco 1 Reservoir and a 1.5-mile riverine reach between Copco 2 Dam and Iron Gate Reservoir. The four Project dams currently store 13.15 million yd^3 of sediment (Reclamation 2011), with Copco 1 Reservoir storing the largest amount of sediment (Table 3.3-2). The sediment stored behind the dams has high water content and 85 percent of its particles are silts and clays (particle size less than 0.063 mm) while 15 percent are sand or coarser (particle size higher than 0.063 mm) (Gathard Engineering Consulting 2006; Stillwater Sciences 2008; Reclamation 2011). As such, most sediment released from behind the dams under the Proposed Action would be silt and clay (less than 0.063 mm) with smaller fractions of sand (0.063 to 2 mm), gravel (2 to 64 mm), and cobble (64 to 256 mm) (Gathard Engineering Consulting 2006; Stillwater Sciences2010a; Reclamation 2011).

Table 3.3-2. Estimated Volume of Sediment Currently Stored within Hydroelectric Reach Reservoirs (Reclamation 2011).

Reservoir	Current Sediment Volume (yd^3)
J.C. Boyle	1,000,000
Copco 1	7,440,000
Copco 2	0
Iron Gate	4,710,000
Total	**13,150,000**

Lower Klamath River: Downstream of Iron Gate Dam

Downstream of Iron Gate Dam, channel conditions reflect the interruption of sediment flux from upstream by Klamath Hydroelectric Project dams and the eventual re-supply of sediment from tributaries entering the mainstem Klamath River (PacifiCorp 2004a; Reclamation 2011). The reach from Iron Gate Dam to Cottonwood Creek (RM 182.1) is characterized by coarse, cobble-boulder bars immediately downstream of the dam, transitioning to a cobble bed with pool-riffle morphology farther downstream near Cottonwood Creek (Montgomery and Buffington 1997; PacifiCorp 2004a; Stillwater Sciences 2010a). Cottonwood Creek to the Scott River is a confined channel with a cobble-gravel bed and pool-riffle morphology (PacifiCorp 2004a). The median bed material ranges from 45 to 50 mm, but bar substrates become finer in the downstream direction, with median sizes of 49 mm and 25 mm at the upstream and downstream ends, respectively. Downstream of the Scott River, including through the Seiad Valley, the Klamath River is cobble-gravel bedded with pool-riffle morphology (PacifiCorp 2004a). PacifiCorp (2004a) also noted increasing quantities of sand and fine gravel on the bed surface with distance downstream, likely reflecting the resupply of finer material from tributaries to the Klamath River.

The Klamath Hydroelectric Project dams trap most of the finer sediment produced in the low sediment yielding, young volcanic terrain upstream of the dams, which results in coarsening of the channel bed downstream of the dams until tributaries resupply the channel with finer sediment. However, most of the supply from the portion of the watershed upstream of J.C. Boyle Reservoir is trapped in Upper Klamath Lake, which is a natural lake. Most (≈98 percent) of the sediment supplied to the mainstem Klamath River (Stillwater Sciences 2010a) is delivered from tributaries downstream of Cottonwood Creek, limiting the effects of interrupting upstream sediment supply downstream of around Scott River.

Reclamation (2011) used reach average hydraulic properties and previously collected grain size data to estimate the flow magnitude and return period at which sediment mobilization occurs downstream of Iron Gate Dam. The estimates did not include the reach from Iron Gate Dam to Bogus Creek, for which there were no grain size data. Reclamation (2011) assumed this reach to be fully armored because there has been no sediment supplied to this reach in the past 50 years because the dams capture sediment from upstream. From downstream of Bogus Creek to Willow Creek, flows to mobilize median substrate sizes (D50) ranged from 6,800 to 12,700 cfs, and recur every 2.6 to 7.5 years, on average (Figure 3.3-4).

Water Quality

Section 3.2.3 provides information regarding water quality as it relates to aquatic resources in the area of analysis. As described, therein, many water bodies in the area of analysis are listed under Section 303 (d) of the Clean Water Act for a variety of parameters including temperature, sediment and turbidity, nutrients, dissolved oxygen, pH, ammonia, Chlorophyll-*a*, and microcystin (Table 3.2-8 in Section 3.2., Water Quality). The SSCs, dissolved oxygen, and temperature are evaluated in greater detail in Section 3.3.3.3. Microcystins are also addressed in Section 3.4, Algae.

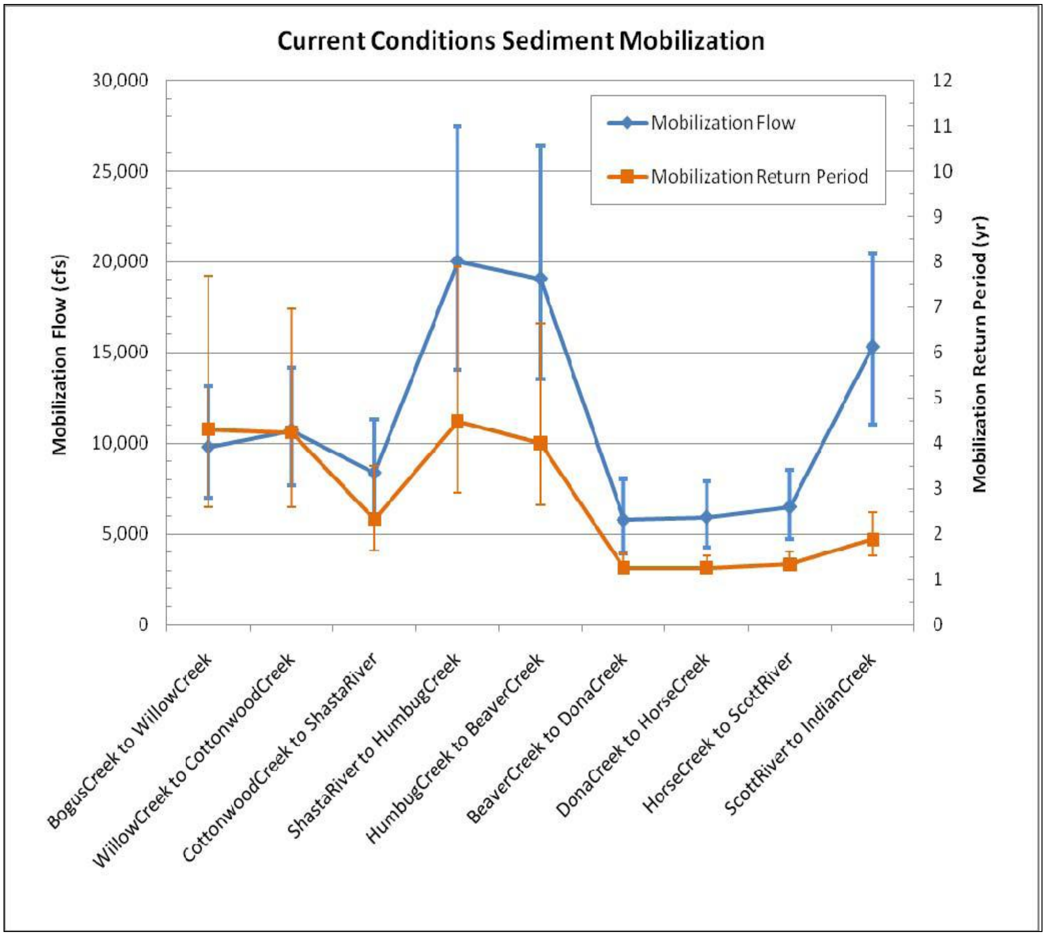

Figure 3.3-4. Mobilization Flow and Return Period at which Sediment Mobilization Occurs (Reclamation 2011).

Water Temperature

As described in Section 3.2, Water Quality, the entire Klamath River, including Upper Klamath Lake, Lost River, and the Klamath Straights Drain, has been listed as impaired for water temperature (Oregon Department of Environmental Quality (ODEQ 2002). Temperatures in the Klamath River are of special concern as they are elevated with a greater frequency and they remain elevated for longer periods of time than temperatures in adjacent coastal anadromous streams, and are currently marginal in the lower mainstem for anadromous salmonids (Bartholow 2005). These elevated temperatures are especially detrimental to anadromous species during the warmer portions of the year (ODEQ 2002). Acute thermal effects for salmonids are expected to occur as mean daily water temperatures begin to exceed 20°C (Bartholow 2005). Bartholow (2005) expressed concern that if water temperature trends in the mainstem Klamath River downstream of Iron Gate Dam continue, some stocks may decline to levels insufficient to ensure survival. Elevated temperatures can affect the timing of different life-history events, altering migration patterns, delaying and shortening the spawning season, impairing reproductive success, reducing growth, and result in an ongoing lack of temporal diversity (Hamilton et al. 2011). High water temperatures can contribute to low dissolved oxygen events by accelerating oxygen-demanding processes, and can facilitate the spread of disease (Wood et al. 2006). Stress associated with high water temperatures can make cold water species more vulnerable to disease and parasites, and have been associated with fish kills in the Klamath River downstream of Iron Gate Dam during low flow periods in late summer (Hardy and Addley 2001).

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir
Summer water temperatures are naturally high in Upper Klamath Lake. In the summer, instantaneous maximum water temperatures of 22 to 24°C are common in the upper 3 to 6 feet of Upper Klamath Lake and temperatures can approach a maximum of 30°C near the surface (PacifiCorp 2004a). Although prolonged exposure to these high temperatures could be lethal for some species, these temperatures remain within tolerance criteria for migrating adult anadromous salmonids (Hamilton et al. 2011), and anadromous salmonids successfully navigated through the lake to spawn in the Upper Basin prior to their access being blocked by the Project. In the late summer and early fall, temperatures in Upper Klamath Lake are actually cooler than those downstream of Iron Gate Dam in the late summer and early fall when fall-run Chinook salmon are migrating. In addition, thermal refugia are available where fish can moderate the temperatures they are exposed to. Upper Klamath Lake supports a population of redband trout that move into cooler tributary habitats in the summer, but which have high growth rates while in the lake. Those in the lake over the summer can find thermal refuge in Pelican Bay, which is fed by springs and remains cool (Dunsmoor and Huntington 2006). Wetlands surround this bay and would be expected to provide juvenile salmonids with excellent rearing habitat (Dunsmoor and Huntington 2006).

Both Upper Klamath Lake and the Keno Impoundment/Lake Ewauna are relatively shallow; temperatures in Upper Klamath Lake, the Keno Impoundment/Lake Ewauna, and J.C. Boyle Reservoir are generally warm during the late spring through early fall (see Section 3.2.3.2). Under existing conditions, water temperatures are suitable for migrating salmonids from mid-September to mid-June in Upper Klamath Lake and Keno Impoundment (Dunsmoor and Huntington 2006).

The Keno Impoundment/Lake Ewauna has generally poor water quality in the summer, with instantaneous maximum water temperatures exceeding 25°C and low dissolved oxygen (Hamilton et al. 2011). These warm temperatures are also present downstream of Keno Dam. However, from November through mid-June, the reach from Link River Dam to Keno Dam is cooler (below 20°C) and meets criteria for migrating adult anadromous salmonids (Hamilton et al. 2011). Temperatures in the Link River and the Keno Impoundment/Lake Ewauna tend to increase in the summer; maximum water temperatures (22 to 25°C) are still within the preferred range for warm- and some cool-water species found in the Upper Klamath Basin (yellow perch, catfish, sunfish, largemouth bass, and spotted bass), but temperatures above 22 to 25°C are potentially lethal to anadromous salmonids.

Hydroelectric Reach: Klamath River from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam

Water temperatures through the Hydroelectric Reach are generally warm in the reservoirs from late spring through early fall, but tributaries are generally cool (see Section 3.2.3.2). In addition, numerous cold-water springs contribute flows to both Copco 1 and Iron Gate Reservoirs. Average monthly water temperatures within reservoirs from 2001 to 2004 ranged from just over 5°C in November to more than 22°C in June through August (FERC 2007), with thermal stratification in Copco 1 and Iron Gate reservoirs resulting in relatively warm discharge waters during summer months. Water temperatures at the downstream end of the J.C. Boyle Bypass Reach and in the Klamath River upstream of Shovel Creek are consistently cooler than other sites sampled between Link Dam and the Shasta River (PacifiCorp 2004b) (see Section 3.2.3.2). Temperatures in the J.C. Boyle Bypass Reach are cooled by the contribution of 200 to 250 cfs of groundwater within the reach. The cool water input from the bypass reach during the summer results in a relatively lower daily water temperature range in the Klamath River in the J.C. Boyle Peaking Reach (FERC 2007).

Temperature data for tributary reaches are based on a limited study period as described in PacifiCorp (2004a). Fall Creek, which flows into Iron Gate Reservoir, is generally cold year-round and does not exceed 14°C degrees during the summer (Pacificorp 2004a). Temperatures in Jenny Creek, which also flows into Iron Gate Reservoir, vary seasonally, ranging from less than 10°C in the spring to more than 22°C in July and August (PacifiCorp 2004a). Temperatures in Shovel Creek are generally low year-round and do not exceed 15°C in the summer (PacifiCorp 2004a). Spencer Creek temperatures are low during spring (<15°C) and are generally below 18°C, but can exceed 20°C for short durations (Pacificorp 2004a)

Copco 1 and Iron Gate Reservoirs reach maximum temperatures exceeding 20°C near their surfaces during the summer while maintaining average temperatures near 8°C or 10°C when stratified (PacifiCorp 2004a). These cooler water temperatures at a depth >6–8 m below the surface (see Appendix C, Section C.1.1.4) are a result of 4°C water entering Copco 1 and Iron Gate Reservoirs from upstream areas during the winter and the relatively shallow outlets of both reservoirs (PacifiCorp 2004a). During reservoir stratification, dissolved oxygen in Iron Gate and Copco 1 in deeper waters decreases and can reach minimum values close to 0 mg/L by July near the reservoir bottoms (see Appendix C, Section C.4.1.4). Although temperatures are increasing in the summer months, temperatures documented in these reaches are all within the tolerance ranges of the species observed there (see Section 3.2.3.2), but would be considered stressful for cold water species.

Lower Klamath River: Downstream of Iron Gate Dam

Water temperatures in spring in the Lower Klamath Basin downstream of Iron Gate Dam can be slightly cooler from reservoir releases than those upstream of Iron Gate Dam (see Section 3.2.3.2), with this difference diminishing downstream of Iron Gate Dam with no noticeable difference just upstream of the Salmon River confluence. Summer weather conditions, however, can be severe from June through September, and rising ambient air temperatures can lead to increased water temperatures (Hamilton et al. 2011). Downstream of Iron Gate Dam, mean monthly temperatures in the river are 3 to 6°C in January and 20 to 22.5 °C in July and August (Bartholow 2005). Substantial losses of juvenile salmonids have occurred during their migration through the lower Klamath River, and were especially severe during low-water years with periods of sustained high water temperatures, which may cause them to crowd into thermal refugia and may reduce the resistance of these fish to disease and other stressors (Scheiff et al. 2001). Summary statistics compiled by the United States Environmental Protection Agency indicate that water temperatures at locations between Iron Gate Dam and the Klamath River's confluence with the Scott River range from about 16 to 22°C in June, and from 16 to 26°C in July (FERC 2007). The Klamath Basin downstream of Iron Gate Dam (i.e., the Lower Klamath Basin) supports a variety of species of anadromous fish including fall and spring Chinook salmon, coho, steelhead, green sturgeon, and Pacific lamprey. From May through September (peaking in June–August) summer temperatures begin to warm to stressful levels for cold water species such as salmon, steelhead, and Pacific lamprey.

Klamath River Estuary and Pacific Ocean Nearshore Environment
Water temperatures in the estuary range from 5 to 12 °C from December through April (Hiner 2006). Warmer air temperatures and lower flows in summer and fall months result in increased water temperatures ranging from 20 to 24°C (Hiner 2006). Under summer low-flow conditions, water temperatures in the Klamath Estuary exceed those for optimal growth as well as critical thermal maxima for Chinook salmon, coho salmon, and steelhead (Stillwater Sciences 2009a). Input of cool ocean water provides cooler areas for fish and fog along the coast minimizes this effect much of the time.

Disease and Parasites
Fish diseases, specifically the myxozoan parasites *Ceratomyxa shasta* (*C. shasta*) and *Parvicapsula minibicornis*, periodically result in substantial mortality for Klamath River salmonids, (though steelhead are generally resistant to *C. shasta*). Additional diseases that may affect fish in the Klamath Basin include *Ichthyophthirius multifis* (Ich) and *Flavobacterium columnare* ("columnaris disease"). These parasites and diseases occur throughout the watershed, but appear to cause the most severe mortality in the Lower Klamath Basin where *C. shasta* has been observed to result in high rates of mortality in salmon. Ich and columnaris occur episodically, occasionally resulting in substantial mortality (e.g., the 2002 fish kill of juvenile and adult Chinook salmon). The effects of Ich and columnaris are generally not as harmful as the myxozoan parasites, although impacts on juvenile salmonids and other species have not been well studied.

Both *P. minibicornis* and *C. shasta* spend part of their life cycle in an invertebrate host and another part in a fish host. Transmission of these parasites is limited to areas where the invertebrate host is present. In the Klamath River, their invertebrate host is the annelid polychaete worm *Manayunkia speciosa* (Bartholomew et al. 1997, 2007). Once the polychaetes are infected, they release *C. shasta* actinospores into the water column. Actinospores are generally released when temperatures rise above 10°C and remain viable from 3 to 7 days at temperatures from 11 to 18ºC, with temperatures outside that range resulting in a shorter period of viability (Foott et al. 2007). The longer the period of viability, the wider the distribution of the actinospores, raises exposure rate of salmon over a larger area of the river (Bjork and Bartholomew 2010). Actinospore abundance, a primary determinant of infectious dose, is controlled by the number of infected polychaetes and the prevalence and severity of infection within their population.

Salmon become infected when the actinospores enter the gills, eventually reaching the intestines where the parasite replicates and matures to the myxospore stage. Myxospores are shed by the dying and dead salmon, and the cycle continues with infection of polychaete worms by the myxospores (Bartholomew and Foott 2010). The polychaete host for the parasite is present in a variety of habitat types, including runs, pools, riffles, edge-water, and reservoir inflow zones, as well as sand, gravel, boulders, bedrock, aquatic vegetation, and is frequently present with a periphyton species: *Cladophora* (Bartholomew and Foott 2010). Slow-flowing and more stable habitats (e.g., pools with sand) may support higher densities of polychaetes, (Bartholomew and Foott 2010), especially if instream flows remain constant.

Bartholomew (1998) noted that native populations of salmonids in waters where *C. shasta* is endemic generally develop a high degree of resistance to the disease. Stocking et al. (2006) conducted studies of the seasonal and spatial distribution of *C. shasta* in the Klamath River. The study included the exposure of fall Chinook salmon (*Oncorhynchus tshawytscha*; Iron Gate Hatchery strain). The study found the polychaete host, *M. speciosa*, from Upper Klamath Lake to the mouth of the river. Although infection rates were high in non-native, non-resistant, rainbow trout, used as sentinel fish in the upper Klamath River upstream of Iron Gate Dam and below the Williamson River, mortality rates were very low (Stocking et al. 2006). Chinook salmon at this location did not become infected. Minimal mortality in both was likely due to low levels of parasites in this area and a predominance of Type 0 genotype of *C. shasta* (see below). Because the parasites are endemic to the watershed, the native salmonid populations have some level of resistance to the disease. However, an altered river channel below Iron Gate Dam, where the bed has been atypically stable, has provided favorable habitat for the polychaete worm host, likely increasing the parasite load to which the fish are exposed. High parasite loads are believed to lead to higher rates of mortality.

Susceptibility to *C. shasta* is also influenced by the genetic type of *C. shasta* fish encounters. Atkinson and Bartholomew (2010) conducted an analysis of the genotypes of *C. shasta* and the association of these genotypes with different salmonid species, including Chinook and coho salmon, steelhead, rainbow trout, and redband trout. In the Williamson River, although parasite densities had been found to be high, Chinook salmon were resistant to infection because the genotype specific to Chinook salmon was absent. In a genetic analysis, the *C. shasta* genotypes were characterized as Type 0, Type I, Type II and Type III (Table 3.3-3):

Table 3.3-3. *C. shasta* Genotypes in the Klamath Basin.

C. shasta Genotype	Distribution	Affected Species	Notes
Type 0	Upper and Lower Klamath Basin	native steelhead, rainbow, and redband trout	Usually occurs in low densities, is not very virulent, and causes little or no mortality
Type I	Lower Klamath Basin	Chinook salmon	If the Type I genotype were carried into the Upper Basin, only Chinook salmon would be affected
Type II	Klamath Lake, Upper and Lower Klamath Basin	coho salmon and non-native rainbow trout	The "biotype" found in the Upper Basin does not appear to affect coho salmon, and risks to native rainbow/redband trout are low[1]
Type III	Assumed widespread in Klamath Basin based on presence in fish	all salmonid species	Prevalence of this genotype is low and it infects fish but does not appear to cause mortality

[1] (J. Bartholomew, pers. comm.)

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir

Fish in the upper Klamath River are exposed to disease and parasites. All of the diseases and parasites described above can occur here. *C. shasta* and *P. minibicornis* are both known to occur in the Upper Basin, and *C. shasta* density is reported to be as high in the Williamson River as it is in the area downstream of Iron Gate Dam. In this section of the river, however, *C. shasta* does not have the same serious effects as it does downstream of Iron Gate Dam, because of the genotype of the parasite and the higher resistance of the redband trout to the disease. Historically *C. shasta* and *P. minibicornis* occurred in the Upper Basin and resident fish above the dams evolved with these parasites.

Despite the fact that Klamath River fish disease science has advanced greatly in the past five years, no recent information indicates a conflict with the finding that the movement of anadromous fish above Iron Gate Dam presents a relatively low risk of introducing pathogens to resident fish (Administrative Law Judge 2006, USFWS/NOAA Fisheries Service Issue 2(B)).

Hydroelectric Reach: Klamath River from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam

As described above, Stocking et al. (2006) found the polychaete host for *C. shasta* and *P. minibicornis* throughout the mainstem Klamath River, including the reach from J.C. Boyle Reservoir to Iron Gate Dam (the Hydroelectric Reach). In J.C. Boyle Reservoir, densities of polychaetes increased with distance from the reservoir inflow. Stocking and Bartholomew (2007) noted that the ability of some polychaete populations to persist through disturbances (e.g., large flow events) indicates that the lotic populations are influenced by the stability of the microhabitat they occupy.

Lower Klamath River: Downstream of Iron Gate Dam

In the lower Klamath River, the polychaete host for *C. shasta* and *P. minibicornis* is aggregated into small, patchy populations mostly concentrated between the Interstate 5 bridge and the Trinity River confluence, and especially above the Scott River (Stocking and Bartholomew 2007). The reach of the Klamath River from the Shasta River to Seiad/Indian Creek is known to be a highly infectious zone with high actinospores exposure, particularly from May through August (Beeman et al. 2008). This portion of the river contains areas of dense populations of polychaetes within low-velocity habitats with *Cladophora* (a type of green algae), sand-silt, and fine benthic organic material in the substrate (Stocking et al. 2007). High parasite prevalence in the lower Klamath River is considered to be a combined effect of high spore input from heavily infected, spawned adult salmon that congregate downstream of Iron Gate Dam and Iron Gate Hatchery and the proximity to dense populations of polychaetes (Bartholomew et al. 2007). The highest rates of infection occur in the lower Klamath River downstream of Iron Gate Dam (Stocking and Bartholomew 2007; Bartholomew and Foott 2010).

Despite potential resistance to the disease in native populations, fish (particularly juvenile fish, and more so at higher water temperatures) exposed to high levels of the parasite may be more susceptible to disease. Chinook and coho salmon migrating downstream have been found to have infection rates as high as 90 percent and 50 percent, respectively (Bartholomew and Foott 2010). The number of juvenile salmonids that become infected is estimated to be 10 to 70 percent annually based on surveys of fish captured in the river (True et al. 2010). High infection rates are apparently resulting in high mortality of outmigrating smolts. Studies of outmigrating coho salmon smolts by Beeman et al. (2008) estimated that disease-related mortality rates were between 35 and 70 percent in the Klamath River near Iron Gate Dam. Their studies suggested that higher spring discharge increased smolt survival (Beeman et al. 2008). In 2008, mortality rates were as high as 85 percent in May (7-day exposure for age 1+ coho smolts), and 96 percent (age 0+ coho smolts) and 84 percent (0+ Chinook smolts) in June (3-day exposure). In May 2004, the USFWS, the Yurok Tribe and the Karuk Tribe, reported high levels of mortality and disease infections among naturally produced juvenile Chinook salmon captured in downstream migrant traps fished in the Klamath River (Klamath Fish Health Assessment Team [KFHAT] 2005). The symptoms observed included bloated abdominal cavities, pale gills, bloody vents, and pop-eye. Infected fish also exhibited lethargic behavior, poor swimming ability and increased vulnerability to handling stress. The primary cause of the disease was found to be *C. Shasta*, with *P. minibicornis* observed as well. The 2004 mortality event was not quantified, because of limited resources and other problems associated with sampling small fish in a large river system. Other recent fish kills include the June 2000 and June 1998 fish kills. CDFG (2000) estimated 10,000 to 300,000 individuals, mostly young-of-year killed in the June 2000 event, believed to be infected with *C. shasta* and columnaris.

Ich and columnaris have occasionally had a substantial impact on adult salmon downstream of Iron Gate Dam as well, particularly when habitat conditions include exceptionally low flows, high water temperatures, and high densities of fish (such as adult Chinook salmon migrating upstream in the fall and holding at high densities in pools). In 2002, these habitat factors were present, and an outbreak of disease occurred, with more than 33,000 adult salmon and steelhead losses. Most of the fish affected by the 2002 fish die-off were fall-run Chinook salmon in the lower 36 miles of the Klamath River (CDFG 2004). Although losses of adult salmonids can be substantial when events such as the 2002 fish die-off occur, the combination of factors that leads to adult infection by Ich and columnaris disease may not be as frequent as the annual exposure of juvenile salmonids to *C. shasta* and *P. minibicornis*, as many juveniles must migrate each spring downstream past established populations of the invertebrate polychaete worm host.

Klamath River Estuary and Pacific Ocean Nearshore

While disease and parasites occur in the Klamath Estuary and Pacific Ocean, these areas are not known to be important source areas for these stressors. Juvenile salmonids that are weakened by disease or parasites upstream may succumb to those diseases once they enter the estuary or ocean as a result of the additional stress created by adapting to the saline environment.

<u>Algal Toxins</u>

Algae produced in Upper Klamath Lake and the reservoirs in the Klamath Hydropower Reach (Copco 1 and Iron Gate Reservoirs) may be deleterious to the health of aquatic organisms in Upper Klamath Lake and the Klamath River. Some cyanobacteria species, such as *M. aeruginosa*, produce toxins that can cause irritation, sickness, or in extreme cases, death to exposed organisms (see Section 3.2.3.7 and Appendix C, Section C.6). While direct links to fish health are still somewhat unclear, recently collected data from the Klamath Basin indicates that algal toxins are bioaccumulating in fish tissue at concentrations that may be detrimental to the affected species.

In Upper Klamath Lake, a preliminary study of the presence, concentration, and dynamics of microcystin as related to Lost River sucker (*Deltistes luxatus*) and shortnose sucker (*Chasmistes brevirostris*) exposure is currently ongoing. United States Geological Survey (USGS) collected water samples at multiple lake sites from July to October 2007 and June through September 2008 and found evidence of gastro-intestinal lesions in juvenile suckers that had ingested chironomid larvae, which had in turn ingested *A. flos-aquae* and colonies of *M. aeruginosa*. The lesions were observed when liver necrosis was either present or absent suggesting that the gastro-intestinal tract was the first point of toxin contact. The authors indicated that the totality of the evidence suggests that the fish were exposed to algal toxins, and that the route of exposure to toxins was an oral route through the food chain, rather than exposure to dissolved toxins at the gills (VanderKooi et al. 2010).

In the Klamath River downstream of Iron Gate Dam, preliminary results from salmonid tissue samples collected by the Karuk Tribe in 2010 show that three of seven Chinook salmon livers collected near Happy Camp had detectable levels of microcystin (Kann et al. 2011). During the period the Chinook salmon were collected, the 2010 longitudinal microcystin sampling showed very high microcystin levels being exported directly from Iron Gate Reservoir and then transported downstream to areas where Chinook salmon were migrating upstream (Kann and Johnson 2010). In addition, data from 2007 indicate microcystin bioaccumulation in juvenile salmonids reared in Iron Gate Hatchery (Kann 2008). Trace concentrations of microcystin were also found in Klamath River steelhead livers in 2005 (Fetcho 2006).

Aquatic Habitat

One of factors that influence habitat availability for aquatic species is instream flow. Reclamation manages Upper Klamath Lake to meet the requirements of biological opinions from the USFWS (2008) and NOAA Fisheries Service (2010a) and its contract requirements for the Reclamation's Klamath Project (Reclamation 2010). If implemented, the Proposed Action would result in changes in the operations of Upper Klamath Lake (see Section 2.4.3.9). These changes would affect reservoir elevations in Upper Klamath Lake, and river flows in downstream reaches. These hydrologic changes would result in changes to instream habitat. Studies to determine how fish habitat changes with flow have been conducted in areas of the Klamath River, including two reaches between J.C. Boyle Reservoir and Iron Gate Dam, for selected life stages of rainbow trout (Bureau of Land Management 2002) and seven locations between Iron Gate Dam and the estuary for selected life stages of Chinook salmon, coho salmon, and steelhead (Hardy et al. 2006).

The following sections describe the amount of flow-related habitat in various portions of the basin for the species for which information exists. Where specific information is not available for a species or area, the Lead Agencies used hydrologic changes, species habitat requirements, and comparisons with those species for which the Lead Agencies does have specific information to qualitatively assess changes in flow-related habitat. This information was used to evaluate how the Proposed Action and alternatives might result in changes to the amount of flow-related habitat. The Lead Agencies determined that the hydrologic record of the past decade was insufficient for describing the amount of habitat available under existing conditions because of management actions made over the past eight years to protect listed fish species (minimum lake elevations; minimum flows downstream of Iron Gate Dam). These changes are described in biological opinions from USFWS (2008) and NOAA Fisheries Service (2002, 2010a). The flows under existing conditions and with the various alternatives are described in Section 3.6, Flood Hydrology.

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir

This area was not evaluated for flow-related habitat, as no known flow-related habitat relationships exist for the Klamath or Link Rivers in this area. Some changes in flow-related habitat in tributaries to Upper Klamath Lake may occur; however, the location and magnitude of these changes are unknown at this time.

Water surface elevations in Upper Klamath Lake are expected to vary as a result of implementation of the Proposed Action and alternatives. The USFWS biological opinion (2008) provides information on the amount of habitat provided for Lost River and shortnose suckers at different lake elevations, with higher elevations providing increased habitat for all life stages of sucker. It requires that Reclamation maintain the lake at minimum elevations from February through October each year to protect shortnose and Lost River suckers.

Under existing conditions (as indicated by the hydrologic modeling for the No Action/No Project Alternative), lake elevations are maintained at elevations ranging from about 4,138 to 4,142.2 feet in drier conditions (90 percent exceedance) and 4,139.8 to

4,143.3 feet under wetter conditions (20 percent exceedance). Lake elevations increase during the fall and winter, peak in April or May, and then decline until October.

Hydroelectric Reach: Klamath River from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam

Under its existing license, PacifiCorp operates the J.C. Boyle Powerhouse in peaking mode, meaning that water is run through the powerhouse to generate electricity cyclically depending on water availability and power demand. Flows through the reach downstream of Copco 2 Dam are only about 5 cfs unless spill is occurring as a result of high runoff or project maintenance (PacifiCorp 2004a). Based on an Indicators of Hydrologic Alteration (IHA) Analyses (Richter et al. 1996) of flows within the reach downstream of J.C. Boyle Powerhouse, Huntington (2004) found a high rate of deviation from conditions that would be expected without the project influencing conditions. Substantial changes in flow (350 to 3,000 cfs) can occur within the course of a single day in the 17-mile long J.C. Boyle Peaking Reach (the reach of the Klamath River between J.C. Boyle Powerhouse and Copco 1 Reservoir). These flow fluctuations can result in temperature fluctuations in this reach ranging 5–15°C during the summer months (ODEQ 2010). These extreme flow fluctuations may also result in stranding of fish and invertebrates (Dunsmoor 2006, as cited in FERC 2007), reductions in aquatic invertebrate production (City of Klamath Falls 1986, as cited in Hamilton et al. 2011), displacement of fish, and higher energetic costs to fish to maintain their position (FERC 2007). In the Trial-type Hearing for the relicensing of the Klamath Hydroelectric Project (Administrative Law Judge 2006), it was found that this reach had lower macroinvertebrate drift rates, indicating a reduced food base for fish.

Lower Klamath River: Downstream of Iron Gate Dam

The Biological Opinion issued in 2010 by NOAA Fisheries Service for the protection of coho salmon changed the flow requirements immediately downstream of Iron Gate Dam from those contained in the annual license. These changes to operations increased minimum flows downstream of Iron Gate Dam, set ramping rates to match those of Upper Klamath Lake inflows, and set target water surface elevations for Upper Klamath Lake. The revised ramp-down rates are defined as follows.

- When flows at Iron Gate Dam are 3,000 cfs or above, Iron Gate Dam ramp-down rates will follow the rate of decline to inflows to Upper Klamath Lake combined with accretions between Keno Dam and Iron Gate Dam.
- When flows at Iron Gate Dam are between 1,750 cfs and 3,000 cfs, Iron Gate Dam ramp down rates will be 300 cfs or less per 24-hour period and no more than 125 cfs per 4 hour period.
- When flows at Iron Gate Dam are 1,750 cfs or less, Iron Gate Dam ramp down rates will be 150 cfs or less per 24 hour period and no more than 50 cfs per two hour period.

Because Upper Klamath Lake has limited storage capacity, Reclamation operates the lake on an annual refill basis. The proposed minimum lake levels (measured as feet above mean sea level at Iron Gate Dam) limit the drawdown of Upper Klamath Lake over the course of the summer. The minimum flows downstream of Iron Gate Dam, and the proposed minimum lake elevations and refill targets for Upper Klamath Lake are provided below (Table 3.3-4):

Table 3.3-4. 2010 Biological Opinion Proposed Flows and Lake Elevations.

Month	Klamath River	Upper Klamath Lake	
	Proposed Minimum Flows below Iron Gate Dam (cfs)	Proposed Minimum Lake Elevations (msl)[1]	Proposed Lake Refill Target Elevations (msl)[1]
October	1,000	--	4139.1
November	1,300	--	4139.9
December	1,260	--	4140.8
January	1,130	--	4141.7
February	1,275	4141.5	4142.5
March	1,325	4142.2	4143.0
April	1,175	4142.2	--
May	1,025	4141.6	--
June	805	4140.5	--
July	880	4139.3	--
August	1,000	4138.1	--
September	1,000	4137.5	--

[1] "msl" defined as feet above mean sea level

There are no provisions for flow through or minimum stream flow for the Hydroelectric Reach in the Biological Opinion with the exception of the minimum flow requirements below Iron Gate Dam described above.

Klamath River Estuary and Pacific Ocean

Flow-related habitat has not been described for the Klamath River estuary.

Critical Habitat

The ESA requires that USFWS and NOAA Fisheries Service designate critical habitat[2] for the listed species they manage. Critical habitat has been designated for three species within the area of analysis: coho salmon, green sturgeon, and bull trout, and has been proposed for an additional two: shortnose and Lost River suckers. An endangered population of killer whales that includes Klamath River salmon in its diet is also discussed here.

[2] The ESA defines critical habitat as "the specific areas within the geographical area occupied by the species, at the time it is listed, on which are found those physical or biological features (I) essential to the conservation of the species and (II) which may require special management considerations or protection; and specific areas outside the geographical area occupied by the species at the time it is listed that are determined by the Secretary to be essential for the conservation of the species."

Coho Salmon

Critical habitat for the SONCC Coho ESU was designated on May 5, 1999 and includes all river reaches accessible to listed coho salmon between Cape Blanco, Oregon and Punta Gorda, California, and includes water, substrate, and adjacent riparian zones of estuarine and riverine reaches, including off-channel habitat. “Accessible reaches” are defined as those within the historical range of the ESU that can still be occupied by any life stage of coho salmon. Specifically, in the Klamath Basin, all river reaches downstream of Iron Gate Dam on the Klamath River and Lewiston Dam on the Trinity River are designated as critical habitat (NOAA Fisheries Service 1999b).

Essential features of critical habitat considered essential for the conservation of the SONCC ESU (NOAA Fisheries Service 1997b) include (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions. Primary Constituent Elements (PCEs) for SONCC coho salmon are described in NOAA Fisheries Service (1999b) as follows: "In addition to these factors, NMFS also focuses on the known physical and biological features (primary constituent elements) within the designated area that are essential to the conservation of the species and that may require special management considerations or protection. These essential features may include, but are not limited to, spawning sites, food resources, water quality and quantity, and riparian vegetation."

Shortnose Sucker and Lost River Sucker

The USFWS proposed critical habitat for the shortnose sucker and Lost River sucker of approximately 182,400 hectares and 170,000 hectares, respectively, of stream, lake, and shoreline areas, but critical habitat has not yet been formally designated. The proposed designation includes six habitat units across the range of the two species: (1) Clear Lake and Watershed; (2) Tule Lake; (3) Klamath River; (4) Upper Klamath Lake and Watershed [excluding Williamson and Sprague rivers]; (5) Williamson and Sprague Rivers; and (6) Gerber Reservoir and watershed (USFWS 1994). Proposed critical habitat for the Lost River sucker includes all of the above habitat units except Gerber Reservoir and watershed. The PCEs identified in the critical habitat proposal are as follows: (1) water of sufficient quantity and suitable quality; (2) sufficient physical habitat, including water quality refuge areas and habitat for spawning, feeding, rearing, and travel corridors; and (3) a sufficient biological environment, including adequate food levels, and patterns for predation, parasitism, and competition that are compatible with recovery (USFWS 1994). A Recovery Plan was written for both species (USFWS 1994), but did not include critical habitat. A new draft recovery plan and proposed critical habitat is currently being developed and expected to be released in 2011 (L. Sada, pers. comm., 2011). Predominate threats to these suckers are lack of spawning habitat, continued loss of habitat, lake elevation fluctuations that reduce access to vegetative habitat, water diversions, competition and predation by introduced species, hybridization with other sucker species, isolation of remaining habitats, and drought (USFWS 1988). Decreases in water quality resulting from timber harvest, dredging activities, removal of riparian vegetation, and livestock grazing may also cause problems for these species (USFWS 1988).

Green Sturgeon

In 2009, NOAA Fisheries Service designated critical habitat for the Southern DPS of green sturgeon, which encompasses all coastal marine waters of the United States less than 60 fathoms deep (approximately 110 m) from Monterey Bay, California north to Cape Flattery, Washington. The estuary portion of the Eel and Klamath/Trinity Rivers was specifically excluded from the critical habitat designation (NOAA Fisheries Service 2009b).

Bull Trout

Critical habitat designations for bull trout were finalized in 2005, but were then remanded in 2009 and republished in 2010. The final 2010 rule designates 277 miles of stream shoreline and 9,329 acres of reservoirs or lakes as critical habitat within the Klamath River Recovery Unit. This habitat includes Agency Lake and its tributaries and an assortment of headwater streams. A map of designated critical habitat is available from the USFWS (http://www.fws.gov/oregonfwo/Species/Data/BullTrout/Maps/final_krb.pdf). Critical habitat areas have at least one PCE essential to the conservation of bull trout. These features are the PCEs laid out in the appropriate quantity and spatial arrangement for conservation of the species. These include: (1) Space for individual and population growth and for normal behavior; (2) Food, water, air, light, minerals, or other nutritional or physiological requirements; (3) Cover or shelter; (4) Sites for breeding, reproduction, or rearing (or development) of offspring; and (5) Habitats that are protected from disturbance or are representative of the historical, geographical, and ecological distributions of a species.

Eulachon

NOAA Fisheries Service proposed critical habitat for eulachon on January 5, 2011 (NOAA Fisheries Service 2011). The proposed critical habitat designation for the Southern Eulachon DPS included 12 areas comprising freshwater streams, rivers, and estuaries along the coast of Washington, Oregon, and California. The proposed designation does not include the Klamath River.

Southern Resident Killer Whale

In November 2006, NOAA Fisheries Service designated critical habitat for Southern Resident Killer Whales (NOAA Fisheries Service 2006b). Critical habitat includes all waters relative to a contiguous shoreline-delimited by the line at a 20-foot depth relative to extreme high water within three designated areas: (1) the Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca. Coastal and offshore areas have not been designated as critical habitat, though they are recognized as important for the Southern Resident Killer Whales and NOAA Fisheries Service anticipates additional information on coastal habitat use from research projects in the coming years (NOAA Fisheries Service 2006b).

Based on the natural history of the Southern Residents and their habitat needs, the following physical or biological features were identified as essential to conservation: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction, and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging (71 FR 69054). There is the potential for Southern Resident Killer Whales to feed on Klamath River salmonids during the period from about September through May when they spend more time in outer coastal waters and may range from central California to northern British Columbia (Hanson et al. 2010). Southern Resident Killer Whales would not be expected to be affected by any of the alternatives, apart from their effects on salmon production.

Essential Fish Habitat

EFH is designated for commercially fished species under the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (Magnuson-Stevens Act). The Magnuson-Stevens Act requires federal fishery management plans, developed by NOAA Fisheries Service and the Pacific Southwest Fisheries Management Council, to describe the habitat essential to the fish being managed and to describe threats to that habitat from both fishing and nonfishing activities. To protect EFH, federal agencies are required to consult with the NOAA Fisheries Service on activities that may adversely affect EFH.

EFH has been designated for 3 species of salmon, 83 groundfish species, and 5 pelagic species. Descriptions of EFH within the area of analysis are provided below.

Chinook and Coho Salmon

Coho salmon are also managed under the Magnuson-Stevens Act, under the authority of which EFH for coho salmon is described in Amendment 14 to the Pacific Coast Salmon Fishery Management Plan (50 CFR 660.412). EFH for Chinook salmon is also described in the same management plan, and is identical to that for coho salmon in the Klamath basin. EFH has been designated for the mainstem Klamath River and its tributaries from its mouth to Iron Gate Dam, and upstream to Lewiston Dam on the Trinity River. EFH includes the water quality and quantity necessary for successful adult migration and holding, spawning, egg-to-fry survival, fry rearing, smolt migration, and estuarine rearing of juvenile coho and Chinook salmon.

Although specific Habitat Areas of Particular Concern have not been established for coho or Chinook salmon in the Klamath Basin, the Preliminary Draft of the Pacific Coast Salmon EFH Review recommend designating complex channels and floodplain habitats: meandering, island-braided, pool-riffle and forced pool riffle habitats; thermal refugia; spawning habitat; estuaries; and marine and estuarine submerged aquatic vegetation (NOAA Fisheries Service 2010a).

Groundfish

NOAA Fisheries Service defined EFH to include those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (16 USC 1802 (10)). EFH for Pacific Coast groundfish includes all waters and substrate within areas with a depth less than or equal to 3,500 m (1,914 fm) shoreward to the mean higher high water level or the upriver extent of saltwater intrusion (defined as upstream and landward to where ocean-derived salts measure less than 0.5 ppt during the period of average annual low flow). The Klamath River Estuary, which extends from the river's mouth upstream to near the confluence with Ah Pah Creek, is included in the Pacific groundfish EFH (50 CFR § 660.395).

Pelagic Fish

EFH for coastal pelagic species, including finfish (northern anchovy, Pacific sardine, Pacific (chub) mackerel, and jack mackerel) and market squid occurs from the shorelines of California, Oregon, and Washington westward to the exclusive economic zone and above the thermocline where sea surface temperatures range from 10 to 26ºC. During colder winters, the northern extent of EFH for coastal pelagic species may be as far south as Cape Mendocino, and during warm summers it may extend into Alaska's Aleutian Islands. In each of these seasonal examples the Klamath Estuary and coastline would be included as EFH for these species.

3.3.4 Environmental Consequences

3.3.4.1 Effects Determination Methods

This section provides a brief overview of the methods used in the evaluation of important factors to aquatic resources. More complete descriptions are provided in the Methods and Criteria Technical Memorandum (Reclamation 2011), Appendix E for suspended sediment, and Appendix F for bedload sediment.

Suspended Sediment

As described in Appendix E, the potential effects of suspended sediment on anadromous fish species for the Proposed Action and alternatives were assessed using SRH-1D (Huang and Greimann 2010, as summarized in Greimann et al. 2010). The SRH-1D model provides an estimate of SSCs at different points on the river on a daily average estimate. This information is used to assess the impacts of SSCs on fish based on the concentration and duration of exposure using Newcombe and Jensen's (1996) approach. Duration of exposure is based on the time a species and lifestage would be exposed to elevated SSCs. These effects are compared to those that fish would be expected to encounter under baseline conditions. Estimated existing conditions were also simulated using the SRH-1D model, to provide a comparison of what SSCs would be with and without dam removal in the years 2020 and 2021 (No Action/No Project Alternative). This approach is similar to that used in Stillwater Sciences (2008, 2009a, 2009b).

Daily durations of SSC concentrations were modeled assuming the Proposed Action occurred within each of the 48 years in the available hydrology record since 1961. The results of modeling all potential years were summarized for each life-stage of each species assessed. Because the suspended sediment varies with hydrology, and in order to account for (and compare) the range of results and impacts that might occur under each alternative, two scenarios were analyzed for the Proposed Action, and for action alternatives, with the goal of predicting the potential impacts to fish that has either a 50% (likely to occur) or 10% (unlikely, or worst case) probability of occurring, defined as follows:

For Existing Conditions and the No Action/No Project Alternative:

- **Normal conditions:** suspended sediment concentrations and durations with a 50 percent exceedance probability for the mainstem Klamath River downstream of Iron Gate Dam (i.e., the probability of these concentrations and durations being equaled or exceeded for each assessed species and life-stage in any one year is 50 percent). Exceedance probabilities were based on modeling SSC using hydrologic data from all water years subsequent to 1961 with facilities in place. To assess "normal conditions" the median (50 percent) suspended sediment concentration and duration from these results was estimated.

- **Extreme conditions:** suspended sediment concentrations and durations with a 10 percent exceedance probability (i.e., the probability of these concentrations and durations being equaled or exceeded for each assessed species and life-stage in any 1 year is 10 percent).

For the Proposed Action– Full Facilities Removal of Four Dams:

- **Most likely scenario:** suspended sediment concentrations and durations with a 50 percent exceedance probability for the mainstem Klamath River downstream of Iron Gate Dam (i.e., the probability of these concentrations and durations being equaled or exceeded for each assessed species and life-stage in any one year is 50 percent). Exceedance probabilities were based on the results of modeling suspended sediment in the Klamath River downstream of Iron Gate Dam in all water years observed since 1961 with facility removal. To assess the "most likely scenario" the median (50 percent exposure concentration) was estimated.

- **Worst-case scenario:** suspended sediment concentrations and durations with a 10 percent exceedance probability (i.e., the probability of these concentrations and durations being equaled or exceeded for each assessed species and life-stage in any 1 year is 10 percent).

Bedload Sediment

As described in Appendix F, the analysis of potential changes to bedload sediment also relied upon output from the SRH-1D model (Huang and Greimann 2010). The changes in bedload were evaluated for a range of hydrologic conditions for short-term (2-year) and long-term (5-, 10-, 25-, 50-year) changes using a range of flows taken from historical hydrology. A long-term simulation was not conducted for the Klamath River upstream of Iron Gate Dam under the assumption that the bedload sediment conditions at the end of 2 years are representative and would persist through time, allowing for mild fluctuations as a function of hydrology (Reclamation 2011; D. Varyu, pers. comm., January 4, 2011).

The effects determination used results from the analysis and knowledge of habitat requirements of affected fish species to determine how changes in bed elevation and substrate composition would affect aquatic resources (e.g., pool habitat, spawning gravel, benthic habitat). Changes in substrate composition occurring as a result of dam removal that decreased habitat suitability were assumed to be deleterious to salmonids. Bedload transport in the area upstream of the influence of J.C. Boyle Reservoir are not anticipated to be affected by dam removal and are not expected to be substantially affected by the Proposed Action, and are not evaluated further in this document. Link and Keno Dams would remain in place and would continue to affect hydrology and sediment transport in much the way they do currently.

Water Quality

The potential short- and long-term water quality-related effects on fish were based on water quality effects determinations (see Section 3.2, Water Quality) for parameters to which fish are most sensitive (i.e., water temperature, sediment and turbidity, dissolved oxygen, pH, ammonia toxicity), as well as effects determinations for state and approved tribal designated beneficial uses that are directly related to fish (see Table 3.2-3). Potential effects of sediment toxins on fish were evaluated using the results of multiple screening level comparisons of sediment contaminant levels identified in reservoir sediments. These water quality methods are described in greater detail in Section 3.2, Water Quality.

Water Temperature

Potential impacts of water temperature on species within each analysis area were evaluated using available modeled water temperatures (PacifiCorp 2004c; Dunsmoor and Huntington 2006; FERC 2007). Because model results were not developed for all of the alternatives, this evaluation assumes that the Partial Facilities Removal Alternative would result in temperatures similar to those that would occur under the Proposed Action. It is assumed that the Fish Passage at Four Dams Alternative would result in similar temperatures to the No Action/No Project Alternative. The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative was assumed to result in temperatures intermediate to the Proposed Action and No Action/No Project Alternative. Because the remaining reservoirs are small relative to Copco 1 and Iron Gate Reservoirs, with correspondingly lower amounts of thermal heating and residence time, the temperatures under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would likely be more similar to those under the Proposed Action than they would be to the No Action/No Project Alternative. Water temperature data were compared to the thermal tolerances of focal species and associated life stages as determined from the literature to determine relative suitability for these species under the various alternatives.

Neither implementation of total maximum daily loads (TMDLs) nor climate change was incorporated into the existing models. For purposes of the analysis it was assumed that TMDL objectives would be met within the analysis period (see Section 3.2, Water Quality) and that climate change would result in 2.5 to 3.0°C warming by the end of the analysis period (Snyder et al. 2004; Bartholow 2005; Stillwater Sciences 2009a).

Fish Disease and Parasites

Fish diseases, specifically *C. shasta* and *P. minibicornis*, can contribute to reduced survival and have periodically contributed to substantial mortality for Klamath River salmonids. Generally, Klamath River steelhead are resistant to *C. shasta* (Administrative Law Judge 2006). Environmental variables such as temperature, flow, and nutrients are thought to affect the abundance of *P. minibicornis* and *C. shasta*; therefore, differences in river habitat conditions that could occur under the Proposed Action and alternatives could affect the abundance of these parasites and their infection rates in Klamath Basin fish. Bartholomew and Foott (2010) prepared a compilation of available information regarding Myxozoan disease relative to the Klamath River and, in their analysis they considered several factors that could, if co-occurring, lead to high infections rates of fish:

- Physical habitat components that support the invertebrate host species (pools, eddies, sediment)
- Microhabitats with low velocity and stable flows
- Close proximity to spawning areas
- Temperatures higher than 15°C

Aquatic Habitat

Changes to habitat area were assessed for each life stage qualitatively, using knowledge of habitat requirements and expected changes under the alternatives. Quantitative descriptions of the relationship between fish habitat and flow are available for the current channel configuration at some locations (Bureau of Land Management 2002; Hardy et al. 2006). However, extrapolation of these relationships to describe the habitat changes that would be anticipated under each of the proposed alternatives would not provide an appropriate method to assess the effects of the project alternatives because the channel configuration itself is anticipated to change as a result of alterations to sediment supply and the temporal resolution (mean monthly or biweekly time steps) of modeled flows would not accurately represent daily flow conditions. Qualitative analyses relied on data evaluated for other affected factors (water temperature and fish passage) and expected changes in geomorphic processes, such as short- and long-term changes in sediment transport and deposition, to determine increases or decreases in habitat relative to existing conditions for the different species and life stages in the various reaches.

Critical Habitat

NOAA Fisheries Service has designated critical habitat for coho salmon and Southern Resident Killer Whales, and the USFWS has designated critical habitat for bull trout. Within critical habitat, NOAA Fisheries Service has determined that the PCEs essential for the conservation of these species are those sites and habitat components that support one or more life stage, as described in Section 3.3.3.3. Critical habitat for Southern Resident Killer Whales does not extend into coastal or offshore habitats (71 FR 69054).The effects of each alternative on critical habitat were based on evaluation of the physical, chemical and biological changes that were expected to occur to designated critical habitat within the area of analysis and how those changes would affect the PCEs for that critical habitat in the short and long term.

Essential Fish Habitat

The effects of each alternative on EFH were based on evaluation of the physical, chemical and biological changes that were expected to occur to EFH within the area of analysis and whether those changes would have beneficial effects on this habitat in terms of its quantity and quality in the short and long term.

Freshwater Mussels

Increased levels of fine sediment, both suspended in the water column and along the channel bed, can inhibit the growth, production, and abundance of freshwater mussels and clams. Therefore, the analysis of impacts associated with dam removal focused on short- and long-term changes in SSCs (Aldridge et al. 1987, as cited in Henley et al. 2000) and stream substrate texture (Howard and Cuffey 2003; Vannote and Minshall 1982). The evaluation focuses on freshwater mussels because of the lack of information regarding the effects of SSCs and sediment transport on clams. Suspended sediment impacts on freshwater mussel species were evaluated using output from the SRH-1D (Huang and Greimann 2010) sediment transport model as discussed above for suspended and bedload sediment.

Aldridge et al. (1987, as cited in Henley et al. 2000) showed that exposure to SSCs of 600-750 mg/L led to reduced survival of freshwater mussels found in the eastern United States. No duration of exposure was cited in the study. No comparable data are available for the species in the Klamath River. Using 600 mg/L as the minimum SSCs that would be detrimental to freshwater mussels, alternatives were compared to each other by determining the number of days during which this criterion threshold would be exceeded.

Analysis of impacts due to changes in bedload transport on the four species of freshwater mussels considered modeled changes in median sediment size, under the Proposed Action and each project alternative. The effects of changes in water quality on freshwater mussels were evaluated in the same manner as described for fish. The analysis presented here, focuses on effect on freshwater mussels because of their longer lifespan and a lack of information on the effects of water quality on clams.

Benthic Macroinvertebrates

Suspended sediment and turbidity can cause stress to benthic macroinvertebrates through impaired respiration, reduced feeding, growth, and reproductive abilities, and reduced primary production (Lemly 1982; Vuori and Joensuu 1996). Therefore, potential short-term and long-term effects of the Proposed Action and alternatives on benthic macroinvertebrates were evaluated for both short- and long-term changes in SSCs and bedload sediment. Suspended sediment impacts on benthic macroinvertebrates were evaluated using output from the SRH-1D (Huang and Greimann 2010) sediment transport model as discussed above for suspended and bedload sediment.

Changes in substrate size or embeddedness may influence the distribution, abundance, and community structure of benthic macroinvertebrates (Bjornn et al. 1977; McClelland and Brusven 1980; Ryan 1991). Bed texture changes that would occur under the Proposed Action and alternatives were qualitatively evaluated to determine whether changes in substrate composition would decrease macroinvertebrate abundance or alter the community composition to the extent that these communities could no longer support sufficient fish populations in the Klamath system.

The effects of changes in water quality, Biochemical Oxygen Demand/Immediate Oxygen Demand, and toxicity effects on BMIs were based on water quality determinations (see Section 3.2, Water Quality) and evaluated in the same manner as described for fish and mollusks. Potential toxicity to BMIs was also evaluated using the results of bioassays.

3.3.4.2 Significance Criteria

The Proposed Action and alternatives could affect aquatic resources directly or indirectly through a variety of mechanisms, as described in the preceding section. These effects could be additive or offsetting. For purposes of this evaluation, the Lead Agencies considered the total effect of the factors described above on native fish populations and their habitat. These impacts could vary substantially in intensity, geographic extent, and duration. The intensity of an impact refers to how severely it affects an organism. This severity can range from sublethal behavioral adaptations such as avoidance of a specific condition, to mortality. The geographic extent refers to how much of the species' potential habitat and what proportion of the total population is expected to be affected. The temporal duration refers to how long the effect is anticipated to persist (hours, days, months, or years). The Lead Agencies considered effects in the short term (less than 2 years) and the long term (more than 2 years), but either short- or long-term impacts could be significant.

For the purposes of this EIS/EIR, the following determinations were considered:

- No change from existing conditions: Effect would not result in alterations to existing conditions.
- Significant: As defined below.
- Less-than-significant: Effect influences an aquatics species, but does not result in a significant effect.
- Beneficial: Results in a substantial increase in the abundance of a year class in the short or long term.

For the purposes of this EIS/EIR, effects would be significant if they would result in the following:

Short term:

- Substantially reduce the abundance of a year class in the short term.
- Substantially decrease the habitat quality or availability for a native species over a large proportion of the habitat available to it in the short term.
- Substantially decrease the quality or availability of a large proportion of critical habitat under the ESA or EFH under the Magnuson-Stevens Fishery Conservation and Management Act in the short term.

Long term:

- Substantially reduce the population of a native species for more than two generations after removal of all dams (if removed all at once) or after the last dam (if removed sequentially).
- Substantially decrease the habitat quality or availability for a native species or community in the long term.

- Substantially decrease the habitat quality or availability for a native species over a large proportion of the habitat available to it in the long term.
- Substantially decrease the habitat quality or availability of a large proportion of critical habitat under the ESA or EFH under the Magnuson-Stevens Fishery Conservation and Management Act in the long term.
- Continue or worsen conditions that are currently causing a species to decline in the long term.
- Eliminate a year class of salmon or steelhead, thereby jeopardizing the long-term viability within the Klamath Basin. Because of the fixed, 3-year timing of the coho salmon life cycle, which has little to no plasticity, this criterion was added for the protection of coho salmon in particular and could result in a jeopardy decision.

3.3.4.3 Effects Determinations

Alternative 1: No Action/No Project

Under this alternative, none of the actions under consideration would be implemented. The Klamath Hydroelectric Project would continue current operations under the terms of an annual license until a long-term license is finalized. Annual licenses would not include actions associated with the KHSA and KBRA. Several Interim Measures (IMs) from the KHSA would be implemented through other PacifiCorp's Habitat Conservation Plan or other means; these measures are included in the No Action/No Project Alternative. Some KBRA actions have already been initiated and would continue under the No Action/No Project Alternative. These include the Williamson River Delta Project, the Agency Lake and Barnes Ranch Project, fish habitat restoration work, and ongoing climate change assessments. The TMDLs would be implemented under all alternatives as they are an unrelated regulatory action; however, TMDL goals would likely be met at a later date than under alternatives with KBRA. Hydroelectric operations would continue as they have been, providing peaking power generation during the summer as demand requires and conditions allow.

Key Ecological Attributes

Suspended Sediment

Suspended sediment effects under the No Action/No Project Alternative are described in detail in Appendix E, and summarized here. Under the No Action/No Project Alternative, suspended sediment would be the same as under existing conditions. Most suspended sediment is supplied by tributaries; Iron Gate Dam currently interrupts both fine and coarse sediment transport, so suspended sediment generally increase in a downstream direction. The lower Klamath River downstream of the Trinity River confluence (RM 40.0) to the estuary mouth is listed as sediment impaired under Section 303(d) of the Clean Water Act (see Section 3.2.2). Under both normal and extreme conditions, the magnitude and duration of the SSCs modeled for the No Action/No Project Alternative are expected to cause major stress to migrating adult and juvenile salmonids primarily during winter (Newcombe and Jenson 1996; Appendix E).

Bedload Sediment

Bedload sediment effects under the No Action/No Project Alternative are described in detail in Appendix F, and summarized here.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
Under the No Action/No Project Alternative, the Klamath Hydroelectric Project dams would continue to trap fine and coarse sediment and reduce the storage capacity of the reservoirs. Reclamation (2011) estimates that the four subject reservoirs would store 2.35 million yd^3 of fine and coarse sediment by 2061. As reservoir water storage capacities decreased (i.e., as they filled with sediment), sediment trapping efficiency could also decrease, allowing sediment to pass through reservoirs. The No Action/No Project Alternative would have no effects associated with bedload sediment relative to existing conditions for any aquatic species in this reach.

Lower Klamath River: Downstream of Iron Gate Dam Under the No Action/No Project Alternative, the channel directly downstream of Iron Gate Dam would continue to coarsen over time due to retention of fine and coarse sediment supply from sources upstream of Iron Gate Dam (Reclamation 2011), but this effect would gradually decrease in the downstream direction as coarse sediment was resupplied by tributary inputs (Hetrick et al. 2009), and would be substantially reduced at the Cottonwood Creek confluence (PacifiCorp 2004b). The coarser bed material is mobilized at higher flows that occur less frequently, resulting in channel features that are more stable. This impact would be limited to the area upstream of Cottonwood Creek. Under the No Action/No Project Alternative, rearing habitat would be expected to remain similar to existing conditions.

Klamath River Estuary The No Action/No Project Alternative would not change bedload transport to the estuary or Pacific Ocean, relative to existing conditions.

Water Quality

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir As described in Section 3.2, Water Quality, long-term dissolved oxygen levels under the No Action/No Project Alternative would continue to exhibit seasonal variability. These dissolved oxygen levels would not consistently meet Oregon and California Basin Plan water quality objectives for dissolved oxygen, and would not consistently support designated beneficial uses in Oregon for cold-water aquatic life, cool-water aquatic life, warm-water aquatic life, and spawning and in California for cold freshwater habitat, warm freshwater habitat, and spawning habitat beneficial uses.

Klamath TMDL model results for riverine conditions between Link River Dam and the upstream end of J.C. Boyle Reservoir predict that dissolved oxygen concentrations will meet the 6.5 mg/L objective year round and achieve the modeled natural conditions baseline during the warm summer and fall months (see Section 3.2.4.3.1.4 Upper Klamath Basin). Thus, full attainment of the Oregon TMDLs would eventually be beneficial for dissolved oxygen in this reach. Under full TMDL compliant conditions, the California 85 percent saturation objective (based on natural receiving water temperatures) is also met at state line under the No Action/No Project Alternative (see Section 3.2.4.3.1.4). Thus, full attainment of the Oregon and California TMDLs would eventually be beneficial for dissolved oxygen in the Hydroelectric Reach. Full attainment could require decades to achieve and it is highly dependent on improvements in dissolved oxygen in Upper Klamath Lake and the upstream reach from Link River Dam to J.C. Boyle Dam (particularly Keno Impoundment and Lake Ewauna).

The overall anticipated effect on dissolved oxygen in the Upper Klamath Basin under the No Action/No Project Alternative would be an increasing trend toward compliance with water quality objectives and support of designated beneficial uses, but may not meet minimum dissolved oxygen objectives for California at the downstream end of the Hydroelectric Reach during the late summer/early fall months.

Restoration activities such as floodplain rehabilitation, riparian vegetation planting, and purchase of conservation easements/land related to nutrients under the No Action/No Project Alternative are currently ongoing in the Upper Klamath Basin and are expected to continue to improve long-term pH in the Upper Klamath Basin. These restoration actions and implementation of water quality improvement measures under Oregon and California TMDLs to address water quality impairments are expected to improve pH during the period of analysis (50 years) under the No Action/No Project Alternative.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Under the No Action/No Project Alternative, continued high rates of algal photosynthesis in the reservoirs would result in pH values that would not consistently meet applicable ODEQ and California Basin Plan water quality objectives (see Section 3.2, Water Quality). Based on existing conditions, pH during summer through fall within the reservoirs would continue to range from just above neutral (7) to greater than 9 (slightly basic). The ongoing presence of the reservoirs in the Hydroelectric Reach would continue to provide the conditions necessary for blue-green algae, including *M. aeruginosa*, which can contribute to reduced health and increased mortality rates for fish and other aquatic resources both within the reservoirs and in areas downstream. The lower levels of the J.C. Boyle, Copco, and Iron Gate Reservoirs would continue to have very low oxygen levels when stratified (FERC 2007). This would affect dissolved oxygen levels downstream of these reservoirs.

Lower Klamath River: Downstream of Iron Gate Dam Ongoing efforts to improve water quality conditions are underway through the TMDL process and considerable efforts to improve habitat are also underway (Hamilton et al. 2011). Once implemented, these efforts could reduce existing conditions that contribute to reduced health and increased mortality rates for aquatic resources (described below) to some extent, but this process would be slower and more challenging than with the dams removed. In the interim, water quality conditions that may reduce survival of fish and other aquatic resources would persist downstream of Iron Gate Dam.

Given existing conditions, long-term dissolved oxygen levels under the No Action/No Project Alternative would continue to exhibit seasonal variability and would not consistently meet California Basin Plan and Hoopa Valley Tribe water quality objectives for dissolved oxygen and they would not consistently support designated beneficial uses in the lower Klamath River downstream of Iron Gate Dam.

Modeling conducted for development of the California Klamath River TMDL indicates that under the No Action/No Project Alternative, dissolved oxygen concentrations downstream of Iron Gate Dam to the Shasta River (RM 176.7), without additional mitigation, would not meet the North Coast Basin Plan water quality objective of 85 percent saturation during July–September and from the Shasta River to approximately the Scott River (RM 143) from September–November (see Section 3.2.4.3.1.4 Lower Klamath Basin). Farther downstream with full attainment of TMDL allocations, predicted dissolved oxygen concentrations would remain at or above 85 percent saturation, meeting the North Coast Region Basin Plan water quality objective from Seiad Valley (RM 129.4) to the Klamath Estuary.

Under the No Action/No Project Alternative, continued high rates of algal photosynthesis in the reservoirs would result in high pH values in the lower Klamath River downstream of Iron Gate Dam (see Section 3.2, Water Quality). Under the No Action/No Project Alternative, pH would continue to be elevated with high diurnal variability during summer and early fall months.

The overall anticipated effect on dissolved oxygen in the lower Klamath River under the No Action/No Project Alternative would be an increasing trend toward compliance with water quality objectives and support of designated beneficial uses, but with possible continued seasonally low dissolved oxygen downstream of Iron Gate Dam, and so would not consistently meet California Basin Plan and Hoopa Valley Tribe water quality objectives for dissolved oxygen. Turbine venting studies, currently ongoing as part of KHSA IMs (see Section 3.2, Water Quality), could be used to further increase dissolved oxygen in the river downstream of the dam in the long term under the No Action/No Project Alternative. However, results from turbine venting studies are inconclusive at this time and it is uncertain whether or not increases of dissolved oxygen downstream of Iron Gate Dam can be consistently achieved. The No Action/No Project Alternative would continue to periodically result in dissolved oxygen levels that may be deleterious to aquatic resources below Iron Gate Dam, but this effect would be similar to or less than that which currently occurs.

Water Temperature

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the No Action/No Project Alternative, the temperature in the upper Klamath River would remain similar to existing conditions in the near term, but would be expected to show a gradual cooling trend through implementation of the TMDLs.

Climate change is expected to play a role in future temperatures. Climate change impacts on the Klamath River and Estuary are based on current estimates of potential future changes in air temperature and precipitation patterns for the California North Coast hydrologic region (Stillwater Sciences 2009a). Regional climate models estimate that median annual air temperature would increase 2.5 to 3ºC by 2050 (Snyder et al. 2004). These ambient air temperatures could in turn raise water temperatures. Additionally, decreases in snowpack from higher air temperatures from January to March are also predicted, resulting in a more modest spring runoff peak. Despite climate predictions, temperatures in Upper Klamath Lake have exhibited a downward trend from 1990 to 2009 (Jassby and Kann 2010).

As described in Section 3.2, Water Quality, the Wood River Wetland Restoration Project and the Agency Lake and Barnes Ranches Project represent a reasonably foreseeable set of actions under the No Action/No Project Alternative that would improve springtime water temperatures for rearing fish in the upper basin. Specific options for both projects still need to be developed and studied as part of a separate project-level National Environmental Policy Act evaluation and ESA consultation.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Under the No Action/No Project Alternative, the effects of ongoing and future upstream water quality improvements under the TMDLs would improve water temperatures below Keno Dam. However, climate change would offset temperature improvements. The river's thermal regime downstream of the reservoirs would continue to be out of phase with the natural temperature regime (Hamilton et al. 2011). Unnatural temperature fluctuations would continue downstream from the J.C. Boyle Bypass Reach, from the mixture of cold-water inflow from Big Springs and the warmer water discharge from the J.C. Boyle Powerhouse (Hamilton et al. 2011). Similar impacts from climate change as described above are also predicted to occur in this reach; therefore, water temperatures are expected to remain similar to existing conditions. Project operations have and continue to be deleterious to the resident trout fishery by: a) confining the resident trout between the Four Facilities and associated reservoir thereby impairing their utilization of the full range of life history strategies and spawning productivity; b) unscreened flow through Project turbines result in mortality of juvenile and adult trout migrating down stream; and the inability to effectively migrate will reduce the genetic health and long-term survival of the resident species (Administrative Law Judge 2006).

Lower Klamath River: Downstream of Iron Gate Dam The lower Klamath River downstream of Iron Gate Dam would continue to have elevated water temperatures in the summer and fall in the near term. These elevated water temperatures are primarily influenced by the reservoirs and their perpetuation of an increased hydraulic residence time and thermal mass (Bartholow et al. 2005). Bartholow et al. (2005) and PacifiCorp (2004a) showed that the reservoirs delay seasonal thermal signatures by 18 days. Implementation of the TMDLs in these mainstem and tributaries is expected to result in lower water temperatures over time; however, these improvements would likely be offset by the effects of climate change, as described above. In the long term, water temperatures in the mainstem and tributaries are expected to remain similar to existing conditions.

Under this alternative, the current phase shift and lack of temporal diversity will persist, including current warm temperatures in late summer and fall. Current cooler temperatures in spring and early summer could benefit both adult and juvenile salmonids migrating during spring. However, juveniles and adults migrating later in the year would continue to experience warm temperatures in late summer and fall that could be deleterious to health and survival, including increased risk of disease, and high rates of delayed spawning and prespawn mortality (Hetrick et al. 2009).

In addition to the direct stress that increasing temperatures could place on salmonids, these increasing water temperatures could result in an increased intensity and duration of algal blooms, decreased dissolved oxygen levels, and increased parasite abundance. These effects would put additional stress on cold-water fish communities, and be deleterious to warm-water fish communities as well.

Klamath River Estuary and Pacific Ocean Nearshore Environment Under the No Action/No Project Alternative, the temperature in the Klamath River Estuary and Pacific Ocean would remain similar to the existing conditions and climate change would continue to play a role in future temperatures as described above.

Fish Disease and Parasites

The ongoing presence of the dams under the No Action/No Project Alternative would continue to contribute to the stable, warm habitat conditions that are favorable for polychaetes and for *C. shasta* and *P. minibicornis*. The hatchery would continue to operate and discharge its nutrient-rich effluent to the river. Salmon would continue to concentrate below the Iron Gate Dam, where the polychaete hosts are abundant, facilitating the cross infection between the fish and the polychaetes. Based on this scenario, mortality associated with *C. shasta* and *P. minibicornis* would be expected to remain similar to existing conditions. If temperatures warm over time with climate change, these infection rates could increase. The No Action/No Project Alternative would result in continued substantial deleterious effects on salmon in terms of fish disease.

Algal Toxins

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the No Action/No Project Alternative, high nutrient inputs supporting the growth of toxin-producing nuisance algal species such as *M. aeruginosa* in Upper Klamath Lake would remain similar to existing conditions for decades into the future. This would result in continued bioaccumulation of microcystin in suckers in Upper Klamath Lake and could be deleterious to fish health. Upon full attainment of the TMDLs (implementation mechanism and timing currently unknown), nutrients and toxin-producing nuisance algal species would decrease (see Sections 3.2, Water Quality and 3.4, Algae for additional detail regarding TMDLs and algal growth). Accordingly, with full attainment of the TMDLs, improvements to microcystin tissue levels in suckers in the lake would occur.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
Continued impoundment of water at the Four Facilities under the No Action/No Project Alternative would support growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa* in Copco 1 and Iron Gate Reservoirs, resulting in high seasonal concentrations of algal toxins in the Hydroelectric Reach for decades into the future. This would result in continued bioaccumulation of microcystin in fish tissue for species in the Hydroelectric Reach and could be deleterious to fish health. Upon full attainment of the TMDLs (implementation mechanism and timing currently unknown), nutrients and toxin-

producing nuisance algal species would decrease in the Hydroelectric Reach (see Sections 3.2 and 3.4 for additional detail regarding TMDLs and algal growth). Accordingly, with full attainment of the TMDLs, improvements to microcystin tissue levels in fish in the Hydroelectric Reach would occur.

Lower Klamath River: Downstream of Iron Gate Dam Continued impoundment of water at the Four Facilities under the No Action/No Project Alternative would support the seasonal transport of toxin-producing nuisance algae and microcystin to the Klamath River downstream of Iron Gate Dam. This would result in continued bioaccumulation of microcystin in fish tissue for species in the river and could be deleterious to fish health. Upon full attainment of the TMDLs (implementation mechanism and timing currently unknown), nutrients and toxin-producing nuisance algal species would decrease in the Hydroelectric Reach (see Sections 3.2 and 3.4 for additional detail regarding TMDLs and algal growth). Accordingly, with full attainment of the TMDLs, improvements to microcystin tissue levels in fish in the Klamath River downstream of Iron Gate Dam would occur.

Aquatic Habitat

Under the No Action/No Project Alternative, hydrology of the Klamath River from its headwaters to the estuary would generally remain the same as under existing conditions, subject to the influence of climate change (discussed under 3.10, Greenhouse Gases/Global Climate Change). Activities currently underway to recover salmonid and sucker populations within the Klamath Basin would continue at their current levels. The ongoing Wood River Wetland Restoration, Agency Lake and Barnes Ranches Project, and the Williamson River Delta Project would likely improve springtime rearing habitat for fish in the upper basin. Recovery actions under the Klamath River Coho Salmon Recovery Plan would continue, depending on available funding. These actions would improve habitat conditions over time relative to current conditions.

Under the No Action/No Project, PacifiCorp would need to obtain a long-term operating license for the Klamath Hydroelectric Project from FERC to continue operating the Project (FERC 2007). Until a new license is issued, operations would continue under the annual license terms described in Section 3.3.3.3.

Aquatic Resources Effects

Critical Habitat

As described below, continued impoundment of water within reservoirs under the No Action/No Project Alternative could alter the water quality and habitat suitability within critical habitat.

Coho Salmon As described above in detail, under the No Action/No Project Alternative, habitat supporting PCEs for coho salmon will continue to be degraded (NOAA Fisheries Service 1999b, NOAA Fisheries Service 2010a). Spawning habitat would continue to be impaired by sediment and instream flows within tributary streams, with little mainstem spawning. Rearing habitat with food resources would continue to be impaired as result of habitat degradation, high water temperature, and disease within tributaries and the mainstem. Water quantity supporting PCEs would continue to be depleted both within tributaries and within the mainstem. The quality of PCEs would likely improve gradually over time, through the actions undertaken under the Klamath River Coho Salmon Recovery Plan. TMDL implementation is anticipated to result in improved water quality to meet PCEs; however, water quality would initially be reduced similar to that under existing conditions. However, full attainment of the water temperature TMDLs is likely to be offset by climate change. **The effect of the No Action/Np Project Alternative would be would be no change from existing conditions for coho salmon critical habitat in the short and long term.**

Bull Trout Because bull trout are restricted in distribution to the headwaters of limited number of streams, under the No Action/No Project Alternative, PCEs of critical habitat supporting bull trout are not expected to be affected by implementation of the Oregon TMDL processes. Over the long-term climate change would be expected to result in warmer temperatures, although the headwater streams supporting bull trout may be not be affected. **The effect of the No Action/No Project Alternative would be no change from existing conditions for bull trout critical habitat in the short and long term.**

Southern Resident Killer Whale The Klamath River may affect PCEs of critical habitat for Southern Resident Killer Whales through its potential contribution of Chinook salmon to the food supply for Southern Resident Killer Whales, the survival and fecundity of which appears dependent upon the abundance of this species (Ward et al. 2009; Ford et al. 2009). Chinook salmon originating from the Fraser River are the dominant prey of resident killer whales in the summer months when they are usually in inland marine waters (Hanson et al. 2010). Less is known of their diet during the remainder of the year (September through May) when they spend much of their time in outer coastal waters, but it is believed likely that they preferentially feed on Chinook salmon when available, and roughly in proportion to their relative abundance (Hanson et al. 2010). The contribution of Klamath-origin salmonids to the diet of Southern Residents is unknown, but during this period they may travel from central California to northern British Columbia (Krahn et al. 2004, as cited in Hanson et al. 2010). No change from existing conditions is expected in the short term.

TMDL implementation in the basin could improve water quality conditions over time, which might result in increased Chinook salmon production over time. However, full attainment of the water temperature TMDLs is likely to be offset by climate change. **The effect of the No Action/No Project Alternative would be no change from existing conditions for Southern Resident Killer Whales in the short and long term.**

Essential Fish Habitat

Dams and the continued impoundment of water within reservoirs under the No Action/No Project Alternative could alter the availability and suitability of Essential Fish Habitat (EFH).

Chinook and Coho Salmon EFH Under the No Action/No Project Alternative, EFH for Chinook and coho salmon would be expected to remain similar to its current condition. Access to habitat would be limited to its current levels; water quality would improve through TMDL implementation, but would be offset by warming expected as a result of climate change. The amount of suitable habitat in currently accessible tributaries would likely be reduced by climate change. Conditions under the No Action/No Project Alternative would continue to contribute to elevated concentrations of disease parasites and would provide the conditions required for the cross infection of fish and polychaetes. These interacting factors could decrease the viability of Chinook and coho salmon populations in the future. **The effect of the No Action/No Project Alternative would be no change from existing conditions for Chinook and coho salmon EFH in the short and long term.**

Groundfish EFH Under the No Action/No Project Alternative, sediment and habitat conditions in the estuary and nearshore ocean would remain the same as they are under existing conditions. **The effect of the No Action/No Project Alternative would be no change from existing conditions for groundfish EFH in the short and long term.**

Pelagic Fish EFH Under the No Action/No Project Alternative, sediment and habitat conditions in the estuary and nearshore ocean would continue to be the same as they are under existing conditions. **The effect of the No Action/No Project Alternative would be no change from existing conditions for pelagic fish EFH in the short and long term.**

Species-Specific Impacts

As described below, continued impoundment of water within reservoirs under the No Action/No Project Alternative, and the continued blockage of habitat access at project dams, could affect aquatic species.

Species-specific impacts are based upon existing conditions for key ecological attributes summarized above.

Fall-Run Chinook Salmon As described in Section 3.2, Water Quality, long-term dissolved oxygen levels under the No Action/No Project Alternative would continue to exhibit seasonal variability. These dissolved oxygen levels would not consistently meet Oregon and California Basin Plan water quality objectives for dissolved oxygen, and would not consistently support designated beneficial uses in Oregon for cold-water aquatic life, cool-water aquatic life, warm-water aquatic life, and spawning and in California for cold freshwater habitat, warm freshwater habitat, and spawning habitat beneficial uses. In addition, the thermal regimes downstream of Iron Gate Dam would continue to be altered as a result of project facilities and operations, particularly retention time of water in the reservoirs.

Under the No Action/No Project Alternative, Iron Gate Dam would continue to block fall-run Chinook salmon access to an estimated 420 miles of their historical habitat, which used to extend upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). The consequences of this ongoing loss of habitat to the population could include reduced resilience to recover from catastrophic disturbances of natural or anthropogenic origin, such as wildfire or chemical spills. Because areas upstream of the barrier include cold-water refugia, opportunities for the population to adapt to changing temperatures are reduced, whether these temperatures are a result of short- or long-term changes.

Under the No Action/No Project Alternative, the system of reservoirs and dams in the hydroelectric reach will continue to create conditions conducive to the spread of parasites among the fall-run Chinook salmon population downstream of Iron Gate Dam, especially where adults tend to congregate in high numbers, just downstream of Iron Gate Dam (Stocking and Bartholomew 2007, Bartholomew and Foott 2010), but also in other locations further downstream. Additional factors related to the project would continue to exacerbate the situation downstream of Iron Gate Dam, including increased water temperatures and dampened thermal variability, reduced dissolved oxygen concentrations, loss of sediment transport through the reach due to capture of sediment by the dams, and reservoirs contributing plankton to the filter-feeding polychaete hosts of the myxozoan parasites (Hamilton et al. 2011). Under the No Action/No Project Alternative, downstream-migrating juvenile Chinook salmon may continue to have high infection rates (Bartholomew and Foott 2010) during summer months in some years. Heavy parasite loads may increase disease-related mortality in outmigrant smolts, particularly when water temperatures are high, or may reduce ocean survival by affecting growth or fitness.

Effects of suspended sediment on fall-run Chinook salmon under the No Action/No Project Alternative and existing conditions are described in Appendix E, Section E.3.1.1. Overall, fall-run Chinook salmon use the mainstem Klamath River for spawning, rearing, and as a migratory corridor. Although SSCs under existing conditions and the No Action/No Project Alternative are relatively high in the mainstem downstream of Orleans, and even more so downstream of the Trinity River (California State Water Resources Control Board [SWRCB] 2006, NCRWQCB 2010) (see Section 3.2.3), they are relatively low in the reach downstream of Iron Gate Dam where most mainstem spawning occurs. Suspended sediment concentrations and durations during upstream and downstream migration, even under extreme conditions, are low enough that effects are limited to physiological stress and possibly reduced growth rates. In general, fall-run Chinook salmon appear relatively unaffected by current suspended sediment conditions because smolt outmigration primarily occurs when SSC are naturally low.

Under the No Action/No Project Alternative, ongoing hatchery operations would continue to mitigate for habitat lost due to construction of the dam by releasing millions of juvenile and yearling Chinook salmon annually. These fish may compete with the progeny of naturally spawned fish for food and other limited resources, such as thermal refugia, or can increase disease infection rates through crowding. In addition, some adult fish may stray and spawn with wild fish, which can reduce genetic and phenotypic diversity and reproductive success within the wild population (McLean et al. 2003, Araki et al. 2007, Araki et al. 2009, all as cited in Hamilton et al. 2011).

Under the No Action/No Project Alternative, the interruption of sediment transport processes by the dams would continue, reducing spawning gravel supply to downstream reaches and changing the dynamics of channel morphology and riparian vegetation communities that create and maintain rearing habitats for fry and juvenile fall-run Chinook salmon. It may also be contributing to the high densities of polychaetes downstream of Iron Gate Dam that host salmonid parasites.

The effect of the No Action/No Project Alternative would be no change from existing conditions for fall-run Chinook salmon in the short and long term.

Spring-Run Chinook Salmon Under the No Action/No Project Alternative, poor water quality conditions caused partly by nutrient enrichment during spring-run Chinook salmon upstream and downstream migration may cause high stress. Water quality in the mainstem Klamath River below Iron Gate Dam is characterized by altered seasonal water temperature patterns, dissolved oxygen, and increased nutrient input, as well occasional blooms of *M. aeruginosa*. Although water quality tends to improve downstream of the Salmon River (current upstream extent of spring-run distribution in the Klamath River), the effect of water quality alterations is that conditions (especially water temperature and DO) are critically stressful for spring-run Chinook salmon for much of the summer (June through September). Maximum temperatures often reach 25°C during summer, considered lethal for most Pacific salmon (Sullivan et al.2000). Spring Chinook salmon that are stressed by high temperatures, whether adults or juveniles, likely have lower survival rates, especially when challenged by additional water quality factors, such as low dissolved oxygen, the presence of toxic blue-green algae (*M. aeruginosa*) and fish diseases, and high pH and unionized ammonia. High water temperatures during summer may reduce the growth of juvenile fish that are rearing and migrating downstream to the ocean due to greater metabolic requirements. Because size is correlated with ocean survival, this could lead to reduced smolt survival and subsequently, reduced escapement. Finally, high temperatures can selectively reduce the survival of fish migrating later in the summer (the "summer run"), thus reducing genetic and life-history diversity. High water temperatures likely limit adult holding and summer rearing habitat for spring Chinook salmon in main spawning tributaries, the Salmon and Trinity Rivers, which would likely reduce overall production. Low flows in dry years can cause migration barriers to form, reducing habitat available to spawning and rearing fish.

Under the No Action/No Project Alternative, Iron Gate Dam would continue to block spring-run Chinook salmon access to an estimated 420 miles of their historical habitat, which used to extend upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). The consequences of this ongoing loss of habitat to the population could include reduced resilience to recover from catastrophic disturbances of natural or anthropogenic origin, such as wildfire or chemical spills. Because areas upstream of the barrier include cold-water refugia, opportunities for the population to adapt to changing climate are reduced, whether these changes are a result of short- or long-term cycles or trends.

Effects of suspended sediment on spring-run Chinook salmon under the No Action/No Project Alternative and existing conditions are described in Appendix E, Section E.3.1.2. Overall, spring Chinook salmon mostly use the mainstem Klamath River as a migratory corridor during adult migration, and downstream smolt migration. Although suspended sediment under existing conditions and the No Action/No Project Alternative is relatively high in the mainstem Klamath River downstream of Orleans, and especially downstream of the Trinity River (Appendix E), increases in suspended sediment in the mainstem Klamath River during critical migratory periods are low enough in concentration and short enough in duration that effects are limited to physiological stress and possibly inhibited growth, even during extreme conditions. Spring-run Chinook salmon appear less vulnerable to suspended sediment impacts than other Klamath River salmon populations (e.g., coho salmon and fall-run Chinook salmon).

One of the main spawning streams for spring-run Chinook salmon, the Salmon River has double the historical sediment production from road, timber harvest, and wildfire disturbance (Elder et al. 2002). Habitat degradation is believed to be the primary cause of the decline of the spring-run salmon population in the Klamath River system. Under the No Action/No Project Alternative, spawning and rearing habitat would continue to be reduced in both quantity and quality, and production may be low in some years.

The effect of the No Action/No Project Alternative would be no change from existing conditions for spring-run Chinook salmon in the short and long term.

Coho Salmon As described in Section 3.2, Water Quality, long-term dissolved oxygen levels under the No Action/No Project Alternative would continue to exhibit seasonal variability. These dissolved oxygen levels would not consistently meet Oregon and California Basin Plan water quality objectives for dissolved oxygen, and would not consistently support designated beneficial uses in Oregon for cold-water aquatic life, cool-water aquatic life, warm-water aquatic life, and spawning and in California for cold freshwater habitat, warm freshwater habitat, and spawning habitat beneficial uses. In addition, the thermal regimes downstream of Iron Gate Dam would continue to be altered as a result of project facilities and operations, particularly retention time of water in the reservoirs.

Under the No Action/No Project Alternative, Iron Gate Dam would continue to block coho salmon to an estimated 68 miles of their historical habitat, 45 of which would be in the mainstem Klamath River and tributaries (United States Department of the Interior [DOI] 2007; NOAA Fisheries Service 2007a) and an additional 23 miles of habitat currently inundated by the reservoirs (Cunanan 2009) which used to extend upstream to Spencer Creek (Hamilton et al. 2005). The consequences of this ongoing loss of habitat to the population could include reduced resilience to recover from catastrophic disturbances of natural or anthropogenic origin, such as wildfire or chemical spills. Because areas upstream of Iron Gate Dam include cold-water refugia, opportunities for the population to adapt to changing climate are reduced under the No Action/No Project Alternative, whether these changes are a result of short- or long-term cycles or trends. The above factors could reduce the natural genetic and life-history diversity found in Klamath Basin subpopulations of coho salmon that make them ideally suited to adapting to changing watershed conditions.

Access to suitable habitat under the No Action/No Project Alternative is also limited by small dams and diversions, culverts, road crossings, and aggraded channels (NRC 2004, CalFish query 2008, http://www.calfish.org). These barriers prevent use of formerly available spawning and rearing habitat, which represents another factor suppressing production under the No Action/No Project Alternative.

Under the No Action/No Project Alternative, upstream-migrating adult coho salmon will continue to be exposed to high water temperatures and poor water quality in the mainstem Klamath River, which can cause physiological stress, delay migration, reduce coldwater refugia, and increase mortality from disease. Low flows and increased sedimentation in tributaries can create barriers at the mouths of spawning streams, which would reduce spawning habitat area and production under the No Action/No Project Alternative in some years.

Effects of suspended sediment on coho salmon under the No Action/No Project Alternative and existing conditions are described in Appendix E Section E.3.1.3. Overall, under existing conditions and the No Action/No Project Alternative, SSC in the mainstem are sufficiently high and of long enough duration that major physiological stress and reduced growth of coho salmon are anticipated in most years. Consistent with these findings, the lower Klamath River downstream of the Trinity River confluence (RM 40.0) to the estuary mouth (RM 0.0) is listed as sediment impaired under Section 303(d) of the Clean Water Act (SWRCB 2006, NCRWQCB 2010) (see Section 3.2.2). Relatively high SSC, in association with elevated water temperatures and disease may be contributing to the high smolt mortality that has been observed in the mainstem Klamath River (Beeman et al. 2007, 2008).

Suitable rearing habitat for juvenile salmon under the No Action/No Project Alternative would continue to be restricted by high temperatures in some areas. High water temperatures may promote higher incidence of disease or parasitism, which may increase direct and indirect mortality (Stutzer et al. 2006, NOAA Fisheries Service2010a). During a 2008 PIT-tag study of juvenile coho salmon in the Shasta River, Chesney et al. (2009) found juvenile coho salmon only in areas where temperatures were moderated by cold springs; the remainder of potential rearing habitat was too warm (>20°C). Rearing habitat would continue to be compromised by livestock grazing and the legacy of logging impacts in riparian habitat that simplify channel and floodplain interactions that are conducive to creating habitat for rearing coho salmon in the winter.

Under historical, unregulated conditions, an annual spring pulse flow occurred in the Klamath River and in its tributaries (NRC 2004). Under current conditions a spring pulse still occurs, but is altered by water management. The magnitude of the spring flow is believed to have resulted in higher survival of coho salmon juvenile outmigrants and smolts relative to current conditions through several mechanisms, including (1) reduced rates of infection in juvenile salmon by *C. shasta* and *P. minibicornis*, (2) a reduced period of residency spent in the mainstem prior to smolting, and (3) greater habitat availability in the mid-Klamath River (Hardy et al. 2006), especially in the reach between Shasta River and Scott River where survival is particularly poor (Beeman et al. 2007, 2008).

High numbers of hatchery fish may affect wild coho salmon in the Klamath Basin under the No Action/No Project Alternative. The vast majority of coho salmon that spawn in the Klamath Basin are believed to be of hatchery origin, although the percentage varies among years (Ackerman et al. 2006).

Coho salmon populations in the Klamath Basin are in decline; less than 70% of streams historically used by coho salmon in the basin still contain small populations (NRC 2004). The No Action/No Project Alternative would likely continue to produce the types of habitat alterations that have helped to cause this decline.

More detail on current conditions for coho salmon can be found in NOAA Fisheries SErvice's (2010a) *Biological opinion on operation of the Klamath Project between 2010 and 2018*.

The effect of the No Action/No Proejct Alternative would be no change from existing conditions for coho salmon from all populations within the Klamath River watershed in the short and long term.

Steelhead As described in Section 3.2, Water Quality, long-term dissolved oxygen levels under the No Action/No Project Alternative would continue to exhibit seasonal variability. These dissolved oxygen levels would not consistently meet Oregon and California Basin Plan water quality objectives for dissolved oxygen, and would not consistently support designated beneficial uses in Oregon for cold-water aquatic life, cool-water aquatic life, warm-water aquatic life, and spawning and in California for cold freshwater habitat, warm freshwater habitat, and spawning habitat beneficial uses. In addition, the thermal regimes downstream of Iron Gate Dam would continue to be altered as a result of project facilities and operations, particularly retention time of water in the reservoirs.

Summer steelhead use the mainstem Klamath River primarily as a migration corridor because most spawning and rearing occurs in the tributaries. Under the No Action/No Proejct Alternative, summer steelhead spawning and rearing habitat availability and distribution would continue to be restricted during summer and fall to reaches downstream of Seiad Valley by high water temperatures farther upstream. If water temperatures upstream of Seiad Valley were historically cooler, then this represents an ongoing loss of habitat that might otherwise be contributing to smolt production and escapement. Conditions in the mainstem are generally suitable for adult upstream migration; however, high water temperatures in the late summer and fall may restrict movements and spawning distribution of later-arriving adults. Under a more normative flow regime, temperatures would be cooler in the summer and fall months for adult migrating fish (Bartholow et al. 2005; FERC 2007). Altered flow patterns downstream of Iron Gate Dam may thus be affecting the population by selecting for earlier-arriving fish, potentially reducing life-history diversity in the population. Water temperatures are likely to rise over the next decades as a result of climate change, which could result in further reduction of suitable habitat, with potential consequences for population abundance.

Fall and winter steelhead are more widely distributed than any other anadromous salmonid downstream of Iron Gate Dam. Under the No Action/No Project Alternative, they would continue to be restricted from hundreds of miles of historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). As with summer steelhead, they use the mainstem primarily as a migration corridor to access tributaries for spawning. Increases in fine sediment in tributaries used by steelhead for spawning could be reducing egg-to-emergence survival in some tributaries.

Under the No Action/No Project Alternative, high summer water temperatures in the summer months can cause density-independent mortality on juveniles that have left spawning tributaries to rear in the mainstem. In the winter months, velocity refuge habitat is often limiting to juvenile salmonids; juvenile steelhead seem to prefer hiding in the interstitial spaces between substrate particles to keep from being displaced by high flows. If fine sediment input has increased due to watershed disturbance, embeddedness of the substrate can reduce the availability of interstitial habitat, reducing the carrying capacity of these streams for juvenile steelhead and forcing them into suboptimal rearing habitats where growth rates are slower.

Effects of suspended sediment on steelhead under the No Action/No Project Alternative and existing conditions are described in Appendix E, Section E.3.1.4. Overall, steelhead use the mainstem Klamath River as a migratory corridor during adult migration, and downstream smolt migration, and for juvenile rearing. Although SSCs under existing conditions and the No Action/No Project Alternative are relatively high in the mainstem Klamath River downstream of Orleans, and especially downstream of the Trinity River (SWRCB 2006, NCRWQCB 2010) (see Section 3.2.3), SSC in the mainstem Klamath River during critical migratory periods, even during extreme conditions, are low enough and exposure times short enough that effects are likely limited to physiological stress and possibly reduced growth rate. Conditions for fish rearing in the mainstem are likely worse, but in general steelhead appear resilient to suspended sediment regimes under existing conditions and the No Action/No Project Alternative.

Habitat conditions for juvenile steelhead rearing in the mainstem are generally suitable, except for reaches upstream of Seiad Valley where summer water temperatures are considered stressful. Juvenile outmigration peaks in the spring and extends through the summer and fall. Growth during their rearing and outmigration may be reduced by high temperatures due to increased metabolism, which can reduce ocean survival. High summer water temperatures causing physiological stress to fish can also make them more vulnerable to mortality from disease or other compounding factors.

The effect of the No Action/No Project Alternative would be no change from existing conditions for steelhead in the short and long term.

Pacific Lamprey Pacific lamprey populations appear to have been in decline since the late 1980s in the Klamath Basin; (Larson and Belchik 1998; Moyle et al. 2009; all as cited in Hamilton et al. 2011), and are considered “vulnerable” throughout their range by the American Fisheries Society (Jelks et al. 2008, as cited in Hamilton et al. 2011). Major factors believed to be affecting their populations include barriers to upstream migration at dams; dewatering of larval habitat through flow regulation; reducing larval habitat by increasing water velocity and/or reducing sediment deposition areas; and susceptibility to contaminants in the larval stage (Close et al. 2002, as cited in Hamilton et al. 2011).

Under the No Action/No Project Alternative, Iron Gate Dam would continue to form a barrier to Pacific lamprey migration, which represents an ongoing loss of available habitat and productive capacity. Although the exact upstream extent of suitable habitat for Pacific lamprey prior to the completion of the Four Facilities is unknown, it is believed that Pacific lamprey would have migrated at least as far as Spencer Creek (Hamilton et al. 2005, as cited in Hamilton et al. 2011). The loss of this portion of historical spawning and larval rearing habitat reduces the basin's population viability through contracting their distribution within the watershed and reducing abundance, although the relative significance of the inaccessible areas upstream of Iron Gate Dam are unknown.

Under the No Action/No Project Alternative, the dams would continue to reduce sediment supply to the mainstem Klamath River downstream of Iron Gate Dam, which may limit availability of gravel-cobble substrates for nest building and fine sediment for burrowing; armoring of substrate would also be expected to reduce spawning habitat quality. The overall effect on the basin population is likely to be small because (1) the effects of the dam on fine sediment and gravel/cobble substrates diminish with distance downstream because of input from tributaries and become less significant downstream of Cottonwood Creek (RM 182.1), and (2) a large proportion of the population may spawn and rear in large tributaries to the mainstem, such as the Trinity, Salmon, Shasta, and Scott Rivers.

Effects of suspended sediment on Pacific lamprey under the No Action/No Project Alternative and existing conditions are described in Appendix E, Section E.3.1.5. Overall, under both normal and extreme conditions, Pacific lamprey are anticipated to suffer from stressful levels of suspended sediment while rearing and migrating through the mainstem Klamath River, with exposure durations generally much longer under extreme conditions. Because there are multiple year-classes of lamprey in the mainstem Klamath River at any given time, and since adults may migrate upstream throughout the year, Pacific lamprey populations may be well-adapted to persisting through years when suspended sediment concentrations are high, especially since they remain within the sublethal range.

The effects of dams and reservoirs would continue to affect water quality downstream of Iron Gate Dam under the No Action/No Project Alternative, which may reduce habitat quality for spawning and rearing Pacific lamprey, as well as reproductive success. Stone et al. (2002) found dissolved oxygen to be positively associated with lamprey presence at the reach scale ($P = 0.0002$). Meeuwig et al. (2005) reported that survival of larval Pacific lamprey under laboratory conditions was optimal at 18°C, but declined sharply at 22°C, with eggs and larvae at these higher temperatures also exhibiting deformities. Under existing conditions and the No Action/No Project Alternative water quality would improve through TMDL implementation, but would be offset by warming expected as a result of climate change.

Flow management under a No Active/No Project Alternative would continue to modify temperature and instream flow patterns from pre-project conditions. Movements of adult, ammocoete, and macropthalmia Pacific lamprey life stages tend to occur in association with discharge, while temperature and day length may be of less importance as life-history cues (Stone et al. 2002, Luzier et al. 2009). Stone et al. (2002) observed downstream migration of macropthalmia (juvenile phase) in Cedar Creek in association with summer low flows, with larger ammocoetes also moving downstream during this period as well, indicating that such movements were voluntary. In contrast, Beamish and Levings (1991, as cited in Stone et al. 2002) found that macropthalmia downstream movements to be associated with high flows, but also observed greater downstream movement of larger, older ammocoetes during these periods.

High discharge appeared to result in involuntary downstream displacement of ammocoetes (especially of smaller individuals) and macropthalmia outside of their normal migration period, which may reduce survival (Stone et al. 2002).

Under the No Action/No Project Alternative, Pacific lamprey populations in the Klamath Basin may remain at current levels or population numbers may continue to decline over the long term (Close et al. 2010). Because so little is known of Pacific lamprey life history and habitat requirements compared to those of anadromous salmonids, it is more difficult to predict the potential effects of alternatives on their abundance and distribution. **The effect of the No Action/No Project Alternative would be no change from existing conditions for Pacific lamprey in the short and long term.**

Green Sturgeon Green sturgeon spend a majority of their lives in estuaries, bays, and nearshore waters, with adults only returning to fresh water to spawn after more than 15 years, and spawning every four years on average (Klimley et al. 2007). In the Klamath River mainstem, green sturgeon spawn and rear in the lower 67 miles, downstream of Ishi Pishi Falls.

The Klamath Basin supports the largest spawning population of Northern Green Sturgeon (Moyle 2002), so it plays a critically important role in the viability and persistence of the entire DPS. Concentration of spawning to only a very few areas renders these spawning populations vulnerable to local catastrophic impacts. A loss of any of the few spawning areas would have much greater effects than the loss of a spawning population of salmon that spawn in other streams throughout their range.

Under the No Action/No Project Alternative, temperatures in the lower Klamath River in dry years may be reducing reproductive success of green sturgeon (Van Eenennaam et al. 2005). Studies conducted by Van Eenennaam et al. suggest that temperatures above 17–18°C are suboptimal for hatching and embryonic development, with temperatures from

23°C to 26°C resulting in 100% pre-hatching mortality. Cech et al. (2000) put the lethal temperature for embryos at 20°C.

Effects of suspended sediment on green sturgeon under the No Action/No Project Alternative and existing conditions are described in Appendix E. Overall, under existing conditions and the No Action/No Project Alternative, green sturgeon in the Klamath River mainstem are regularly exposed to suspended sediment concentrations documented to cause major physiological stress, reduced growth, and mortality in other fish species, especially during their egg and larval stages, and the year-round juvenile rearing period. However, these metrics likely overestimate effects on sturgeon.

Under the No Action/No Project Alternative, changes in the timing and magnitude of high flows downstream of Iron Gate Dam that are related to hydroelectric project operations have the potential to reduce green sturgeon survival in the mainstem. Adult green sturgeon that have held over the summer in the river after spawning appear to migrate downstream in conjunction with increases in discharge in the fall. Attenuation of high flows downstream of Iron Gate Dam may affect a key environmental cue used to stimulate the fall outmigration of adult green sturgeon that have remained in holding pools over the summer (Benson et al. 2007). This lower portion of the river was quite responsive to discharge increases related to rainfall events; the timing of peak flows changed significantly following the construction of the Four Facilities (Balance Hydrologics Inc. 1996). Under existing conditions, the Four Facilities result in higher flows in October compared with historically, and lower flows in late spring and summer (Balance Hydrologics Inc. 1996). Because temperatures in the lower river are close to lethal for eggs and embryos in dry years, reductions in flows related to the Four Facilities may exacerbate the effects of temperature on reproductive survival in these years, as would any temperature increases occurring as a result of climate change in the future. Shifts in the timing of seasonal life-history cues could also affect survival rates by changing the timing of their entry into habitats, such as entry of juveniles into the estuary.

The effect of the No Action/No Project Alternative would be no change from existing conditions for green sturgeon in the short and long term.

Lost River and Shortnose Sucker Upper Klamath Lake, one of the primary habitats of Lost River and shortnose suckers, has long been recognized as eutrophic, characterized by extremely high temperatures and pH in the summer, accompanied by huge daily fluctuations in dissolved oxygen and high ammonia concentrations. Although eutrophic conditions in Upper Klamath Lake have caused fish die-offs since the late 1800s, these have become more frequent and severe in recent years, with chubs and suckers being perhaps the hardest hit species (Perkins et al.2000, Buchanan et al. 2011a, as cited in Hamilton et al. 2011). Upper Klamath Lake inflows and outflows have declined since the 1960s while demand for water has increased for both agriculture and endangered fish species recovery. Along with direct mortality, poor water quality in Upper Klamath Lake affects endangered sucker species through suppressing growth, reducing resistance to disease and parasites, and reducing reproductive success.

Under current conditions, suckers in reaches of the Four Facilities suffer mortality by entrainment in hydroelectric project turbines (Gutermuth et al. 2000). (Partially effective fish screens at J.C. Boyle facility would continue to contribute to entrainment (Administrative Law Judge 2006)). Suckers would continue to be stranded due to Four Facilities operations and peaking.

Reservoir sucker populations are not believed to be self-sustaining or to contribute to populations upstream; but, under the No Action/No Project Alternative, they would persist, providing some additional insurance, no matter how small, that fish would be available for recolonization efforts if for some reason their primary populations underwent catastrophic decline. This would only be feasible with a species of this type, which is extremely long-lived.

Shortnose and Lost River suckers would continue to be subject to poor water quality within reservoirs. But with little or no successful reproduction (Buettner et al. 2006), populations downstream of Keno Dam contribute minimally to conservation goals and insignificantly to recovery (Hamilton et al. 2011).

Under the No Action/No Project Alternative, existing efforts to restore habitat for shortnose and Lost River sucker and improve water quality conditions would continue. These actions would be expected to improve conditions for these species over time and their populations would be expected to increase. **The effect of the No Action/No Project Alternative would be no change from existing conditions for Lost River and shortnose sucker populations in the short and long term.**

Redband Trout Resident trout upstream of Iron Gate Dam are considered to be redband trout. Before construction of the Four Facilities, redband trout in the area belonged to one population, with no migration barriers isolating populations from one another (Administrative Law Judge 2006). Under the No Action/No Project Alternative, genetic exchange and movement between reaches would continue to be limited by the J.C. Boyle fish ladder (Administrative Law Judge 2006) and lack of fish ladders at the Copco 1 and 2 Dams, as will access to productive spawning habitat in Spencer Creek by redband trout in the J.C. Boyle Bypass and Peaking Reaches (Administrative Law Judge 2006). The isolation of this population into several smaller subpopulations renders each more vulnerable to extinction due to stochastic events (wildfire, landslides, disease outbreaks, etc.) and limits genetic exchange among subpopulations.

Redband trout populations in the Four Facilities reaches and reservoirs are isolated from the larger populations upstream of Upper Klamath Lake, such as in the Williamson and Wood Rivers; no natural recruitment from the upper basin to populations in project-affected reaches can occur, as may have occurred historically.

Under the No Action/No Project Alternative, water quality in the Keno Reach would continue to be influenced by Keno Impoundment upstream. In the summer, problems with low dissolved oxygen, high nutrients, and warm temperatures (occasionally exceeding 21°C) may increase physiological stress on redband trout, making them more vulnerable to mortality from other stressors. Measures implemented to meet TMDL targets would likely improve water quality in this area to some degree.

Under the No Action/No Project Alternative, habitat connectivity for redband trout in the Klamath River would continue to be compromised by structural features of the Four Facilities as well as project operations. Fish downstream of J.C. Boyle Dam would continue to be hindered or obstructed from migrating to spawning grounds in Spencer and Shovel creeks by requiring them to ascend a fish ladder at J.C. Boyle Dam (USFWS and ODFW 2004, as cited in Hamilton et al. 2011). Factors influencing their movements include the necessity of passage at the J.C. Boyle Dam fish ladder as well as stresses resulting from power peaking operations downstream of the dam. Migration over the Copco 1 and 2 Dams is in the downstream direction only, as there is no fishway at this project feature.

The lack of functioning fish screens at Iron Gate, Copco 1 and 2 Dams minimizes recruitment of redband trout to downstream reaches, another factor adding to isolation of subpopulations in the Four Facilities area. At the J.C. Boyle facility, the partially effective fish screens would continue to contribute to entrainment (Administrative Law Judge 2006). The use of a Francis turbine at the J.C. Boyle facility would result in high mortality rates for fish that are entrained by it (EPRI 1987).

The health and productivity of redband trout in the J.C. Boyle Peaking Reach and J.C. Boyle Bypass Reach would continue to be affected under the No Action/No Project Alternative. Obstruction of sediment transport at J.C. Boyle Dam has altered substrates and channel features in the peaking and bypass reaches. High flows have mobilized and removed sediment from storage sites and transported them downstream, reducing habitat quality for redband trout as well as for the macroinvertebrates they feed on. In the J.C. Boyle Peaking Reach, redband trout numbers would continue to be subject to large fluctuations in flows that: (1) cause fluctuations in water temperature and pH, (2) strand fish, (3) displace fish downstream, (4) reduce fry habitat along channel margins, (5) reduce access to suitable gravels where they are affected by flow fluctuations, and (6) reduce macroinvertebrate food production by reducing the area of the channel suitable for their survival (City of Klamath Falls 1986, Addley et al. 2005, as cited by Hamilton et al. 2011). All of these conditions could result in substantial declines in redband trout abundance in this reach.

Diversion of water at Keno Diversion Dam would continue to alter flows downstream, reducing base flows in the summer when water quality is a concern, and reducing the magnitude and frequency of high flows important for creating and maintaining physical and ecological processes that affect habitat for trout, their macroinvertebrate food, and other aquatic organisms. Productivity of redband trout in the bypass and peaking reaches would continue to be suppressed by Four Facilities effects that limit spawning and rearing habitat in these reaches (Hamilton et al. 2011). Under existing conditions, spawning of redband trout in the Bypass Reach appears limited to an area just downstream of the emergency canal spillway (Hamilton et al. 2011). Patches of gravel that might otherwise be suitable for spawning are rendered inaccessible to redband trout by reductions in instream flows (FERC 1990, ODFW 2003, Administrative Law Judge 2006, all as cited in Hamilton et al. 2011).

Reduced redband trout abundance and distribution upstream of Iron Gate Dam attributable to Four Facilities features and operations would continue under the No Action/No Project Alternative. Habitat connectivity and suitability are substantially reduced in some reaches, which also suppresses the full range of life-history options formerly available to them. Other features of the redband trout populations in these reaches would likely be sustained under the No Action/No Project Alternative, such as declines in size (Jacobs et al. 2008, as cited in Hamilton et al. 2011) and condition factor (ODFW 2003, as cited in Hamilton et al. 2011).

The effect of the No Action/No Project Alternative would be no change from existing conditions for redband trout in the short and long term.

Bull Trout The distribution and numbers of bull trout are believed to have declined in the Klamath Basin due to habitat isolation, loss of migratory corridors, poor water quality, and the introduction of nonnative species. The geographic isolation of the Klamath populations places them at greater risk of genetic effects and extirpation (NRC 2004).

The effect of the No Action/No Project Alternative would be no change from existing conditions for bull trout in the short and long term.

Eulachon The southern population of Pacific eulachon consists of populations spawning in rivers south of the Nass River in British Columbia, Canada, to and including the Mad River in California (NOAA Fisheries Service 2009a). On March 18, 2010, NOAA Fisheries Service listed the southern DPS of eulachon as threatened under the ESA (NOAA Fisheries Service 2010b). The Klamath River is near the southern limit of the range of eulachon (Hubbs 1925, Schultz and DeLacy 1935, both as cited in BRT 2010). Large spawning aggregations of eulachon historically occurred regularly in the Klamath River (Fry 1979; Moyle et al. 1995; Larson and Belchik 1998; Moyle 2002; Hamilton et al. 2005; Wallace, pers. comm., 2011). However, CDFG did not capture any eulachon in the Klamath River from 1989 to 2003 (Wallace, pers. comm., 2011), and clearly they are in decline.

Under the No Action/No Project Alternative, habitat conditions in the estuary for eulachon would remain the same as they are under existing conditions. However, very little is known about the factors leading to decline of the eulachon.

The effect of the No Action/No Project Alternative would be no change from existing conditions for eulachon in the short and long term.

Longfin Smelt Longfin smelt are a state-listed threatened species throughout their range in California (CDFG 2009), but the USFWS denied the petition for federal listing because the population in California (and specifically San Francisco Bay) was not believed to be sufficiently genetically isolated from other populations (USFWS 2009).

The importance of ocean rearing is unknown. Little is known about longfin smelt populations in the Klamath River, except that they are presumably small.

The effect of the No Action/No Project Alternative would be no change from existing conditions for longfin smelt in the short and long term.

Introduced Resident Species Introduced resident species occur in Lake Ewauna, Upper Klamath Lake, within reservoirs upstream of Iron Gate Dam, and infrequently downstream of Iron Gate Dam. Under the No Action/No Proejct Alternative, conditions favorable for introduced species would continue to occur within the Four Facilities reservoirs (Buchanan et al. 2011a). Because these species were introduced and they occur in other nearby water bodies, their abundance is not considered a benefit from a biological perspective.

The effect of the No Action/No Project Alternative would be no change from existing conditions for introduced resident species in the short and long term.

Freshwater mussels Of the freshwater mussel species found on the mainstem Klamath River, the western ridge freshwater mussel (*G. angulata*) seems to be the most abundant and is widely distributed between Iron Gate Dam and the confluence of the Trinity River (Westover 2010). The floater species (*Anodonta spp*.) are less abundant, with the largest single bed found immediately below Iron Gate Dam (Westover 2010). The western pearlshell (*Margaritifera falcata*) is the least abundant freshwater mussel found in the Klamath River and seems to be mostly found below the confluence of the Salmon River (Westover 2010).

The effect of the No Action/No Project Alternative would be no change from existing conditions for freshwater mussels in the short and long term.

Benthic Macroinvertebrates The effect of the No Action/No Project Alternative would be no change from existing conditions on macroinvertebrates in the short and long term.

Interim Measures

Implementation of J.C. Boyle Gravel Placement and/or Habitat Enhancement could result in alterations to habitat availability and habitat quality, and affect aquatic species. Under this IM, suitable spawning gravel would be placed in the J.C. Boyle Bypass and Peaking Reaches beginning in the fall of 2011 for one year (it is assumed that work would cease in the event of a Negative Determination). This IM would involve placing gravel using a passive approach before high flow periods, or developing other habitat enhancement measures to provide equivalent fishery benefits in the Klamath River upstream of Copco Reservoir. These actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous species following dam removal. **Based on anticipated improvements in habitat availability and habitat quality, implementation of J.C. Boyle Gravel Placement and/or Habitat Enhancement in the fall of 2011 under the No Action/No Project Alternative would**

be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in the basin. Effects on bull trout, freshwater mussels, shortnose and Lost River suckers would be less-than-significant. Effects on green sturgeon, eulachon, and Southern Resident Killer Whales would not change from existing conditions.

Implementation of J.C. Boyle Bypass Barrier Removal could result in alterations to habitat availability, and affect aquatic species. Under this IM, the sidecast rock barrier located approximately three miles upstream of the J.C. Boyle Powerhouse in the J.C. Boyle Bypass Reach would be removed. The objective of this IM is to provide for the safe, timely, and effective upstream passage of Chinook and coho salmon, steelhead, Pacific lamprey, and redband trout. This action would provide improvements in habitat availability for resident fish prior to dam removal, and for resident and anadromous species following dam removal. **Based on anticipated improvements in habitat availability, implementation of J.C. Boyle Bypass Barrier Removal under the No Action/No Project Alternative would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, and redband trout. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in the basin. Effects on bull trout, shortnose and Lost River suckers would be less-than-significant. Effects on macroinvertebrates, freshwater mussels, green sturgeon, eulachon, and Southern Resident Killer Whales would not change from existing conditions.**

Alternative 2: Full Facilities Removal of Four Dams (the Proposed Action)

This alternative includes the removal of the Four Facilities along with the ancillary facilities of each installation in a 20-month period which includes an 8-month period of site preparation and partial drawdown at Copco 1 and a 12-month period for full drawdown and removal of facilities. This includes the entire dam, the powerhouses, spillways, and other infrastructures associated with the power generating facilities, as well as the transfer of the Keno Dam facilities to the DOI, and the implementation of the KBRA. The Proposed Action would result in effects on key ecological attributes that could affect aquatic resources, as summarized below. More detailed technical descriptions of the effects on suspended sediment, bedload sediment, and potential impacts on aquatic species, can be found in Appendices F and G.

Key Ecological Attributes

Suspended Sediment

Lower Klamath River: downstream of Iron Gate Dam Under the Proposed Action, full facility removal would result in the release of 5.3 to 8.6 million yd^3 of sediment stored in the reservoirs into the Klamath River downstream of Iron Gate Dam (Reclamation 2011), resulting in higher SSCs than would normally occur under existing conditions (Figure 3.3-5). SSCs would begin to increase during reservoir drawdown, prior to the deconstruction of the dams and continue to rise through the spring runoff period as material behind the dams is mobilized downstream. Reservoir drawdown is expected to commence in November 2019 for Copco Reservoir and in December 2019 for J.C. Boyle and Iron Gate Reservoirs. Based on the suspended sediment modeling conducted to analyze each alternative (including facility removal) (Reclamation 2011), SSCs are expected to exceed 1,000 mg/L for weeks, with the potential for peak concentrations exceeding 5,000 mg/L for hours or days, depending on hydrologic conditions during facility removal. At Iron Gate Dam (Figure 3.3-5), where SSCs are artificially low under current conditions (because of sediment trapping by the dam) SSCs would remain elevated above existing conditions throughout the first 2 years. At Orleans (Figure 3.3-6), where SSC under existing conditions is higher because of inputs of many tributaries, under a most-likely-to-occur scenario the effects of the Proposed Action would be similar to existing conditions by late April when releases of SSC from the Proposed Action are predicted to decrease. Under extreme conditions, SSCs are projected to remain somewhat elevated above existing conditions until October.

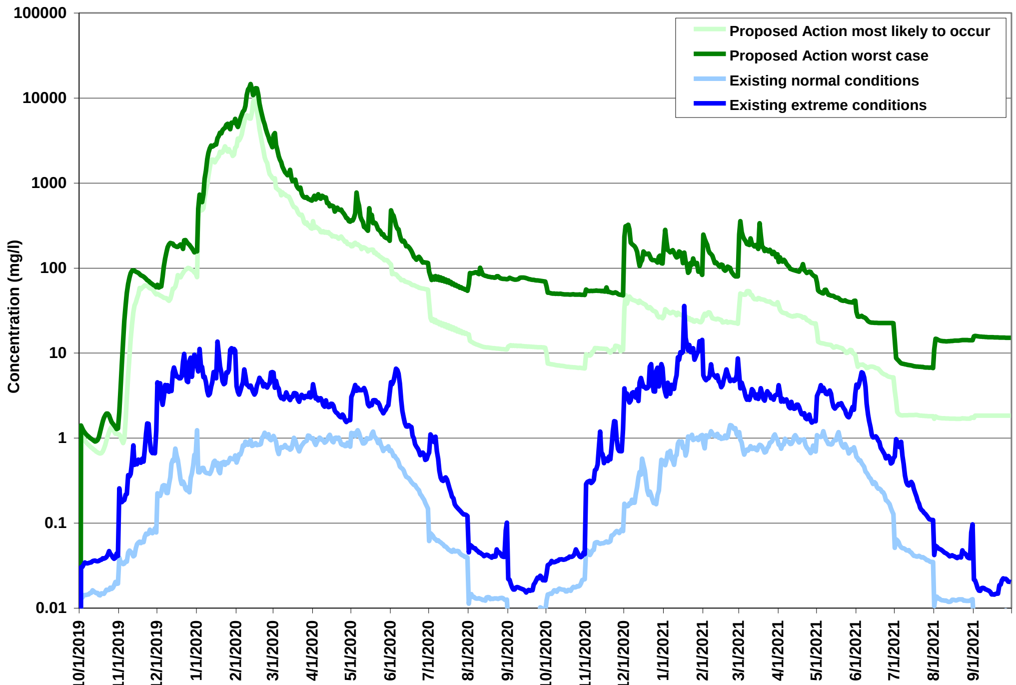

Figure 3.3-5. Comparison of SSCs under Proposed Action and Existing Conditions at Iron Gate Dam, as Predicted Using SRH-1D Model.

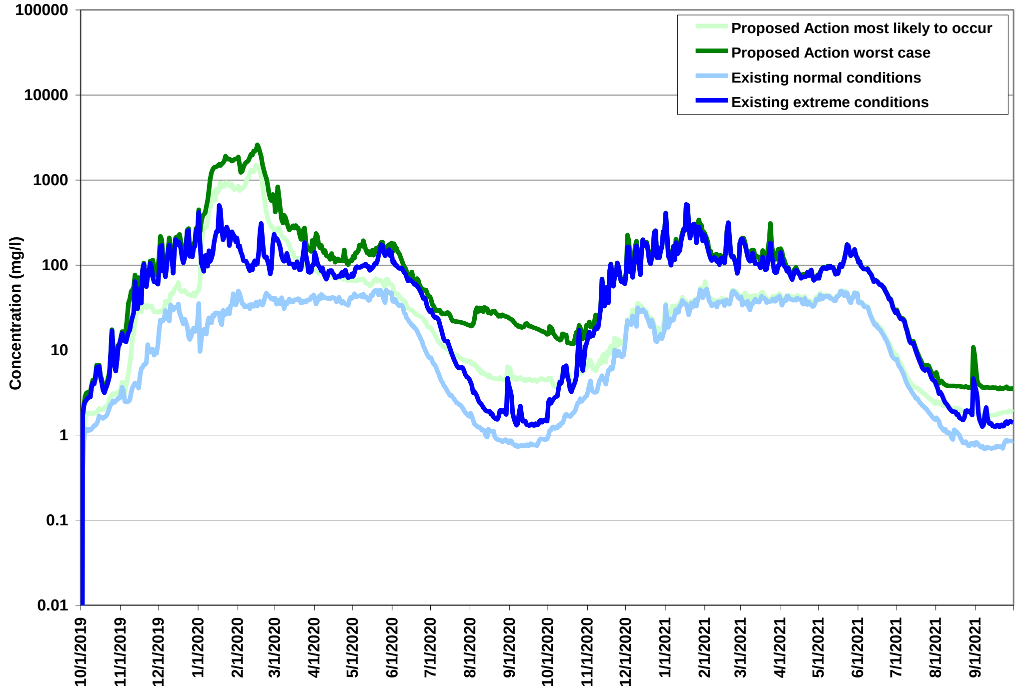

Figure 3.3-6. Comparison of SSCs under Proposed Action and Existing Conditions at Orleans, as Predicted Using SRH-1D Model.

Klamath River Estuary and Pacific Ocean Under the Proposed Action, sediment would be released from Iron Gate Dam, and would decline in concentration in the downstream direction as a result of dilution by input from downstream tributaries. Also, SSCs under existing conditions at Klamath Station are higher than at the upstream sites as a result of sediment input from tributaries. As a result, the difference of SSCs from the Proposed Action relative to existing conditions would be smallest in the Klamath River Estuary (Figure 3.3-7). The SSCs under the most-likely-to-occur scenario would be similar to those that occur under existing extreme conditions, and so resemble those that would be expected to occur about 1 year in 10 on average. Under the worst-case simulation, SSCs concentrations are only marginally higher than those for the existing extreme conditions. Therefore, effects on aquatic species from SSCs within the estuary are not anticipated to be distinguishable from existing conditions.

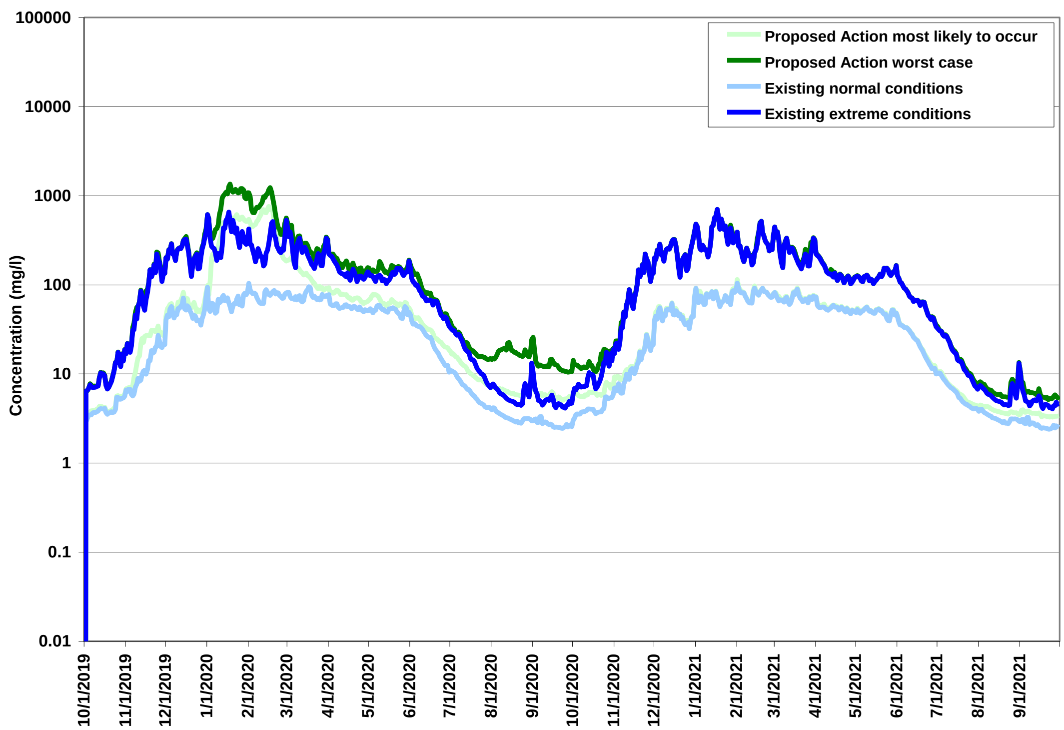

Figure 3.3-7. Comparison of SSCs under Proposed Action and Existing Conditions at Klamath Station, as Predicted Using SRH-1D Model.

Pacific Ocean Nearshore Environment In contrast to the lower Klamath River, modeled short-term SSCs following dam removal are not available for the nearshore marine environment adjacent to the Klamath River. Substantial dilution of the high (>1,000 mg/L) mainstem river SSCs is expected to occur in the nearshore under the Proposed Action; based on data from 110 coastal watersheds in California, where nearshore SSCs were measured at >100 mg/L during the El Nino winter of 1998 (Mertes and Warrick 2001), peak SSCs leaving the Klamath River Estuary may be diluted by 1 to 2 orders of magnitude from >1,000 mg/L to >10-100 mg/L. Based on the modeled SSCs at Klamath Station presented above, the SSCs in the nearshore ocean would be expected to be similar to what would occur during existing extreme conditions. Overall, any SSCs elevations associated with the Proposed Action are not anticipated to have effects on species distinguishable from existing conditions.

Bedload Sediment

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Dams in the Hydroelectric Reach currently store 13,150,000 yd^3 of sediment (Reclamation 2011). No sediment is stored within the Copco 2 Reservoir, Copco 1 Resevoir stores the greatest amount, and J.C. Boyle Reservoir stores the least. The SRH-1D model estimated 41 to 66 percent (5.3 to 8.6 million yd^3) of dam-stored sediment would be eroded the first year after dam removal depending on simulation type (wet, median, or dry) (Figure 3.3-8). Of this sediment, about 15 percent would be transported as bedload. Sediment not eroded from the reservoirs during the first year would be stored in gravel bars and terraces, and released more slowly through surficial and fluvial processes (Stillwater Sciences 2008).

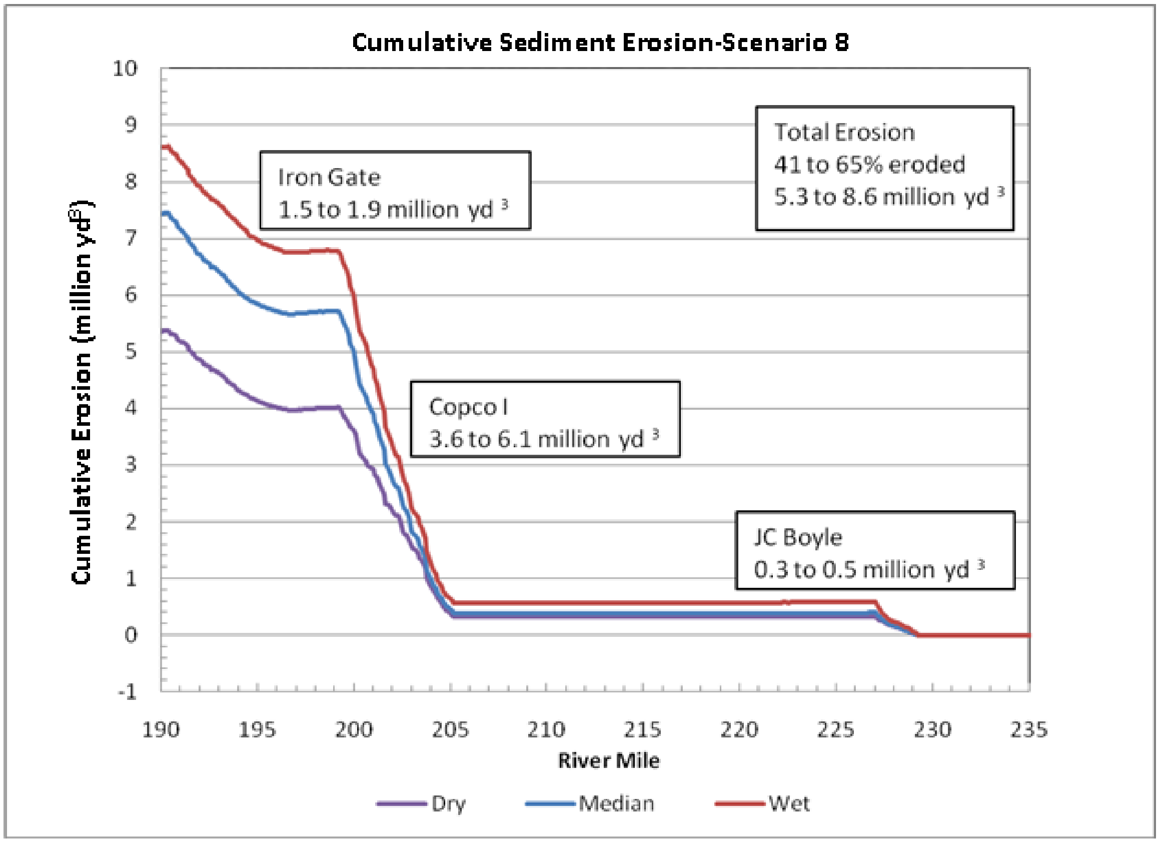

Figure 3.3-8. Cumulative Sediment Erosion from Dams in the Hydroelectric Reach During 2020 Drawdown Beginning in January (Reclamation 2011).

SRH-1D model results indicate decreases in bed elevation and increases in median substrate size within the reservoirs during drawdown (January 2020 to May 2020) (Figure 3.3-9 and Figure 3.3-10). These changes would stabilize within 5 months as the bed within the historical river channel reaches pre-dam elevations (Reclamation 2011; B. Greimann, pers. comm., December 23, 2010). These river sections are expected to revert to and maintain a pool-riffle morphology due to restoration of riverine processes along the Hydroelectric Reach (PacifiCorp 2004a). Still, after dam removal, channels currently inundated by reservoirs would likely vary from narrow, single-threaded channels to wide and sinuous channels with the potential to form complex features, such as meander cut-offs and vegetated islands (Reclamation 2011).

The river reaches upstream of J.C. Boyle Reservoir and from Copco 1 Reservoir to J.C. Boyle Dam show little change in bed composition or median substrate size during drawdown (Figure 3.3-10) (Reclamation 2011). Currently, these reaches are predominantly cobble (90 percent) with small fractions of gravel and sand. Very little temporal change in substrate size would be expected to occur in response to dam removal (Appendix E).

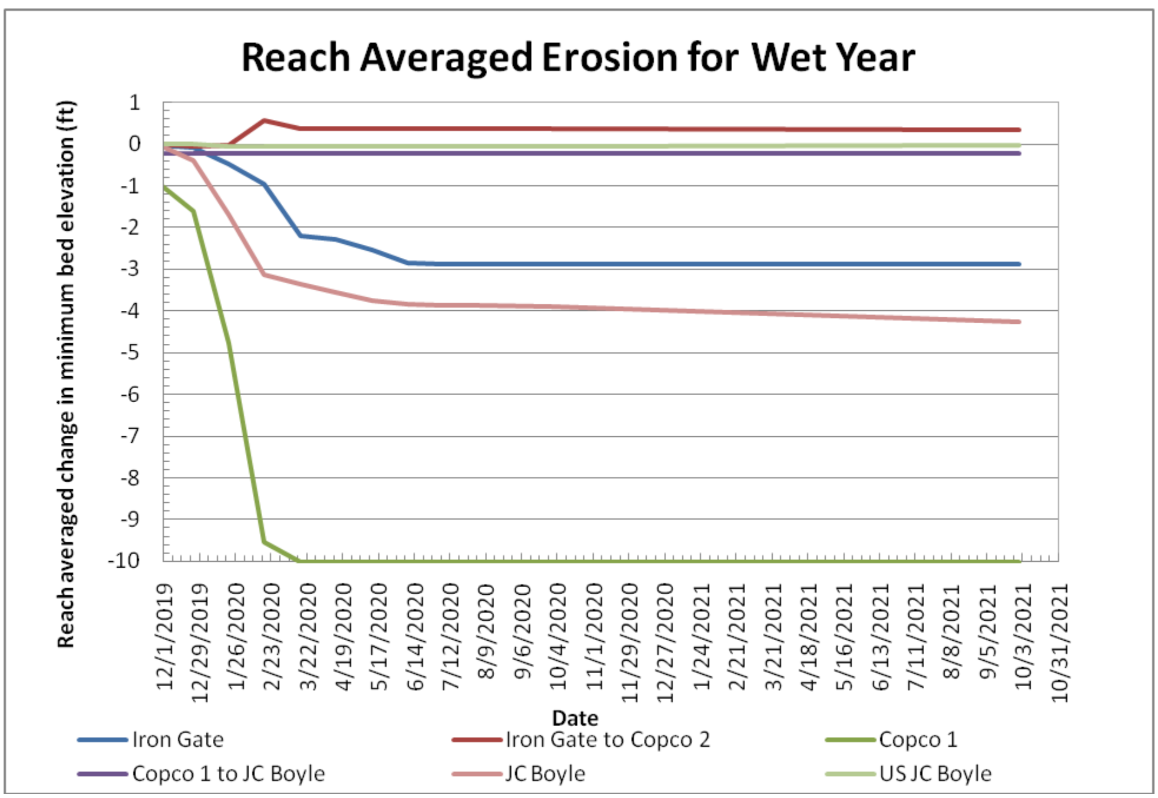

Figure 3.3-9. Reach-Averaged Erosion in the Hydroelectric Reach during Wet Year (Reclamation 2011).

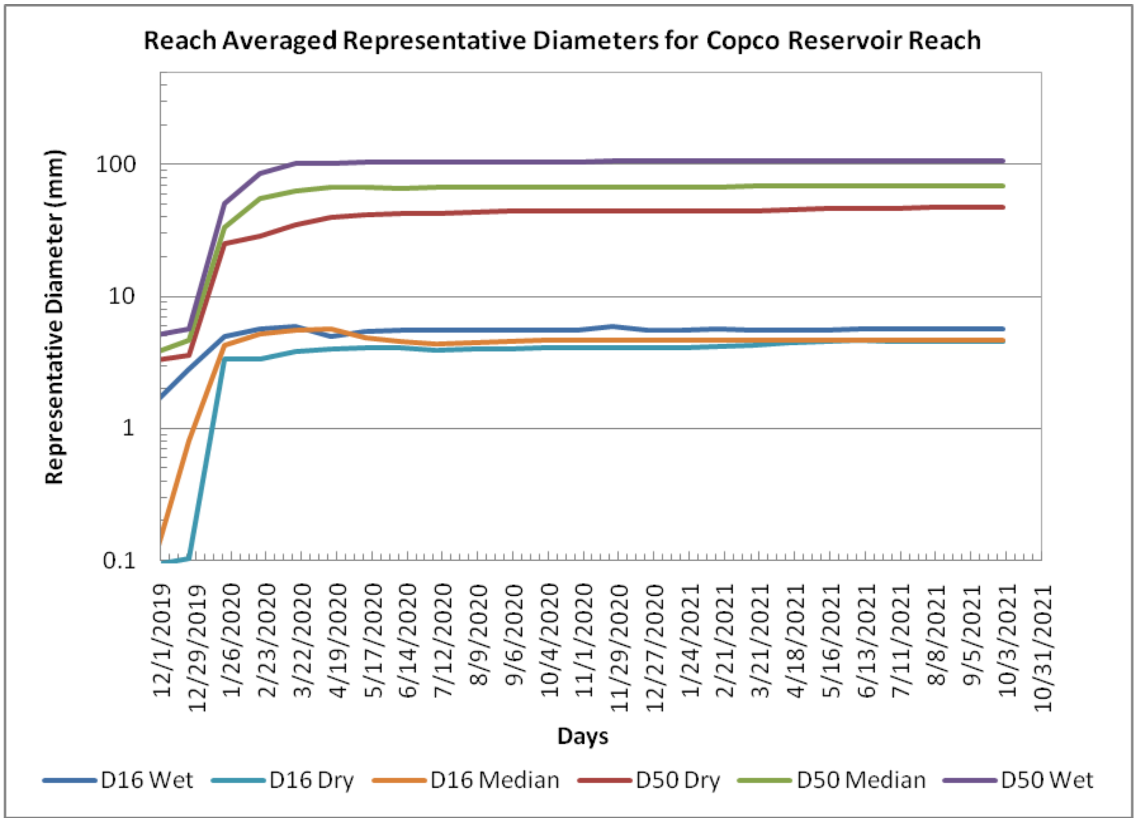

Figure 3.3-10. Reach-Averaged D16 and D50 in Copco 1 Reservoir Reach Following Dam Removal (Reclamation 2011).

The Copco 2 Dam to Iron Gate Reservoir reach shows increases in the proportion of sand to 35 to 45 percent shortly after drawdown (from January 2020 to February 2020) (Figure 3.3-11). In the dry simulation, the percent sand decreases to 20 percent from April 2020 to February 2021, then again to 10 percent from February 2021 to the end of the simulation.

Lower Klamath River: Downstream of Iron Gate Dam The streambed downstream of Iron Gate Dam would be affected by dam-released sediment and reconnection of the natural sediment supply from upstream. The sediment stored within the reservoirs has a high water content and 85 percent of the particles are silts and clays (less than 0.063 mm) while 15 percent are sand or coarser (larger than 0.063 mm) (Gathard Engineering Consulting 2006; Stillwater Sciences 2008; Reclamation 2011). As such, most sediment eroded from the reservoirs would be silt and clay (less than 0.063 mm) with smaller fractions of sand (0.063 to 2 mm), gravel (2 to 64 mm), and cobble (64 to 256 mm) (Gathard Engineering Consulting 2006; Stillwater Sciences2010a; Reclamation 2011). A large portion of the silt and finer substrate would likely be transported as suspended sediment and would travel to the ocean shortly after being eroded and mobilized (Stillwater Sciences2010a). Coarser (larger than 0.063 mm) sediment, including sand, would travel downstream more slowly, attenuated by channel storage and the frequency and magnitude of mobilization flows. The amount of sand transported in suspension would vary with discharge, with greater proportions of sand in suspension at higher discharges. A substantial amount of sand may deposit on the channel, potentially embedding larger substrate.

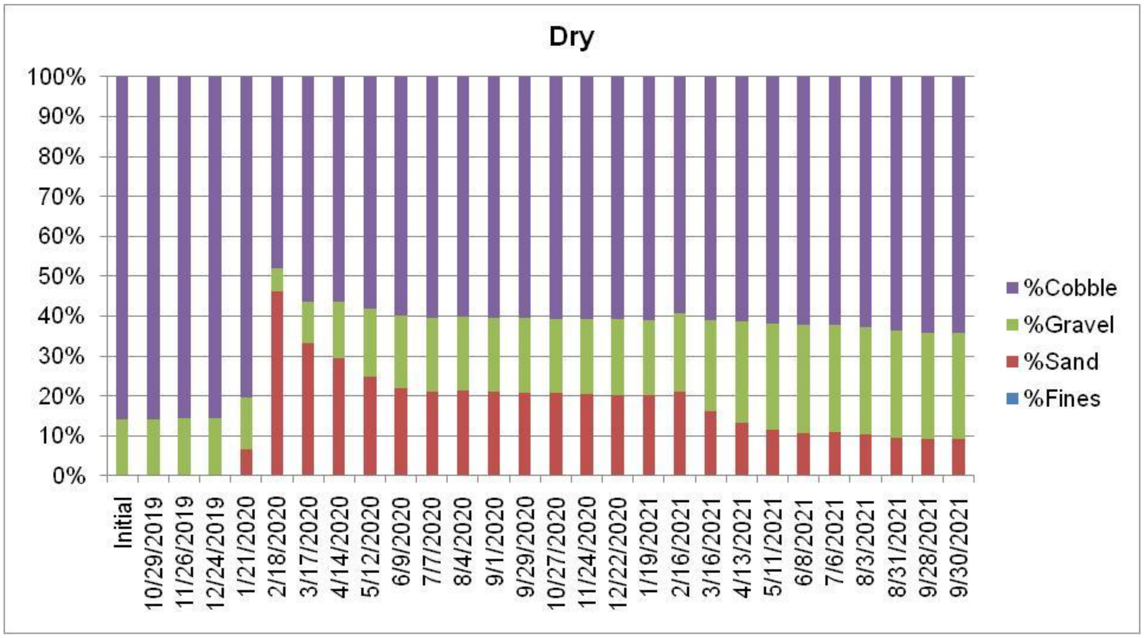

Figure 3.3-11. Simulated Bed Composition from Copco 2 to Iron Gate Reservoirs during Two Successive Dry Water Years after Dam Removal.

The effect of dam-released sediment and sediment resupply would likely extend from Iron Gate Dam to Cottonwood Creek (Reclamation 2011). Estimates of reach-averaged stream power (the ability of the river to move sediment) show a decrease from Iron Gate Dam to Cottonwood Creek, with stream power then increasing again downstream of Cottonwood Creek. The increase suggests that short- or long-term sediment deposition, either from dam release or sediment resupply, is unlikely downstream of Cottonwood Creek. Using this point as the downstream extent of bedload-related effects, 8 miles of channel could be affected by sediment release and resupply. The affected channel represents 4 percent of the total channel length of the mainstem Klamath River downstream of Iron Gate Dam (190 miles).

Short-term (2-year) SRH-1D model simulations estimate up to 5 feet of reach-averaged deposition of fine and coarse sediment between Iron Gate Dam and Bogus Creek (RM 189.8) (2.5 to 5 feet), decreasing to 1.0 to 1.5 feet of deposition between Bogus Creek and Willow Creek (RM 185.2), while reaches farther downstream showed no apparent increase (Figure 3.3-12, Reclamation 2011).

Reach averaged bed elevation between Iron Gate Dam to Bogus Creek would increase by 5 feet after drawdown (January 2020) until March 2020 under dry and median simulations, and would increase by 3 feet after drawdown until April 2020 under the wet simulation (Figure 3.3-12). Elevations under the dry and median simulation would be expected to approach a level similar to the wet simulation (3 feet) over time as flows carry dam released sediment downstream directly below Iron Gate Dam. In the long-term (from 5 to 50 years), after downstream translation of dam released sediment, bed elevation would adjust to a new equilibrium, which includes sediment supplied by upstream tributaries that was formerly trapped by dams within the Hydroelectric Reach. The average bed elevation increase predicted over the next 50 years is 1.5 ft in the reach from Bogus to Willow Creek and less than 1 foot downstream from there (Reclamation 2011). In the long-term (from 5 to 50 years), after downstream translation of dam released sediment, bed elevation would adjust to a new equilibrium, which includes sediment supplied by upstream tributaries that was formerly trapped by dams within the Hydroelectric Reach. Reclamation (2011) expects 2 to 3 feet of aggradation between Iron Gate Dam and Cottonwood Creek over the next 50 years.

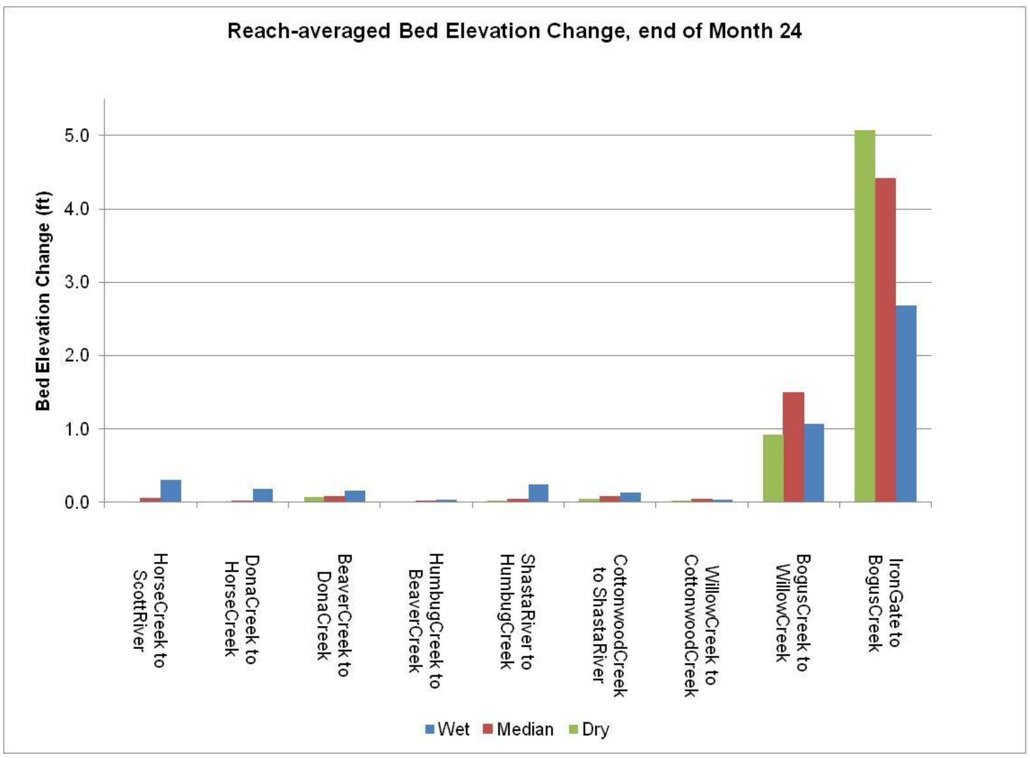

Figure 3.3-12. Reach Averaged Bed Elevation during Two Successive Wet, Median, or Dry Water Years from Iron Gate Dam to Bogus Creek (Reclamation 2011).

In the short-term (within 2 years), SRH-1D model output indicates dam released sediment and sediment resupply would increase the proportion of sand in the bed and decrease median bed substrate size (Figure 3.3-13 and Figure 3.3-14) (Reclamation 2011). The model predicts that after two successive dry years, the proportion of sand on the bed would increase to 30 percent and median substrate size would decrease to 45 mm after drawdown in January 2020 to March 2020 and remain at these values though to September 2021. Longer-term (5, 10, 25, and 50 years) simulations show increases in the proportion of sand to 5 to 22 percent and decreases in D50 to approximately 50 to 55 mm (Appendix E) after 5 years that stabilize and continue through to year 50.

Under the Proposed Action, sediment mobilization flows would decrease from existing conditions. Reclamation (2011) estimated the magnitude and return period of flows required to mobilize sediment downstream of Iron Gate Dam 50 years after dam removal using reach averaged, predicted grain sizes from long-term SRH-1D simulations. The estimates show that under the Proposed Action, sediment mobilization flows from Bogus Creek to Willow Creek and from Willow Creek to Cottonwood Creek would range from 3,000 to 7,000 cfs (1.5 to 2.5 year return period) and 5,000 to 9,000 cfs (1.5 to 3.2 year return period), respectively, lower than existing conditions or the No Action/No Project Alternative (see Figure 3.3-4). Downstream of the Shasta River, there would be no difference in bed mobilization flows or return period between the Proposed Action and existing conditions or the No Action/No Project Alternative.

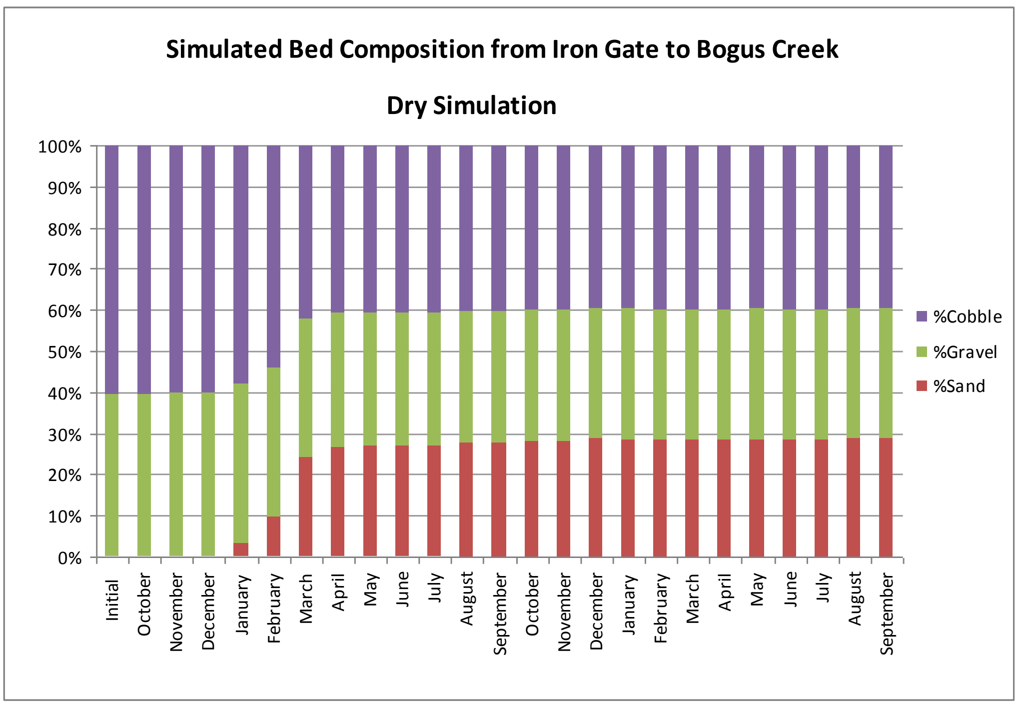

Figure 3.3-13. Simulated Bed Composition from Iron Gate Dam to Bogus Creek during Two Successive Dry Water Years Dam Removal.

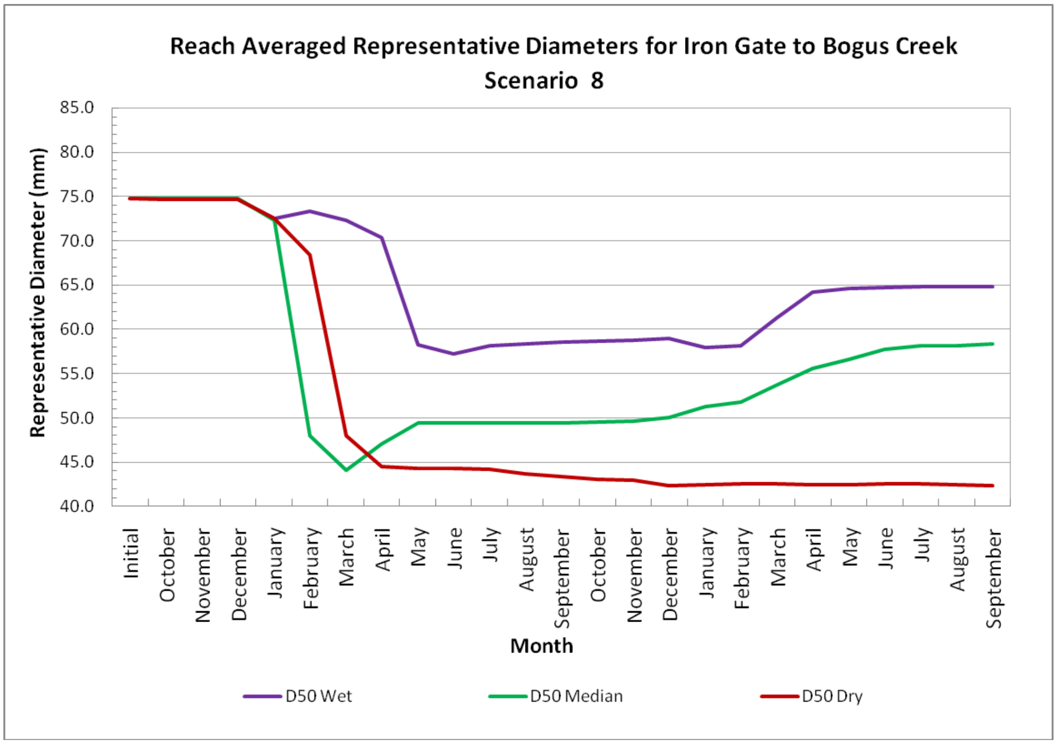

Figure 3.3-14. Simulated D50 (mm) from Iron Gate Dam to Bogus Creek during Successive Wet, Median, and Dry Water Years.

Water Quality

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir The Proposed Action (independent of KBRA actions described below) would not affect water quality in the following areas of the Upper Klamath Basin: Wood, Williamson, and Sprague Rivers, Upper Klamath Lake, and Link River to the upstream end of J.C. Boyle Reservoir.

Water quality problems (e.g., excessive water temperatures) in the Keno Impoundment/Lake Ewauna during late spring, summer, and early autumn, led NOAA Fisheries Service and the DOI to prescribe interim trap-and-haul measures to transport juvenile and adult fish past Keno Impoundment/Lake Ewauna during periods when conditions would be harmful to salmonids. During most years, the Lake Ewauna Reach of the Klamath River (Link River Dam to Keno Dam) has dissolved oxygen concentrations greater than 6 mg/L from mid-November through mid-June; these measurements are within United States Environmental Protection Agency criteria for migrating adult anadromous salmonids for these months (DOI 2007). Interim, seasonal, upstream trap and haul for primarily fall-run adult Chinook salmon around the Keno Impoundment/Lake Ewauna would be necessary when dissolved oxygen and temperature exceed the United States Environmental Protection Agency criteria. Water quality would be expected to improve over the long term through the implementation of the TMDL process (DOI 2007).

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam As described in Section 3.2, Water Quality, the Proposed Action could cause long-term overall increases in dissolved oxygen, as well as increased diel variability in dissolved oxygen, in the Hydroelectric Reach. Facility removal under the Proposed Action would cause slight long-term increases in summer and fall dissolved oxygen, increasing the likelihood of consistently supporting beneficial uses during this period.

California Klamath River TMDLs (NCRWQCB 2010) model results indicate that under the Proposed Action (analogous to the TMDL TOD2RN model run, which includes Oregon TMDL allocations), pH in the Hydroelectric Reach immediately downstream of J.C. Boyle Dam would be slightly less between March and May than pH levels modeled under the No Action/No Project Alternative (analogous to the TMDL T4BSRN model run). At the California-Oregon state line, pH under the Proposed Action would exhibit lower values April through June and October through December, with slightly more diurnal variation July through August than those predicted under the No Action/ No Project Alternative.

Lower Klamath River: Downstream of Iron Gate Dam Sediment release associated with the Proposed Action could cause short-term increases in oxygen demand and reductions in dissolved oxygen that could result in non-attainment of Basin Plan numeric water quality objectives for dissolved oxygen and contribute to reductions in beneficial uses in the lower Klamath River, the Klamath River Estuary, and the Pacific Ocean nearshore environment. As described in Section 3.2, Water Quality, model results indicate that short-term effects on dissolved oxygen would resolve well upstream of the Klamath River Estuary (at approximately 190 miles downstream of Iron Gate Dam) and, therefore, would not affect the Klamath River Estuary or the Pacific Ocean nearshore environment.

Overall, predicted short-term increases in oxygen demand and reductions in dissolved oxygen under the Proposed Action would not cause dissolved oxygen concentrations to fall below the minimum acceptable dissolved oxygen concentration (5 mg/L) for salmonids. However, short-term dissolved oxygen would fall below the Basin Plan numeric water quality objective (>8.1 to 8.8 mg/L) and would contribute to reductions in the most sensitive beneficial use (SPWN) for the mainstem river approximately 30 to 60 miles downstream of Hydroelectric Reach, or generally in the reach downstream of the Beaver Creek confluence and Seiad Valley.

Facility removal under the Proposed Action could cause long-term overall increases in dissolved oxygen, as well as increased diel variability in dissolved oxygen, in the lower Klamath River, particularly for the reach immediately downstream of Iron Gate Dam. Effects would diminish with distance downstream of Iron Gate Dam, such that no effects on dissolved oxygen would occur by the confluence with the Trinity River.

<u>Water Temperature</u>

Upper Klamath Basin Upstream of the Influence of J.C. Boyle Reservoir This region is upstream of any proposed dam removal; therefore, the Proposed Action would not affect water temperature. Any changes in water temperature in this region would be a result of other factors, including climate change. The effects in this area would be similar to those described for the No Action/No Project Alternative.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Under the Proposed Action, the Klamath River would no longer be dominated by hydropower peaking events and flows in the former Hydroelectric Reach would more closely mimic the natural hydrograph. The removal of the dams could also provide habitat for anadromous fish (Hetrick et al. 2009).

In the absence of the reservoirs, hydraulic residence time in this reach would decrease from several weeks to less than a day, and water quality would also be improved by nutrient assimilation in this reach (Hamilton et al. 2011). Evaporation from the surface of reservoirs (about 11,000 acre feet [Reclamation 2011]) would be reduced, adding to the river flow. The reservoir drawdowns would allow tributaries and springs such as Fall, Shovel, and Spencer Creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish (Hamilton et al. 2011). Water quality conditions would also improve further downstream in the Hydroelectric Reach. From Copco 1 to Iron Gate Reservoir, removal of the Four Facilities would result in a 2-10^{o}C decrease in water temperatures during the fall months and a 1-2.5^{o}C increase in water temperatures during spring months (PacifiCorp 2004a, Dunsmoor and Huntington 2006, NCRWQCB 2010a, Perry et al. 2011; see also Section 3.2.4.3.2.1), an increase dissolved oxygen concentrations (PacifiCorp 2004b, NCRWQCB 2010; see also Section 3.2.4.3.2.4), and eliminate reservoir habitat that creates ideal conditions for seasonal nuisance and/or noxious phytoplankton blooms (see Section 3.4, Algae).

Removing the dams would allow access to at least 49 tributaries upstream of Iron Gate Dam that could provide 420 miles of habitat for anadromous fish (DOI 2007), including groundwater-fed areas resistant to water temperature increases caused by changes in climate (Hamilton et al. 2011). In addition, the mainstem downstream of Iron Gate Dam would reflect natural temperature regimes (Hamilton et al. 2011). An additional 22.4 miles of riverine and riparian habitat would improve water quality by restoring the nutrient cycling and aeration processes provided by a natural channel. These improvements resulting from the Proposed Action would likely moderate the anticipated stream temperature increases resulting from climate change.

Lower Klamath River: Downstream of Iron Gate Dam The thermal lag formerly caused by water storage in reservoirs and the associated increased thermal mass would be eliminated in the lower Klamath River. This elimination would cause water temperatures to have natural diurnal variations and become more in sync with historical migration and spawning periods for Klamath River Chinook salmon, warming earlier in the spring, and cooling earlier in the fall compared to existing conditions (Stillwater Sciences 2009b;

Hamilton et al. 2011). These changes would result in water temperature more favorable for salmonids in the mainstem.

Simulations of water temperatures without the reservoirs (as discussed in Hamilton et al. 2011) show that the temperature difference with and without dams would be greatest downstream of Iron Gate Dam, but could extend an additional 120 to130 miles downstream. Estimated decreases in stream temperature with dam removal relative to current conditions are likely to be smaller with continued climate change; however, temperature conditions would be much improved under the Proposed Action as compared to the No Action/No Project Alternative (See Water Quality Section 3.2.4.3.2.1).

Klamath River Estuary and Pacific Ocean Nearshore Environment The influence of the Proposed Action would decrease with distance downstream of Iron Gate Dam (PacifiCorp 2004b), and it is unlikely that facility removal would have detectable effects on temperatures in the Klamath River Estuary and Pacific Ocean nearshore environment.

Fish Disease and Parasites

The Proposed Action would be expected to reduce impacts on salmonids from fish disease. The main factors contributing to parasitic fish disease in the Klamath River include habitat (pools, eddies, and sediment); microhabitat characteristics (stable flows and low velocities); host proximity to spawning areas; and water temperatures greater than 15°C (Bartholomew and Foott 2010).

The removal of the Four Facilities would be likely to reduce habitat quality for the polychaete host by reducing reservoir habitat, and restoring seasonal flow patterns and sediment dynamics that reduce the stability of the host's favored habitats. The removal of Iron Gate Dam would also remove a major barrier to fish migration, reducing the concentration of adults that presently occurs downstream of the dam. Greater dispersal of spawning adult salmon would reduce their proximity to dense populations of polychaetes.

Daily water temperature ranges would be expected to be more variable under the Proposed Action than under existing conditions. Fish might avoid migrating during periods when temperatures are high, or smolts might begin to move downstream earlier in spring, thus reducing their risk of being infected.

Short-term increases in sediment below Iron Gate Dam during drawdown of the reservoirs could also reduce the population density of polychaetes (Bartholomew and Foott 2010). This effect might be limited, as not all populations would be affected, and recolonization could occur following drawdown. However, increased variability in flow management, and the restoration of a more natural sediment regime, would likely reduce the suitability of habitat conditions for *M. speciosa*, the invertebrate host for *P. minibicornis* and *C. shasta*. In some areas, increased mobilization of the substrate would help reduce the availability of habitat for polychaetes (Stocking and Bartholomew 2007).

Among all of the salmonid lifestages, juvenile salmon tend to be most susceptible to *P.minibicornis* and *C. shasta*, particularly during their outmigration in the spring months (Beeman et al. 2008). Infection rates are related in part to warm water temperatures. If flows increase during spring, juvenile migration time could be decreased, potentially resulting in reduced disease exposure, especially for fish originating from lower Klamath River tributaries. The net result of these effects would also depend on temperature and smolt behavior.

Removal of the Four Facilities would allow anadromous salmonid migration upstream in the mainstem Klamath River and tributaries. Movement of adult salmon into the Upper Klamath Basin would result in introduction of new parasite genotypes that were previously restricted to the lower river (e.g., Chinook salmon migrating upstream could introduce the Type I genotype to upstream areas where it does not presently occur). Some degree of host specificity appears to exist (Atkinson and Bartholomew 2010), indicating that newly exposed species, such as redband trout, would not likely be susceptible to the new genotypes of *C. shasta* introduced into the upper watershed. As an example, redband trout are thought to be susceptible to Type 0, which already occurs in the upstream basin and Chinook salmon are susceptible to Type I, which occurs in the lower basin. But Type 0 genotype occurs in low densities and it is not very virulent (infection results in low or no mortality); if Type I genotype were to move above Iron Gate Dam, it would affect only Chinook salmon. It is not expected that introduction of *C. shasta* genotypes upstream would be deleterious because fish in the upstream basin have shown resistance to the downstream genotypes. Prior to the installation of Copco 1 Dam in 1918, Chinook salmon are known to have accessed the upper watershed, including tributaries to Upper Klamath Lake. Redband trout would presumably have been exposed to genotypes of *C. shasta* at that time, and their populations were abundant. Because the salmonid species in the Klamath Basin already co-occur with the genotype of *C. shasta* to which they are susceptible, and the salmonid species are less susceptible to other genotypes of *C. shasta*, expanding the distribution of the different genotypes of *C. shasta* would be unlikely to be deleterious to salmonids. New research findings in the past five years do not appear to contradict the finding that movement of anadromous salmonids into the Upper Basin presents a relatively low risk of introducing pathogens to resident fish (Administrative Law Judge 2006, USFWS/NOAA Fisheries Service Issue 2(B)).

Algal Toxins

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir This region is upstream of any proposed dam removal; therefore, removal of the reservoirs at the Four Facilities under the Proposed Action would not affect fish health as related to algal toxins. Any changes in algal toxin production in this region would be a result of other factors, including TMDL implementation. The effects in this area would be similar to those described for the No Action/No Project Alternative.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Removal of the reservoirs at the Four Facilities under the Proposed Action would eliminate growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa* in the Hydroelectric Reach, alleviating high seasonal concentrations of algal toxins and associated bioaccumulation of microcystin in fish tissue for species in this reach. While some microcystin may be transported downstream from large blooms occurring in Upper Klamath Lake, the levels would not be as high as those currently experienced due to the prevalence of seasonal in-reservoir blooms. Overall, bioaccumulation of algal toxins in fish tissue would be expected to decrease in the Hydroelectric Reach and would be beneficial.

Lower Klamath River: Downstream of Iron Gate Dam Removal of the reservoirs at the Four Facilities under the Proposed Action would eliminate growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa*, alleviating the transport of high seasonal concentrations of algal toxins to the Klamath River downstream of Iron Gate Dam. This would also decrease the associated bioaccumulation of microcystin in fish tissue for species downstream of the dam. While some microcystin may be transported downstream from large blooms occurring in Upper Klamath Lake, the levels would not be as high as those currently experienced due to the prevalence of seasonal in-reservoir blooms. Overall, bioaccumulation of algal toxins in fish tissue would be expected to decrease in the Klamath River downstream of Iron Gate Dam and would be beneficial.

<u>Aquatic Habitat</u>

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Under the Proposed Action, short-term effects would include the release of water stored in the Four Facilities. Based on modeling results, this release is expected to last about 4 months, from January 1 into April 2020, but could vary depending on hydrologic conditions (Reclamation 2011), increasing flows downstream of the dams during the drawdown period. River flows would be expected to remain below the 10-year flood event of 11,000 cfs. Flows would increase not only in the bypass reaches, but also all other mainstem reaches due to changes in operations and the absence of reservoir evaporation. Hydrology in the J.C. Boyle Peaking Reach would follow the natural hydrograph more closely, including increased duration and magnitude of high flows, and cessation of daily extreme flow fluctuations (characteristic of hydroelectric peaking operations). Seasonal high flows will contribute to improving the quality of riparian habitat in the J.C. Boyle Bypass Reach by increasing the sediment deposit within the channel and decreasing reed canary grass (Administrative Law Judge 2006). The more normative flow regime associated with this alternative would provide these seasonal high flows.

These flow increases would provide more habitat than under existing conditions for redband/rainbow trout and other resident riverine species, as well as anadromous fish or lamprey that reestablish in this area. These flows are expected to meet channel maintenance needs to route coarse sediments, build bars, erode banks, flush fine sediments, scour vegetation and undercut and topple large woody riparian vegetation NRC 2008). The removal of project dams would reestablish geomorphic and vegetative processes that form channels that provide fish habitat and spawning gravels in this reach, especially in the former bypassed reaches (FERC 2007). In addition, the impacts associated with daily extreme flow fluctuations resulting from peaking operations, such as stranding, displacement, reduced food production, and increased stress, would no longer occur. The removal of the Four Facilities would eliminate existing habitat for adult shortnose and Lost River suckers, as well as nonnative species occupying the reservoirs. The few shortnose and Lost River suckers that have been observed in these reservoirs are believed to be fish that have moved down from the upstream areas, but are not thought to represent a viable, self-supporting population (Buettner et al. 2006). The Proposed Action would restore 22.4 miles of riverine habitat (Cunanan 2009) for resident and anadromous fish through removal of reservoirs.

Overall, because the Proposed Action would result in flows more favorable to all life stages, eliminate peaking operations, and remove barriers that have isolated populations, the Proposed Action would result in benefits to salmonid populations and their habitat.

Following drawdown of the reservoirs, revegetation efforts would be initiated to support establishment of native wetland and riparian species on newly exposed reservoir sediment. No short-term effects are anticipated from these reservoir restoration efforts, and in the long-term aquatic habitat may be improved from restored riparian vegetation.

Lower Klamath River: Downstream of Iron Gate Dam As described above, the Proposed Action would result in elevated flows for about 4 months once drawdown begins, but the flows would be expected to remain below the 5-year flood event. These elevated flow rates could have the beneficial effect of maintaining unsuitable habitat conditions for introduced species in the river downstream of Iron Gate Dam. These increased flows could result in faster transport of outmigrant fish and slower upstream migration of adult fish in the Klamath River during this time.

Over the long term, the Proposed Action would alter the hydrograph so that the duration, timing, and magnitude of flows would be more similar to the unregulated conditions under which the native fish community evolved (Hetrick et al. 2009). While mean annual flows would not substantially change from existing flows due to the lack of active reservoir storage (Stillwater Sciences 2009b; Greimann et al. 2010), flow variability would increase.

The Proposed Action would substantially decrease the transit time of water in the Hydroelectric Reach, because it would no longer be detained by the reservoirs, resulting in a shift in the timing of the minimum flows (Balance Hydrologics Inc. 1996; NRC 2004, Fig. 4-2, p. 148, accessible at http://www.nap.edu/openbook.php?record_id=10838&page=144). These hydrologic effects would likely be more important in upstream areas (directly downstream of Iron Gate Dam) than downstream areas (below the confluence of the Scott River) due to the substantial flow contribution of tributaries to the Klamath River (Reclamation 2011, Hydrologic modeling, Appendix E). In addition, these hydraulic changes would result in changes to water quality, water temperatures, sediment transport, and riparian habitat, as described in subsequent sections.

Klamath River Estuary and Pacific Ocean Nearshore Environment Modeling results indicate that because of the influence of the tributaries entering the Klamath River downstream of Iron Gate Dam, the flow changes for the Proposed Action would not substantially affect the flows entering the estuary. Section 3.6, Flood Hydrology, provides further information on this effect. Therefore, the Proposed Action would not affect flow-related fisheries habitat in the estuary or the Pacific Ocean.

Aquatic Resources Effects

Critical Habitat

As described below, lowering the water surface elevation of the reservoirs associated with dam removal under the Proposed Action could alter the quality of critical habitat. In addition, the removal of dams and reservoirs could alter the availability and quality of critical habitat.

Coho Salmon Elevated levels of SSCs occurring during 3 to 4 months of drawdown would degrade critical habitat for coho salmon. Bedload movement following dam removal would cause substantial aggradation and increase supply of gravel below the dam as far downstream as Cottonwood Creek. This effect would potentially improve critical habitat for coho salmon by reducing median substrate to a size more favorable for spawning (Reclamation 2011).

The Proposed Action would increase the amount of habitat available to coho salmon upstream of currently designated critical habitat and improve water quality in the mainstem Klamath River within current critical habitat. NOAA Fisheries Service may consider whether to designate the newly available habitat as critical habitat as part of its 5-year status review or as a separate reconsideration of the critical habitat designation for the species (J. Simondet, NOAA Fisheries Service, pers. comm., 2011). Removal of the Four Facilities would allow coho salmon access to at least 68 miles of additional habitat and possibly up to as much as 82 miles (Administrative Law Judge 2006), including approximately 38 miles in the mainstem and at least 30 miles in tributaries such as Fall, Jenny, Shovel, and Spencer Creeks, and others. These tributaries are thought to provide habitat suitable for coho salmon. In addition, coho salmon could find suitable temperatures for holding in pockets within the J.C. Boyle Bypass Reach, although the average and maximum temperatures in this reach are expected to exceed optimal temperatures for coho salmon. Access to this habitat would increase the availability of spawning sites, result in additional food resources, and provide access to areas of better water quality. Water quality conditions would also improve within the mainstem downstream of the J.C. Boyle Powerhouse. Removal of the Four Facilities would result in lower water temperatures during the fall months, but would increase water temperatures slightly in the spring months, increase dissolved oxygen concentrations, and eliminate reservoir habitat that creates the conditions necessary for the growth of blue green algae and other phytoplankton. These changes would be beneficial for coho salmon critical habitat. **Based on reductions in habitat quality during reservoir drawdowns that would be detrimental to PCEs, the Proposed Action would have a significant effect on coho salmon critical habitat in the short term. Based on benefits to the PCEs, the Proposed Action would have a beneficial effect on critical habitat for coho salmon in the long term.**

Bull Trout Based on the restricted distribution of bull trout, implementation of the Proposed Action would not affect the physical or chemical components of critical habitat. However, the Proposed Action would allow Chinook salmon and steelhead to access areas they have not been able to access since the completion of the Copco 1 Development in 1918. These species would potentially compete with and prey upon bull trout fry and juveniles; however, bull trout would also be expected to consume the eggs and fry of Chinook salmon and steelhead. These species co-evolved in the watershed together, and it is anticipated that they would be able to co-exist in the future. **The Proposed Action would have a less-than-significant impact on critical habitat for bull trout in the short and long term.**

Southern Resident Killer Whale The Klamath River contributes to critical habitat for Southern Resident Killer Whales through its contribution of Chinook salmon to their food supply. The Proposed Action would not affect the geographic extent of critical habitat for this species, as it is located in the state of Washington. The Proposed Action is expected to increase wild populations of anadromous salmonids, which could increase food supply for Southern Resident Killer Whales. In a compilation of potential adult production from habitats upstream of Iron Gate Dam, estimates ranged from 9,180 to 21,245 (Hamilton et al. 2011). Klamath River salmon are anticipated to provide less than 1 percent of the diet of Southern Resident Killer Whales in most months. The Proposed Action would not be likely to materially affect the food supply of Southern Resident Killer Whales. **Based on small influence of the Klamath River on PCEs of Southern Resident Killer Whale, the Proposed Action would have a less-than-significant impact on critical habitat for Southern Resident Killer Whales in the short and long term.**

Essential Fish Habitat

As described below, lowering the water surface elevation of the reservoirs associated with dam removal under the Proposed Action could alter the quality of Essential Fish Habitat (EFH). In addition, the removal of dams and reservoirs could alter the availability and quality of EFH.

Chinook and Coho Salmon EFH The short-term release of sediment from the dams under the Proposed Action would be detrimental to Chinook and coho salmon EFH during the months when SSC concentrations are elevated. In the long term, the Proposed Action would increase habitat for Chinook and coho salmon (upstream of currently designated EFH) by providing access to habitats upstream of Iron Gate Dam. EFH quality would be affected by improved water quality, and decreased prevalence of disease, as described above for coho salmon critical habitat. Improved access to habitats (upstream of designated EFH), improved water quality and decreased prevalence of disease would provide a benefit to EFH for Chinook and coho salmon. **Based on a substantial reduction in EFH quality during reservoir drawdown, the Proposed Action would have a significant effect on EFH for Chinook and coho salmon in the short term. Based on benefits to quality, the Proposed Action would have a beneficial effect on EFH for Chinook and coho salmon in the long term.**

Groundfish EFH Under the Proposed Action, EFH in the estuary could be affected by elevated turbidity from sediment releases during dam removal for about 3 months. After this time, SSCs would return to levels similar to existing conditions. SSCs in the estuary would be less than 40 percent of the peak concentrations that are anticipated to occur immediately downstream of Iron Gate Dam. These peaks would still be substantial, and would be higher than the extreme values estimated by the sediment transport model for existing conditions (see Section 3.2.4.3.2.2).

In the long term, SSCs would be similar to that under existing conditions. Natural bedload transport processes would resume, as the dams would no longer trap sediments upstream of Iron Gate Dam. Bedload in the estuary and ocean would not be appreciably affected, because of the small contribution of the area above Iron Gate Dam to the total bedload in the system. With the exception of algal toxins, water quality benefits resulting from dam removal would largely have dissipated upstream of the estuary, and therefore, water quality in the estuary would be expected to remain similar to existing conditions. **Based on short duration of poor water quality during reservoir drawdown in the estuary, the Proposed Action would have a less-than-significant effect on EFH for groundfish in the short and long term.**

Pelagic Fish EFH The effects of the Proposed Action on pelagic fish EFH would be the same as those described for groundfish EFH, with substantial short-term increases in SSCs. These increases would subside after about 3 months. After this time SSCs would be expected to be similar to those under existing conditions. **Based on short duration of poor water quality during reservoir drawdown in the estuary, the Proposed Action would have a less-than-significant effect on EFH for pelagic fish in the short and long term.**

<u>Species-Specific Impacts</u>

As described below, lowering the water surface elevation of the reservoirs associated with dam removal under the Proposed Action could affect aquatic species. In addition, the removal of dams and reservoirs could alter the availability and quality of habitat, resulting in effects on aquatic species.

Species-specific impacts are based upon effects on key ecological attributes summarized above.

Fall-Run Chinook Salmon To help determine if the Proposed Action will advance restoration of the salmonid fisheries of the Klamath Basin, a Chinook Salmon Expert Panel was convened to attempt to answer specific questions that had been formulated by the project stakeholders to assist with assessing the effects of the Proposed Action compared with existing conditions (Goodman et al. 2011). The Panel concluded that the Proposed Action appears to be a major step forward in conserving target fish populations in the Klamath Basin. The Panel predicted that, based on the information provided to them, it was possible that the Proposed Action would provide a substantial increase in the abundance of naturally spawned Klamath River Chinook salmon above that expected under existing conditions in the reach between Iron Gate Dam and Keno Dam. While the Panel agreed that there was also evidence for dramatic increases in abundance associated with the Proposed Action upstream of Keno Dam, they cautioned that achieving substantial gains in Chinook salmon abundance and distribution in the Klamath Basin is contingent upon successfully resolving key factors (discussed in this report in detail) that will continue to affect population, such as water quality, disease, and instream flows. In addition, they stated the concern that successful implementation of KBRA would be required, and would need appropriate scientific leadership. Quantitative modeling of fall-run Chinook salmon populations further substantiates the conclusions of the Expert Panel. Modeling under both the Proposed Action and existing conditions suggests that dam removal would substantially increase numbers of spawners over a 50-year period (Oosterhout 2005). Additional production modeling efforts support this conclusion (Huntington 2006, Dunsmoor and Huntington 2006, Hendrix 2011, Lindley and Davis 2011). Of these, the Hendrix (2011) approach is considered the most intensive and robust conducted to date, because it used stock-recruitment data from the Klamath River; incorporated variability in watershed, climate, and ocean conditions; and presented variance estimates of uncertainty. Nobel applied a life-cycle model to forecast the abundance of Chinook salmon (fall-run and spring-run combined) for both the Proposed Action and continuation of existing conditions for the years 2012 to 2061. Hendrix (2011) results indicated substantial uncertainty in Chinook salmon stock recruitment dynamics, resulting in uncertain escapement and harvest abundance forecasts. Despite the uncertainty, modeling results indicate that the Proposed Action would result in higher relative abundance of Chinook salmon. Median escapements to the Klamath Basin are predicted to be higher with the Proposed Action than under existing conditions. Harvest is also predicted to be greater with the Proposed Action, and the probability of low escapement leading to fishery closures was less under the Proposed Action. Finally, simulations predicted that there is an approximately 75 percent probability that there would be higher escapement with the Proposed Action, and an approximately 70 percent probability of higher annual harvest.

The influence of the Proposed Action within specific reaches is described below.

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Proposed Action, removal of the Four Facilities would allow fall-run Chinook salmon to gain access to the upper Klamath River upstream of J.C. Boyle Reservoir. The access would expand the Chinook salmon's current habitat to include historical habitat along the mainstem Klamath River, upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). This would be a potential increase in access to 49 significant tributaries in the Upper Klamath Basin, comprising 420 miles of additional potentially productive habitat (DOI 2007), including access to groundwater areas resistant to climate change (Hamilton et al. 2011).

Poor water quality (e.g., severe hypoxia, temperatures exceeding 25°C, high pH) in the reach from Keno Dam to Link Dam might prevent fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011). However, evidence indicates that Upper Klamath Lake habitat is presently suitable to support Chinook salmon for at least the October through May period (Maule et al. 2009). Summer poor water quality conditions, may necessitate seasonal trap and haul around Keno Impoundment for some life stages of Chinook until KBRA and TMDL implementation improve water quality. This is consistent with the fishway prescriptions of DOI and US Department of Commerce (DOC) (DOI 2007; NOAA Fisheries Service 2007). Overall, dam removal and associated KBRA actions would accelerate water quality improvements (Dunne et al. 2011) and TMDL water quality benefits to anadromous fish (Water Quality Subgroup 2011).

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam The Proposed Action would restore fall-run Chinook salmon access to the Hydroelectric Reach. Adults could first access this reach in fall 2020 after dam removal. Because of this they would not exposed to the elevated SSCs that would occur during dam removal. By fall 2020, elevated SSCs from dam removal would have subsided. Most of the sediment stored within the removed reservoirs would likely be eroded within the first 5 months after dam removal, and, at most, cause minor (less than 0.5 foot) deposition in river reaches between reservoirs, settling into pool and other low-velocity habitats as water velocities decrease. River channels within reservoir reaches would likely excavate to their pre-dam elevations within a few months, and revert to and maintain a pool-riffle morphology due to restoration of riverine processes, likely creating holding and rearing habitat for anadromous salmonids.

Modeling data (Reclamation 2011) indicate that after dam removal, spawning gravel in all sections of the Hydroelectric Reach would be within the range usable for fall-run Chinook salmon, but the amount of sand within the bed within former reservoir sections could inhibit spawning success. The bed material within the reservoirs and between Iron Gate to Cottonwood Creek is expected to have a high content (30 to 50 %) of sand immediately following reservoir drawdown until a flushing flow moves the sand sized material out of the reach (Reclamation 2011). The flushing flow is expected to be at least 6,000 cfs and of several days to weeks to return the bed to a bed dominated by cobble and gravel with a sand content less than 20%. After the flushing flow, the bed is expected to maintain fractions of sand, gravel, and cobble which would be expected under natural conditions. Based on the historical record a sufficient flushing flow would likely occur within 5 years following dam removal. Riverine sections between reservoirs would be expected to provide the preferred substrate size range for fall-run Chinook salmon, with very little sand, suggesting that high-quality spawning habitat would be created.

The Proposed Action would establish a flow regime that more closely mimics natural conditions by increasing spring flow and by incorporating more variability in daily flows. The reservoir drawdowns would allow tributaries and springs such as Fall, Shovel, and Spencer Creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish (Hamilton et al. 2011). The removal of the four dams would likely reduce habitat availability for the polychaete host for *C. shasta* and *P. minibicornis*. Drawing down the reservoirs would reduce the amount of lentic habitat available, and increased flow variability would reduce the stability of pools, eddies, and low-velocity habitats. These changes would result in more favorable water temperature for salmonids, as well as improve water quality and reduce the incidence of disease and algal toxins.

Lower Klamath River: Downstream of Iron Gate Dam The Proposed Action would release dam-stored sediment downstream to the lower Klamath River in the short term, and restore a flow regime that more closely mimics natural conditions the long term. Suspended sediment effects on fall-run Chinook salmon under the Proposed Action are described in detail in Appendix E, and summarized here.

Under the most-likely-to-occur scenario or worst-case scenario, no effect from suspended sediment relative to existing conditions is anticipated for all adult fall-run Chinook salmon migrating or spawning within tributaries to the Klamath River during fall 2019 (around 92 percent of the population), or for juveniles rearing within tributaries (Table 3.3-5). Suspended sediment is anticipated to have sublethal effects on Type I and Type II outmigrants (Table 3.3-5). Direct morality from suspended sediment is anticipated to include the following:

- Under the most-likely-to-occur or worst-case scenario predicted complete loss of the eggs of the 2019 brood year deposited in the mainstem in fall 2019. Based on redd surveys from 2001 through 2009 (CDFG, unpublished data), an average of around 4,600 redds could be affected, or around 8 percent of all anticipated redds in the basin in 2019.

- Type III juvenile fall-run Chinook salmon from the 2019 cohort (hatched from eggs laid in 2018) outmigrating to the ocean during spring 2020 would be exposed to high SSCs. However, based on outmigrant trapping in the mainstem Klamath River at Big Bar (Scheiff et al. 2001), Type III age 1 spring outmigrants are very rare, and only 31 were observed at Big Bar in four years of trapping, or around 0.1 percent of trap captures. Under a most-likely-to-occur scenario 0 to 20 percent mortality is predicted, or around 0 to 189 smolts (around 0.02 percent of the total fall-run Chinook salmon smolt production). Under a worst-case scenario mortality rates of up 71 percent are predicted for the Proposed Action, equating to 669 smolts, or around 0.07 percent of the total fall-run Chinook salmon smolt production. Type I and Type II juvenile outmigrants are expected to experience sublethal effects.

The Proposed Action would also result in the release of bedload sediment, as described in detail in Appendix F. Effects associated with release of coarse sediment are expected to impact the same individuals as described for suspended sediment above. For example, bedload sediment is predicted to bury redds constructed in fall 2019, which are the same redds expected to suffer from suspended sediment. In addition, bedload sediment could result in the deposition that could aggrade pools or overwhelm other habitat features that Chinook salmon use for adult holding or juvenile rearing. However, the effect on habitat is anticipated to be short term, and pools would likely return to their pre-sediment release depth within one year (Stillwater Sciences 2008). In the long term, the river is predicted to revert to and maintain a pool-riffle morphology.

Table 3.3-5. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Fall-run Chinook Salmon.

Scenario	Life History Stage: Fall-run Chinook Salmon			
	Adult migration (July 15–Oct 31 2020)	**Spawning through fry emergence (Oct 15 2019–Feb 28 2020)**	**Age 0+ rearing (March 1–March 31 2020)**	**Outmigration (Type I April 1–August 31 2020) (Type II Sept 1–Nov 30 2020) (Type III Feb 1–April 15 2020)**
Most-likely	**Normal Existing Conditions (50% exceedance probabilities)**			
	No effects	No effects.	Moderate stress for age 0 in upper mainstem.	**Type I:** Major stress for Type I fry (about 60% of production) **Type II:** No effects **Type III:** Major stress for about 2 weeks for Type III outmigrants (<1% of production)
	Proposed Action			
	Same as existing conditions	Up to 100% mortality of the progeny of mainstem spawners (approximately 4,600 redds, or around 8% of production).	No juvenile progeny anticipated rearing in mainstem due to impacts during incubation. Most other juveniles assumed to rear in tributaries prior to outmigration.	**Type I:** Major stress and reduced growth **Type II:** Same as existing conditions **Type III:** Major stress, reduced growth, and up to 20% mortality (0 to 189 smolts, or less than 1% of production)
Worst-case	**Extreme Existing Conditions (10% exceedance probabilities)**			
	No effect	A few days of suspended sediment may reduce size at emergence for progeny from mainstem spawning (about 8% of escapement).	Major stress for age 0 in upper mainstem.	**Type I:** Major stress and reduced growth for the about 60% of fry entering mainstem in April–May **Type II:** Moderate stress for the about 40% of Type II juveniles entering mainstem in Sept–Nov **Type III:** Major stress for the less than 1% of juveniles entering mainstem in Feb–April
	Proposed Action			
	Major stress and impaired homing	Up to 100% mortality of the progeny of mainstem spawners (approximately 4,600 redds, or around 8% of production).	No juvenile progeny anticipated in mainstem due to impacts during incubation. Most other juveniles assumed to rear in tributaries prior to outmigration.	**Type I:** Same as existing conditions **Type II:** Moderate (1 day) to major (about 1 wk) stress **Type III:** Major stress, reduced growth, and up to 71% mortality (Up to 669 smolts, or less than 1% of production)

As described in detail in Appendix F, the 2021 cohorts could also be affected by sediment deposits with high levels of sand that would likely remain through fall 2020. In the long term, increased supply of gravel from upstream sources is predicted to increase the amount of fall-run Chinook salmon spawning habitat by decreasing the median substrate size to 40 to 60 mm (Reclamation 2011), within the observed range for Chinook salmon spawning (16 to 70 mm [Kondolf and Wolman 1993]). However, in the short term, sand composition may be as high as 30 percent, reducing the quality of spawning habitat. These levels of sand may continue to affect the 2020 brood year (2021 cohort) as these levels of sand that could remain through fall 2020 unless it is flushed from the substrate during winter flows. Changes in bedload would be limited to the reach from Iron Gate Dam to Cottonwood Creek, a length of 8 miles, or 4 percent of the channel length of the mainstem Klamath River downstream of Iron Gate Dam. The most severe effects would also be limited to a small proportion of the total channel length (0.5 miles, or less than 1 percent of the channel downstream of Iron Gate Dam), as sediment deposition would lessen downstream of Bogus Creek to Cottonwood Creek. At most, around 8 percent of fall-run Chinook salmon in the Klamath Basin are expected to spawn in the mainstem, with an even smaller percentage expected to spawn within the 8-mile affected reach (Appendix E).

The Proposed Action would establish a flow regime that more closely mimics natural conditions in the lower Klamath River. Flows under the Proposed Action are intended to benefit fall-run Chinook salmon. Hetrick's analysis of KBRA type[3] flows showed the greatest benefits would be in years when production was low (Hetrick et al. 2009). Implementing either the KBRA type flows or the Hardy et al. (Hardy et al. 2006) Phase II flow recommendations was predicted to decrease the occurrence of poor production years in the future by two-thirds. This would have significant positive consequences for Chinook salmon given their life cycle in the Klamath River (Hetrick et al. 2009). Dam removal would also cause water temperatures to become warmer earlier in the spring and early summer and cooler earlier in the late summer and fall, and to have diurnal variations more in sync with historical migration and spawning periods (Hamilton et al. 2011). These changes would result in water temperature more favorable for salmonids in the mainstem.

Incidence of disease are expected to be reduced by enhancing the scour capabilities of flow by uninterrupted sediment transport, a flow regime that more closely mimics natural conditions, thereby disturbing the habitat of the polychaete worm that hosts *C. shasta*. Reducing polychaete habitat will likely increase abundance of smolts by increasing outmigration survival, particularly for Type I and Type III life-histories.

<u>Estuary</u> The Proposed Action would not substantially change or affect estuarine habitat used by fall-run Chinook salmon. Short- and long-term improvements to water quality and reductions in algal toxins would be expected with the establishment of a flow regime that more closely mimics natural conditions, and would benefit fall-run Chinook salmon.

[3] This analysis assumed that low flows in water years 2012 to 2020 would resemble low flows in water years 1961 to 2000. The Hetrick et al. (2009) analysis was based on a period of record 1961-2000; thus we refer to these as 'KBRA type' flows.

Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and bedload sediment transport and deposition and affect fall-run Chinook salmon. Fall-run Chinook salmon use the mainstem Klamath River for spawning, rearing, and as a migratory corridor. Overall, the effect of SSC from the Proposed Action on the fall-run Chinook salmon population, under both most-likely and worst-case scenarios, is expected to be relatively minor because of variable life histories, the large majority of age 0 juveniles that remain in tributaries until later in the spring and summer, and because many of the fry that outmigrate to the mainstem come from tributaries in the mid- or lower Klamath, where suspended sediment concentrations resulting from the Proposed Action are expected to be lower due to dilution from tributaries in between. Effects would be distributed over three year-classes, rather than a single year-class. Therefore, Type-II and Type-III progeny of adults that successfully spawn in tributaries during 2020 will produce smolts that outmigrate to the ocean a year after the spring pulse of suspended sediment in 2020 and should not be noticeably affected by the Proposed Action. However, direct mortality is predicted for 4,600 redds (around 8 percent of total redds in the basin), and for around 669 Type III smolts (< 1 percent of production). In addition, sublethal effects on Type I and Type II outmigrants are predicted. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be significant for fall-run Chinook salmon in the short term.**

Mitigation Measures AR-1 through AR-4 (see Section 3.3.4.4) could be implemented to reduce the short-term effects of SSCs on fall-run Chinook salmon incubating eggs and smolts. There would still be short-term effects for fall-run Chinook salmon, including some direct mortality, but no one year class would suffer a substantial decrease in abundance. **Based on minimal reduction in the abundance of a year class in the short term, the Proposed Action would be a less-than-significant effect on fall-run Chinook salmon after mitigation.**

Under the Proposed Action, removal of dams could alter habitat availability, flow regime, water quality, temperature variation, fish disease incidence, and algal toxins, all of which could affect fall-run Chinook salmon in the long term. As stated above, dam removal would also restore connectivity to 420 miles of potentially usable habitat in the Upper Klamath Basin and would create additional spawning and rearing habitat within the Hydroelectric Reach. Almost any type of fish passage structure would be less efficient as a migration corridor for fish than removing the obstacle to passage itself. For example, fish ladders may cause delays in adult upstream migration or may become blocked by debris, and juvenile fish may have to navigate through impoundments with poor water quality or non-native predatory fish. Any of these potential factors has a chance of affecting fitness, survival, or reproductive success (Buchanan et al. 2011a). By providing an unimpeded migration corridor, the Proposed Action would provide the greatest possible benefit related to fish passage, hence, the highest survival and reproductive success. It is anticipated that the Proposed Action would increase the abundance, productivity, population spatial structure, and genetic diversity of fall-run Chinook salmon in the Klamath River watershed. In general, free flowing conditions as per the Proposed Action, would likely provide optimal efficiency, decrease outmigrant delay, and increase concomitant adult escapement (Buchanan et al. 2011a). **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action would be beneficial for fall-run Chinook salmon in the long term**.

Spring-Run Chinook Salmon As discussed above for fall-run Chinook salmon, a Chinook Salmon Expert Panel was convened to attempt to answer specific questions that had been formulated by the project stakeholders to assist with assessing the effects of the Proposed Action compared with existing conditions (Goodman et al. 2011). While noting uncertainties based on existing data, the panel concluded that the prospects for the Proposed Action to provide a substantial positive effect for spring Chinook salmon is more remote than for fall-run Chinook salmon. The primary concern of the panel was that low abundance and productivity (return per spawner) of spring Chinook salmon would limit recolonization of habitats upstream of Iron Gate Dam. However, KBRA includes a reintroduction component to establish populations in the new habitats, at least initially. In addition, KBRA actions would be implemented that are anticipated to improve productivity of existing and potentially newly accessible habitats. The influence of the Proposed Action within specific reaches is described below.

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Proposed Action, dam removal would allow spring-run Chinook salmon to gain access to the upper Klamath River upstream of J.C. Boyle Reservoir. The access would expand the Chinook salmon’s current habitat to include historical habitat along the mainstem Klamath River and upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). This would be a potential increase in access to 49 significant tributaries in the Upper Klamath Basin, comprising 420 miles of additional potentially productive habitat (DOI 2007), including access to areas influenced by groundwater exchange that are more resistant to climate change (Hamilton et al. 2011). The Proposed Action would not result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins and disease. Facilitating the movement of anadromous fish presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006).

Poor water quality (e.g., severe hypoxia, temperatures exceeding 25°C, high pH) in the reach from Keno Dam to Link Dam might prevent fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011). However, evidence indicates that Upper Klamath Lake habitat is presently suitable to support Chinook salmon for at least the October through May period (Maule et al. 2009). Summer poor water quality conditions, may necessitate seasonal trap and haul around Keno Impoundment for some life stages of Chinook until KBRA and TMDL implementation improve water quality. This is consistent with the fishway prescriptions of DOI and DOC (DOI 2007; NOAA Fisheries Service 2007). Overall, dam removal and associated KBRA actions would accelerate water quality improvements (Dunne et al. 2011) and TMDL water quality benefits to anadromous fish (USDI Secretarial Determination Water Quality Subgroup In Review).

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam The Proposed Action would restore spring-run Chinook salmon access to the Hydroelectric Reach. Adults could first access this reach in spring 2021 after dam removal; thus, short-term gains in flow-related habitat or habitat expansion would be limited to later cohorts. Elevated SSCs and bedload movement from dam removal would have dissipated by this time (see Figure 3.3-5, Figure 3.3-6, and Figure 3.3-7), returning to background levels similar to those under existing conditions and would not be expected to affect spring-run Chinook salmon using this area.

The Proposed Action would eliminate the Four Facilities and would establish a flow regime that more closely mimics natural conditions by increasing spring flow and by incorporating more variability in daily flows. The removal of the reservoirs would allow Fall, Shovel, and Spencer Creeks to flow directly into the mainstem Klamath River, along with Big Springs in the J.C. Boyle Bypass Reach and additional springs, which would provide fish with patches of cooler water as refugia (Hamilton et al. 2011). The removal of the four dams would likely reduce habitat availability for the polychaete host for *C. shasta* and *P. minibicornis*. Removal of the reservoirs would reduce the amount of lentic habitat available, and increased flow variability would reduce the stability of pools, eddies, and low-velocity habitats. These changes would result in more favorable water temperature for salmonids, as well as improve water quality and reduce instances of disease and algal toxins.

Lower Klamath River: Downstream of Iron Gate Dam The Proposed Action would release dam-stored sediment downstream to the lower Klamath River Reach in the short term, and would establish a flow regime that more closely mimics natural conditions in the long term. Adult spring-run Chinook salmon do not currently occur upstream of the Salmon River, and would not be expected to be able to use the mainstem Klamath River upstream of Iron Gate Dam until conditions in the Hydroelectric Reach are suitable.

Suspended sediment effects on spring-run Chinook salmon under the Proposed Action are described in detail in Appendix E, and summarized here. The distribution of spring-run Chinook salmon in the Salmon River and tributaries downstream limits their exposure to mostly lower concentrations of suspended sediment. Under the most-likely-to-occur scenario or worst-case scenario, no effect from suspended sediment relative to existing conditions is anticipated for all spring-run Chinook salmon spawning and rearing, which occurs primarily within tributaries (Table 3.3-6). Suspended sediment is anticipated to have sublethal effects on adult migration, primarily for those adult returning to the Salmon River (around 5 percent of all spring-run migrants), and sublethal effects on Type I and Type II outmigrants (Table 3.3-6). Direct morality from suspended sediment is anticipated to include the following:

- Type III juvenile spring-run Chinook salmon from the 2019 cohort (hatched from eggs laid in 2018) outmigrating to the ocean from the Salmon River during spring 2020 would be exposed to high SSCs. However, based on outmigrant trapping in the Salmon River (Karuk Tribe, unpublished data), Type III age 1 spring outmigrants are very rare, and only 30 were observed in five years of trapping.

> Assuming a larger number of Type III smolts outmigrate from the Salmon River and are undetected (assume an average of around 78 Type III smolts per year), under a most-likely-to-occur scenario 0 to 20 percent mortality is predicted or 16 smolts at most (less than 1 percent of the total spring-run Chinook salmon smolt production). Under a worst-case scenario mortality rates of 20 to 36 percent are predicted, or around 28 smolts at worst (<1 percent of all production). Type I and Type II juvenile outmigrants are expected to experience sublethal effects.

Adults could first access the reach upstream of the Iron Gate Dam in Spring 2021 if dam removal is completed by April of that year. As described in detail in Appendix F, short- and long-term changes in bedload would be limited to the reach from Iron Gate Dam to Cottonwood Creek, a length of 8 miles, or 4 percent of the mainstem Klamath River channel downstream of Iron Gate Dam (Appendix F). The most severe effects would also be limited to a small proportion of the total channel length (0.5 miles, or less than 1 percent of the channel downstream of Iron Gate Dam), as sediment deposition would lessen downstream of Bogus Creek to Cottonwood Creek and, thus, would not affect the area currently used by spring-run Chinook salmon. By spring 2021, suspended sediment concentrations would have returned to background levels and the channel would likely have reverted back to its previous pool-riffle morphology (Stillwater Sciences 2008).

The Proposed Action would create a flow regime that more closely mimics natural conditions in the lower Klamath River by increasing spring flow and by incorporating more variability in daily flows. Dam removal would cause water temperatures to warm earlier in the spring and early summer and cool earlier in the late summer and fall, and to have diurnal variations more in sync with historical migration and spawning periods (Hamilton et al. 2011). These changes would result in water temperature more favorable for salmonids in the mainstem. Migrating adults and juveniles rearing or migrating in the mainstem in spring 2020 would be exposed to poor water quality due to the Proposed Action. Because most spawning occurs in the Salmon and Trinity Rivers, magnitude of exposure would be limited by dilution from tributaries entering downstream of Iron Gate Dam.

Table 3.3-6. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Spring-run Chinook Salmon.

Scenario	Life History Stage: Spring-run Chinook Salmon			
	Adult migration (Apr 1–Jun 30, 2020)	**Spawning through fry emergence (Sept 1 2019–Feb 28, 2020)**	**Fry and juvenile rearing (year-round)**	**Outmigration (Type I: April 1–August 31 2020) (Type II: Sept 1–Nov 30 2020) (Type III: Feb 1–April 15 2020)**
Most likely	**Existing Conditions (normal)**			
	Spring Migration: Moderate stress and Impaired homing for adults returning to Salmon River (average 5% of total run, up to 35% of natural run) **Summer Migration:** No effects	Most spawning takes place in tributaries; no effects predicted	Juveniles primarily rear in tributaries; no effects predicted	**Type I:** Major stress for Type I fry from Salmon River (about 80% of Salmon River production) **Type II:** No effects (about 20% of Salmon R. production) **Type III:** Major stress for Type III juveniles from Salmon River (< 1% of Salmon River production)
	Proposed Action			
	Spring Migration: Major stress and impaired homing **Summer Migration:** Same as existing conditions	Same as existing conditions	Same as existing conditions	**Type I:** Same as existing conditions **Type II:** Same as existing conditions **Type III:** Major stress, reduced growth, and up to 20% mortality. (around 16 smolts, less than 1% of the total smolt population from the Salmon River)
Worst-case	**Existing conditions (extreme)**			
	Spring Migration: Major stress and impaired homing **Summer Migration:** Moderate stress	Most spawning takes place in tributaries; no effects predicted	Juveniles primarily rear in tributaries; no effects predicted	**Type I:** Major stress for Type I fry from Salmon River (about 80% of Salmon River production) **Type II:** Moderate stress for Type II juveniles from Salmon River (about 20% of Salmon River production) **Type III:** Major stress for Type III juveniles from Salmon River (<1% of Salmon River production)
	Proposed Action			
	Spring Migration: Same as existing conditions **Summer Migration:** Impaired homing	Same as existing conditions	Same as existing conditions	**Type I:** Same as existing conditions **Type II:** Same as existing conditions **Type III:** Major stress, reduced or no growth, and up to 36% mortality (up to 28 smolts, less than 1% of the total smolt population from the Salmon River)

Incidence of disease are expected to be reduced by enhancing the scour capabilities of flow by uninterrupted sediment transport, a flow regime that more closely mimics natural conditions, thereby disturbing the habitat of the polychaete worm that hosts *C. shasta*. Reducing polychaete habitat would likely increase abundance of smolts by increasing outmigration survival, particularly for Type I and Type III life-histories.

Estuary The Proposed Action is not expected to substantially change or affect spring-run Chinook salmon estuarine habitat. Short- and long-term improvements to water quality and reductions in algal toxins would be expected with the establishment of a flow regime that more closely mimics would benefit spring-run Chinook salmon. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and bedload sediment transport and deposition and affect spring-run Chinook salmon. The overall effect of suspended sediment from the Proposed Action on the spring-run Chinook salmon population is not anticipated to differ much from existing conditions and the No Action/No Project Alternative. There is very little difference from existing conditions and the No Action/No Project Alternative for adult migrants, all of which is predicted to be sublethal, and no effects are anticipated for the spawning, incubation, and fry stages because they do not spawn in the mainstem. Type I and II outmigrants are expected to experience very similar conditions under the Proposed Action as under existing conditions and the No Action/No Project Alternative. However, direct mortality is predicted for around 16 to 28 Type III smolts (< 1 percent of production). In addition, sublethal effects on adult migrants and Type I and Type II outmigrants are predicted. **Based on minimal reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be less-than-significant for spring-run Chinook salmon in the short term.**

Implementation of Mitigation Measures AR-2 (see Section 3.3.4.4) could reduce the short-term effects of SSCs on spring-run Chinook salmon Type III smolts. With implementation of mitigation measures, there would still be short-term effects for spring-run Chinook salmon including some potential direct mortality, but there would not be a substantial reduction in the abundance of a year class. **Based on minimal reduction in the abundance of a year class in the short term, the Proposed Action would be a less-than-significant effect on spring-run Chinook salmon after mitigation.**

Under the Proposed Action, removal of dams could result in alterations in habitat availability, flow regime, water quality, temperature variation, and fish disease incidence, and algal toxins which could affect spring-run Chinook salmon in the long term. Dam removal would restore connectivity to 420 miles of potentially usable habitat in the Upper Klamath Basin, including additional habitat within the Hydroelectric Reach. Access to additional habitat would provide a long-term benefit to spring-run Chinook salmon populations. Almost any type of fish passage structure would be less efficient as a migration corridor for fish than removing the obstacle to passage itself. For example, fish ladders may cause delays in adult upstream migration or may become blocked by debris, and juvenile fish may have to navigate through impoundments with poor water quality or non-native predatory fish. Any of these potential factors has a chance of affecting fitness, survival, or reproductive success (Buchanan et al. 2011a). By providing an unimpeded migration corridor, the Proposed Action would provide the greatest possible benefit related to fish passage, hence, the highest survival and reproductive success. It is anticipated that as a result of the Proposed Action the spring-run Chinook salmon population within the Klamath River watershed would have an increase in abundance, productivity, population spatial structure, and genetic diversity. **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action would be beneficial for spring-run Chinook salmon in the long term.**

Coho Salmon A Coho Salmon and Steelhead Expert Panel was convened and charged with answering specific questions that had been formulated by the project stakeholders to assist with assessing the effects of the Proposed Action on coho salmon and steelhead (Dunne et al. 2011). While noting the constraints of the Panel to arrive at conclusions within a short time period and without adequate quantitative or synthesized information, the conclusion of the Panel was that the Proposed Action would result in a modest increase in the coho salmon population compared with existing conditions. The Panel indicated that a relatively modest increase in coho population would result from dam removal due to the following factors:

- Only modest increases in suitable coho salmon habitat would result from dam removal;
- Coho salmon use more tributary streams and rely less on the mainstem Klamath River habitats primarily affected by dam removal;
- Anticipated positive but unquantifiable changes in tributary habitats where most coho spawn and rear due to KBRA implementation; and,
- Potential for disease and low ocean survival to offset gains in production.

<u>Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir</u> There is no historical evidence that coho salmon occurred upstream of J.C. Boyle Reservoir, primarily because most people at the time did not distinguish between the various anadromous salmonid species Snyder (1931) noted that they occurred in large numbers in the Klamath River. He stated that “Nothing definite was learned about them from inquiry because most people are unable to distinguish them,” but also that “silver salmon are said to migrate to the headwaters of the Klamath to spawn.” Beginning in 1910-1911, adult coho salmon were trapped at the “Klamathon Racks” near the town of Klamathon, which is evidence that they migrated upstream of Iron Gate and Copco Dams.

<u>Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam</u> The Proposed Action would restore access for upper Klamath River Population coho salmon to the Hydroelectric Reach, expanding their distribution to include historical habitat along the mainstem Klamath River and all tributaries upstream as far as Spencer Creek; including in Jenny, Shovel, and Fall Creeks (Hamilton et al. 2005). Adults could first access this reach in fall 2020 after dam removal. By this time, elevated SSCs from dam removal would likely have dissipated, returning to background levels similar to those of existing conditions. Most sediment released from the reservoirs would likely be eroded

within the first five months after dam removal (by May 2020), returning sections of river currently inundated by the Four Facilities and riverine sections between reservoirs to pool-riffle morphology. Within this reach, coho salmon generally spawn in tributaries and not within the mainstem Klamath River, but might rear and migrate through the Hydroelectric Reach. Dam removal would result in the provision of suitable rearing habitat for juveniles and spawning habitat for the few individuals that might spawn in the mainstem Klamath River. Access to the cooler waters associated with spring inputs in the Hydroelectric Reach would benefit coho salmon rearing in the mainstem (Hamilton et al. 2011).

The Proposed Action would also eliminate the Four Facilities and would establish a flow regime that more closely mimics natural conditions by increasing spring flow and by incorporating more variability in daily flows. The reservoir drawdowns would allow tributaries and springs such as Fall, Shovel, and Spencer Creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish (Hamilton et al. 2011). The removal of the four dams would also likely reduce habitat availability for the polychaete host for *C. shasta and P. minibicornis*. Removal of the reservoirs would reduce the amount of lentic habitat available, and increased flow variability would reduce the stability of pools, eddies, and low-velocity habitats. These changes would result in more favorable water temperature for salmonids, and would improve water quality and reduce instances of disease and algal toxins. All of these changes would benefit coho salmon produced in the Hydroelectric Reach in 2020 and thereafter.

<u>Lower Klamath River: Downstream of Iron Gate Dam</u> The Proposed Action would release dam-stored sediment downstream to the lower Klamath River Reach in the short term and would establish a flow regime that more closely mimics natural conditions in the long term. Suspended sediment effects on coho salmon under the Proposed Action are described in detail in Appendix E, and summarized here. There are nine coho salmon population units in the Klamath River watershed (see Section 3.3.3.1). Only negligible effects from suspended sediment would be expected on the three population units in the Trinity River, and on the lower Klamath River Population Unit relative to existing conditions. Effects on the Salmon River Population Unit are anticipated to remain sublethal even under a worst-case scenario (Table 3.3-7). Effects on the upper Klamath River, mid-Klamath River, Shasta, and Scott population units under the most-likely-to-occur or worst-case scenario are anticipated to be sublethal on most life-stages (Table 3.3-7), with the following exceptions:

- Under the most-likely-to-occur or worst-case scenario coho salmon from the Upper Klamath River Population Unit that spawn in the mainstem, as well as their progeny, would suffer up to 100 percent mortality; however, even under existing conditions and the No Action/No Project Alternative, 80–100 percent mortality is expected due to the effects of suspended sediment on these life stages (in addition to other sources of mortality). Based on spawning surveys conducted from 2001 to 2005 (Magneson and Gough 2006), from 6 to 13 redds could be affected in 2019 during the Proposed Action, many of which are thought to be hatchery

Table 3.3-7. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Coho Salmon.

Scenario	Life History Stage: Coho Salmon					
	Adult migration (Sept 1, 2019–Jan 1, 2020)	**Spawning through fry emergence (Nov 1, 2019–Mar 14, 2020)**	**Age 0+ rearing during summer (Mar 15–Nov 14, 2020)**	**Age 1+ rearing during winter (Nov 15, 2019–Feb 14, 2020)**	**Outmigration Early spring outmigration: (Feb 15–March 31, 2020) Late spring outmigration: (April 1– June 30, 2020)**	
Most Likely	**Existing Conditions (normal)**					
	Stressful SSCs for about 5 days; deleterious affects on adults unlikely	Low survival (<20%)	**Age 0+ summer:** Major stress for age 0+ from 2020 cohort in mainstem (<50% of fry)	**Age 1+ winter:** Moderate stress for age 1+ juveniles from 2019 cohort in mainstem (assume <1% of juveniles)	**Early spring outmigration:** Major stress mortality for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during early spring (approximately 44% of run outmigrate in early spring)	**Late spring outmigration:** Major stress for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during late spring (approximately 56% of run)
	Proposed Action					
	Major stress and impaired homing	Up to 100% mortality of progeny of mainstem spawners (about 13 redds, or 0.7–26% of Upper Klamath River Population Unit natural escapement)	**Age 0+ summer:** Reduced growth	**Age 1+ winter:** Major stress, reduced growth, and up to 20% mortality	**Early spring outmigration:** Major stress, reduced growth, and up to 20% mortality for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during early spring (~44 percent of run outmigrate in early spring). (2,668 smolts, 3% of total production in basin)	**Late spring outmigration:** Major stress and reduced growth

Table 3.3-7. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Coho Salmon.

Scenario	Life History Stage: Coho Salmon				
	Adult migration (Sept 1, 2019–Jan 1, 2020)	**Spawning through fry emergence (Nov 1, 2019–Mar 14, 2020)**	**Age 0+ rearing during summer (Mar 15–Nov 14, 2020)**	**Age 1+ rearing during winter (Nov 15, 2019–Feb 14, 2020)**	**Outmigration Early spring outmigration: (Feb 15–March 31, 2020) Late spring outmigration: (April 1– June 30, 2020)**
Worst-case	**Existing Conditions (extreme)**				
	Major stress and impaired homing	Up to 100% mortality of progeny of mainstem spawners (about13 redds, or 0.7–26% of Upper Klamath River Population Unit natural escapement)	**Age 0+ summer:** Major stress and reduced growth for fish rearing in mainstem (< 50% of fry)	**Age 1+ winter:** Major stress and reduced growth for fish rearing in mainstem (assume <1% of juveniles)	**Early spring outmigration:** Major stress and reduced growth for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during early spring (approximately 44% of run outmigrate in early spring) **Late spring outmigration:** Major stress for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during late spring (approximately 56% of run)
	Proposed Action				
	Same as existing conditions	Same as existing conditions	**Age 0+ summer:** No growth	**Age 1+ winter:** Major stress, reduced growth and up to 52% mortality	**Early spring outmigration:** Major stress, reduced growth, and up to 49% mortality for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during early spring (approximately 44% of run outmigrate in early spring) (6,536 smolts, 8% of total production in basin) **Late spring outmigration:** Major stress and reduced growth

returning fish (NOAA Fisheries Service 2010a). Based on the range of escapement estimates of Ackerman et al. (2006), 13 redds could represent anywhere from 0.7 to 26 percent of the naturally returning spawning in the Upper Klamath River Population Unit, and much less than 1 percent of the natural and hatchery returns combined.

- Coho salmon smolts outmigrating from tributaries in the Upper or Mid-Klamath River, Shasta, or Scott populations during early spring (around 46 percent of outmigrating smolts compared to those that outmigrate in late spring) are predicted to experience 20 percent mortality under a most-likely-to-occur scenario, or 49 percent mortality under a worst-case scenario. Anticipated total mortality varies by population, and is detailed in Appendix E.

The Proposed Action would also result in the release of bedload sediment, as described in detail in Appendix F. Effects associated with release of coarse sediment are expected to affect the same individuals described for suspended sediment above. For example, bedload sediment is predicted to bury redds constructed in fall 2019, which are the same redds expected to suffer from suspended sediment (~13 redds, or 0.7–26 percent of Upper Klamath River Population unit natural escapement). In addition, bedload sediment could result in the deposition that could aggrade pools or overwhelm other habitat features that coho salmon use for adult holding or juvenile rearing. However, the effect on habitat is anticipated to be short term, and pools would likely return to their pre-sediment release depth within one year (Stillwater Sciences 2008). If the magnitude and duration of flows in spring 2020 are sufficiently high to effectively mobilize the bed, coho salmon spawning habitat in the mainstem downstream of Iron Gate Dam could improve over existing conditions. In the long term, the river is predicted to revert to and maintain a pool-riffle morphology.

The described changes in water temperature would benefit upstream migrant adults and juveniles during fall upstream migration and juvenile redistribution to overwintering habitats by providing a broader window of suitable habitat. Spring outmigrants may also move out earlier, potentially reducing their susceptibility to parasites. As with SSCs, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to poor water quality due to the Proposed Action, but these effects would be short term.

Incidence of disease are expected to be reduced by enhancing the scour capabilities of flow by uninterrupted sediment transport, a flow regime that more closely mimics natural conditions, thereby disturbing the habitat of the polychaete worm that hosts *C. shasta*. Reducing polychaete habitat would likely increase abundance of smolts by increasing outmigration survival.

<u>Estuary</u> The Proposed Action is not expected to substantially change or affect coho salmon estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and bedload sediment transport and deposition and affect coho salmon. In general, the wide distribution and use of tributaries by both juvenile and adult coho salmon will likely protect the population from the worst effects of the Proposed Action. However, direct mortality is anticipated for around 13 redds, or 0.7–26 percent of Upper Klamath River Population unit natural escapement. Direct mortality is also anticipated for 2,668 smolts under the most-likely to occur scenario, or 6,536 smolts under a worst-case scenario. This equates to no mortality for the Salmon River, Trinity River, and lower Klamath River populations under the most likely or worst-case scenarios, and 9 percent of the production from the upper Klamath River, mid-Klamath River, Shasta River, and Scott River population units, or 22 percent under a worst-case scenario. Sublethal effects are anticipated for all other life-stages. All population units would be expected to recover from these losses within one or two generations, given the long-term benefits described below. Although no single year-class is expected to be completely lost, mortality of a portion of the smolt outmigration from the upper Klamath River, mid-Klamath River, Shasta River, and Scott River population units may affect the strength of the 2018 year class, requiring two or three generations to recover from losses. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be significant for the coho salmon from the Upper Klamath River, Mid-Klamath River, Shasta River, and Scott River population units in the short term. Based on no reduction in the abundance of a year class, the effect of the Proposed Action would be less-than-significant for the coho salmon from the three Trinity River population units, Salmon River and the Lower Klamath River Population Unit in the short term.**

Implementation of Mitigation Measures AR-1 through AR-4 (see Section 3.3.4.4) could reduce the short-term effects of SSCs on coho salmon adults, incubating eggs, and smolts. With implementation of mitigation measures there would still be short term effects for coho salmon including direct mortality to as high as 18 percent of the smolts from some population units under a worst-case scenario (see Section 3.3.4.4). **Based on substantial reduction in the abundance of a year class in the short term, the Proposed Action would have a significant effect on coho salmon from the Upper Klamath River, Mid-Klamath River, Shasta River, and Scott River population units after mitigation in the short term.**

Under the Proposed Action, removal of dams could result in alterations in habitat availability, flow regime, water quality, temperature variation, and fish disease incidence, and algal toxins which could affect coho salmon in the long term. Dam removal would restore connectivity to habitat on the mainstem Klamath River up to and including Spencer Creek and would create additional habitat within the Hydroelectric Reach. It is anticipated that as a result of the Proposed Action, the upper Klamath River, mid-Klamath River, Shasta River, Scott River, Salmon River, and lower Klamath River coho salmon population units would have an increase in abundance, productivity, population spatial structure, and genetic diversity. In general, free flowing conditions as per the Proposed Action, would likely provide optimal efficiency, decrease outmigrant delay, and increase concomitant adult escapement (Buchanan et al. 2011a). It is anticipated that as a result of the Proposed Action, the three Trinity River population units would have increased productivity. **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action would be beneficial for the coho salmon from the Upper Klamath River, Mid-Klamath River, Lower Klamath River, Shasta River, Scott River, and Salmon River population units in the long term**. **Based on improved habitat quality, the effect of the Proposed Action on coho salmon from the three Trinity River population units would be less-than-significant for the long term.**

Steelhead A Coho Salmon and Steelhead Expert Panel was convened and charged with answering specific questions that had been formulated by the project stakeholders to assist with assessing the effects of the Proposed Action on coho salmon and steelhead (Dunne et al. 2011). The conclusion of the Panel was that the Proposed Action would result in increased spatial distribution and abundance of steelhead. This assessment is based on the observations that steelhead would be able to access a substantial extent of new habitat, steelhead are relatively tolerant to warmer water (compared to coho salmon), they are similar to other species (resident redband/rainbow trout) that are currently thriving in upstream habitats, and that while steelhead are currently at lower abundances than historical values, they are not yet rare. The influence of the Proposed Action within specific reaches is described below.

<u>Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir</u> Under the Proposed Action, dam removal would allow steelhead to gain access to the upper Klamath River upstream of J.C. Boyle Reservoir. This would expand the population's distribution to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). Steelhead are known to use intermittent tributaries for spawning; Huntington (2006), counting only perennial stream miles, estimated that potential new habitat could reach 500 miles. Current distribution of redband trout within areas that would be accessible to steelhead has been estimated at 496 miles by ODFW (W. Tinniswood, pers. comm., 2011). Because redband trout have habitat requirements similar to those of steelhead, this can be used as a rough estimate of habitat that may also be available to steelhead. The Proposed Action would not result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins and disease. Facilitating the movement of anadromous fish presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006).

<u>Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam</u> The Proposed Action would restore steelhead access to the Hydroelectric Reach. Adults could first access this reach in fall 2020 (winter steelhead) or winter 2021 (summer steelhead) after dam removal (summer steelhead spawning typically does not begin until December). Elevated suspended sediment concentrations resulting from dam removal would likely have returned to background levels similar to existing conditions. Steelhead could use this reach as a migration corridor, as most sediment released from the reservoirs would likely be eroded within the first 5 months after dam removal (by May 2020) and would not impede upstream movement. Reaches currently inundated by

reservoirs and reaches between reservoirs would likely return to a pool-riffle morphology, which would benefit rearing steelhead.

The Proposed Action would also eliminate the reservoirs and establish a flow regime that more closely mimics natural conditions by increasing spring flow and by incorporating more variability in daily flows. The reservoir drawdowns would allow tributaries and springs such as Fall, Shovel, and Spencer Creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish (Hamilton et al. 2011). The action would also be likely to nearly eliminate blue-green algae blooms and their associated toxins, improving water quality. These changes would benefit steelhead.

Lower Klamath River: Downstream of Iron Gate Dam The Proposed Action would release dam-stored sediment downstream to the lower Klamath River in the short term, and restore a flow regime that more closely mimics natural conditions in the long term. Suspended sediment effects on steelhead under the Proposed Action are described in detail in Appendix E, and summarized here.

Under the most-likely-to-occur scenario or worst-case scenario, no effect from suspended sediment relative to existing conditions is anticipated for the half-pounder life history, all spawning (which occurs primarily in tributaries), and age 0 rearing (Table 3.3-8). Sublethal effects are anticipated for all other life stages (Table 3.3-8), with the following exceptions:

- Under the most-likely-to-occur scenario, up to 36 percent mortality is predicted for the winter run steelhead (up to 1,008 adults, or up to 14 percent of the total winter run escapement). On average around 20 percent of winter steelhead migrate prior to initiation of reservoir drawdown on December 15th. In addition, steelhead are highly mobile species that have been known to stray to avoid habitat degradation (Bisson et al. 2005), and regularly occur in environments with high SSC, and therefore the predictions described here are likely more dire than would occur. It is likely that at least some would enter tributaries if conditions within the mainstem were adverse.
- Under the most-likely-to-occur scenario, up to 52 percent mortality is predicted for age 1 juveniles in the mainstem (up to 8,200 juveniles or around 14 percent of total basin-wide age 1 production).
- Under the most-likely-to-occur scenario, up to 52 percent mortality is predicted for age 2 juveniles in the mainstem (up to 6,893 juveniles or around 13 percent of total basin-wide age 2 production).
- Under the worst-case scenario, 0 to 20 percent mortality is predicted for the summer run steelhead (from 0 to 130 adults, or from 0 to 9 percent of the basin-wide escapement).

Table 3.3-8. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Summer and Winter Steelhead.

Scenario	Life History Stage: Summer and Winter Steelhead					
	Adult migration Summer run: (Mar 1–June 30, 2020) Winter run: (Aug 1 2019–Mar 31, 2020)	**Adult runbacks: (Apr 1–May 30, 2020) Half-pounder residency (Aug 15, 2019–Mar 31, 2020)**	**Spawning through fry emergence (Dec 1, 2019–June 1, 2020)**	**Age 0+ rearing (Mar 15–Nov 14, 2020)**	**Juvenile rearing Age 1+: (year-round 2019 and 2020) Age 2+: (Nov 15, 2019–Mar 31, 2020)**	**Outmigration (Apr 1–Nov 14, 2020)**
Most likely	**Existing Conditions (normal)**					
	Summer run: Major stress, possibly impaired homing for fish spawning in mid- and upper-Klamath tributaries (about 45% of escapement) **Winter run:** Major stress, possibly impaired homing for fish spawning in mid- and upper-Klamath tributaries (about 80% of escapement)	**Adult runbacks:** Major stress depending on time spent in mainstem **Half-pounder residency:** Many will have returned to the ocean or estuary; those remaining may experience major stress in the mainstem, but may avoid suspended sediment by entering nearby tributaries	Most spawning takes place in tributaries; no effects predicted	Major stress for age 0+ juveniles in mainstem (about 60% of juveniles)	**Age 1+ rearing:** Major stress for juveniles in mainstem (about 60% of juveniles) **Age 2+ rearing:** Major stress for juveniles in mainstem (about 60% of juveniles)	Major stress during outmigration, depending on time spent in mainstem; about 57% outmigrate from Trinity River and will have less exposure

Table 3.3-8. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Summer and Winter Steelhead.

Scenario	Life History Stage: Summer and Winter Steelhead					
	Adult migration Summer run: (Mar 1–June 30, 2020) Winter run: (Aug 1 2019–Mar 31, 2020)	**Adult runbacks: (Apr 1–May 30, 2020) Half-pounder residency (Aug 15, 2019–Mar 31, 2020)**	**Spawning through fry emergence (Dec 1, 2019–June 1, 2020)**	**Age 0+ rearing (Mar 15–Nov 14, 2020)**	**Juvenile rearing Age 1+: (year-round 2019 and 2020) Age 2+: (Nov 15, 2019–Mar 31, 2020)**	**Outmigration (Apr 1–Nov 14, 2020)**
	Proposed Action					
Most likely	**Summer run:** Same as existing conditions **Winter run:** Major stress, impaired homing, and up to 36% mortality (Up to 1,008 adults, or up to 14% of the total escapement)	**Adult runbacks:** Same as existing conditions **Half-pounder residency:** Same as existing conditions	Same as existing conditions	Major stress resulting in reduced growth	**Age 1+ rearing:** Major stress, reduced growth, and up to 52% mortality. (Up to 8,200 juveniles or around 14% of total age 1 production) **Age 2+ rearing:** Reduced growth and up to 52% mortality (Up to 6,893 juveniles or around 13% of total age 2 production)	Major stress and reduced growth

Table 3.3-8. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Summer and Winter Steelhead.

Scenario	Life History Stage: Summer and Winter Steelhead					
	Adult migration Summer run: (Mar 1–June 30, 2020) Winter run: (Aug 1 2019–Mar 31, 2020)	**Adult runbacks: (Apr 1–May 30, 2020) Half-pounder residency (Aug 15, 2019–Mar 31, 2020)**	**Spawning through fry emergence (Dec 1, 2019–June 1, 2020)**	**Age 0+ rearing (Mar 15–Nov 14, 2020)**	**Juvenile rearing Age 1+: (year-round 2019 and 2020) Age 2+: (Nov 15, 2019–Mar 31, 2020)**	**Outmigration (Apr 1–Nov 14, 2020)**
Worst-case	**Existing conditions (extreme)**					
	Summer run: Major stress, impaired homing for fish spawning in mid- and upper-Klamath tributaries (about 53% of run) **Winter run:** Major stress and potential for impaired homing for fish spawning in mid- and upper-Klamath tributaries (about 80% of run)	**Adult runbacks:** Major stress; exposure dependant on time it takes runbacks to return to sea **Half-pounder residency:** Major stress and reduced growth for any in mainstem, but most assumed to remain in tributaries or to have returned to the ocean or estuary. Those remaining may experience major stress and reduced growth in the mainstem, but may avoid suspended sediment by entering nearby tributaries.	Most spawning takes place in tributaries; no effects predicted	Major stress and reduced growth for age 0+ juveniles in mainstem (about 60% of juveniles)	**Age 1+ rearing:** Stress, reduced growth, and up to 20% mortality for juveniles in mainstem (about 60% of juveniles) **Age 2+ rearing:** Major stress and reduced growth for juveniles in mainstem for juveniles in mainstem (about 60% of juveniles)	Major stress resulting in reduced growth, about 57% outmigrate from Trinity River and will have less exposure

Table 3.3-8. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario SSCs Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Summer and Winter Steelhead.

Scenario	Life History Stage: Summer and Winter Steelhead					
	Adult migration Summer run: (Mar 1–June 30, 2020) Winter run: (Aug 1 2019–Mar 31, 2020)	**Adult runbacks: (Apr 1–May 30, 2020) Half-pounder residency (Aug 15, 2019–Mar 31, 2020)**	**Spawning through fry emergence (Dec 1, 2019–June 1, 2020)**	**Age 0+ rearing (Mar 15–Nov 14, 2020)**	**Juvenile rearing Age 1+: (year-round 2019 and 2020) Age 2+: (Nov 15, 2019–Mar 31, 2020)**	**Outmigration (Apr 1–Nov 14, 2020)**
	Proposed Action					
Worst-case	**Summer run:** Major stress, impaired homing, and up to 20% mortality (from 0 to 130 adults, or from 0 to 9% of the basin-wide escapement) **Winter run:** Major stress, impaired homing, and up to 71% mortality. The proportion migrating prior to January would not be affected. (Up to 1,988 adults, or up to 28% of the basin-wide escapement).	**Adult runbacks:** Major stress **Half-pounder residency:** Same as existing conditions	Same as existing conditions	Same as existing conditions	**Age 1+ rearing:** Stress, reduced growth, and up to 71% mortality Up to 11,207 juveniles or around 19% of total age 1 production) **Age 2+ rearing:** Stress, reduced growth and up to 71% mortality (Up to 9,412 juveniles or around 18% of total age 2 production).	Same as existing conditions

- Under the worst-case scenario, 71 percent mortality is predicted for the winter run steelhead (up to 1,988 adults, or up to 28 percent of the basin-wide escapement). On average around 20 percent of winter steelhead migrate prior to initiation of reservoir drawdown on December 15th. In addition, steelhead are highly migratory species that stray to avoid habitat degradation (Bisson et al. 2005), and regularly occur in environments with high SSC, and therefore the predictions described here are likely more dire than would occur.
- Under the worst-case scenario, up to 71 percent mortality is predicted for age 1 juveniles in the mainstem (up to 11,207 juveniles or around 19 percent of total basin-wide age 1 production).
- Under the worst-case scenario, up to 71 percent mortality is predicted for age 2 juveniles in the mainstem (up to 9,412 juveniles or around 18 percent of total basin-wide age 2 production).

As described in detail in Appendix F, dam-released sediment associated with the Proposed Action might aggrade pools or overwhelm other habitat features used for adult holding or juvenile rearing above Cottonwood Creek. The effect would be short term, as pools would likely return to their pre-sediment release depth relatively quickly (Stillwater Sciences 2008). In the long term, the river would revert to and maintain a pool-riffle morphology.

The Proposed Action would establish a flow regime that more closely mimics natural conditions in the lower Klamath River. Dam removal would cause water temperatures to warm earlier in the spring and early summer and cool earlier in the late summer and fall, and to have diurnal variations more in sync with historical migration and spawning periods. These changes would result in water temperature more favorable for salmonids occurring in the mainstem. Migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to low dissolved oxygen due to the Proposed Action, but these effects would be short term. Restoring flow variability and natural sediment transport processes would likely reduce habitat conditions for the polychaete host for salmonid parasites, although this would benefit Chinook and coho salmon to a greater degree because steelhead are generally resistant to infection. All of these long-term changes would benefit steelhead using the lower Klamath River Reach.

Estuary The Proposed Action is not expected to substantially change or affect steelhead estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and bedload sediment transport and deposition and affect steelhead. In general, the effects of suspended sediment resulting from the Proposed Action on steelhead are likely to be much higher than under existing conditions and the No Action/No Project Alternative, particularly for the portion of the population that spawns in tributaries upstream of the Trinity River. For that portion of the population, effects are anticipated for at least six year-classes, including on adults, run-backs, half-pounders, any juveniles rearing in the mainstem, and outmigrating smolts. However, the broad spatial distribution of steelhead in the Klamath Basin and their flexible life history suggests that some will avoid the most serious effects of the Proposed Action by (1) remaining in tributaries for extended rearing, (2) rearing farther downstream where SSC should be lower due to dilution (e.g., the progeny of the adults that spawn in the Trinity River Basin or tributaries downstream of the Trinity River), and/or (3) moving out of the mainstem into tributaries and off-channel habitats during winter. In addition, the life-history variability observed in steelhead means that, although numerous year classes will be affected, not all individuals in any given year class will be exposed to the effects of the Proposed Action. In addition, some portion of the progeny of those adults that spawn successfully would rear in tributaries long enough to not only avoid the most serious impacts of the Proposed Action in 2020, but may also not return to spawn for up to two years, when any suspended sediment resulting from the Proposed Action should be greatly reduced. The high incidence of repeat spawning among summer-run steelhead (ranging from 40 to 64 percent, Hopelain 1998) should also increase that population's resilience (including of all year classes) to effects of the Proposed Action. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be significant for summer and winter steelhead in the short term.**

Implementation of Mitigation Measures AR-2 and AR-3 (see Section 3.3.4.4) could be implemented to reduce the short-term effects of SSCs on steelhead adults and outmigrating juveniles. With implementation of mitigation measures there would still be short-term effects on summer and winter steelhead, including sublethal and lethal effects. **Based on substantial reduction in the abundance of a year class in the short term, the Proposed Action would be a significant effect on summer and winter steelhead in the short term after mitigation.**

Under the Proposed Action, removal of dams could result in alterations in habitat availability, flow regime, water quality, temperature variation, and algal toxins which could affect steelhead in the long term. Dam removal would restore connectivity to 496 miles of historical habitat in the Upper Klamath Basin and would create additional habitat within the Hydroelectric Reach (W. Tinniswood, pers. comm., 2011). It is anticipated that as a result of the Proposed Action the summer and winter steelhead within the Klamath River watershed would have an increase in abundance, productivity, population spatial structure, and genetic diversity. In general, free flowing conditions as per the Proposed Action, would likely provide optimal efficiency, decrease outmigrant delay, and increase concomitant adult escapement (Buchanan et al. 2011a). Almost any type of fish passage structure would be less efficient as a migration corridor for fish than removing the obstacle to passage itself. For example, fish ladders may cause delays in adult upstream migration or may become blocked by debris, and juvenile fish may have to navigate through impoundments with poor water quality or non-native predatory fish. Any of these potential factors has a chance of affecting fitness, survival, or reproductive success (Buchanan et al. 2011a). By providing an unimpeded migration corridor, the Proposed Action would provide the greatest possible benefit related to fish passage, hence, the highest survival and reproductive success. **Based on increased habitat**

availability and improved habitat quality, the effect of the Proposed Action would be beneficial for summer and winter steelhead in the long term.

Pacific Lamprey A Lamprey Expert Panel (Panel) was convened to compare the potential effects of the Proposed Action and existing conditions on lamprey (Close et al.2010). The conclusion was that the Proposed Action could increase Pacific lamprey production by up to 14 percent. The increase could potentially be more if habitat in the Upper Klamath Basin is accessible and suitable. The Panel expects that adult Pacific lamprey would recolonize newly accessible habitat after dam removal, but natural colonization of all habitat available to them may take decades. Larval rearing capacity downstream of Iron Gate Dam is expected to increase after dam removal because a large amount of fine sediment—a major component of larval rearing habitat—would be released through dam removal. The available burrowing habitat for larvae would subsequently decrease over time, but would likely remain higher than under current conditions because sediment input and transport processes would be restored and KBRA measures would increase sediment transport (Close et al. 2010). In addition, the return to a temperature regime and flows that more closely mimic natural patterns would likely benefit Pacific lamprey, which evolved under those conditions. The influence of the Proposed Action within specific reaches is described below.

<u>Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir</u> Pacific lamprey did not historically occur upstream of J.C. Boyle Reservoir (Hamilton et al. 2005) and are not anticipated to occupy this reach after implementation of this alternative.

<u>Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam</u> The Proposed Action would provide Pacific lamprey with access to the Hydroelectric Reach and to the mainstem Klamath River and its tributaries upstream as far as Spencer Creek, including Jenny, Shovel, and Fall creeks (Hamilton et al. 2011). Most sediment released from the reservoirs would likely be eroded within the first five months after dam removal (by May 2020), returning sections of river currently inundated by reservoirs and riverine sections between reservoirs to a pool-riffle morphology. After erosion of dam-stored sediment, the Hydroelectric Reach would likely contain gravel suitable for lamprey spawning and rearing.

The Proposed Action would also eliminate the reservoirs and establish a flow regime that more closely mimics natural conditions. Drawing down the reservoirs would allow tributaries and springs such as Fall, Shovel, and Spencer Creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish (Hamilton et al. 2011). These changes would result in more favorable water temperatures for native fishes, and improved water quality. These changes would provide a long-term benefit to Pacific lamprey produced in the Hydroelectric Reach.

Lower Klamath River: Downstream of Iron Gate Dam The Proposed Action would release dam-stored sediment and reduce dissolved oxygen downstream to the lower Klamath River in the short term, and restore a flow regime that more closely mimics natural conditions in the long term. Suspended sediment effects on Pacific lamprey under the Proposed Action are described in detail in Appendix E, and summarized here.

Under the most-likely-to-occur scenario or worst-case scenario sublethal effects from suspended sediment relative to existing conditions is anticipated for outmigrants, and for Pacific lamprey migrating to or from the Trinity River or tributaries further downstream (Table 3.3-9). High rates of mortality are predicted for adults and ammocoestes in the mainstem Klamath River during winter and spring 2020. However, there is little to no literature on the effects of suspended sediment on lamprey. This analysis used the effects of suspended sediment on salmonids to predict effects on lamprey, with the assumption that effects on lamprey are equivalent or less severe than on salmonids. In general, most life stages of Pacific lamprey appear more resilient to poor water quality conditions than salmonids (Zaroban et al. 1999), so this is likely a conservative assessment of potential effects.

The Proposed Action would affect spawning and incubation in the area between Iron Gate Dam and Cottonwood Creek by burying gravel in dam-released sediment and increasing the proportion of sand in the bed, thereby decreasing ammocoete survival. The river would be expected to return to its existing bedform after a few years.

The Proposed Action would establish a flow regime that more closely mimics natural conditions in the lower Klamath River Reach. Dam removal would cause water temperatures to have natural diurnal variations. These changes would result in water temperatures that are more similar to those that Pacific lamprey evolved with and would improve water quality. These long-term changes would likely provide a benefit to Pacific lamprey using the lower Klamath River.

Estuary The Proposed Action is not expected to substantially change or affect Pacific lamprey estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

Table 3.3-9. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Pacific Lamprey.

Scenario	Life History Stage: Pacific Lamprey			
	Adult Migration and Spawning (all of 2020)	Ammocoete Rearing (all of 2020)	Outmigration Spring (May 1–June 30, 2020) Fall/winter (Sept 1–Dec 31, 2020)	
Most Likely	**Existing Conditions (normal)**			
	Major stress and impaired homing; later-returning adults and those returning to lower tributaries would have less exposure	**Ammocoete rearing*:*** Major stress of ammocoetes in mainstem for multiple year classes of ammocoetes in mainstem; majority rear in tributaries and would have lower exposure	**Spring outmigration:** Major stress	**Fall and winter outmigration:** Moderate stress and reduced feeding
	Proposed Action			
	Major stress and up to 36% mortality; later-returning adults and those returning to lower tributaries would have less exposure	**Ammocoete rearing*:*** Major stress, reduced growth, and up to 52% mortality	**Spring outmigration:** Same as existing conditions	**Fall and winter outmigration:** Same as existing conditions
Worst-case	**Existing Conditions (extreme)**			
	Major stress and impaired homing; later-returning adults and those returning to lower tributaries would have less exposure	**Ammocoete rearing*:*** Major stress and reduced growth	**Spring outmigration*:*** Moderate to major stress and reduced growth	**Fall and winter outmigration*:*** Major stress
	Proposed Action			
	Major stress, reduced growth, and up to 71% mortality	**Ammocoete rearing*:*** Major stress, reduced growth, and up to 71% mortality for multiple year classes of ammocoetes in mainstem; majority rear in tributaries and would not suffer mortality	**Spring outmigration*:*** Same as existing conditions	**Fall and winter outmigration*:*** Same as existing conditions

Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and bedload sediment transport and deposition and affect Pacific lamprey. The Proposed Action would have short-term effects related to SSCs, bedload sediment transport and deposition, and water quality (particularly dissolved oxygen). Overall, because multiple year classes of lamprey rear in the mainstem Klamath River at any given time, and since adults will migrate upstream over the entire year, including January 2020 when effects from the Proposed Action will be most pronounced, effects on Pacific lamprey adults and ammocoetes could be much higher in the mainstem Klamath River than under existing conditions and the No Action/No Project Alternative. However, most of the population would likely avoid the most severe suspended sediment pulses resulting from the Proposed Action. In addition, Pacific lamprey are considered to have low fidelity to their natal streams, and may not enter the mainstem Klamath River if environmental conditions are unfavorable in 2020. Migration into the Trinity River and other lower Klamath River tributaries may also increase during 2020 because of poor water quality. Low fidelity also increases the potential that lamprey can recolonize mainstem habitat if ammocoetes rearing there suffer high mortality. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be significant for Pacific lamprey in the short term.**

Implementation of Mitigation Measures AR-2 and AR-5 (see Section 3.3.4.4) could be implemented to reduce the short-term effects of dissolved oxygen and SSCs on lamprey ammocoetes. With implementation of mitigation measures there could still be short-term effects for lamprey including sublethal and lethal effects. **Based on substantial reduction in the abundance of a year class in the short term, the Proposed Action would be a significant effect on Pacific lamprey in the short term after mitigation.**

Under the Proposed Action, removal of dams could result in alterations in habitat availability, flow regime, water quality, and temperature variation which could affect Pacific lamprey in the long term. The Proposed Action would provide access to habitat in the Hydroelectric Reach and tributaries to this reach. It is anticipated that as a result of the Proposed Action the Pacific lamprey population within the Klamath River watershed would have an increase in abundance, productivity, population spatial structure, and genetic diversity. **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action would be beneficial for Pacific lamprey in the long term**.

Green Sturgeon Listed Southern Green Sturgeon may enter the Klamath River estuary to forage during the summer months. They would not be present when the most severe effects of dam removal are occurring, and are not expected to be affected by the Proposed Action. The remainder of this section focuses on the effects of the Proposed Action on the Northern Green Sturgeon DPS. Northern Green Sturgeon do not occur upstream of Ishi Pishi Falls and would not be affected by Proposed Action effects that do not extend downstream past these falls.

<u>Lower Klamath River: Downstream of Iron Gate Dam</u> The Proposed Action would release dam-stored sediment downstream to the lower Klamath River in the short term, and restore a flow regime that more closely mimics natural seasonal flow patterns in the

long term. Suspended sediment effects on green sturgeon under the Proposed Action are described in detail in Appendix E, and summarized here.

Under the most-likely-to-occur scenario or worst-case scenario no effect relative to existing conditions is predicted for adults (Table 3.3-10), mostly because green sturgeon distribution within the mainstem Klamath River is primarily limited to areas downstream of Orleans, where the effects of SSC resulting from the Proposed Action are more diluted from tributary accretion. Up to 100 percent mortality is predicted for incubating eggs and larval life stages, and up to 20 percent mortality is predicted for rearing juveniles under a most-likely-to-occur scenario, or up to 40 percent mortality under a worst-case scenario. However, around 30 percent of juveniles rear in the Trinity River and would not be exposed to SSC from the Proposed Action.

Bedload sediment effects related to dam-released sediment would not extend as far downstream to Ishi Pishi Falls and would not affect green sturgeon.

The Proposed Action would establish a flow regime that more closely mimics natural conditions in the lower Klamath River and would improve water quality and reduce instances of algal toxins. These long-term effects would benefit green sturgeon using the lower Klamath River reach.

<u>Estuary</u> The Proposed Action is not expected to substantially change or affect estuarine habitat. Sediment, flow, and water temperature effects resulting from the Proposed Action would likely not extend downstream to the estuary.

Reservoir drawdown associated with dam removal under the Proposed Action could alter SSCs and affect green sturgeon. Overall the effects of the Proposed Action are most likely to include physiological stress, inhibited growth, and high mortality for some portion of the age-0 2020 cohort and age 1 2019 cohort. However, effects on salmonids likely overestimate those on sturgeon. To summarize, green sturgeon in the Klamath Basin have the following traits likely to enhance the species' resilience to impacts of the Proposed Action:

- Most of the population (subadult and adult) would be in the ocean during the year of the Proposed Action (2020) and would be unaffected (Appendix E).
- The approximately 30 percent of the population that spawn and rear in the Trinity River would be unaffected.
- Much of the spawning and rearing of green sturgeon occurs downstream of the Trinity River, where sediment concentrations would be similar to existing conditions and the No Action/No Project Alternative.
- Green sturgeon are long-lived (>40 years) and are able to spawn multiple times (~8 times) (Klimley et al. 2007), so effects on two year classes may have little influence on the population as a whole.

Table 3.3-10. Proposed Action, Most-Likely Scenario SSCs Compared with Normal Existing Conditions (50% Exceedance Probabilities) and Proposed Action, Worst-Case Scenario Compared with Extreme Existing Conditions (10% Exceedance Probabilities) for Green Sturgeon. Based on salmonid literature; effects likely overestimated.

Scenario	Life History Stage: Green Sturgeon			
	Adult migration	**Post-spawning holding**	**Spawning through hatching/larvae**	**Juvenile Rearing (year-round) and Outmigration**
Most Likely	**Existing conditions (normal)**			
	Moderate to major stress; 75% of adults not expected to migrate in 2020	No effects	Up to 68% mortality; about 30% that spawn in Trinity River would be unaffected (based on salmonid literature; effects likely overestimated)	Major stress; about 30% of juveniles rear in Trinity River and would be unaffected (based on salmonid literature; effects likely overestimated)
	Proposed Action			
	Major stress	Same as existing conditions	76% mortality for all mainstem production	Reduced growth and up to 20% mortality
Worst-case	**Existing conditions (extreme)**			
	Major stress	Short period (<1 week) of relatively low SSCs, not expected to result in deleterious effects	84% mortality for all mainstem production	Major stress and reduced or no growth (based on salmonid literature; effects likely overestimated)
	Proposed Action			
	Same as existing conditions; about 25% of adults expected to be exposed in 2020	Same as existing conditions; about 75% of adults hold in mainstem after spawning; remainder return to ocean	95% mortality for all mainstem production ; about 30% that spawn in Trinity River would be unaffected	Reduced growth and up to 36% mortality; about 30% of juveniles rear in Trinity River and would be unaffected

Based on substantial reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be significant for green sturgeon in the short term.

Implementation of Mitigation Measure AR-3 (see Section 3.3.4.4) could be implemented to reduce the short-term effects of SSCs on green sturgeon adults post-spawning. With implementation of mitigation measures there would still be short-term effects for green sturgeon including sublethal and sublethal effects. **Based on substantial reduction in the abundance of a year class in the short term, the Proposed Action would be a significant effect on green sturgeon in the short term after mitigation.**

Under the Proposed Action, removal of dams could result in alterations in flow regime, water quality, temperature variation, and algal toxins which could affect green sturgeon in the long term. It is anticipated that as a result of the Proposed Action, the green sturgeon population within the Klamath River watershed would have an increased productivity. **Based on improvements in habitat quality within part of their range, the effect of the Proposed Action would be less-than-significant for green sturgeon in the long term.**

Lost River and Shortnose Sucker
Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Proposed Action, water elevations in Upper Klamath Lake would be higher, which would benefit Lost River and shortnose suckers, but the difference in habitat value would not be substantive. The KBRA is expected to provide benefits to sucker populations through the following measures: nutrient reduction, reconnecting former wetlands to Agency Lake, reconstructing quality rearing habitat for early life stages, and restoring shoreline spring spawning habitat restoration, among others.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Lost River and shortnose suckers are found within reservoirs in Hydroelectric Reach. The Proposed Action would eliminate reservoir habitat, and as dams within the Hydroelectric Reach were removed, sediment would move downstream. Under the Proposed Action adult Lost River and shortnose suckers in reservoirs downstream of Keno Dam would be captured and relocated to Upper Klamath Lake (Buchanan et al. 2011a). Those not relocated to the Upper Basin would likely be lost; however, little or no reproduction occurs downstream of Keno Dam (Buettner et al. 2006), there is no potential for interaction with upstream populations, and they are not considered to substantially contribute to the achievement of conservation goals or recovery (Hamilton et al. 2011). Lost River and shortnose suckers are listed as fully protected species under California Fish and Game code; thus, any take of these species is prohibited. However, a component of the Proposed Action includes legislation to permit the take of some individuals during implementation.

Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006). Generally, with the exception of *F. columnaris* and

Ich, pathogens associated with anadromous fish do not impact non-salmonids (e.g. suckers) (Administrative Law Judge 2006).

Reservoir removal associated with dam removal under the Proposed Action could alter habitat availability and affect lost river and shortnose suckers. **Based on reduction in abundance within reservoirs, the effect of the Proposed Action would be significant for Lost River and shortnose sucker populations in the short term.**

Implementation of Mitigation Measure AR-6 (see Section 3.3.4.4) could be implemented to reduce the impact to individuals within reservoirs by rescuing fish prior to reservoir drawdown. **Based on small numbers of individuals affected after mitigation, and on anticipated legislation allowing take, the effect of the Proposed Action would be less-than-significant for Lost River and shortnose sucker populations in the short term after mitigation.**

Restoration action associated with KBRA implementation under the Proposed Action could alter habitat availability and suitability and affect lost river and shortnose suckers. In the long term, restoration actions under KBRA are anticipated to improve conditions for sucker populations within Klamath Lake. **Based on improved habitat quality, the effect of the Proposed Action would be beneficial for Lost River and shortnose sucker populations in the long term.**

Redband Trout A Resident Fish Expert Panel (Panel) was convened to compare the potential effects of the Proposed Action and existing conditions on resident fish, including redband trout (Buchanan et al. 2011a). The Panel concluded that the habitat improvements associated with KBRA implementation, including water quality and quantity and riparian corridor improvements and protection, are anticipated to increase trout productivity in headwater and lower tributary areas of the Upper Klamath Lake Basin. The Panel predicted that following the Proposed Action, the abundance of redband trout in the free-flowing reach between Keno Dam and Iron Gate Dam could increase significantly. In addition, they expect the existing trout and colonizing anadromous steelhead to co-exist, as they do in other watersheds, although there may be shifts in abundance related to competition for space and food. The influence of the Proposed Action within specific reaches is described below.

<u>Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir</u> Under the Proposed Action, redband trout would be able to migrate more successfully from the Hydroelectric Reach to the Upper Klamath Basin (Hamilton et al. 2011) than under existing conditions. Establishment of a flow regime that more closely mimics natural conditions downstream of Keno Dam would eliminate the stranding of redband trout caused by flow reductions at Klamath Hydroelectric Project facilities, and would create stable stream habitat between J.C. Boyle Reservoir and the California state line.

Redband trout could be affected by increased predation from reintroduced salmonids, but this loss might be offset by an increase in available food sources (e.g., eggs, fry, and juveniles of reintroduced salmonids) (Hamilton et al. 2011). Adult salmon moving into the Upper Basin would likely bring with them genotypes of *C. shasta* that had previously been restricted to the lower river. However, facilitating the movement of anadromous fish presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006). While the effects of these introductions are uncertain, at least some degree of host specificity appears to exist (Atkinson and Bartholomew 2010), indicating that newly exposed species, such as redband trout, might not be susceptible to the new genotypes. Additionally, the changes in habitat that could result from dam removal (fewer areas of slow-flowing, stable habitat) would likely reduce the density of polychaete populations, resulting in reduced disease exposure for fish. The close similarities between anadromous steelhead trout and resident rainbow/redband trout suggest these species historically co-existed. The distribution and resistance of rainbow/redband trout in Upper Klamath Lake to *C. Shasta* lends additional support that the two species co-existed and intermingled prior to the construction of Copco 1 Dam in 1917. There are many examples from nearby river systems in the Pacific Northwest showing that wild anadromous salmon and resident rainbow/redband trout can co-exist and maintain abundant populations without negative consequences. The Deschutes River in Oregon, the Yakima River in Washington, and the river systems in Idaho are examples (Administrative Law Judge 2006).

<u>Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam</u>
Under existing conditions, redband trout are found within the Hydroelectric Reach, migrating between tributaries and the reservoirs to complete their life cycle (Hamilton et al. 2011). Redband trout throughout this reach of the mainstem, except upstream of J.C. Boyle Reservoir, would be affected by high suspended sediment concentrations for a period of three to four months during reservoir drawdown associated with the Proposed Action. Redband trout in riverine reaches between the reservoirs in the Hydroelectric Reach would be vulnerable to sublethal and lethal effects of sediment released during dam removal and bedload deposition (Newcombe and Jensen 1996, Buchanan et al. 2011a); however, a large proportion of the adult population should be already spawning in Spencer or Shovel creeks during the dam removal. Juvenile redband trout outmigrating from Spencer Creek would be expected to recolonize the mainstem by late spring or summer when water conditions become suitable. Those in the affected area could move to tributaries for refuge.

The Proposed Action would eliminate reservoir habitat, returning sections of river currently inundated by reservoirs and riverine sections between reservoirs to a pool-riffle morphology. Modeling data indicate that after dam removal, spawning gravel in all sections of the Hydroelectric Reach would be within the range usable for salmonids, but the amount of sand within the bed within former reservoir sections might inhibit spawning success. Riverine sections between reservoirs would be expected to provide the gravel with very little sand, suggesting high-quality spawning habitat. The initial movement of coarse and fine sediment after drawdown would likely create unfavorable conditions for redband trout within the mainstem Klamath River, but these conditions would be short term. Buchanan et al. (2011a) estimate that 43 miles of additional riverine habitat would be available to resident redband trout as a result of the Proposed Action. The adfluvial life-history strategy would no longer be possible within this reach. Migratory opportunities would increase for these fish, allowing them to access areas with suitable habitat when conditions become unfavorable in one area of their range. The Proposed Action would also increase the number of thermal refugia available to redband trout as they would have access to more tributaries, as well as to the cool areas near the mouths of tributaries and the many springs in this reach.

The Proposed Action would have short term effects related to SSCs and bedload movement. **Based on a small proportion of the population with a potential to be exposed to short-term effects, the effect of the Proposed Action would be less-than-significant for redband trout in the short term.**

Dam removal would increase connectivity between Upper Klamath Basin and the Hydroelectric Reach and would create additional riverine habitat within the Hydroelectric Reach. **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action would be beneficial for redband trout in the long term.**

Bull Trout

Upper Klamath River Upstream of the Influence of J.C. Boyle Reservoir To evaluate the effects of the Proposed Action on bull trout, a four member expert panel (Buchanan et al. 2011a) was convened and tasked with reviewing all available information on bull trout in the upper Klamath River, and information on potential effects of the Proposed Action. The panel concluded that the Proposed Action provides promise for preventing extinction of bull trout and for increasing overall population abundance and distribution (Buchanan et al. 2011a).

Buchanan et al. (2011a) observed that the proposed KBRA actions would enhance resident populations of headwater bull trout, and implementation of KBRA could have a significant contribution toward recovery of these populations. Passage from Sun Creek to the Wood River may be improved by KBRA actions allowing for fluvial life history forms of bull trout in the Wood River system. The cold waters of the Wood River may successfully provide habitat for reintroductions of anadromous salmon and steelhead. Rearing anadromous juveniles could provide an increased prey base for fluvial bull trout and produce predator/prey interactions ecologically similar to historical conditions (Buchanan et al. 1997).

Dam removal associated with the Proposed Action could alter habitat availability for anadromous fish, which could affect bull trout. **Based on the restricted distribution of bull trout, the Proposed Action would have a less-than-significant impact on bull trout in the short and long term**.

Eulachon

Lower Klamath River: Downstream of Iron Gate Dam The Proposed Action would release dam-stored sediment downstream to the lower Klamath River. Adult eulachon entering the Klamath River after January 2020 might be exposed to elevated SSCs for a portion of their migration period. However, these SSCs are expected to be similar to those encountered about one in ten years under existing conditions. Because eulachon generally occur within 8 miles of the coast and dam-release-related SSCs would decrease in the downstream direction from Iron Gate Dam due to dilution from tributaries, the magnitude of the effect would likely be low. Short-term decreases in water quality associated with the Proposed Action might affect adults and larvae in the mainstem Klamath River. As with SSCs, these effects might be muted by tributary inputs.

Estuary The Proposed Action is not expected to substantially change or affect estuarine habitat. SSCs are likely to be elevated above those occurring normally under existing conditions, but would be similar to those observed under extreme existing conditions. In the long term, sediment, flow, and water temperature effects resulting from the Proposed Action would likely not extend downstream to the estuary.

The Proposed Action would have short term effects related to SSCs and bedload movement. **Based on short duration of poor water quality during reservoir drawdown in the estuary, the Proposed Action would have a less-than-significant effect on eulachon in the short and long term.**

Longfin Smelt Impacts to longfin smelt would be the same as those described for eulachon.

Based on short duration of poor water quality during reservoir drawdown in the estuary, the Proposed Action would have a less-than-significant effect on longfin smelt in the short and long term.

Introduced Resident Species

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Introduced resident species occur in Lake Ewauna and Upper Klamath Lake, but the Proposed Action would not affect populations in this area.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam The Proposed Action would eliminate reservoir habitat upstream of Iron Gate Dam, and thus the abundance of these species would decline substantially or be reduced to nothing, as their preferred reservoir habitat would be eliminated (Buchanan et al. 2011a).

Lower Klamath River: Downstream of Iron Gate Dam A few introduced resident species occur in the lower Klamath River, but habitat conditions there are generally not suitable for these species. Under the Proposed Action, conditions would be expected to become less suitable.

The Proposed Action would eliminate habitat for introduced resident species in the Hydroelectric Reach. **Because these species were introduced and they occur in other nearby water bodies, their loss would not be considered significant from a biological perspective, and would benefit native species. Their loss would, however, decrease opportunities for recreational fishing for these species, as discussed in Section 3.20, Recreation.**

Freshwater mussels

Suspended Sediment Concentrations Due to the limited data available regarding overall abundance, distribution, life history, and population recruitment of freshwater mussels within the mainstem Klamath River, the overall effects that would be associated with predicted short- and long-term exposure to elevated SSCs on freshwater mussel populations as a result of the Proposed Action are difficult to determine.

Under the Proposed Action, SSCs would be expected to be higher than under existing conditions and would likely exceed 600 mg/L, the minimum SSCs level that would be considered detrimental to freshwater mussels, for 2 to 4 months after facility removal, depending on hydrologic conditions and location on the river. The SSCs in excess of 600 mg/L for 2 to 3 months would occur as far downstream as Klamath Station (at RM 5.0; see Figure 3.3-10); however, the highest levels, well in excess of 1,000 mg/L, would occur between Seiad Valley and Iron Gate Dam. Over time, as sediment stored behind the dams was diminished, the expected increase in SSCs over background levels would also diminish. Under existing conditions, SSCs could spike to levels exceeding 600 mg/L upstream of Orleans, although these spikes generally occur for a few days as opposed to several months, which is what would be expected under the Proposed Action. SSCs in excess of 600 mg/L for more than 4- to 5-day periods within the mainstem Klamath River would cause major physiological stress to freshwater mussels and might result in substantial mortality. The most significant impacts would occur downstream of Iron Gate Reservoir, especially to those individual freshwater mussels or freshwater mussel beds upstream of Orleans and closest to Iron Gate Dam.

Because freshwater mussels found within the Klamath River are so long lived (from 10 to more than 100 years, depending on the species) and sexual maturity might not be reached until 4 years of age or more, even relatively short term (e.g., for more than 5 consecutive days) SSCs in excess of 600 mg/L, would be expected to be detrimental for freshwater mussel populations within the mainstem Klamath River. However, it is anticipated that mainstem Klamath freshwater mussel populations would rebound, recolonizing through the transport of larvae (glochidia) by host fish from downstream populations less affected by excessive SSCs or from populations within tributaries, such as the Salmon or Scott Rivers, or from populations on the Klamath River upstream of Iron Gate Reservoir. This process is expected to take many years, however.

Changes in Bed Elevation Silt and fine material make up the largest proportion of the volume of sediment stored behind the dams and would be transported downstream primarily as suspended sediment. Courser material (larger than 0.063 mm) would also be transported downstream and would likely be deposited in the river channel, changing riverbed elevations from the existing condition 8 miles between Iron Gate Dam and Cottonwood Creek. The 182 miles of mainstem downstream of Cottonwood Creek are not predicted to have any substantial aggradation.

Of the freshwater mussel species found on the mainstem Klamath River, the western ridge freshwater mussel (*G. angulata*) seems to be the most abundant and is widely distributed between Iron Gate Dam and the confluence of the Trinity River (Westover 2010). The floater species (*Anodonta spp*.) are less abundant, with the largest single bed found immediately below Iron Gate Dam (Westover 2010). The western pearlshell (*Margaritifera falcata*) is the least abundant freshwater mussel found in the Klamath River and seems to be mostly found below the confluence of the Salmon River (Westover 2010). It is not known how well any of these species could tolerate deposition of sediment and whether they could move upward through deposited material to the surface to breathe and feed. It seems reasonable to presume that some percentage of Klamath River freshwater mussels buried under 0.5 to 3.0 feet of new sediment would not survive. Because of the relatively small area affected, these changes in bed elevation are not expected to substantially affect the overall population of freshwater mussels. It is anticipated that Klamath freshwater mussel populations would rebound eventually, recolonizing through the transport of larvae (*glochidia*) by host fish from downstream populations less affected by bed elevation changes or from populations within tributaries, such as the Trinity, Salmon or Scott Rivers, or from populations on the Klamath River upstream of Iron Gate Reservoir. However, due to the extended time it takes for freshwater mussels to reach sexual maturity (4 years or more, depending on the species), the reestablishment of freshwater mussel populations within affected reaches might be slow and might not be readily noticeable for some time, possibly a decade or more. The seven to eight species of fingernail clams and peaclams, including the montane peaclam, found in the Hydroelectric Reach and from Iron Gate Dam to Shasta River, are expected to be similarly affected.

<u>Changes in Bed Substrate</u> Draining the Four Facilities under the Proposed Action would result in the erosion of accumulated sediments, changing substrate characteristics within the Klamath River, especially within the current reservoir reaches. The reformation of river channels in the reservoir reaches is expected to occur within 5 months (see Figure 3.3-9). The reformation of river channels between Iron Gate Dam and the upstream reaches of J.C. Boyle Reservoir would benefit freshwater mussels by providing more suitable substrates (i.e., large gravel, cobble, and boulder) than currently exists, especially within the current reservoir reaches. In addition, the Proposed Action would also open access to river reaches upstream of Iron Gate Dam to migratory fish species, which might serve as host fish for parasitic freshwater mussel larvae (glochidia). As a result, suitable habitats upstream of Iron Gate Dam might be opened to additional, or more rapid, colonization of freshwater mussel species, transported as glochidia from downstream reaches by migratory fish species, which are currently blocked by Iron Gate Dam. However, due to the long time it might take for freshwater mussels to reach sexual maturity, the recolonization and/or growth of existing freshwater mussel populations upstream of Iron Gate Dam might be slow and might not readily noticeable for some time.

The Proposed Action would have short term effects related to SSCs and bedload movement. **Based on substantial reduction in the abundance of multiple year classes in the short term and the slow recovery time of freshwater mussels, the effect of the Proposed Action would be significant for mussels in the short term.**

Implementation of Mitigation Measure AR-7 (see Section 3.3.4.4) could be implemented to reduce the short- and long-term impacts of the Proposed Action on freshwater mussels.

With implementation of mitigation measures there would still be impacts to a portion of the freshwater mussel population, and there could still be a substantial reduction in the abundance of at least one year class. **Based on substantial reduction in year classes, the Proposed Action would have a significant effect on freshwater mussels after mitigation in the short term.**

Dam removal would increase connectivity between Upper Klamath Basin and the Hydroelectric Reach and would create additional riverine habitat within the Hydroelectric Reach. **Based on increased habitat availability and habitat quality in the long term, the effect of the Proposed Action would be beneficial for mussels in the long term.**

Benthic Macroinvertebrates

Suspended Sediment Concentrations Under the Proposed Action, increased SSCs would be expected to affect filter-feeding BMIs in much the same fashion as described for freshwater mussels. Excessive levels of SSCs for durations longer than normally occur under existing conditions are expected to cause physiological stress, reduced growth, and potential mortality to filter-feeding BMIs. The scraper-grazers feeding guild among the BMIs are also expected to be deleteriously affected, but due to their increased mobility, would be affected less than the filter-feeders. This could affect BMI as far downstream as the Orleans. The high concentrations of suspended sediment released during winter are not predicted to have a severe effect on macroinvertebrates during their winter dormancy period. During spring and summer SSC will be lower, but would be expected to impact macroinvertebrates during the peak of their feeding and reproductive period. Recolonization of affected BMI populations would occur relatively quickly due to the shortened life cycle of BMIs and rapid dispersal through drift and/or the flying stages of many BMI adults. In addition, recolonization is expected to occur rapidly through drift or dispersal of adult life stages from established BMI populations within the many tributary rivers and streams of the Klamath River.

Changes in Bed Elevation Under the Proposed Action, changes in bed elevation would affect BMIs in much the same fashion as described for freshwater mussels. Higher levels of sediment deposition than would normally occur under existing conditions would be expected to cause physiological stress, reduced growth, and potentially mortality to BMIs. As with the freshwater mussels, the most substantial impacts on BMIs would occur between Cottonwood Creek and Iron Gate Dam (approximately 8 river miles), with the greatest impacts occurring between Willow Creek and Iron Gate Dam. Recolonization of affected BMI populations would occur relatively quickly due to the shortened life cycle and greater dispersal capabilities of BMIs compared to freshwater mussels.

Changes in Bed Substrate The reformation of river channels in the reservoir reaches upstream of Iron Gate Dam under the Proposed Action would benefit BMIs by providing more suitable substrates than currently exist. As a result, suitable habitats formed upstream of Iron Gate Dam might be opened to additional colonization by BMIs through rapid dispersal by drift from upstream populations within current riverine reaches and/or dispersion of adult life stages. In addition, recolonization would occur rapidly from established BMI populations within the many tributary rivers and streams of the Klamath River.

The Proposed Action would have short term effects related to SSCs and bedload movement. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Proposed Action would be significant for macroinvertebrates in the short term.**

While a large proportion of macroinvertebrate populations in the Hydroelectric Reach and in the mainstem Klamath River downstream of Iron Gate Dam would be affected in the short term by the Proposed Action, their populations would be expected to recover quickly because of the many sources for recolonization and their rapid dispersion through drift or aerial movement of adults. *Dam removal would increase connectivity between Upper Klamath Basin and the Hydroelectric Reach and would create additional riverine habitat within the Hydroelectric Reach.* **Based on increased habitat availability and improved habitat quality, the effect of the Proposed Action on macroinvertebrates would be beneficial in the long term.**

Deconstruction

As described below, disturbance to the river channel during construction could affect aquatic species.

The Proposed Action would require relocation of the City of Yreka's water supply pipeline in Iron Gate Reservoir, demolition of the dams and their associated structures, power generation facilities, transmission lines, installation of cofferdams, road upgrading, hauling, reservoir restoration, and other activities (as described in Section 2.4.3.1). These actions would include the use of heavy equipment, and blasting as necessary, and as such, have the potential to disturb aquatic species. Activities at the J.C. Boyle, Copco 1, and Copco 2 Dams would affect the riverine and introduced resident species in the Hydroelectric Reach.

At Iron Gate Dam, anadromous species could also be affected. These effects could include shockwaves associated with breaking down the dam structure using explosives or heavy equipment, potential crushing of aquatic species from operation of heavy equipment in the river, sedimentation, and release of oil, gasoline, or other toxic substances from construction sites. Demolition of the dams and their associated structures, power generation facilities, installation of cofferdams, and other activities are scheduled to occur at Iron Gate Dam between January 10 and June 26, with cofferdam installation scheduled to occur between 2 January 2020 and 6 February 2020. Therefore, this activity would occur during the first month of reservoir drawdown and the peak of SSC associated with reservoir drawdown. As discussed above, any aquatic species within the vicinity of Iron Gate Dam tailrace during this time would also be subject to SSC during the reservoir drawdown that are estimated to range from 80 to >10,000 mg/L during the January 10 through June 26, 2020 period. These SSCs corresponds to Newcombe and Jensen (1996) severity ratings of from 8 to 12, which equate to sub-lethal and lethal effects aquatic species. It is anticipated that this release of sediment would result in the displacement of any individuals that are rearing in the mainstem into tributaries or further downstream prior to deconstruction or cofferdam activities. Therefore, impacts associated with deconstruction would generally be of small magnitude, short duration, and low intensity when compared to those that would occur as a result of the changes in habitat structure and release of sediments stored behind the dams if they were removed.

To minimize these potential construction impacts, construction areas would be isolated from the active river where possible, and water would be routed around the construction area, allowing the flow to move down the other portion of the river, while the isolated portion of the dam is removed. After a work area is isolated, fish rescues to remove any native fish trapped in the work area would be conducted. Fish would be relocated to an area of suitable habitat within the Klamath River. Implementation of soil erosion and sedimentation control and stormwater pollution prevention would minimize soil erosion and water quality effects on anadromous fish downstream of the work area, during and after construction. **Because best management practices for construction incorporated into the Proposed Action will prevent substantial effects, construction activities associated with the Proposed Action would be less–than-significant.**

Coastal Zone Consistency Determination

The following section provides an analysis of the effects of the Proposed Action on each of the relevant policies of the California Coastal Management Program as outlined in the California Coastal Act of 1976. The deconstruction activities of the Proposed Action would begin approximately 190 miles from the mouth of the Klamath River. Therefore, this analysis focuses on impacts that would be evident many river miles downstream in the estuary and near shore. The policies identified as applicable are Article 4 Marine Environment Section 30231 and Section 30236 (see *italicized* text below). Articles 2, Article 3, Article 5, Article 6, and Article 7 are not applicable due to the distance of deconstruction activities from the near shore environment and will not be further addressed in this analysis. Also this is a phased Coastal Zone Management Act (CZMA) analysis. Additional implementation specific analysis will be completed as needed if the Secretary makes an Affirmative Determination.

Section 30231 The biological productivity and the quality of coastal waters, streams, wetlands, estuaries and lakes appropriate to maintain optimum populations of marine organisms and for the protection of human health shall be maintained and, where feasible restored through, among other means, minimizing adverse effects of waste water discharges and entrainment, controlling runoff, preventing depletion of ground water supplies and substantial interference with surface water flow; encouraging waste water reclamation, maintaining natural vegetation buffer areas that protect riparian habitats, and minimizing alterations of natural streams.

As described above, the Proposed Action would result in substantial short-term increases in suspended sediment during 2020 while the reservoirs are drawndown in preparation for facility removal. The effect of these short-term increases would be significant for some species within the Klamath River. However, as described above, aquatic species within the river would benefit from increased habitat availability and improved habitat suitability in the long term. In addition, under a worst-case scenario, suspended sediment concentrations resulting from the Proposed Action would be elevated within the estuary and nearshore environment for approximately three months (January, February, and March) in 2020. As described in Section 3.2.4.3.2, SSC levels within the estuary and near-shore environment would not be substantially higher than under existing conditions, especially when compared with extreme winter conditions. Based on the short duration of poor water quality during reservoir drawdown in the estuary and near-shore environment, the Proposed Action would not be deleterious in the short-term, and would not likely affect the estuary and near-shore environment in the long term.

For all species analyzed, when the short-term deleterious effects occurring during reservoir drawdown in 2020 are weighed against the long-term benefits to the Klamath River, the systemic restoration espoused in the Proposed Action improves biological productivity and the quality of waters, streams, wetlands, estuaries, and lakes. Therefore the Proposed Action is consistent with the California Coast Act Policy 30231.

Section 30236 Channelizations, dams or other substantial alterations of rivers and streams shall incorporate the best mitigation measures feasible and be limited to (1) necessary water supply projects, (2) flood control projects where no other method for protecting existing structure in the flood plain is feasible and where such protections is necessary for public safety or to protect existing development, or (3) developments where the primary function is the improvement of fish and wildlife habitat

The primary function of the Proposed Action is to improve fish and wildlife habitat and water quality. For this reason, the Proposed Action deconstruction schedule was crafted with careful attention to the timing necessary to limit the impact of sediment release on aquatic resources and water quality. The timing in the Proposed Action is designed to limit the effects on water quality to one single large increase in suspended sediment and one single reduced dissolved oxygen event occurring within the winter and early spring of 2020. By limiting the duration of elevated suspended sediment and reduced dissolved oxygen, the Proposed Action avoids multiple years of effects to aquatic species and minimizes impacts to the sensitive juvenile rearing and smolt life stages of migratory fish. In addition to this built-in avoidance and minimization measure, the Proposed Action includes several required best management practices for the deconstruction activities including erosion and stormwater management, dust abatement, and hazardous spill prevention and response measures. To further address the alteration of rivers and streams and the effects of returning some of the natural processes to the Klamath River system, mitigation measures are being considered including AR 1: Protection of Mainstem Spawning, AR2: Protection of Outmigrating Juveniles, AR3: Fall Pulse Flows, AR-4: Hatchery Management, and AR-5 Pacific Lamprey Capture and Relocation.

Given the careful crafting of the Proposed Action, the required Best Management Practices and mitigation measures, and the fact that the primary function of the project is improvement of fish and wildlife habitat, the Proposed Action is consistent with the California Coast Act Policy 30236.

The Proposed Action could require the relocation of the City of Yreka water supply pipeline. The existing water supply pipeline for the City of Yreka passes under the Iron Gate Reservoir and would have to be relocated prior to the decommissioning of the dam to prevent damage from deconstruction activities or increased water velocities once the reservoir has been drawn down. The pipeline would either be suspended from a pipe bridge across the river near its current location, or rerouted along the underside of the Lakeview Bridge just downstream of Iron Gate Dam. Standard construction Best Management Practices would reduce the likelihood and extent of aquatic impacts. **Therefore, the relocation of the Yreka pipeline would have less-than-significant impacts to aquatic resources.**

Keno Transfer

Implementation of the Keno Transfer could cause adverse aquatic resource effects. The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in the generation of new impacts on aquatic resources compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (KHSA Section7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

East and West Side Facilities

Decommissioning the East and West Side Facilities could cause adverse aquatic resource effects. Decommissioning of the East and West Side canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would redirect water flows currently diverted at Link River Dam into the two canals, back in to Link River. Following decommissioning of the facilities, there would be no change in outflow from Upper Klamath Lake or inflow into Lake Ewauna. **Therefore, implementation of the East and West Side Facility Decommissioning action would result in no change from existing conditions.**

Interim Measures

The Proposed Action includes IMs to be implemented prior to the initiation of dam removal in 2020 (as described in Section 2.4.3). As described below, two of these have the potential to affect aquatic resources, including:

- IM 7: J.C. Boyle Gravel Placement and/or Habitat Enhancement, and
- IM 16: Water Diversions.

Implementation of J.C. Boyle Gravel Placement and/or Habitat Enhancement could result in alterations to habitat availability and habitat quality, and affect aquatic species. Under this IM, suitable spawning gravel would be placed in the J.C. Boyle Bypass and Peaking reaches following an Affirmative Determination and continuing through 2019. The first year would be before the Secretary makes a determination, and would therefore be included in the No Action/No Project Alternative. The following seven years would be part of the Proposed Action. This measure would use a passive approach to place gravel before high flow periods, or develop for other habitat enhancement that would provide equivalent fishery benefits in the Klamath River upstream of Copco Reservoir. These actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous species following dam removal. **Based on anticipated improvements in habitat availability and habitat quality, implementation of J.C. Boyle Gravel Placement and/or Habitat Enhancement under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in the basin. Effects on bull trout, freshwater mussels, shortnose and Lost River suckers would be less-than-significant. Effects on green sturgeon, eulachon, and Southern Resident Killer Whales would not change from existing conditions.**

Implementation of IM 16 (Water Diversions) could result in alterations to habitat availability and habitat quality, and affect aquatic species. Under this IM, PacifiCorp would seek to eliminate three screened diversions (the Lower Shovel Creek Diversion [7.5 cfs], Upper Shovel Creek Diversion [2.5 cfs], and Negro Creek Diversion [5 cfs]) from Shovel and Negro Creeks and would seek to modify its water rights to move the points of diversion from Shovel and Negro creeks to the mainstem Klamath River. If this were successful the screened diversions would be removed prior to dam removal in 2020. The intent of this measure is to provide additional water to Shovel and Negro creeks, thus increasing the quality and amount of suitable habitat for aquatic species within these tributaries, while not diminishing PacifiCorp's water rights. These actions would provide improvements in the quality and amount of suitable habitat for resident and anadromous aquatic species following dam removal. **Based on anticipated improvements in habitat availability and habitat quality with increased flow, implementation of IM 16 (Water Diversions) under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in the basin. Effects on bull trout, freshwater mussels, shortnose and Lost River suckers would be less-than-significant. Effects on green sturgeon, eulachon, and Southern Resident Killer Whales would not change from existing conditions.**

KBRA

The KBRA, which is a component of the Proposed Action, encompasses several programs that could affect aquatic resources, including:

- Phases I and 2 Fisheries Restoration Plan
- Fisheries Monitoring Plan
- Fisheries Reintroduction and Management Plan - Phase I
- Water Diversion Limitations
- On-Project Plan
- Water Use Retirement Program
- Fish Entrainment Reduction
- Klamath River Tribes Interim Fishing Site
- Upper Klamath Lake and Keno Nutrient Reduction

The actions that would be taken under the KBRA would generally benefit aquatic resources by reducing the impacts of past and ongoing disturbance on aquatic habitats. Any undesirable impacts associated with the actions would be short-term in nature and could be largely avoided by employing Best Management Practices for construction activities in and near water. Individual components of the KBRA are described below.

Phases I and 2 Fisheries Restoration Plans and Fisheries Monitoring Plan
Implementation of Phases I and 2 Fisheries Restoration Plans and Fisheries Monitoring Plan could result in alterations to water quantity, water quality, habitat availability and habitat quality, and affect aquatic species. The Phases I and 2 Fisheries Restoration Plans and Fisheries Monitoring Plans are designed to improve habitat for aquatic species and measure the efficacy of restoration actions. These plans prioritize restoration needs within the basin and establish a monitoring and adaptive management program to evaluate and optimize the success of restoration actions.

Measures that are ongoing in the basin or that have been identified for inclusion in the plans include floodplain rehabilitation, large woody debris emplacement, fish passage improvement, livestock exclusion fencing, riparian vegetation management, purchase of conservation easements, road decommissioning, and treatment of fine sediment sources. These activities were chosen to benefit native fish populations as well as the health of the aquatic and riparian ecosystems of the Klamath Basin. Fish passage improvements would be designed to increase access to historical habitat. Many of these activities would be constructed to reduce fine sediment supply to streams within the project area, improving spawning habitat and productive macroinvertebrate habitat.

Purchase of conservation easements or land could provide long-term protection to areas beneficial to the riverine ecosystem as a whole or specific areas of importance to fish species such as endangered suckers. It could also protect areas where restoration actions have been used to improve or restore habitats.

Some restoration activities under the Phases I and 2 Fisheries Restoration Plans and Fisheries Monitoring Plan could have short-term negative impacts, generally associated with construction and active management phases. Generally, these impacts would be localized and could be avoided through implementation of best management practices, such as control and containment of sediment and toxic discharge, isolation of work areas from the active channel of streams or rivers where possible, and rescuing fish where mortality may result from an action. The long-term water quality improvements generated by implementation of Phases I and 2 Fisheries Restoration Plans and Fisheries Monitoring Plan would contribute to the long-term improvements anticipated from hydroelectric facility removal. **Based on anticipated improvements in water quantity, water quality, habitat availability and habitat quality, implementation of Phases I and 2 Fisheries Restoration Plans and Fisheries Monitoring Plan under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, benthic macroinvertebrates, and shortnose and Lost River suckers. These actions would also be beneficial for coho salmon, except those in the Trinity River population units, where they would be less-than-significant. Effects on green sturgeon, bull trout, eulachon, Southern Resident Killer Whales, and freshwater mussels would not change from existing conditions.**

Phase I Fisheries Reintroduction and Management Plan
Implementation of Phase I of the Fisheries Reintroduction and Management Plan could result in alterations to habitat availability (fish access), and could affect aquatic species. The Phase I Fisheries Reintroduction and Management Plan is intended to support the reintroduction and management of fish in the Upper Basin during and after implementation of the KHSA. The plan would include provisions for the continued operation of a fish hatchery at Fall Creek or in the Iron Gate Dam area and the construction of fish collection facilities to support primarily the transport of fall-run Chinook salmon around areas of poor water quality, when needed, on an interim basis.

The initial use of the hatchery facility at Iron Gate Dam or on Fall Creek would provide conservation of native salmon stocks during the impact period of dam removal. The development of guidelines for the use of the conservation hatchery at Iron Gate Dam or on Fall Creek outlined in the Phase I Fisheries Reintroduction and Management Plan would be to support the establishment of naturally producing populations in the Klamath River Basin following implementation of the KHSA. Additionally, it is anticipated that a smaller production facility would be constructed in the Upper Basin to provide necessary research stock and locally reared fish for the reintroduction.

Volitional upstream and downstream passage facilities would be developed for passage around areas of poor water quality and will provide for volitional passage during the majority of the year. In addition, the development of fish collection facilities upstream and downstream of Keno Impoundment/Lake Ewauna would be required to provide effective migration for fall-run Chinook salmon when water quality is poor during the period from June 15 to November 15. During the limited period of use, fish collection and release facilities would be operated to minimize any delay and stress and provide for adequate acclimation. For adult fall-run Chinook salmon, fish transport would be an effective fish passage method because transport would be for a short distance on a seasonal, interim basis[4]. For adult fall-run Chinook salmon, seasonal collection and

[4] This seasonal, transport on an interim basis is not to be confused with permanent, year round trap and haul which does not provide equal benefits for the Klamath River when compared with the Services' fishway prescriptions (U.S. Department of the Interior (2007) The Department of the Interior's Filing of Modified Terms, Conditions, and Prescriptions (Klamath Hydroelectric Project, No. 2082). Sacramento,

transport mortality when water quality is poor would be minor compared to mortality associated with unaided passage through areas of poor water quality at this time of year.

In some instances, the collection and transport of fall-run Chinook salmon around areas of poor water quality could result in limited, seasonal mortality as follows:

1. Some juvenile federally listed suckers would likely be collected incidentally and may suffer related stress and mortality. However, regardless of any remediation at an upstream collection facility, nearly all these downstream migrant suckers would eventually die in the absence of lacustrine habitat below Keno Impoundment. There is little to no evidence of recruitment of suckers in downstream reservoirs currently and this habitat does not contribute significantly to the recovery of the species. Suckers may be collected and returned to habitat above Keno Impoundment.
2. Some redband trout may be collected incidentally resulting in displacement and incidental collection-related stress and mortality. Redband trout may be collected and returned to habitat above Keno Impoundment.
3. For fall-run Chinook salmon emigrants, the seasonal poor quality conditions are not expected to overlap with the peak migration period, thus the majority of juvenile Chinook salmon would not be affected. For those fall-run Chinook salmon emigrants collected and transported when during poor water quality conditions, transport related mortality would be minor compared to the mortality associated with unaided passage through areas of poor water quality at this time of year.
4. For steelhead trout and spring-run Chinook salmon, migration would likely occur primarily when water quality was adequate, thus, collection and transport of these fish would not be necessary or minimal. However, all anadromous salmonids would be collected and transported when water quality is poor during the period from June 15 through November 15. Transport related mortality would be minor compared to the mortality associated with unaided passage through areas of poor water quality at this time of year.

Limited, seasonal transport of fall-run Chinook salmon would provide a net benefit by allowing them migration to and from additional (historical) spawning habitat, by providing more effective migration, and by reducing the density of spawners below Keno Dam in certain poor water quality situations. The majority of fish transported would likely be fall-run Chinook salmon. However, the Phase I Fisheries Reintroduction and Management Plan may include seasonal, interim transport for a minor component of the spring-run Chinook, and steelhead migrants. Thus, these fish would also receive benefits from this program. Increased anadromous fish abundance, especially Chinook salmon, would result in more prey availability for Southern Resident Killer Whales when the whales are near the Oregon and California coasts.

California: 650 p.; NOAA Fisheries Service (2007). NOAA Fisheries Service Modified Prescriptions for Fishways and Alternatives Analysis for the Klamath Hydroelectric Project (FERC Project No. 2082): 151 p.).

Other reintroduction activities under the Phase I Fisheries Reintroduction and Management Plan could have short-term impacts, generally associated with construction and active management phases. Generally, these impacts would be localized and could be avoided or minimized through implementation of best management practices, such as control and containment of sediment and toxic discharge, isolation of work areas from the active channel of streams or rivers where possible, and rescuing fish where mortality may result from an action. The habitat improvements generated by implementation of the Phase I Fisheries Reintroduction and Management Plan would contribute to the long-term improvements anticipated from hydroelectric facility removal. **Based on access to additional, historical habitat and the anticipated improvements in fish health, implementation of the Phase I Fisheries Reintroduction and Management Plan under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, Southern Resident Killer Whales, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon, except those Trinity River population units, through continued support from the fish hatchery. The Trinity River population units, would experience no change from existing conditions in the long-term. Effects on green sturgeon, bull trout, eulachon, and freshwater mussels would be no change from existing conditions. These actions would be less than significant for redband trout as well as for shortnose and Lost River suckers.**

Water Diversion Limitations

Implementation of Water Diversion Limitations could result in reducing uncertainties associated with maintaining adequate ecological flows for aquatic species and their habitats, especially in low-flow years, and could alter water quality, and water temperatures in certain seasons and affect aquatic species. This component of the KBRA would establish limits on specific diversions within Reclamation’s Klamath Project to protect flows in the mainstem and ensure that adequate water supply is available for allocation to the wildlife refuges.

Reduced surface water deliveries associated with the diversion limitations could result in the increased use of groundwater for irrigation supply. A plan would be developed for monitoring groundwater in order to restrict pumping to no more than 6 percent of flows in the reach upstream of Copco 1 Dam that is fed predominantly by springs. This measure would protect an important resource that provides stable habitat conditions that may be critical to the survival of some species. This reliable source of cool inflow provides benefit to aquatic species by influencing temperature, dissolved oxygen, algal growth, and the dilution of contaminants or natural toxins, such as those produced by *M. aeruginosa*.

The long-term water quality and quantity improvements generated by implementation of diversion limitations would contribute to the long-term improvements anticipated from hydroelectric facility removal. **Based on anticipated improvements in water quantity and water quality, implementation of Water Diversion Limitations under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run**

Chinook salmon, steelhead, Pacific lamprey, redband trout, and shortnose and Lost River suckers. These actions would also be beneficial for coho salmon, except those in the Trinity River population units, where they would be no change from existing conditions. Effects on green sturgeon, bull trout, eulachon, Southern Resident Killer Whales, freshwater mussels, and benthic macroinvertebrates would be no change from existing conditions.

On-Project Plan

Implementation of the On-Project Plan could result in alterations to water quantity and water quality and affect aquatic species. The On-Project Plan would include a groundwater monitoring plan that limits pumping so that flows from springs in the watershed upstream of Copco 1 Dam would not be reduced by more than 6 percent, protecting these important habitats that provide stable habitat conditions and often support rare or unique species. It would also provide a plan to implement the water diversion limitations described above. This measure would help protect flows in the mainstem with the benefits described above. The long-term water quality and quantity improvements generated by implementation of the On-Project Plan would contribute to the long-term improvements anticipated from hydroelectric facility removal. **Based on anticipated improvements in water quantity and water quality, implementation of Water Diversion Limitations under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and shortnose and Lost River suckers. These actions would also be beneficial for coho salmon, except those in the Trinity River population units, where they would be no change from existing conditions. Effects on green sturgeon, bull trout, eulachon, Southern Resident Killer Whales, freshwater mussels, and benthic macroinvertebrates would be no change from existing conditions.**

Water Use Retirement Program

The Water Use Retirement Program could alter water quantity and water quality, and affect aquatic species. This component of the KBRA would increase inflow to Upper Klamath Lake by 30,000 acre-feet per year on average. A variety of mechanisms would be used to achieve this objective, including acquisition of water rights, forbearance agreements, water leasing, changes in agricultural cropping patterns, land fallowing, juniper removal, and forest thinning. The additional water provided would increase flows in tributaries to Upper Klamath Lake improving habitat for redband trout, shortnose and Lost River suckers, and bull trout. Anadromous salmon and steelhead that would have access to these tributaries as a result of the Proposed Action would also be expected to benefit.

This additional water could be used for a variety of purposes downstream of Upper Klamath Lake, including augmenting the base flow or high flow components of the annual hydrograph. Maintaining base flows, particularly during extreme droughts, is critical for fish spawning, rearing, passage, and preventing excessively warm water temperatures for all life stages. High flows are critical for shaping stream and river channels, creating diverse habitats, and connecting these habitats to riparian zones, terraces, and flood plains that provide nutrients to the riverine ecosystem and shelter for fish and other aquatic organisms when conditions in the river are unsuitable. Periodic springtime high flow events also have the potential of scouring the channel of fine-grained sediments and cladaphora which harbor intermediate hosts for organisms that produce high mortality in juvenile salmon. High flows mobilize the streambed, which removes fine sediments and organic material that can reduce spawning success and macroinvertebrate production, as well as reduce interstitial habitat used as cover by small fish. They are also important drivers of riparian ecosystem functions, such as dispersing and germinating seeds of riparian plants, and creating new areas for vegetation colonization through erosion. Riparian ecosystems are important for filtering fine sediment from hillslope runoff, buffering streams from contaminants, providing shade and temperature regulation, bank stability, and nutrients to the stream. Augmenting low flows in some years may be critical due to temperature, water quality, or disease concerns.

The additional water flows generated by implementation of the Water Use Retirement Program would contribute to the long-term improvements anticipated from hydroelectric facility removal. **Based on anticipated improvements in water quantity, and water and stream channel quality, implementation of Water Use Retirement Program under the Proposed Action would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and shortnose and Lost River suckers. These actions would also be beneficial for coho salmon, except those in the Trinity River population units, where there would be no change from existing conditions. Effects on green sturgeon, bull trout, eulachon, Southern Resident Killer Whales, freshwater mussels, and benthic macroinvertebrates would be no change from existing conditions.**

Fish Entrainment Reduction

Implementation of the Fish Entrainment Reduction could result in alterations to potential alterations to mortality risk and affect aquatic species. This KBRA action would involve designing and installing fish screens at Project Diversions, including the Lost River Diversion Channel and associated diversion points, North Canal, Ady Canal, and other Reclamation and Reclamation contractor diversions. This action would reduce mortality caused by entrainment of fish at these diversions, to the benefit of endangered shortnose and Lost River suckers, as well as to redband trout. Steelhead and fall- and spring-run Chinook salmon would also benefit from this action once they recolonize areas upstream of Keno Dam. The reductions in entrainment mortality generated by implementation of the Water Use Retirement Program would contribute to the long-term improvements in anadromous species health anticipated from hydroelectric facility removal. **Based on anticipated reductions in entrainment mortality, implementation of Fish Entrainment Reduction under the Proposed Action would be beneficial for shortnose and Lost River suckers, redband trout, fall-run Chinook salmon, spring-run Chinook salmon, steelhead, and Pacific lamprey. These actions would also be beneficial for coho salmon from the Upper Klamath River population unit, and would be no change from existing conditions for all other coho salmon population units. Effects on green sturgeon, bull trout, eulachon, Southern Resident Killer Whales, freshwater mussels, and benthic macroinvertebrates would be no change from existing conditions.**

Klamath River Tribes Interim Fishing Site

Implementation of the Klamath River Tribes Interim Fishing Site could result in alterations to managed harvest mortality of fish species that are culturally important to the Klamath River Tribes, including Chinook and coho salmon, steelhead, and Pacific lamprey. The harvest, which would take place between Iron Gate Dam and Interstate 5, would be coordinated with harvest by other tribes and the commercial fishery to remain within the predicted sustainable limits for the fishery. The coordinated harvest at the Klamath River Tribes Interim Fishing Site would not be expected to contribute to any changes generated by the hydroelectric facility removal action. **Based on anticipated fisheries management coordination as part of the implementation of Klamath River Tribes Interim Fishing Site under the Proposed Action, this action would result in no change from existing conditions for aquatic species.**

Upper Klamath Lake and Keno Nutrient Reduction

Implementation of the Interim Flow and Lake Level Program could result in decreases in summer water temperature and nutrient inputs to Upper Klamath Lake. KBRA (Appendix C-2, line 11) includes a program to study and reduce nutrient concentrations in the Keno Impoundment and Upper Klamath Lake in order to reduce dissolved oxygen problems and algal problems in both water bodies. Restoration actions to control nutrients have not been developed, and there are many diverse possibilities that could require construction of treatment wetlands, construction of facilities, or chemical treatments of bottom sediment, among other possibilities. A nutrient reduction program in the Keno Impoundment and Upper Klamath Lake would be designed to improve water quality (increasing dissolved oxygen and reducing algal concentration) and to provide fish passage through the Keno Impoundment in summer and fall months; however, implementation of this nutrient reduction program will require future environmental compliance investigations and a determination on significance cannot be made at this time.

The specific locations in which some of these KBRA actions would be undertaken are unknown at this time, but they would be implemented at different locations and times than KHSA actions. Many of these actions would require additional environmental documentation and permitting before being implemented, and are covered programmatically in this document. Generally, the KBRA actions described above would be expected to result in a net benefit for fisheries resources and the aquatic environment. Any potential deleterious effects identified could be avoided or mitigated through careful planning and management.

Alternative 3: Partial Facilities Removal of Four Dams Alternative

The Partial Facilities Removal of Four Dams Alternative would include removal of enough of J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams to allow free-flowing river conditions and volitional fish passage at all times. Under this alternative, portions of each dam would remain in place along with ancillary buildings and structures such as powerhouses, foundations, tunnels, and pipes, all of which would be outside of the 100 year flood-prone width. Under this alternative, partial removal of the embankment/earth-filled dam and concrete dam structures would allow release of dam-stored sediment. The retention of these structures would not be expected to result in any difference in the physical or biological effects of dam removal from those described for the Proposed Action. This alternative would include the transfer of the Keno Facility to the DOI and implementation of the KBRA.

Key Ecological Attributes

Aquatic ecological attributes under the Partial Facilities Removal of Four Dams Alternative would have indistinguishable effects on aquatic species from the Proposed Action.

Species-Specific Impacts

Lowering the water surface elevation of the reservoirs associated with dam removal under this alternative could affect aquatic species. In addition, the removal of dams and reservoirs could alter the availability and quality of habitat, resulting in effects on aquatic species. The impacts were considered for each of the following species and groups: fall-run Chinook salmon, spring-run Chinook salmon, coho salmon, steelhead, lamprey, green sturgeon, Lost River and shortnose suckers, redband trout, bull trout, eulachon, longfin smelt, introduced resident species, freshwater mussels and benthic macroinvertebrates. The effects of this Partial Facilities Removal of Four Dams Alternative on aquatic species would be indistinguishable from those described for the Proposed Action.

The Proposed Action would require the relocation of the City of Yreka water supply pipeline. Under the Partial Facilities Removal Alternative, the relocation of the Yreka water supply pipeline would have the same impacts as under the Proposed Action.

Keno Transfer

Implementation of the Keno Transfer could cause adverse aquatic resource effects. The Keno Transfer is a transfer of title for the Keno Facility from PacifiCorp to the DOI. This transfer would not result in the generation of new impacts on aquatic resources compared with existing facility operations. Following transfer of title, DOI would operate Keno in compliance with applicable law and would provide water levels upstream of Keno Dam for diversion and canal maintenance consistent with agreements and historic practice (KHSA Section7.5.4). **Therefore, implementation of the Keno Transfer would result in no change from existing conditions.**

East and West Side Facilities

Decommissioning the East and West Side Facilities could cause adverse aquatic resource effects. Decommissioning of the East and West Side canals and hydropower facilities of the Link River Dam by PacifiCorp as a part of the KHSA would redirect water flows currently diverted at Link River Dam into the two canals, back in to Link River. Following decommissioning of the facilities there would be no change in outflow from Upper Klamath Lake or inflow into Lake Ewauna. **Therefore, implementation of the East and West Side Facility Decommissioning action would result in no change from existing conditions.**

Interim Measures

Implementation of IMs 7 (J.C. Boyle Gravel Placement and/or Habitat Enhancement) and 16 (Water Diversions) could result in alterations to habitat availability and habitat quality, and affect aquatic species. These IMs would increase spawning gravel or habitat upstream of Copco Reservoir and would increase flows in Shovel and Negro Creeks. As described under the Proposed Action, these actions would provide improvements in habitat quality for resident fish prior to dam removal, and for resident and anadromous species following dam removal. **Based on anticipated improvements in habitat availability and habitat quality, implementation of IMs 7 and 16 under the Partial Facilities Removal would be beneficial for fall-run Chinook salmon, spring-run Chinook salmon, steelhead, Pacific lamprey, redband trout, and benthic macroinvertebrates. These actions would also be beneficial for coho salmon from the Upper Klamath River Population Unit, and less-than-significant for all other population units in the basin. Effects on bull trout, freshwater mussels, shortnose and Lost River suckers would be less-than-significant. Effects on green sturgeon, eulachon, and Southern Resident Killer Whales would not change from existing conditions.**

KBRA

The KBRA would be implemented under the Partial Facilities Removal of Four Dams Alternative and would have indistinguishable effects on aquatic species from the Proposed Action.

Alternative 4: Fish Passage at Four Dams Alternative

The Fish Passage at Four Dams Alternative would provide upstream and downstream fish passage at the Four Facilities, but would not include implementation of the KBRA. The ongoing restoration actions, described in the No Action/No Project Alternative, would continue. The alternative would incorporate the prescriptions from the Departments of Interior and Commerce imposed during the FERC relicensing process, including fishway installation for both upstream and downstream migrations at all facilities and barriers to prevent juvenile salmonid entrainment into turbines. In addition to the fishways, there are a series flow-related measures, including a condition that requires at least 40 percent of the inflow to the J.C. Boyle Reservoir to be released downstream. This alternative would limit generation of peaking power at J.C. Boyle Powerplant to one day per week as water supplies allow, and would include recreation flows one day a week.

Pursuant to the FERC's Licensing Regulations, the Department of Interior filed its comments regarding the impacts of facilities and operations of the Klamath Hydroelectric Project (FERC No. 2082) on public resources and recommended various terms and conditions to be incorporated into any new license to address these impacts. In addition, the Secretaries of Interior and Commerce filed fishway prescriptions under Section 18 of the Federal Power Act (FPA) to provide safe, timely, and effective fish passage, and, in doing so, specifically address the loss of fish habitat after the project was constructed.

Pursuant to the regulations of FERC (18 C.F.R. 385.604), many of the Parties to the FERC licensing proceeding undertook confidential settlement discussions to resolve disputed issues in the licensing proceeding, resulting in the KHSA. Section 3.2.1 of the KHSA provides that the Secretary of Interior is to undertake National Environmental Policy Act analysis and other appropriate actions to determine whether to proceed with Facilities Removal. Chapter 1 of this EIS/EIR states the purpose of the proposed federal action "is to advance restoration of the salmonid fisheries in the Klamath Basin that is in the public interest, and is consistent with the KHSA and KBRA and their objectives." Consistency with the KHSA and KBRA and their objectives thus underlies the alternatives and analyses presented in this document. The reader should note, however, that the FERC has not taken final action on PacifiCorp's application for license. Therefore, the Department of Interior's position in that proceeding, has not changed, including the various impacts of PacifiCorp's dams on public resources and the need for and benefits of the fishways prescribed by the Secretaries. Fishways installed as part of fish passage alternatives in this EIS/EIR would need to comply with the Section 18 prescriptions for the construction, operation, and maintenance of upstream and downstream passage (DOI 2007). General prescriptions cover anadromous (fall- and spring-run Chinook salmon, coho salmon, steelhead, and Pacific lamprey) and resident (rainbow and redband trout, shortnose and Lost River suckers) fish passage at all Klamath Hydroelectric Project dams, and include implementing operation and maintenance plans and prescribing attraction flows for upstream migrants (DOI 2007). Specific provisions apply to individual dams and include performance standards for upstream and downstream passage facilities.

DOI and NOAA Fisheries Service passage prescriptions for Keno Dam include the collection of adult Chinook salmon for transport past Lake Ewauna during summer months when water quality is poor (DOI 2007). If dissolved oxygen concentrations are less than 6 mg/L and water temperatures are higher than 20°C, as measured at Miller Island (RM 246), trap and haul would occur from June 15 through November 15 until restoration efforts improve water quality to conditions suitable for anadromous fish (DOI 2007). Conditions in the reach from Keno Dam to Link River Dam are expected to eventually improve through implementation of TMDL water quality measures and imposition of state water quality certification conditions to allow year-round volitional passage.

Fish passage at Iron Gate Dam would provide fish with access to Scotch, Slide, Camp, Jenny, Fall, and Salt Creeks, and the Copco 2 Bypass Reach. Passage at Copco 1 Dam would provide access to 4.5 miles of reservoir habitat, 21 miles of mainstem habitat, and an additional 6 miles of tributary habitat. Passage would also allow access to cooler water in the J.C. Boyle Bypass Reach provided by springs (an estimated 200-250 cfs) (DOI 2007; FERC 2007). Passage at J.C. Boyle Dam would provide access to 4.7 miles of mainstem habitat, to Spencer Creek. Overall, passage would provide access to 49 significant tributaries in the Upper Klamath Basin, comprising 420 miles of additional potentially productive anadromous fish habitat upstream of Iron Gate Dam (DOI 2007), including access to groundwater discharge areas resistant to effects of climate change (Hamilton et al. 2011). There would continue to be 22.4 miles of spawning and rearing habitat inundated by reservoirs (Cunanan 2009).

Key Ecological Attributes

Suspended Sediment

Under the Fish Passage at Four Dams Alternative, SSCs would be the same as under existing conditions. Therefore, this alternative would have no effects associated with suspended sediment transport relative to existing conditions for any aquatic species.

Bedload Sediment

Under the Fish Passage at Four Dams Alternative, the dams would not be removed and sediment would continue to be stored behind Klamath Hydroelectric Project dams, similar to the No Action/No Project Alternative.

Water Quality

Under the Fish Passage at Four Dams Alternative, water quality would be the same as under the No Action/No Project Alternative. Anadromous fish would be able to move through the Hydroelectric Reach and might be exposed to poor water quality during upstream and downstream migration. Dissolved oxygen concentrations within reservoirs can be stressful for anadromous fish from June to September (FERC 2007) and continued high rates of algal photosynthesis in the reservoirs would result in pH values that would not consistently meet applicable ODEQ and California Basin Plan water quality objectives (see Section 3.2.4.3). Implementation of water quality improvement measures under Oregon and California TMDLs (to address water quality impairments within the period of analysis) would improve conditions for migratory fish.

Water Temperature

Under the Fish Passage at Four Dams Alternative, the effects on water temperature are predicted to be similar to those that are predicted for the No Action/No Project Alternative. Anadromous fish would be able to move through the Hydroelectric Reach and might be exposed to high temperatures during upstream and downstream migration. Water temperature in the reservoirs can be particularly high from June to September (see Section 3.2.3.2) and might exceed thermal tolerances for anadromous or resident fish.

Under existing conditions, there is a delay in the normal progression of water temperatures below Iron Gate Dam (or Phase Shift from historical timing) (Bartholow et al. 2005). Under this alternative, the current phase shift and lack of temporal diversity would persist, including current warm temperatures in late summer and fall. Current cooler temperatures in spring and early summer could benefit both adult and juvenile salmonids migrating during spring. However, juveniles and adults migrating later in the year would continue to experience warm temperatures in late summer and fall that could be deleterious to health and survival, including increased risk of disease, and high rates of delayed spawning and prespawn mortality (Hetrick et al. 2009).

Fish Disease and Parasites

The incidence of fish disease in salmon may be reduced under the Fish Passage at Four Dams Alternative, or may remain similar to the No Action/No Project Alternative because many of the primary factors affecting fish infection and disease rates from *C. shasta* and *P. minibicornis* would remain unchanged (e.g., habitat conditions favorable for the invertebrate hosts, sediment transport, and temperature would remain similar to existing conditions). Fish passage upstream by anadromous salmonids would increase under this alternative, which could reduce the concentration of salmon using the area immediately below Iron Gate Dam for spawning, potentially reducing the transfer of myxospores from fish to the polychaete hosts. However, concentrations of adults downstream of Iron Gate Dam may still be high while fish hold prior to ascending the fish ladder, and the continued operation of Iron Gate Hatchery. Overall, under this alternative, disease in salmon would be expected to continue because: (1) conditions promoting high densities of polychaetes and parasites would generally persist; (2) a small proportion of spawning salmon produce the bulk of the myxospores; and (3) infected salmon may be less likely to successfully utilize the ladders. Therefore, under this alternative, disease impacts would be reduced, but would continue to be detrimental to salmon.

Algal Toxins

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at Four Dams Alternative, high nutrient inputs supporting the growth of toxin-producing nuisance algal species such as *M. aeruginosa* in Upper Klamath Lake would remain similar to existing conditions for decades into the future. This would result in continued bioaccumulation of microcystin in suckers in Upper Klamath Lake and could be deleterious to fish health. Upon full attainment of the TMDLs (implementation mechanism and timing currently unknown), nutrients and toxin-producing nuisance algal species would decrease (see Sections 3.2 and 3.4 for additional detail regarding TMDLs and algal growth). Accordingly, with full attainment of the TMDLs, improvements to microcystin tissue levels in suckers in the lake would occur.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Continued impoundment of water at the Four Facilities under the Fish Passage at Four Dams Alternative would support growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa* in Copco 1 and Iron Gate Reservoirs, resulting in high seasonal concentrations of algal toxins in the Hydroelectric Reach for decades into the future. This would result in continued bioaccumulation of microcystin in fish tissue for species in the Hydroelectric Reach and could be deleterious to fish health. Upon full attainment of the TMDLs (implementation mechanism and timing currently unknown), nutrients and toxin-producing nuisance algal species would decrease in the Hydroelectric Reach (see Sections 3.2 and 3.4 for additional detail regarding TMDLs and algal growth). Accordingly, with full attainment of the TMDLs, improvements to microcystin tissue levels in fish in the Hydroelectric Reach would occur.

Lower Klamath River: Downstream of Iron Gate Dam Continued impoundment of water at the Four Facilities under the Fish Passage at Four Dams Alternative would support the seasonal transport of toxin-producing nuisance algae and microcystin to the Klamath River downstream of Iron Gate Dam. This would result in continued bioaccumulation of microcystin in fish tissue for species in the river and could be deleterious to fish health. Upon full attainment of the TMDLs (implementation mechanism and timing currently unknown), nutrients and toxin-producing nuisance algal species would decrease in the Hydroelectric Reach (see Sections 3.2 and 3.4 for additional detail regarding TMDLs and algal growth). Accordingly, with full attainment of the TMDLs, improvements to microcystin tissue levels in fish in the Klamath River downstream of Iron Gate Dam would occur.

Aquatic Habitat

Under the Fish Passage at Four Dams Alternative, the hydrology of the Klamath River from Iron Gate Dam to the Klamath River Estuary would generally remain the same as under existing conditions, subject to the influence of climate change (discussed under Section 3.10, Greenhouse Gases/Global Climate Change). Activities currently underway to recover salmonid and sucker populations within the Klamath Basin would continue at their current levels. Fish would be able to migrate past the dams and would gain access to substantial areas of additional habitat; however, access could be delayed at the ladders and seasonally impaired by poor water quality conditions in the reservoirs.

In addition, juveniles and smolt traveling through the four hydroelectric reservoirs would be exposed to some level of predation by introduced resident fish including largemouth bass, catfish, and yellow perch, resulting in mortality rates that would depend largely on their size (larger migrants would do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rogers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).

Fish traveling through reservoirs would be protected from entrainment at the hydroelectric intake by fish collection and routing facilities as required under the Section 18 prescriptions for the FERC relicensing of the Klamath Hydroelectric Project (DOI 2007). Under this alternative, there would be substantial changes to hydroelectric operations. J.C. Boyle Powerhouse would no longer generate in peaking mode, and higher flow releases would be made through the J.C. Boyle Bypass Reach than under existing conditions. Higher base flows would also be provided in the Copco 2 Bypass Reach. Peaking operations would only occur one day a week to coincide with recreation flows, at least 40 percent of flow would go into the Bypass Reach (and not enter the powerhouse), and ramping rates would be slower than they are currently. Seasonal high flows will contribute to improving the quality of riparian habitat in the J.C. Boyle Bypass Reach by increasing the sediment deposit within the channel and decreasing reed canary grass (Administrative Law Judge 2006). The more normative flow regime associated with this alternative would provide these seasonal high flows. These modifications would benefit fish in this reach, including redband trout and anadromous fish.

Aquatic Resources Effects

Critical Habitat

As described below, continued impoundment of water within reservoirs and access to additional habitat under the Fish Passage at Four Dams Alternative could alter currently designated critical habitat.

Coho Salmon Under the Fish Passage at Four Dams Alternative, coho salmon would be able to access habitat in the Hydroelectric Reach by ascending the fishways associated with each of the dams. The upstream boundary of critical habitat for coho salmon in the Klamath Basin is Iron Gate Dam; any newly accessible areas would be outside of their currently designated critical habitat. NOAA Fisheries Service may want to consider including the newly accessible reaches as critical habitat as part of their 5-year status review or in a separate decision (J. Simondet, NOAA Fisheries Service, pers. comm., 2011). Under this alternative, the KBRA would not be implemented. However, ongoing restoration activities will continue. The areas inundated by the reservoirs would not provide suitable spawning or rearing habitat for coho salmon, but they would gain access to the riverine reaches on the mainstem and to the tributaries, although the downstream ends of most of the tributaries would be inundated by the reservoirs. Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows.

Water temperatures would continue to be affected by the reservoirs. They would be warmer in the summer and fall when adults are migrating upstream and would continue to be deleterious to adult migrants, downstream of Iron Gate Dam, upon entry into the reservoirs, and in bypass reaches. Many of the primary factors influencing salmon infection and disease rates from *C. shasta* and *P. minibicornis* would remain unchanged. The ongoing presence of the dams would continue to contribute to the stable, warm habitat conditions favorable for polychaetes and for *C. shasta* and *P. minibicornis* downstream of Iron Gate Dam. Fish passage upstream by anadromous salmonids would increase under this alternative, which could reduce the concentration of salmon using the area immediately below Iron Gate Dam for spawning, potentially reducing the transfer of myxospores from fish to the polychaete hosts. However, concentrations of adults downstream of Iron Gate Dam may still be high while fish hold prior to ascending the fish ladder, and the continued operation of Iron Gate Hatchery. Overall, under this alternative disease in salmon would be expected to continue because: (1) conditions promoting high densities of polychaetes and parasites would generally persist; (2) a small proportion of spawning salmon produce the bulk of the myxospores; and (3) infected salmon may be less likely to successfully utilize the ladders. Therefore, under this alternative, disease impacts would be reduced, but would continue to be detrimental to salmon.

In terms of Primary Constituent Elements of coho salmon critical habitat, this alternative would provide access to additional spawning habitat upstream of currently designated critical habitat, including in Fall, Jenny, Shovel and Spencer Creeks, although the downstream ends of these streams would continue to be inundated by the reservoirs and would not provide suitable spawning or rearing habitat. The food resources in these tributaries would also become available to fry and juvenile coho salmon rearing in those streams. Water quality conditions in the Hydroelectric Reach and downstream of Iron Gate Dam would be expected to improve over time with TMDL implementation, but would not improve as quickly or to the same extent as under the Proposed Action. **Based on the current designation of critical habitat, the effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for coho salmon critical habitat in the short and long term.**

Bull Trout Under the Fish Passage at Four Dams Alternative, the physical and chemical components of critical habitat for bull trout would be improved by the Oregon TMDL processes, but the KBRA would not be implemented. However, ongoing restoration activities will continue to occur. Actions taken as part of the Fish Passage at Four Dams Alternative would not affect the physical or chemical components of critical habitat, but would allow Chinook salmon and steelhead to access areas they have not been able to access since the completion of the Copco 1 Development in 1918. These species could compete with and prey upon bull trout fry and juveniles. However, bull trout would also be expected to consume the eggs and fry of Chinook salmon and steelhead. Because these species co-evolved in the watershed together, it is anticipated that they would be able to co-exist in the future. **Based on the restricted distribution of bull trout, the Fish Passage at Four Dams Alternative would result in no change from existing conditions.**

Southern Resident Killer Whale Klamath River contributes to critical habitat for Southern Resident Killer Whales through its contribution of Chinook salmon to their food supply. The Proposed Action would not affect critical habitat for this species. Implementation of the Fish Passage at Four Dams Alternative, by providing anadromous salmonids with access to habitat upstream of Iron Gate Dam, is expected to increase production of wild Chinook salmon. The Iron Gate Hatchery would continue to operate, ensuring ongoing production of hatchery Chinook salmon and contribution to ocean stocks. Klamath River Chinook salmon likely represent only a very small proportion of the diet of this killer whale population because most of their feeding is on Fraser River and Puget Sounds stocks (Hanson et al. 2010); therefore, any increase in salmon production from the Proposed Action would not substantially affect this species. **Based on small influence of the Klamath River on PCEs of Southern Resident Killer Whales, the Fish Passage at Four Dams Alternative would result in no change from existing conditions.**

Essential Fish Habitat

As described below, continued impoundment of water within reservoirs and access to additional habitat under the Fish Passage at Four Dams Alternative could alter the availability and suitability of Essential Fish Habitat (EFH).

Chinook and Coho Salmon EFH Implementation of the Fish Passage at Four Dams Alternative would increase habitat for Chinook and coho salmon (upstream of currently designated EFH) by providing access to habitat upstream of Iron Gate Dam. However, under this alternative, EFH for Chinook and coho salmon would be expected to remain similar to its current condition, as described for the No Action. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for Chinook and coho salmon EFH in the short and long term.**

Groundfish EFH Implementation of the Fish Passage at Four Dams Alternative would not affect groundfish EFH. SSCs and bedload would remain the same as under existing conditions, as would water quality. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for groundfish EFH in the short and long term.**

Pelagic Fish EFH Implementation of the Fish Passage at Four Dams Alternative would not affect pelagic fish EFH. SSCs and bedload would remain the same, as would water quality. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for pelagic fish EFH in the short and long term.**

Species-Specific Impacts
A described below, fish ladders could alter the availability of habitat resulting in effects on aquatic species.

Fall-Run Chinook Salmon
Upper Klamath Basin upstream of J.C. Boyle Reservoir Under the Fish Passage at Four Dams Alternative, fish passage facilities installed at the four dams within the Hydroelectric Reach would allow fall-run Chinook salmon to gain access to the upper Klamath River upstream of J.C. Boyle Reservoir. The access would expand the Chinook salmon's current habitat to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). This would be a potential increase in access to 49 significant tributaries in the Upper Klamath Basin, comprising 420 miles of additional potentially productive habitat (DOI 2007), including access to groundwater discharge areas relatively resistant to effects of climate change (Hamilton et al. 2011). There would continue to be 22.4 miles of spawning and rearing habitat inundated reservoirs (Cunanan 2009). Implementation of the Fish Passage at Four Dams Alternative would not result in changes to the suspended sediments or bedload sediment, flow-related habitat, or algal toxins and disease. Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006).

Poor water quality (e.g., severe hypoxia, temperatures exceeding 25°C, high pH) in the reach from Keno Dam to Link Dam might prevent fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011). However, evidence indicates that Upper Klamath Lake habitat is presently suitable to support Chinook salmon for at least the October through May period (Maule et al. 2009). Poor water quality conditions from Link Dam to Keno Dam during the late summer and fall could be detrimental to fish in this area, particularly anadromous salmonids. Therefore, the Fish Passage at Four Dams Alternative would include an interim seasonal trap and haul operation that would involve capturing and trucking both upstream and downstream migrant fish around this area when water quality conditions would be prohibitively stressful. As adult fall-run Chinook salmon in the Klamath River migrate upstream from August through October, and juveniles migrate to the ocean from spring to early fall, stress-related mortality associated with seasonal, interim trap and haul activities would affect this species to some degree.

Some degree of stress and mortality of adult and juvenile salmon may result from the interim seasonal trap and haul operations (Buchanan et al. 2011b), especially between Link Dam and Keno Dam, and during periods with high water temperatures or poor water quality. The distance that fish would be transported under this alternative would be limited however, and trap and haul would only be used when fish would otherwise be exposed to stressful conditions.

<u>Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam</u>
Implementation of the Fish Passage at Four Dams Alternative would restore fall-run Chinook salmon access to the Hydroelectric Reach. Passage through the reach would provide approximately 52 miles of additional habitat along the mainstem and within accessible tributaries (DOI 2007). Riverine habitat under the existing reservoirs would continue to be inaccessible. Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows. Passage structures would provide access to thermal refugia created by 200 to 250 cfs of spring flow accretion in the J.C. Boyle Bypass Reach (DOI 2007; FERC 2007). Under this alternative, suspended and bedload sediment, water quality, water temperature, and the occurrence of fish disease and algal toxins would be the same as under existing conditions.

Similar to the No Action/No Project Alternative, fish migrating through reservoirs would continue to be exposed to more stressful water quality conditions including high temperatures with low dissolved oxygen in the summer and fall, changes in dissolved oxygen, pH, and ammonia associated with algal blooms, and exposure to microcystin from *M. aeruginosa* blooms (Dunsmoor and Huntington 2006; FERC 2007). These conditions can become severely stressful in June through September, contributing to lower resistance to disease, and potentially causing direct mortality. Springs beneath the reservoirs would not provide thermal refugia, as they would discharge into layers of water with low DO that occur at the bottoms of the reservoirs. These juveniles would also be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch, resulting in mortality rates that would depend largely on their size (larger migrants would do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rogers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006). The combination and timing of effects (adults migrate from August through October, juveniles migrate from spring to early fall), could result in stress, migration delays, or mortality of fall-run Chinook salmon as they move through the Hydroelectric Reach.

<u>Lower Klamath River: Downstream of Iron Gate Dam</u> Under the Fish Passage at Four Dams Alternative, suspended sediment would be the same as under existing conditions, thus having no suspended sediment effects relative to existing conditions for any aquatic species. Klamath Hydroelectric Project dams would continue to trap fine and coarse sediment and reduce the storage capacity of the reservoirs. The channel directly downstream of Iron Gate Dam would continue to be starved of fine sediment, but the effect would gradually decrease in the downstream direction as coarse sediment would be resupplied by tributary inputs (Hetrick et al. 2009; Stillwater Sciences 2010a). Coarsening of the bed could reduce spawning habitat for fall-run Chinook salmon below the dam over time, but this impact would be limited to the area upstream of Cottonwood Creek. Rearing habitat would be expected to remain similar to existing conditions.

Under the Fish Passage at Four Dams Alternative, the lower Klamath River downstream of Iron Gate Dam reach would continue to have poor water quality because of the continued presence of the reservoirs with their increased hydraulic residence time and thermal mass (Bartholow 2005). The delay in thermal signature would continue to delay the migration and spawning of fall-run Chinook salmon downstream of Iron Gate Dam, and prespawn mortality would remain high (Hamilton et al. 2011). Current cooler temperatures in spring and early summer could benefit rearing life history of anadromous species (Hamilton et al. 2011).

Many of the primary factors influencing salmon infection and disease rates from *C. shasta* and *P. minibicornis* would remain unchanged. The ongoing presence of the dams would continue to contribute to the stable, warm habitat conditions favorable for polychaetes and their parasites *C. shasta* and *P. minibicornis* downstream of Iron Gate Dam. Upstream fish passage would likely reduce salmon spawning density immediately downstream of Iron Gate Dam, which in turn is likely to reduce the transfer of myxospores from salmon to their polychaete hosts. However, concentrations of adults downstream of Iron Gate Dam may still be high while fish hold prior to accessing the fish ladder, and the continued operation of Iron Gate Hatchery. Therefore, under this alternative, disease impacts could be reduced, but continue to be detrimental to fall-run Chinook salmon.

Dissolved oxygen concentrations during July–October immediately downstream of Iron Gate Dam would continue to be low (less than 8 mg/L). In addition, the presence of microcystin, associated with the dense blooms of *M. aeruginosa* in Iron Gate and Copco Reservoirs, would continue to occur downstream of Iron Gate Dam.

Estuary The Fish Passage at Four Dams Alternative is not expected to substantially change or affect fall-run Chinook salmon estuarine habitat relative to existing conditions.

Under this alternative, fish ladders could result in alterations in habitat availability for fall-run Chinook salmon in the long term. Under the Fish Passage at Four Dams Alternative, fall-run Chinook salmon would gain access to mainstem and tributary habitat in the upper Klamath River and Hydroelectric Reach, and thermal refugia within the Hydroelectric Reach, which would benefit the population. Some degree of stress and mortality of adult and juvenile salmon may result from the interim seasonal trap and haul operations (Buchanan et al. 2011b), especially between Link Dam and Keno Dam, and during periods with high water temperatures or poor water quality. Poor water quality, high water temperature, low dissolved oxygen, algal blooms and toxins, and predation could result in low survival of fall-run Chinook salmon passing through the four reservoirs. The distance that fish would be transported under this alternative would be limited however, and trap and haul only used when fish would otherwise be exposed to stressful conditions.

This alternative would result in continuation of many of the stresses that currently affect Chinook salmon populations. The presence of dams under the Fish Passage at Four Dams Alternative would continue to cause poor water quality, and high late summer and early fall water temperatures, allowing many conditions favorable for the transmission of fish disease to persist. These conditions would continue to have negative short- and long-term impacts on fall-run Chinook salmon populations. Further, under the Fish Passage at Four Dams Alternative, the KBRA would not be implemented, so any potential habitat improvements from KBRA restoration projects would not be realized. However, ongoing restoration activities would continue to occur. Climate change could also increase the frequency and duration of stressful water temperatures for salmonids under the Fish Passage at Four Dams Alternative. It is anticipated that as a result of the Fish Passage at Four Dams Alternative the fall-run Chinook salmon population within the Klamath River watershed would have an increase in abundance, population spatial structure, and genetic diversity. However, smolts produced from tributaries downstream of Iron Gate Dam would experience a continuation of existing deleterious effects. **Based on increased habitat availability, the effect of the Fish Passage at Four Dams Alternative would be beneficial for fall-run Chinook salmon in the short and long term.**

Spring-Run Chinook Salmon

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at Four Dams Alternative, fish passage facilities installed at the four dams within the Hydroelectric Reach would allow spring-run Chinook salmon to gain access to the upper Klamath River upstream of J.C. Boyle Reservoir. The access would expand the Chinook salmon's current habitat to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005, Butler et al. 2010). Passage at Keno Dam would provide access to 20 miles of reservoir habitat and 1.2 miles of riverine habitat between Keno and Link River Dams (FERC 2007). Overall, the Fish Passage at Four Dams Alternative would provide access to 49 significant tributaries in the Upper Klamath Basin, comprising 420 miles of additional potentially productive anadromous fish habitat upstream of Iron Gate Dam

(DOI 2007), including access to groundwater areas resistant to climate change (Hamilton et al. 2011). There would continue to be 22.4 miles of spawning and rearing habitat inundated by reservoirs (Cunanan 2009). The Fish Passage at Four Dams Alternative is not expected to result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins and disease. Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006).

Poor water quality (e.g., severe hypoxia, temperatures exceeding 25°C, high pH) in the reach from Keno Dam to Link Dam might prevent fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011). However, evidence indicates that Upper Klamath Lake habitat is presently suitable to support Chinook salmon for at least the October through May period (Maule et al. 2009). Poor water quality conditions, particularly in Lake Ewauna during the late summer and early fall, could be detrimental to fish in this area, particularly anadromous salmonids. Therefore, an interim seasonal trap and haul operation would be implemented to capture and truck migrant fish around Lake Ewauna during stressful water quality conditions (from June 15th to November 15th, see Section 3.3.2). As adult spring-run Chinook salmon in the Klamath River migrate upstream from April through June, and most juveniles migrate from April through May or October through November, trap and haul activities would be expected to have only minor effects on this run of Chinook salmon.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam The Fish Passage at Four Dams Alternative would include restoring spring-run Chinook salmon access to the Hydroelectric Reach. Passage through the Reach would provide approximately 52 miles of additional habitat along the mainstem and within accessible tributaries (DOI 2007). Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows. Further, passage structures would provide fish with some refuge from high temperatures because the cooler water from tributaries would flow directly into the mainstem Klamath River, in addition to that provided by 200 to 250 cfs of accretion from springs in the J.C. Boyle Bypass Reach (DOI 2007; FERC 2007; Hamilton et al. 2011). Under this alternative, suspended and bedload sediment, water quality, water temperature, and the occurrence of fish disease and algal toxins would be the same as under existing conditions.

This alternative would result in continuation of many of the stresses that currently affect Chinook salmon populations. The presence of J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams under the Fish Passage at Four Dams Alternative would continue to cause poor water quality, and high late summer and early fall water temperatures, allowing conditions favorable for the transmission of fish disease to persist. Adult spring-run Chinook salmon in the Klamath River migrate upstream from April through June, and most juveniles migrate from April through May or October through November, as such, similar to trap and haul, poor water quality in reservoirs would have minor effects on the fitness of this species. Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch, resulting in mortality rates that would depend largely on their size (larger migrants would do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rogers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).

Lower Klamath River: Downstream of Iron Gate Dam Under the Fish Passage at Four Dams Alternative, suspended sediment would be the same as under existing conditions, thus having no suspended sediment effects relative to existing conditions for any aquatic species. Klamath Hydroelectric Project dams would continue to trap fine and coarse sediment and reduce the storage capacity of the reservoirs. Under the Fish Passage at Four Dams Alternative, the lower Klamath River downstream of Iron Gate Dam would continue to have poor water quality because of the continued presence of the reservoirs, with their increased hydraulic residence time and thermal mass (Bartholow et al. 2005). Current cooler temperatures in spring and early summer could benefit both adult and juvenile migrant spring-run Chinook salmon; however, juveniles migrating later in the year would experience warm temperatures in late summer and fall that could be deleterious to health and survival.

Many of the primary factors influencing salmon infection and disease rates from *C. shasta* and *P. minibicornis* would remain unchanged. The ongoing presence of the dams would continue to contribute to the stable, warm habitat conditions favorable for polychaetes and their parasites *C. shasta* and *P. minibicornis* downstream of Iron Gate Dam. The Iron Gate Hatchery would continue to operate and would discharge its nutrient-rich effluent to the river. Upstream fish passage would likely reduce salmon spawning density immediately downstream of Iron Gate Dam, which in turn is likely to reduce the transfer of myxospores from salmon to their polychaete hosts. Therefore, under this alternative, disease impacts would be reduced, but would continue to be detrimental to spring-run Chinook salmon.

Dissolved oxygen concentrations during July–October immediately downstream of Iron Gate Dam would continue to be low (less than 8 mg/L). In addition, the presence of microcystin, associated with the dense blooms of *M. aeruginosa* in Iron Gate and Copco Reservoirs, would continue to occur downstream of Iron Gate Dam.

Estuary The Fish Passage at Four Dams Alternative is not expected to substantially change or affect spring-run Chinook salmon estuarine habitat relative to existing conditions.

Under this alternative, fish ladders could result in alterations in habitat availability which could affect spring-run Chinook salmon in the long term. Under the Fish Passage at Four Dams Alternative, spring-run Chinook salmon would gain access to mainstem and tributary habitat in the upper Klamath River and Hydroelectric Reach and thermal refugia within the Hydroelectric Reach. Stress to migrating adults and juveniles associated with potential interim seasonal trap and haul operation and poor reservoir water quality would likely be minor. Predation could result in reduced survival of spring-run Chinook salmon juveniles passing through the reservoirs. Cooler water temperatures (similar to existing conditions) during the spring would continue to benefit upstream migrating adult and downstream migrant juvenile spring-run Chinook salmon. Warmer water temperatures in the fall would continue to be detrimental to juveniles migrating at that time. These effects would be most pronounced for fish migrating through areas upstream of the Scott River.

This alternative would result in continuation of many of the stresses that currently affect Chinook salmon populations. The presence of J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams under the Fish Passage at Four Dams Alternative would continue to cause poor water quality, and high late summer and early fall water temperatures, allowing conditions favorable for the transmission of disease for salmon to persist. These conditions would continue to have negative short- and long-term impacts on spring-run Chinook salmon populations. Further, under the Fish Passage at Four Dams Alternative, the KBRA would not be implemented, so any potential habitat improvements from KBRA restoration projects would not be realized. However, ongoing restoration activities will continue to occur. Climate change could also increase the frequency and duration of stressful water temperatures for salmonids under the Fish Passage at Four Dams Alternative. It is anticipated that as a result of the Fish Passage at Four Dams Alternative the spring-run Chinook salmon population within the Klamath River watershed would have an increase in abundance, population spatial structure, and genetic diversity. However, smolts produced from the Salmon River and tributaries downstream of Iron Gate Dam would experience a continuation of existing deleterious effects. **Based on increased habitat availability the effect of the Fish Passage at Four Dams Alternative would be beneficial for spring-run Chinook salmon in the short- and long term.**

Coho Salmon

<u>Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir</u> Hamilton et al. (2005) states that historically coho salmon occurred at least to Spencer Creek (J.C. Boyle Reservoir). The Fish Passage at Four Dams Alternative may not affect coho salmon in the Upper Klamath Basin upstream of J.C. Boyle Reservoir Reach.

<u>Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam</u>
Coho salmon below Iron Gate Dam belonging to the Upper Klamath River Population Unit would migrate above the dam if access was provided by fishways (Administrative Law Judge 2006). Over time, access to habitat above Iron Gate Dam would benefit the Upper Klamath River Population Unit by: a) extending the range and distribution of the species thereby increasing the coho salmon’s reproductive potential; b) increase genetic

diversity in the coho stocks; c) reduce the species vulnerability to the impacts of degradation; and d) increase the abundance of the coho salmon population (Administrative Law Judge 2006). Implementation of the Fish Passage at Four Dams Alternative would restore Upper Klamath River Population Unit access to the Hydroelectric Reach, thereby expanding their distribution to include historical habitat along the mainstem Klamath River not inundated by reservoirs (although these areas would continue to be affected by the reservoirs) and all tributaries upstream at least to Spencer Creek, including Jenny, Shovel, and Fall creeks (Hamilton et al. 2005). Passage through the reach would provide approximately 48 miles of additional habitat within the mainstem and accessible tributaries (DOI 2007). Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows. Furthermore, upstream passage would provide fish with some refuge from high temperatures because the cooler water from tributaries would flow directly into the mainstem Klamath River, in addition to the 200 to 250 cfs provided by coldwater springs in the J.C. Boyle Bypass Reach (DOI 2007; FERC 2007; Hamilton et al. 2011).

Under this alternative, suspended and bedload sediment, water quality, water temperature, and the occurrence of fish disease and algal toxins would be the same as under existing conditions.

This alternative would result in continuation of many of the stresses that currently affect coho salmon populations. The presence of J. C. Boyle, Copco 1, Copco 2, and Iron Gate Dams under the Fish Passage at Four Dams Alternative would continue to cause poor water quality, and high late summer and early fall water temperatures, allowing conditions favorable for the transmission of fish disease to persist. Although water temperature in the summer above Iron Gate Dam is an issue, the record evidence shows that water temperature would not preclude coho salmon from successfully utilizing the habitat within the Project area (Administrative Law Judge 2006). Adult coho salmon enter the Klamath River between late September and mid-December, with peak upstream migration occurring between late October and mid-November, and fry outmigrate to the ocean beginning in late February, with most outmigration occurring in April and May, as such, poor water quality in reservoirs would have minor affect on this species. Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rodgers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, coho salmon and other anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).

Lower Klamath River: Downstream of Iron Gate Dam Under the Fish Passage at Four Dams Alternative, suspended sediment would be the same as under existing conditions, thus having no suspended sediment effects relative to existing conditions for any aquatic species. Klamath Hydroelectric Project Dams would continue to trap fine and coarse sediment and reduce the storage capacity of the reservoirs. Most spawning and rearing takes place within tributaries. But for the few coho salmon from the Upper Klamath River Population Unit that spawn in the mainstem, coarsening of the bed could reduce spawning habitat for coho salmon between Iron Gate Dam and Cottonwood Creek over time. Rearing habitat would be expected to remain similar to existing conditions.

Under the Fish Passage at Four Dams Alternative, the lower Klamath River downstream of Iron Gate Dam would continue to have poor water quality because of the continued presence of the reservoirs, with their increased hydraulic residence time and thermal mass (Bartholow et al. 2005). The delay in thermal signature would continue to delay anadromous spawning downstream of Iron Gate Dam, and pre-spawn mortality would remain high (Hamilton et al. 2011).

Many of the primary factors influencing salmon infection and disease rates from *C. shasta* and *P. minibicornis* would remain unchanged. The ongoing presence of the dams would continue to contribute to the stable, warm habitat conditions favorable for polychaetes and their parasites *C. shasta* and *P. minibicornis* downstream of Iron Gate Dam. The Iron Gate Hatchery would continue to operate and would discharge its nutrient-rich effluent to the river. Upstream fish passage would likely reduce salmon spawning density immediately downstream of Iron Gate Dam, which in turn is likely to reduce the transfer of myxospores from salmon to their polychaete hosts. Therefore, under this alternative, disease impacts would be reduced, but continue to be detrimental to coho salmon.

Dissolved oxygen concentrations during July–October immediately downstream of Iron Gate Dam would continue to be low (less than 8 mg/L). In addition, the presence of microcystin, associated with the dense blooms of *M. aeruginosa* in Iron Gate and Copco Reservoirs, would continue to occur downstream of Iron Gate Dam.

Estuary The Fish Passage at Four Dams Alternative is not expected to substantially change or affect spring-run Chinook salmon estuarine habitat relative to existing conditions.

Under this alternative, fish ladders could result in alterations in habitat availability which could affect coho salmon in the long term. Under the Fish Passage at Four Dams Alternative, coho salmon would gain access to mainstem and tributary habitat in the Hydroelectric Reach, and thermal refugia within the Hydroelectric Reach. Stress to migrating adults and juveniles associated with poor reservoir water quality and predation would occur, but would likely be minor.

As the presence of dams under the Fish Passage at Four Dams Alternative would continue to cause poor water quality, and high late summer and early fall water temperatures, allowing conditions favorable for the transmission of fish disease to persist. These conditions would continue to have negative short- and long-term impacts on coho salmon populations. Further, under the Fish Passage at Four Dams Alternative, the KBRA would not be implemented, so any potential habitat improvements from KBRA restoration projects would not be realized. However, ongoing restoration activities will continue to occur. Climate change could also increase the frequency and duration of stressful water temperatures for salmonids under the Fish Passage at Four Dams Alternative. It is anticipated that as a result of the Fish Passage at Four Dams Alternative the Upper Klamath River Population Unit would have an increase in abundance, population spatial structure, and genetic diversity. It is anticipated that as a result of the Fish Passage at Four Dams Alternative the Mid-Klamath River, Shasta River, Scott River, Salmon River population units would experience a continuation of existing deleterious effects, and the three Trinity River population units, and the lower Klamath River population units would not be affected. **Based on increased habitat availability the effect of the Fish Passage at Four Dams Alternative would be beneficial for coho salmon from the Upper Klamath River population unit in the short- and long term. Based on the continuation of existing conditions for populations downstream of Iron Gate Dam, this alternative would be no change from existing conditions for the coho salmon from the Mid-Klamath River, Shasta River, Scott River, and Salmon River, three Trinity River population units, and the Lower Klamath River population units in the short- and long term.**

Steelhead

<u>Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir</u> Under the Fish Passage at Four Dams Alternative, steelhead would gain access to the Upper Klamath Basin upstream of J.C. Boyle Reservoir. This would expand the population's distribution to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005, Butler et al. 2010). Huntington (2006) estimated that the amount of potential new habitat for steelhead could be 500 miles; only perennial streams were counted in this estimate, but steelhead are also known to spawn in intermittent streams. Current redband trout distribution within areas that would become accessible to steelhead has been estimated at 496 miles by ODFW (W. Tinniswood, pers. comm., 2011). Because steelhead have habitat requirements similar to those of redband trout, this can be used as a rough estimate of habitat that may also be available to steelhead. Reservoirs would continue to inundate 22.4 miles of potential spawning and rearing habitat (Cunanan 2009). This alternative would not result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins and disease. Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006). Poor water quality (e.g., severe hypoxia, temperatures exceeding 25°C, high pH) in the reach from Keno Dam to Link Dam might prevent fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011).

Poor water quality conditions, particularly in Lake Ewauna during the late spring and early summer could be detrimental to fish in this area, particularly anadromous salmonids. Therefore, the Fish Passage at Four Dams Alternative includes interim seasonal trap and haul to capture and transport migrant fish around the Keno Impoundment/Lake Ewauna when water quality conditions would be prohibitively stressful. Long distance trap and haul could potentially increase stress on summer steelhead (entering the Klamath River from March to June) and winter steelhead (entering the river and migrating from August to March), potentially causing direct mortality as well as post-release pre-spawning mortality (Steward and Associates 2007; Buchanan et al. 2011b).

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
Fish Passage at Four Dams would provide steelhead with access to the Hydroelectric Reach, which would expand the population's distribution to include historical habitat in the mainstem Klamath River and its tributaries, including Jenny, Shovel, and Fall creeks (Hamilton et al. 2005). Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows. Overall, because of their greater capacity for ascending potential obstacles to migration that might exclude Chinook and coho salmon, the Fish Passage at Four Dams Alternative would provide steelhead with access to approximately 59 miles of additional habitat in the mainstem and accessible tributaries, comprising hundreds of miles of additional potentially productive anadromous fish habitat upstream of Iron Gate Dam (DOI 2007), including access to groundwater discharge areas more resistant to effects of climate change (Hamilton et al.2011). There would continue to be 22.4 miles of spawning and rearing habitat inundated by reservoirs (Cunanan 2009).

Poor water quality conditions in reservoirs, such as high temperatures with low dissolved oxygen, fluctuations in dissolved oxygen, pH, ammonia associated with algal blooms, and microcystin from *M. aeruginosa* blooms would continue to be severely stressful to fish from June through September (Dunsmoor and Huntington 2006; FERC 2007). Summer steelhead enter the Klamath River from March to June, while winter steelhead enter and migrate from August to March; thus, poor water quality could have an effect on these fish as they move through reservoirs. Steelhead spawn in tributaries, and juveniles typically outmigrate from April through November, but the peak occurs from April through June, so most individuals would be likely to avoid poor reservoir water quality. Juveniles would be subject to some predation by introduced resident species such as largemouth bass, catfish, and yellow perch, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rogers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids above Iron Gate Dam is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous salmonid juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).

Lower Klamath River: Downstream of Iron Gate Dam Under the Fish Passage at Four Dams Alternative, suspended sediment would be the same as under existing conditions, thus having no suspended sediment effects relative to existing conditions for any aquatic species. Klamath Hydroelectric Project Dams would continue to trap fine and coarse sediment and reduce the storage capacity of the reservoirs. Current summer steelhead distribution extends from the mouth of the Klamath River upstream to Empire Creek, while winter steelhead are distributed throughout the lower Klamath River up to Iron Gate Dam (Stillwater Sciences2010b). Summer and winter steelhead do not spawn in the mainstem Klamath River, nor are they expected to in the future, so spawning habitat would not be affected by alterations to bedload composition downstream of Iron Gate Dam under the Fish Passage at Four Dams Alternative. Changes to bedload sediment would not be expected to affect juvenile rearing and migration.

Under the Fish Passage at Four Dams Alternative, the lower Klamath River downstream of Iron Gate Dam Reach would continue to have poor water quality because of the continued presence of the reservoirs, with their increased hydraulic residence time and thermal mass (Bartholow et al. 2005). Current cooler temperatures in spring and early summer may benefit both adult and juvenile migrant steelhead; however, juveniles migrating later in the year would be deleteriously affected by warm temperatures in late summer and fall.

Dissolved oxygen concentrations during July–October immediately downstream of Iron Gate Dam would continue to be low (less than 8 mg/L). In addition, the presence of microcystin, associated with the dense blooms of *M. aeruginosa* in Iron Gate and Copco Reservoirs, would continue to occur downstream of Iron Gate Dam.

Estuary The Fish Passage at Four Dams Alternative is not expected to substantially change or affect steelhead estuarine habitat relative to existing conditions.

Under this alternative, fish ladders could result in alterations in habitat availability which could affect steelhead in the long term. Under the Fish Passage at Four Dams Alternative, steelhead would gain access to mainstem and tributary habitat in the Hydroelectric Reach, and thermal refugia within the Hydroelectric Reach. Stress to migrating adults and juveniles associated with poor reservoir water quality would likely be minor. Survival during migration through reservoirs could be negatively affected at some level by predation.

This alternative would result in continuation of many of the stresses that currently affect steelhead populations. The presence of dams under the Fish Passage at Four Dams Alternative would continue to cause poor water quality, and high late summer and early fall water temperatures, allowing conditions favorable for the transmission of fish disease to persist. These conditions would continue to have negative short- and long-term impacts on steelhead populations. Further, under the Fish Passage at Four Dams Alternative, the KBRA would not be implemented, so any potential habitat improvements from KBRA restoration projects would not be realized. However, ongoing restoration activities will continue to occur. Climate change could also increase the frequency and duration of stressful water temperatures for salmonids under the Fish Passage at Four Dams Alternative. It is anticipated that as a result of the Fish Passage at Four Dams Alternative the summer and winter steelhead within the Klamath River watershed would have an increase in abundance, population spatial structure, and genetic diversity. **Based on increased habitat availability, the Fish Passage at Four Dams Alternative would be beneficial for summer and winter steelhead in the short- and long term**.

Pacific Lamprey

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Pacific lamprey did not historically occur upstream of J.C. Boyle Reservoir (Hamilton et al. 2005) and are not anticipated to occupy this reach after implementation of this alternative.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam The Fish Passage at Four Dams Alternative would provide Pacific lamprey with access to the Hydroelectric Reach and to the mainstem Klamath River and all its tributaries upstream as far as Spencer Creek, including Jenny, Shovel, and Fall Creeks (Hamilton et al. 2005). Passage through the reach would provide additional habitat along the mainstem and within accessible tributaries (DOI 2007). Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows. In addition, passage would provide fish with some refuge from high temperatures by allowing cooler tributaries to flow directly into the mainstem Klamath River, adding to the 200 to 250 cfs provided by coldwater springs in the J.C. Boyle Bypass Reach (DOI 2007; FERC 2007; Hamilton et al. 2011). Under this alternative, suspended and bedload sediment, water quality, water temperature, and the occurrence of algal toxins would continue to be the same as under existing conditions.

Poor water quality conditions in reservoirs, such as high temperatures with low dissolved oxygen, changes in dissolved oxygen, pH, and ammonia associated with algal blooms, and microcystin from *M. aeruginosa* blooms would continue to be severely stressful from June to September (Dunsmoor and Huntington 2006; FERC 2007). Pacific lamprey adults migrate from winter through spring, while juveniles (age 2 to age 10) outmigrate year-round, with peaks during late spring and fall. Poor reservoir quality would likely not affect migrating adults, but could affect juveniles. Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch (FERC 2007). Volitional passage for Pacific lamprey has been designed and is in place in other river systems (Administrative Law Judge 2006).

Lower Klamath River: Downstream of Iron Gate Dam Under the Fish Passage at Four Dams Alternative, Klamath Hydroelectric Project Dams would continue to trap fine and coarse sediment and reduce the storage capacity of the reservoirs. Suspended sediment would be the same as under existing conditions, thus having no suspended sediment effects relative to existing conditions for any aquatic species. The channel directly downstream of Iron Gate Dam would continue to be starved of fine sediment. Coarsening of the bed could reduce spawning habitat for lamprey downstream of the dam over time, but this impact would be limited to the area upstream of Cottonwood Creek, as coarse sediment was resupplied by tributary inputs (Hetrick et al. 2009; Stillwater Sciences 2010a).

Under the Fish Passage at Four Dams Alternative, the lower Klamath River downstream of Iron Gate Dam reach would continue to have poor water quality. Water quality would continue to be influenced by reservoirs, with increased hydraulic residence time and thermal mass (Bartholow et al. 2005). Finally, the KBRA would not be implemented, so any potential habitat improvements from KBRA restoration projects would not be realized. However, ongoing restoration activities will continue to occur.

Estuary The Fish Passage at Four Dams Alternative is not expected to substantially change or affect Pacific Lamprey estuarine habitat relative to existing conditions.

Under this alternative, fish ladders could result in alterations in habitat availability which could affect Pacific lamprey in the long term. Under the Fish Passage at Four Dams Alternative, lamprey would gain access to mainstem and tributary habitat in the upper Klamath River and Hydroelectric Reach, and thermal refugia within the Hydroelectric Reach. Poor reservoir quality would likely not affect migrating adults, but could affect juveniles. Juveniles would also be exposed to predation from nonnative resident fish.

This alternative would result in continuation of many of the stresses that currently affect lamprey populations. The presence of dams under the Fish Passage at Four Dams Alternative would continue to cause poor water quality and high late summer and early fall water temperatures. Climate change could also increase the frequency and duration of stressful water temperatures for lamprey under the Fish Passage at Four Dams Alternative. It is anticipated that as a result of the Fish Passage at Four Dams Alternative the Pacific lamprey population within the Klamath River watershed would have an increase in abundance, population spatial structure, and genetic diversity (Administrative Law Judge 2006). However, lamprey downstream of Iron Gate Dam would experience a continuation of existing deleterious effects. **Based on increased habitat availability, the Fish Passage at Four Dams Alternative would be beneficial for Pacific lamprey in the short- and long term**.

Green Sturgeon *Under this alternative, fish ladders could result in alterations in habitat availability which could affect Pacific lamprey in the long term.* Under the Fish Passage at Four Dams Alternative, conditions in the area occupied by green sturgeon are unlikely to change relative to existing conditions as green sturgeon occur downstream of Ishi Pishi Falls, and the effects of this alternative are not anticipated to extend that far downstream.

It is anticipated that as a result of the Fish Passage at Four Dams Alternative the green sturgeon population within the Klamath River watershed would experience a continuation of deleterious effects. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for green sturgeon in the short- and long term.**

Shortnose and Lost River Sucker Upper Klamath River: The KBRA would not be implemented under this alternative. However, ongoing restoration activities will continue to occur.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
Construction of fishways could affect shortnose and Lost River Sucker populations by continuing poor water quality and high rates of predation. Shortnose and Lost River suckers would continue to be subject to poor water quality and high rates of predation within reservoirs. But with little or no successful reproduction (Buettner et al. 2006), populations downstream of Keno Dam contribute minimally to conservation goals and insignificantly to recovery (Hamilton et al. 2011). Fish passage was not prescribed for sucker species at Iron Gate, J.C. Boyle, Copco 1, or Copco 2 Dams.

Under the Fish Passage at Four Dams Alternative, existing efforts to restore habitat for shortnose and Lost River sucker and improve water quality conditions would continue. These actions would be expected to improve conditions for these species over time and their populations would be expected to increase. **The effect of the Fish Passage at Four Dams Alternative would be less-than-significant for Lost River and shortnose sucker populations in the short and long term.**

Redband Trout
Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at Four Dams Alternative, redband trout would be able to migrate more successfully from the Hydroelectric Reach to the Upper Klamath Basin (Hamilton et al. 2011) than under existing conditions. Fish passage facilities would improve connectivity to Spencer Creek, which provides important spawning habitat and temperature refugia for redband trout (DOI 2007; Buchanan et al. 2011b). Upstream fish passage would also restore connectivity of resident redband populations in the mainstem Klamath River to those in Lake Ewauna, the Link River, and Upper Klamath Lake (DOI 2007). The Fish Passage at Four Dams Alternative is not expected to result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins and disease.

Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to redband trout above Iron Gate Dam (Administrative Law Judge 2006). Redband could be affected by increased predation from reintroduced salmonids, but this loss might be offset by an increase in available food sources (e.g., eggs, fry, and juveniles of reintroduced salmonids) (Hamilton et al. 2011). Adult salmon moving into the upper basin would likely bring with them genotypes of *C. shasta* that had previously been restricted to the lower river. While the effects of these introductions are uncertain, at least some degree of host specificity appears to exist (Atkinson and Bartholomew 2010), indicating that newly exposed species, such as redband trout, might not be susceptible to the new genotypes. Additionally, the changes in habitat that could result from dam removal (fewer areas of slow-flowing, stable habitat) would likely reduce the density of polychaete populations, resulting in reduced disease exposure for fish. The close similarities between anadromous steelhead trout and resident rainbow/redband trout suggest these species historically co-existed. The distribution and resistance of rainbow/redband trout in Upper Klamath Lake to *C. Shasta* lends additional support that the two species co-existed and intermingled prior to the construction of Copco 1 Dam in 1917. There are many examples from nearby river systems in the Pacific Northwest that show wild anadromous salmon and resident rainbow/redband trout can co-exist and maintain abundant populations without deleterious consequences. The Deschutes River in Oregon, the Yakima River in Washington, and the river systems in Idaho are examples (Administrative Law Judge 2006).

<u>Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam</u> Fish passage resulting from the Fish Passage at Four Dams Alternative would allow redband trout to express the seasonal movements and migration patterns that were historically in place, restore population connectivity and genetic diversity, and allow greater utilization of existing habitat and refugia. Fish passage at Copco 1 and Copco 2 Dams would restore connectivity throughout the Hydroelectric Reach to Shovel Creek, which provides spawning habitat and temperature refugia (DOI 2007). Passage at Iron Gate Dam would restore connectivity between populations in the mainstem Klamath River and those in the Copco 2 bypass channel and in Slide, Scotch, Camp, Jenny, Salt, and Fall Creeks, which also provide spawning habitat and temperature refugia (DOI 2007). The current fish screen and ladder at the J.C. Boyle Dam do not meet current state and federal fish passage criteria and the ladder impairs upstream migration (Administrative law Judge 2006). Improvements in efficiency to the fishway at J.C. Boyle Dam would result in significant trout population migration above the dam over time (Administrative Law Judge 2006). Habitat in the J.C. Boyle bypass and peaking reaches and the Copco 2 Bypass Reach would be improved through reduced (but not eliminated) peaking operations and increasing base flows.

Populations of nonnative species within the reservoirs of the Hydroelectric Reach would continue to prey on smaller redband trout rearing in those reservoirs. Water quality would continue to be poor, although TMDL implementation would improve water quality conditions from existing conditions throughout the basin through time, benefiting this species. Climate change would result in warmer conditions, which would reduce the suitability of habitat.

Under this alternative, fish ladders and changes in operations could result in alterations in habitat availability and suitability which could affect redband trout in the long term. The Fish Passage at Four Dams Alternative would improve habitat connectivity throughout the Hydroelectric Reach and to the upper Klamath River in the long term, increasing access to spawning habitat and temperature refugia. Redband trout would still be subject to poor water quality, and predation within the reservoirs, but increases in connectivity and reduced effects of hydropower operations would likely provide a benefit to redband trout populations. **Based on increased habitat connectivity, the effect of the Fish Passage at Four Dams Alternative would be beneficial for redband trout in the short- and long term.**

Bull Trout
Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Bull trout upstream of J.C. Boyle Reservoir could be affected by increased predation from reintroduced salmonids, but this loss could be offset by an increase in available food sources (e.g., eggs, fry, and juveniles of reintroduced salmonids) (Buchanan et al. 1997**.**

Fish ladders could alter habitat access for anadromous fish, which could affect bull trout. **Based on the restricted distribution of bull trout, the Fish Passage at Four Dams Alternative would have a less-than-significant impact on bull trout in the short- and long term.**

Eulachon Under the Fish Passage at Four Dams Alternative, the extent and quality of eulachon habitat would be expected to remain similar to that under existing conditions. Because eulachon occur far downstream in the river, mixing and inflows from intervening tributaries would reduce poor water quality conditions originating in the dams. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for eulachon in the short and long term.**

Longfin Smelt Under the Fish Passage at Four Dams Alternative, the extent and quality of longfin smelt habitat would be expected to remain similar to that under existing conditions. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for longfin smelt in the short and long term.**

Introduced Resident Species *The Fish Passage at Four Dams Alternative would not affect introduced resident species upstream of J.C. Boyle Reservoir.* Under the Fish Passage at Four Dams Alternative, dams in the Hydroelectric Reach would not be removed, allowing reservoir habitat to remain similar to existing conditions. Connectivity between the reservoirs could increase available habitat area for these species if they are able to migrate through passage facilities. Over time the total volume of habitat would diminish, as sediment accumulates in the reservoirs. TMDL implementation would be expected to improve water quality conditions over time, but climate change would cause temperatures to increase. These species are adapted to warm-water conditions, and are not expected to be affected by these changes. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for introduced resident species population.**

Freshwater Mussels *Under the Fish Passage at Four Dams Alternative, suspended sediment would be the same as under existing conditions*, thus having no suspended sediment effects relative to existing conditions for any aquatic species. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for mussels in the short and long term.**

Benthic Macroinvertebrates *Under the Fish Passage at Four Dams Alternative, suspended sediment would be the same as under existing conditions*, thus having no suspended sediment effects relative to existing conditions for any aquatic species. **The effect of the Fish Passage at Four Dams Alternative would be no change from existing conditions for macroinvertebrates in the short and long term.**

Trap and Haul – Programmatic Measure

Implementation of trap and haul measures could affect aquatic species. Trap and haul measures would pass upstream and downstream migrating fish around Keno Impoundment and Link River during periods of poor water quality. The measures would provide effective migration for fall-run Chinook salmon when water quality is poor during the period from June 15 to November 15. During the limited period of use, fish collection and release facilities would be operated to minimize any delay and stress and provide for adequate acclimation. For adult fall-run Chinook salmon, fish transport would be an effective fish passage method because transport would be for a short distance on a seasonal, interim basis[5]. For adult fall-run Chinook salmon, seasonal collection and transport mortality when water quality is poor is likely to be minor compared to mortality associated with unaided passage through areas of poor water quality at this time of year.

In some instances, the collection and transport of fall-run Chinook salmon around areas of poor water quality could result in limited, seasonal mortality as follows:

1. Some juvenile federally listed suckers would likely be collected incidentally and may suffer related stress and mortality. However, regardless of any remediation at an upstream collection facility, nearly all these downstream migrant suckers would eventually die in the absence of lacustrine habitat below Keno Impoundment. There is little to no evidence of recruitment of suckers in downstream reservoirs currently and this habitat does not contribute significantly to the recovery of the species. Suckers may be collected and returned to habitat above Keno Impoundment.
2. Some redband trout may be collected incidentally resulting in displacement and incidental collection-related stress and mortality. Redband trout may be collected and returned to habitat above Keno Impoundment.
3. For fall-run Chinook salmon emigrants, the seasonal poor quality conditions are not expected to overlap with the peak migration period, thus the majority of juvenile Chinook salmon would not be affected. For those fall-run Chinook salmon emigrants collected and transported when water quality is poor, transport related mortality would be minor compared to the mortality

[5] This seasonal, transport on an interim basis is not to be confused with permanent, year round trap and haul which does not provide equal benefits for the Klamath River when compared with the Services' fishway prescriptions (U.S. Department of the Interior (2007) The Department of the Interior's Filing of Modified Terms, Conditions, and Prescriptions (Klamath Hydroelectric Project, No. 2082). Sacramento, California: 650 p.; NOAA Fisheries Service (2007). NOAA Fisheries Service Modified Prescriptions for Fishways and Alternatives Analysis for the Klamath Hydroelectric Project (FERC Project No. 2082): 151 p.).

associated with unaided passage through areas of poor water quality at this time of year.

4. For steelhead trout and spring-run Chinook salmon, migration would primarily be expected to occur when water quality was adequate, thus, collection and transport of these fish would not be necessary or minimal. However, all anadromous salmonids would be collected and transported when water quality is poor during the period from June 15 through November 15. Transport related mortality would be minor compared to the mortality associated with unaided passage through areas of poor water quality at this time of year.

Limited, seasonal transport of fall-run Chinook salmon would provide a net benefit by allowing them migration to and from additional (historical) spawning habitat, by providing more effective migration, and by reducing the density of spawners below Keno Dam in certain poor water quality situations.

In the short-term, constructing fish handling facilities could have localized construction-related impacts; however, they could be avoided or minimized through implementation of best management practices, such as control and containment of sediment and toxic discharge, isolation of work areas from the active channel of streams or rivers where possible, and rescuing fish where mortality may result from an action. In the long term, trap and haul would benefit fish because of the access to additional habitat and avoidance of areas with poor water quality. **Based on access to additional, historical habitat and the anticipated improvements in fish health, implementation of trap and haul measures in the Fish Passage at Four Dams Alternative would be beneficial for fall-run Chinook salmon.**

Alternative 5: Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative proposes to remove the two largest dams in the Hydroelectric Reach (Copco 1 and Iron Gate Dams) and install fishways for volitional fish passage on the remaining installations (J.C. Boyle and Copco 2). The prescriptions and conditions would still apply to the remaining dams, including flow requirements, the specific provisions and performance standards for both upstream and downstream fish passage facilities at the remaining dams, and the interim seasonal trap and haul trap actions at Keno Dam as described above under the Fish Passage at Four Dams Alternative.

Because the four dams would not be removed as required under the KHSA, the KBRA would not be implemented. The ongoing restoration actions described in the No Action/No Project Alternative would continue. Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, peaking power would not be generated due to limits on flow regulation at J.C. Boyle and Copco 2 Reservoirs. Similar to the Fish Passage at Four Dams Alternative, 40 percent of the inflow to J.C. Boyle Reservoir would be passed through to the Bypass Reach, except in periods when inflow to J.C. Boyle Reservoir falls below 470 cfs, at which point outflow to the Bypass Reach is required to equal reservoir inflow.

Key Ecological Attributes

Suspended Sediment

Under this alternative, SSCs have not been modeled, but would be very similar to those under the Full Facilities Removal of Four Dams Alternative described in Section 3.3.4.3, because most stored sediment affecting downstream resources is stored in Copco 1 and Iron Gate Reservoirs. Therefore, this alternative would have very similar effects on aquatic species associated with suspended sediment transport as the Proposed Action.

Bedload Sediment

Under this alternative, J.C. Boyle Dam would continue to store sediment, but the storage capacity of Copco 2 Dam would likely be filled by the release of sediments during the Copco 1 Dam removal, and then bedload would likely pass through Copco 2. This scenario has not been modeled, but the effects of bedload sediment movement under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to, but of slightly lesser magnitude, than under the Proposed Action.

Water Quality

Under this alternative, the effects on water quality would have results intermediate between the Proposed Action and Fish Passage at Four Dams Alternatives. As Copco 1 and Iron Gate Reservoirs are the largest of the four reservoirs, they have the greatest impact on water quality (FERC 2007), and their removal would result in water quality conditions similar to those of the Proposed Action. Because of their small size and short residence times, the retention of J.C. Boyle and Copco 2 Dams would not result in the same poor water quality conditions as occur under current conditions.

Since Alternative 5 would include no peaking power generation or release of flow for recreation at J.C. Boyle, water temperature effects in the J.C. Boyle Bypass and Peaking Reaches would be the same as under the Proposed Action, i.e., warmer and more variable water temperatures in the bypass reach during summer and early fall, and cooler temperatures in late fall and winter; and, slightly cooler and less variable water temperatures in the peaking reach during summer and early fall. Further downstream, at the Oregon-California state line, water temperatures would be similar to those under the No Action/No Project Alternative since large temperature effects of the peaking operations do not extend this far downstream. Within the remainder of the Hydroelectric Reach, effects on water temperature under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be the same as effects for the Hydroelectric Reach under the Proposed Action, i.e., long-term increases in spring water temperatures and decreases in late summer/fall water temperatures (see Section 3.2.4.3.5.1).

Fish Disease and Parasites

Under this alternative, there would be fewer deleterious effects in terms of fish disease as compared to the No Action/No Project Alternative. Although it would not result in the same level of reduction in fish disease as the Proposed Action, removal of Iron Gate and Copco 1 Dams would result in water quality improvements and would reduce favorable habitat for polychaete worms below Iron Gate Dam. The removal of the two dams would likely increase the availability of nutrients and physical habitat (i.e., periphyton mats) favorable to the polychaete host for *C. shasta* and *P. minibicornis* in the Hydroelectric Reach and downstream of Iron Gate Dam, although to a slightly lesser extent than under the Proposed Action because J.C. Boyle Dam would not be removed. Flow variability and scouring in the Hydroelectric Reach and downstream of Iron Gate Dam will be increased similar to the Proposed Action, with the exception of downstream of J.C. Boyle Dam where peaking flows will be eliminated. Removal of the two dams would likely result in more favorable water temperature for salmonids than under existing conditions as well as improve water quality and reduce instances of algal toxins (see Section 3.2.4.3.5).

Under this alternative, spawning fish would be expected to disperse more fully throughout the watershed than under the Fish Passage at Four Dams Alternative, as the remaining dams would be relatively small, and the ladders would, therefore, be easier to ascend. Fish passage conditions would not be as good as those under the Proposed Action.

As described for the Proposed Action, fish passage upstream by anadromous salmonids could be increased under this alternative, but would not be expected to be deleterious to aquatic resources in the Upper Basin through spread of the disease (Administrative Law Judge 2006).

Algal Toxins

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir This region is upstream of any proposed dam removal; therefore, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would not affect fish health as related to algal toxins. Any changes in algal toxin production in this region would be a result of other factors, including TMDL implementation. The effects in this area would be similar to those described for the No Action/No Project Alternative.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would eliminate growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa* in the Hydroelectric Reach, alleviating high seasonal concentrations of algal toxins and associated bioaccumulation of microcystin in fish tissue for species in this reach. While some microcystin may be transported downstream from large blooms occurring in Upper Klamath Lake, the levels would not be as high as those currently experienced due to the prevalence of seasonal in-reservoir blooms. Overall, bioaccumulation of algal toxins in fish tissue would be expected to decrease in the Hydroelectric Reach and would be beneficial.

Lower Klamath River: Downstream of Iron Gate Dam The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would eliminate growth conditions for toxin-producing nuisance algal species such as *M. aeruginosa*, alleviating the transport of high seasonal concentrations of algal toxins to the Klamath River downstream of Iron Gate Dam. This would also decrease the associated bioaccumulation of microcystin in fish tissue for species downstream of the dam. While some microcystin may be transported downstream from large blooms occurring in Upper Klamath Lake, the levels would not be as high as those currently experienced due to the prevalence of seasonal in-reservoir blooms. Overall, bioaccumulation of algal toxins in fish tissue would be expected to decrease in the Klamath River downstream of Iron Gate Dam and would be beneficial.

Aquatic Habitat

Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, flow increases would provide more habitat than under existing conditions for redband/rainbow trout and other resident riverine species, as well as any anadromous fish or lamprey that reestablish in the Hydroelectric Reach, but habitat gains would be less than under the Proposed Action. The removal of the two dams would eliminate existing habitat in Copco 1 and Iron Gate Reservoirs for adult shortnose and Lost River suckers, as well as nonnative species, while habitat within J.C. Boyle Reservoir would remain. This Alternative would restore 22.4 miles of riverine habitat (Cunanan 2009) for resident and anadromous fish through removal of reservoirs.

The alternative would incorporate barriers to prevent juvenile salmonid entrainment into turbines. There would also be substantial changes to hydroelectric operations. J.C. Boyle would no longer generate in peaking mode, and higher flow releases would be made through the J.C. Boyle Bypass Reach than under existing conditions. Higher base flows would also be provided in the Copco 2 Bypass Reach, and ramping rates would be slower than they are currently. These modifications would benefit fish in this reach, including redband trout and anadromous fish. Seasonal high flows will contribute to improving the quality of riparian habitat in the J.C. Boyle bypass reach by increasing the sediment deposit within the channel and decreasing reed canary grass (Administrative Law Judge 2006). The more normative flow regime associated with this alternative would provide these seasonal high flows. Similar to the Proposed Action, under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, flow-related habitat changes for species downstream of Iron Gate Dam would increase over the No Action/No Project Alternative and historical conditions (Hetrick et al. 2009).

Following drawdown of the reservoirs, revegetation efforts would be initiated to support establishment of native wetland and riparian species on newly exposed reservoir sediment. No short-term effects are anticipated from these reservoir restoration efforts; however, aquatic habitat may be improved from restored riparian vegetation in the long term.

Aquatic Resources Effects

<u>Critical Habitat</u>

As described below, lowering the water surface elevation of the reservoirs associated with dam removal under this alternative could alter the quality of critical habitat. In addition, the removal of two dams and two reservoirs could alter the availability and quality of critical habitat.

Coho Salmon The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would increase the amount of habitat available to coho salmon (currently upstream of designated critical habitat) and the quality of the existing critical habitat by improving water quality in the mainstem Klamath River. NOAA Fisheries Service may consider whether to designate the newly available habitat as critical habitat as part of its 5 year status review or as a separate reconsideration of the critical habitat designation for the species (J. Simondet, NOAA Fisheries Service, pers. comm., 2011). The effects of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative on critical habitat for coho salmon would be similar to those for the Proposed Action, but somewhat reduced by the ongoing presence of Copco 2 and J.C. Boyle Reservoirs. The same habitat expansion expected under the Proposed Action would occur, with the exception of habitat under Copco 2 and J.C. Boyle Reservoirs and the downstream portion of Spencer Creek, which would continue to be inundated by J.C. Boyle Reservoir and may be designated as critical habitat in the future. Fish passage would be provided past the remaining dams, and because only two fishways would need to be negotiated instead of four and are considerably smaller than Iron Gate or Copco 1, passage through the ladders would be improved. Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through elimination of peaking operations and higher baseflows.

The NOAA Fisheries Service (2010a) current biological opinion for Reclamation's Klamath Project, specifies flows downstream of Iron Gate Dam, and this biological opinion would likely need to be revised to reflect flows that would need to be provided below Copco 2 Dam if this alternative were adopted. Copco 1 and Iron Gate Reservoirs also cause the majority of the water temperature and water quality issues in the Hydroelectric Reach, so these conditions would be more similar to the Proposed Action than to the Fish Passage at Four Dams Alternative. These water quality improvements would accrue to areas downstream of Iron Gate Dam as well. Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle and Copco 2 Reservoirs, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rogers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).

Although upstream of current designated critical habitat, implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would expand the geographic extent of habitat available to coho salmon. Water quality within currently designated critical habitat is anticipated to improve relative to existing conditions. **Based on reduced habitat quality during reservoir drawdown affecting PCEs, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a significant effect on coho salmon critical habitat in the short term. Based on benefits to the PCEs downstream of Iron Gate Dam, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a beneficial effect on critical habitat for coho salmon in the long term.**

Bull Trout The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be expected to have a similar effect on critical habitat for bull trout as the Fish Passage at Four Dams Alternative. **Based on the restricted distribution of bull trout, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less-than-significant impact on critical habitat for bull trout in the short- and long term.**

Southern Resident Killer Whales The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be expected to have a similar impact on critical habitat for Southern Resident Killer Whales as the Proposed Action. Chinook salmon would be provided access to areas upstream of Iron Gate Dam and into the upper watershed, boosting natural production. Water quality issues would be improved both in the Hydroelectric Reach and in the lower Klamath River. Fish parasitism would decrease as conditions became less favorable for the polychaetes host of *C. shasta* and *P. minibicornis*. However, because Chinook salmon from the Klamath River make up a very small proportion of the Southern Resident Killer Whale diet, this benefit to Southern Resident Killer Whales is expected to be small. **Based on small influence of the Klamath River on PCEs of Southern Resident Killer Whales, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less-than-significant impact on critical habitat for Southern Resident Killer Whales in the short- and long term.**

Essential Fish Habitat *As described below, lowering the water surface elevation of the reservoirs associated with dam removal under this alternative could alter the quality of Essential Fish Habitat (EFH). In addition, the removal of two dams and two reservoirs could alter the availability and quality of EFH.*

Chinook and Coho Salmon EFH The effects of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative on EFH for Chinook and coho salmon would be similar to those for the Proposed Action, but would be somewhat reduced by the ongoing presence of Copco 2 and J.C. Boyle Reservoirs. Water quality in the mainstem Klamath River is expected to be improved. Most of the habitat expansion expected (upstream of currently designated EFH) under the Proposed Action would occur, with the exception of habitat under Copco 2 and J.C. Boyle Reservoirs and the downstream portion of Spencer Creek, which would continue to be inundated by J.C. Boyle Reservoir. Fish passage would be provided past the remaining dams, and because only two fishways would need to be negotiated instead of four and these remaining dams are considerably smaller than Iron Gate or Copco 1 dams, passage through the ladders would be improved over existing conditions.

The NOAA Fisheries Service (2010a) current biological opinion for Reclamation's Klamath Project, specifies flows downstream of Iron Gate Dam, and this biological opinion would likely need to be revised to reflect flows that would need to be provided below Copco 2 Dam if this alternative were adopted. Copco 1 and Iron Gate reservoirs also cause the majority of the water temperature and water quality issues in the Hydroelectric Reach, so these conditions would be more similar to the Proposed Action than to the Fish Passage at Four Dams Alternative. These water quality improvements would accrue to areas downstream of Iron Gate Dam as well.

Based on a substantial reduction in EFH quality during reservoir drawdown, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a significant effect on EFH for Chinook and coho salmon in the short term. Based on benefits to the habitat quality, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a beneficial effect on EFH for Chinook and coho salmon in the long term.

Groundfish EFH The effects of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be similar to those of the Proposed Action Alternative, with similar effects on SSCs, bedload and water quality.

Based on short duration of poor water quality during reservoir drawdown in the estuary, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less-than-significant effect on EFH for groundfish in the short- and long term.

Pelagic Fish EFH The effects of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative on pelagic fish EFH would be similar to those described for the Proposed Action.

Based on short duration of poor water quality during reservoir drawdown in the estuary, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less-than-significant effect on EFH for pelagic fish in the short- and long term.

<u>Species-Specific Impacts</u>

As described below, lowering the water surface elevation of the reservoirs associated with dam removal under this alternative could affect aquatic species. In addition, the *removal of two dams and two reservoirs could alter the availability and quality of habitat, resulting in effects on aquatic species.*

Fall-Run Chinook Salmon

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, dam removal and the addition of fish passage facilities at J.C. Boyle and Copco 1 Dams would allow fall-run Chinook salmon to gain access to the upper Klamath River upstream of J.C. Boyle Reservoir. The access would expand the Chinook salmon's current habitat to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). This would be a potential increase in access to 49 significant tributaries in the Upper Klamath Basin, comprising 420 miles of additional potentially productive habitat (DOI 2007), including access to groundwater discharge areas resistant to effects of climate change (Hamilton et al. 2011).

The removal of the two dams would likely reduce the availability of physical habitat favorable to the polychaete host for *C. shasta* and *P. minibicornis*. Flow variability would not be as great as under the Proposed Action; therefore, although removal of the two reservoirs would reduce the amount of lentic habitat available, some low-velocity habitats favorable to polychaetes might persist. Removal of the two dams would likely result in more favorable water temperature for salmonids than under existing conditions as well as improve water quality and reduce instances of algal toxins.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would restore fall-run Chinook salmon access to the Hydroelectric Reach. Suspended and bedload sediment effects would be similar to those described for the Proposed Action.

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would include removal of Copco 1 and Iron Gate Reservoirs, with continued power generation at J.C. Boyle and Copco 2 hydroelectric plants. Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through elimination of peaking operations and higher baseflows. The reservoir drawdowns would allow tributaries and springs such as Fall and Shovel creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish (Hamilton et al. 2011). Spencer Creek would continue to flow into J.C. Boyle Reservoir at its upstream end. Anadromous fish provided access to these reaches would have access to the tributaries as well.

Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle and Copco 2 Reservoirs, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rodgers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).

<u>Lower Klamath River: Downstream of Iron Gate Dam</u> The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would result in the release of sediment stored within Copco 1 and Iron Gate Reservoirs downstream to the lower Klamath River. Of the reservoirs in the Hydroelectric Reach, J.C. Boyle Reservoir stores the least amount of sediment, less than 10 percent of the total amount. As such, suspended and bedload sediment conditions and effects on fall-run Chinook salmon in the lower Klamath River reach would be similar to those described for the Proposed Action, but would be of slightly lesser magnitude.

The removal of two dams and restoration of free flowing sections of river would likely result in more favorable water temperatures for salmonids than under existing conditions. As it would be under the Proposed Action, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to reduced water quality from increased suspended sediment concentrations, but these effects would be short term. Flow variability likely would not be as great as under the Proposed Action, but would still likely reduce habitat conditions favorable for polychaetes and algal toxins.

<u>Estuary</u> The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect fall-run Chinook salmon estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and bedload sediment transport and deposition and affect fall-run Chinook salmon. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for fall-run Chinook salmon in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability, flow regime, water quality, temperature variation, fish disease incidence, and algal toxins which could affect fall-run Chinook salmon. As stated above, dam removal would also restore connectivity to 420 miles of potentially usable habitat in the Upper Klamath Basin and would create additional spawning and rearing habitat within the Hydroelectric Reach. **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at**

J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for fall-run Chinook salmon in the long term.

Spring-Run Chinook Salmon

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, dam removal and the addition of fish passage facilities at J.C. Boyle and Copco 1 Dams would allow spring-run Chinook salmon to gain access to the upper Klamath River upstream of J.C. Boyle Reservoir. The access would expand the spring-run Chinook salmon's current habitat to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood Rivers (Hamilton et al. 2005). This would be a potential increase in access to 49 significant tributaries in the Upper Klamath Basin, comprising 420 miles of additional potentially productive habitat (DOI 2007), including access to groundwater discharge areas resistant to effects of climate change (Hamilton et al. 2011). Similar to the Proposed Action, this alternative is not expected to result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins and disease. Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006). Poor water quality (e.g., severe hypoxia, temperatures exceeding 25°C, high pH) in the reach from Keno Dam to Link Dam might prevent fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011). However, evidence indicates that UKL habitat is presently suitable to support Chinook salmon for at least the October through May period (Maule et al. 2009).

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
Implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would restore spring-run Chinook salmon access to the Hydroelectric Reach. Suspended and bedload sediment effects would be similar to those described for the Proposed Action.

Habitat in the J.C. Boyle bypass and peaking reaches and the Copco 2 Bypass Reach would be improved through eliminating peaking operations and increasing base flows. The reservoir drawdowns would allow tributaries and springs such as Fall and Shovel creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish (Hamilton et al. 2011). Spencer Creek would continue to flow into J.C. Boyle Reservoir at its upstream end. Anadromous fish provided access to these reaches would have access to the tributaries as well.

The removal of the two dams would likely reduce the availability of physical habitat favorable to the polychaete host for *C. shasta* and *P. minibicornis*, although to a lesser extent than under the Proposed Action. Flow variability would not be as great as under the Proposed Action; therefore, although removal of the two reservoirs would reduce the amount of lentic habitat available, some low-velocity habitats favorable to polychaetes might persist. Removal of the two dams would likely result in more favorable water temperature for salmonids than under existing conditions as well as improve water quality and reduce instances of algal toxins.

Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle Reservoir, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rodgers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).

<u>Lower Klamath River: Downstream of Iron Gate Dam</u> The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would result in the release of sediment stored within Copco 1 and Iron Gate reservoirs downstream to the lower Klamath River. Of the reservoirs in the Hydroelectric Reach, J.C. Boyle stores the least amount of sediment, less than 10 percent of the total amount. As such, suspended and bedload sediment conditions and effects on spring-run Chinook salmon in the lower Klamath River reach would be similar to those described for the Proposed Action, but of slightly lesser magnitude.

The removal of two dams and restoration of free flowing sections of river would likely result in more favorable water temperatures for salmonids than under existing conditions. As it would be under the Proposed Action, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to reduced water quality, but these effects would be short term. Flow variability likely would not be as great as under the Proposed Action, but would still likely reduce habitat conditions favorable for polychaetes and algal toxins.

<u>Estuary</u> The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect spring-run Chinook salmon estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and bedload sediment transport and deposition and affect spring-run Chinook salmon. **Based on minimal reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2,**

Remove Copco 1 and Iron Gate Alternative would be less-than-significant for spring-run Chinook salmon in the short term.

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability, flow regime, water quality, temperature variation, fish disease incidence, and algal toxins which could affect spring-run Chinook salmon. **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for spring-run Chinook salmon in the long term.**

Coho Salmon

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Coho salmon did not historically occur upstream of J.C. Boyle Reservoir, and are not anticipated to occupy this reach after implementation of this alternative. Implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative may not affect coho salmon in the Upper Klamath Basin upstream of J.C. Boyle Reservoir Reach.

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, coho salmon access to the Hydroelectric Reach would be restored, which would expand the population's current range to include historical habitat within the mainstem Klamath River and all tributaries upstream as far as Spencer Creek, including Jenny, Shovel, and Fall Creeks (Hamilton et al. 2005). Spencer Creek flows into the upstream end of J.C. Boyle Reservoir and would still be partially inundated under this alternative, but suitable habitat in the Spencer Creek would be accessible to coho salmon. Suspended and bedload sediment effects would be similar to those described for the Proposed Action. Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through eliminating peaking operations and increasing base flows.

The removal of the two dams would likely reduce the availability of physical habitat favorable to the polychaete host for *C. shasta* and *P. minibicornis*, although to a lesser extent than under the Proposed Action. Flow variability would not be as great as under the Proposed Action; therefore, although removal of the two reservoirs would reduce the amount of lentic habitat available, some low-velocity habitats favorable to polychaetes might persist. Removal of the two dams would likely result in more favorable water temperature for salmonids than under existing conditions as well as improve water quality and reduce instances of algal toxins.

Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle Reservoir, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rodgers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).

Lower Klamath River: Downstream of Iron Gate Dam The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would result in the release of sediment stored within Copco 1 and Iron Gate Reservoirs downstream to the lower Klamath River. Suspended and bedload sediment conditions and effects on coho salmon in the lower Klamath River reach would be similar to those described for the Proposed Action, but of slightly lesser magnitude.

The removal of two Dams and restoration of free flowing sections of river would likely result in more favorable water temperatures for salmonids than under current conditions. As it would be under the Proposed Action, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to reduced water quality, from increased suspended sediment concentrations, but these effects would be short term. Flow variability likely would not be as great as under the Proposed Action, but would still likely reduce habitat conditions favorable for polychaetes and algal toxins.

Estuary The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect coho salmon estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and bedload sediment transport and deposition and affect coho salmon. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for the coho salmon from the Upper Klamath River, Mid-Klamath River, Shasta River, Scott River, and Salmon River population units in the short term. Based on indistinguishable effects predicted to occur during reservoir drawdown, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less-than-significant for the coho salmon from the three Trinity River population units, and the Lower Klamath River Population Unit in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability, flow regime, water quality, temperature variation, fish disease incidence, and algal toxins which could affect coho salmon. Dam removal would restore connectivity to habitat on the mainstem Klamath River up to and including Spencer Creek and would create additional habitat within the Hydroelectric Reach. It is anticipated that as a result of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative the upper Klamath River, mid-Klamath River, lower Klamath River, Shasta River, Scott River, and Salmon River coho salmon population units would have an increase in abundance, productivity, population spatial structure, and genetic diversity. It is anticipated that as a result of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative the three Trinity River population units would have increased productivity. **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for the coho salmon from the Upper Klamath River, Mid-Klamath River, Lower Klamath River, Shasta River, Scott River, and Salmon River population units in the long term**. **Based on improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less-than-significant for the coho salmon from the three Trinity River population units in the long term.**

Steelhead

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at Two Dams Alternative, dam removal and the addition of fish passage facilities at J.C. Boyle and Copco 1 would allow steelhead to gain access to the upper Klamath River upstream of J.C. Boyle Reservoir. This would expand the population's distribution to include historical habitat along the mainstem Klamath River upstream to the Sprague, Williamson, and Wood rivers (Hamilton et al. 2005). Steelhead are known to use intermittent tributaries for spawning, and because redband trout have habitat requirements similar to those of steelhead, this can be used as a rough estimate of habitat that may also be available to steelhead. Current distribution of redband trout within areas that would be accessible to steelhead has been estimated at 496 miles by ODFW (W. Tinniswood, pers. comm., 2011). Similar to the Proposed Action, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to result in changes to suspended or bedload sediment, flow-related habitat, or algal toxins and disease. Facilitating the movement of anadromous fish presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006). Poor water quality (e.g., severe hypoxia, temperatures exceeding 25°C, high pH) in the reach from Keno Dam to Link Dam might prevent fish passage at any time from late June through mid-November (Sullivan et al. 2009; USGS 2010; both as cited in Hamilton et al. 2011). However, evidence indicates that UKL habitat is presently suitable to support salmonids for at least the October through May period (Maule et al. 2009).

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would restore steelhead access to the Hydroelectric Reach. Suspended and bedload sediment effects would be similar to those described for the Proposed Action.

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would include removal of Copco 1 and Iron Gate reservoirs, with continued power generation at J.C. Boyle and Copco 2 hydroelectric plants. Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through eliminating peaking operations and increasing base flows. The reservoir drawdowns would allow tributaries and springs such as Fall and Shovel creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish (Hamilton et al. 2011). Spencer Creek would continue to flow into J.C. Boyle Reservoir at its upstream end. Anadromous fish provided access to these reaches would have access to the tributaries as well.

The removal of the two dams would be likely to reduce the availability of physical habitat favorable to the polychaete host for *C. shasta* and *P. minibicornis*, although to a lesser extent than the Proposed Action. Flow variability would not be as great; therefore, although removal of the two reservoirs would reduce the amount of lentic habitat available, some low-velocity habitats favorable to polychaetes might persist. Steelhead are not as susceptible to these parasites, as Chinook salmon or coho salmon, but may still receive some benefit. Removal of the two dams would likely result in more favorable water temperature for salmonids, as well as improved water quality and reduced instances of algal toxins.

Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle Reservoir, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rodgers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Based on the reservoir dynamics and the predator population that currently occurs, predation of outmigrating salmonids is anticipated to be low (Administrative Law Judge 2006). In restoration efforts elsewhere in the Pacific Northwest, anadromous juveniles successfully pass through reservoirs under similarly difficult circumstances (Administrative Law Judge 2006).

<u>Lower Klamath River: Downstream of Iron Gate Dam</u> The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would result in the release of sediment stored within Copco 1 and Iron Gate reservoirs downstream to the lower Klamath River. Of the reservoirs in the Hydroelectric Reach, J.C. Boyle Reservoir stores the least amount of sediment, less than 10 percent of the total amount. As such, suspended and bedload sediment conditions and effects on steelhead in the lower Klamath River reach would be similar to those described for the Proposed Action, but of slightly lesser magnitude.

The removal of two dams and restoration of free flowing sections of river would likely result in more favorable water temperatures for salmonids than under current condition. As it would be under the Proposed Action, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to reduced water quality from increased suspended sediment concentrations, but these effects would be short term. Flow variability likely would not be as great as under the Proposed Action, but would still likely reduce habitat conditions favorable for polychaetes and algal toxins.

Estuary The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect steelhead estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and bedload sediment transport and deposition and affect steelhead. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for summer and winter steelhead in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability, flow regime, water quality, and temperature variation, which could affect steelhead. Implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would restore connectivity to 496 miles of potentially usable habitat in the Upper Klamath Basin and would create additional spawning and rearing habitat within the Hydroelectric Reach (W. Tinniswood, pers. comm., 2011). **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for summer and winter steelhead in the long term**.

Pacific Lamprey

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Pacific lamprey did not historically occur upstream of J.C. Boyle Reservoir (Hamilton et al. 2005) and are not anticipated to occupy this reach after implementation of this alternative.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, dam removal and the addition of fish passage facilities at J.C. Boyle and Copco 1 Dams would provide Pacific lamprey access to the Hydroelectric Reach, which would expand the population's current range to include habitat within the mainstem Klamath River and its tributaries upstream at least as far as Spencer Creek, including Jenny, Shovel, and Fall Creeks (Hamilton et al. 2005). Spencer Creek flows into the upstream end of J.C. Boyle Reservoir and would still be potentially accessible to lamprey. Pacific lamprey below Iron Gate Dam would migrate above the dam if access was provided through fishways (Administrative Law Judge 2006). Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through eliminating peaking operations and increasing base flows. Suspended and bedload sediment effects would be similar to those described for the Proposed Action. The reservoir drawdowns would allow tributaries and springs such as Fall and Shovel Creeks and Big Springs to flow directly into the mainstem Klamath River, creating patches of cooler water that could be used as temperature refugia by fish (Hamilton et al. 2011). Removal of the two dams would likely result in more favorable water temperature for native fishes, and would improve water quality.

Juveniles would be subject to some level of predation by introduced resident species including largemouth bass, catfish, and yellow perch in J.C. Boyle Reservoir, resulting in mortality rates that will depend largely on their size (larger migrants will do better) (Administrative Law Judge 2006). Predation rates on juvenile salmonids in reservoirs and near dams is partially determined by water temperature, prey availability and size, prey condition, predator abundance, and the behavior of predatory fish species (Rodgers and Burley 1991, Vigg et al. 1991). Predation risk for juvenile salmon during the seaward migration can be minimized when flows reduce the exposure time to predatory fish. Effective passage at dams is key to minimizing prey because aggregation of juvenile salmonids near passage facilities or in the dam tailrace can increase predation rates (Rieman et al. 1991). Volitional fish passage for Pacific lamprey has been designed and is in place in other river systems (Administrative Law Judge 2006).

<u>Lower Klamath River: Downstream of Iron Gate Dam</u> The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would release sediment stored within Copco 1 and Iron Gate Reservoirs downstream to the lower Klamath River. Of the reservoirs in the Hydroelectric Reach, J.C. Boyle Reservoir stores the least amount of sediment—less than 10 percent of the total. As such, suspended and bedload sediment conditions and effects on Pacific lamprey in the lower Klamath River reach would be similar to those described for the Proposed Action, but of slightly lesser magnitude.

The removal of two dams and restoration of free flowing sections of river would likely result in water temperature more favorable for Pacific lamprey occurring in the mainstem, as well as improve water quality. As it would be under the Proposed Action, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to reduced water quality from increased suspended sediment concentrations, but these effects would be short term.

<u>Estuary</u> The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect Pacific lamprey estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and bedload sediment transport and deposition and Pacific *lamprey*. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for Pacific lamprey in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability, flow regime, water quality, temperature variation, fish disease incidence, and algal toxins which could affect Pacific lamprey. Dam removal would restore connectivity to usable habitat in the Hydroelectric Reach and would create additional spawning and rearing habitat within the Hydroelectric Reach. **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for Pacific lamprey in the long term**.

Green Sturgeon

Upper Klamath River Green sturgeon did not historically occur upstream of Iron Gate Dam (Hamilton et al. 2005) and are not anticipated to occupy this reach after implementation of this alternative. The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would not affect green sturgeon upstream of Iron Gate Dam.

Lower Klamath River: Downstream of Iron Gate Dam The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would result in the release of sediment stored within Copco 1 and Iron Gate reservoirs downstream to the lower Klamath River. Of the reservoirs in the Hydroelectric Reach, J.C. Boyle stores the least amount of sediment, less than 10 percent of the total amount. As such, suspended and bedload sediment conditions and effects on green sturgeon in the lower Klamath River reach would be similar to those described for the Proposed Action, but of slightly lesser magnitude.

Bedload sediment effects related to dam-released sediment or sediment resupply would likely extend as far as the Cottonwood Creek. Current green sturgeon distribution extends from the mouth of the Klamath River upstream to the Ishi Pishi Falls (Moyle 2002; FERC 2007), with some observed migrating into the Salmon River. Short- and long-term changes to bedload sediment under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative are not expected to affect green sturgeon.

The removal of two dams and restoration of free flowing sections of river would likely result in water temperature more favorable for green sturgeon occurring in the mainstem, as well as improve water quality and reduce instances of algal toxins. As with SSCs, migrating adults and juveniles rearing or migrating in the mainstem after dam removal would be exposed to poor water quality due to dam removal, but these effects would be short term.

Estuary The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect estuarine habitat. Sediment, flow, and water temperature effects would likely not extend downstream to the estuary.

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and affect green sturgeon. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for green sturgeon in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in flow regime, water quality, temperature variation, and algal toxins which could affect green sturgeon. **Based on small improvements in habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less-than-significant for green sturgeon in the long term.**

Shortnose and Lost River Sucker

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Shortnose and Lost River suckers upstream of Keno Dam would not be affected by the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative. Effects on populations downstream of Keno Dam are detailed below in the description of the Hydroelectric Reach. The KBRA would not be implemented under this alternative. However, ongoing restoration activities will continue to occur.

Hydroelectric Reach: From Upstream End of J.C. Boyle Reservoir to Iron Gate Dam Federally endangered shortnose and Lost River suckers are found within reservoirs in Hydroelectric Reach, but in lower abundance than in reservoirs and lakes upstream. Similar to the Proposed Action, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would eliminate reservoir habitat as dams within the Hydroelectric Reach were removed and sediment was allowed to move downstream. Adult Lost River and shortnose suckers in reservoirs downstream of Keno Dam would be captured and relocated to Upper Klamath Lake (Buchanan et al.2011a). Those not relocated to the Upper Basin would likely be lost, but with little or no successful reproduction (Buettner et al. 2006), the populations downstream of Keno Dam contribute minimally to conservation goals and insignificantly to recovery (Hamilton et al. 2011). Lost River and shortnose suckers are listed as fully protected species under California Fish and Game; thus any take of these species is prohibited. However, a component of this alternative would include legislation to permit the take of some individuals during implementation.

Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006). Generally, with the exception of *F. columnaris* and Ich, pathogens associated with anadromous fish do not impact non-salmonids (e.g. suckers) (Administrative Law Judge 2006).

Based on the low occurrence of suckers within Iron Gate and Copco 1 reservoirs, only a small reduction in abundance could occur, and therefore the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less-than-significant for Lost River and shortnose sucker populations in the short- and long term.

Redband Trout

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, dam removal and the addition of fish passage facilities at J.C. Boyle and Copco 1 dams would allow redband trout to migrate more successfully from the Hydroelectric Reach to the Upper Klamath Basin (Hamilton et al. 2011) than under existing conditions.

Under this alternative, a flow regime that more closely mimics natural conditions would not be established downstream of Keno Dam; therefore, the increases in stream habitat upstream of J.C. Boyle Dam might not be realized under this alternative. Habitat in the J.C. Boyle Bypass and Peaking Reaches and the Copco 2 Bypass Reach would be improved through eliminating peaking operations and increasing base flows.

Facilitating the movement of anadromous fish via prescribed fishways presents a relatively low risk of introducing pathogens to resident fish above Iron Gate Dam (Administrative Law Judge 2006). Redband could be affected by increased predation from reintroduced salmonids, but this loss might be offset by an increase in available food sources (e.g., eggs, fry, and juveniles of reintroduced salmonids) (Hamilton et al. 2011). Adult salmon moving into the upper basin would likely bring with them genotypes of *C. shasta* that had previously been restricted to the lower river. While the effects of these introductions are uncertain, at least some degree of host specificity appears to exist (Atkinson and Bartholomew 2010), indicating that newly exposed species, such as redband trout, might not be susceptible to the new genotypes. Additionally, the changes in habitat that could result from dam removal (fewer areas of slow-flowing, stable habitat) would likely reduce the density of polychaete populations, resulting in reduced disease exposure for fish. The close similarities between anadromous steelhead trout and resident rainbow/redband trout suggest these species historically co-existed. The distribution and resistance of rainbow/redband trout in Upper Klamath Lake to *C. Shasta* lends additional support that the two species co-existed and intermingled prior to the construction of Copco 1 Dam in 1917. There are many examples from nearby river systems in the Pacific Northwest that show wild anadromous salmon and resident rainbow/redband trout can co-exist and maintain abundant populations without deleterious consequences. The Deschutes River in Oregon, the Yakima River in Washington, and the river systems in Idaho are examples (Administrative Law Judge 2006).

Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam
Similar to the Proposed Action, dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would allow redband trout to migrate between tributaries and reservoirs to complete their lifecycle, and would restore 22.4 miles of reservoir habitat to riverine habitat (Cunanan 2009). Suspended and

bedload sediment effects would be similar to those described for the Proposed Action. However, sediment would continue to be trapped in J.C. Boyle, and spawning habitat would not likely improve for redband trout in the mainstem.   .

As described for the Proposed Action, reservoir drawdown associated with dam removal under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and affect redband trout. **Based on a small proportion of the population with a potential to be exposed to short-term effects, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be less-than-significant for redband trout in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability and flow regime, which could affect redband trout. As described for the Proposed Action, dam removal would increase connectivity between Upper Klamath Basin and the Hydroelectric Reach and would create additional habitat within the Hydroelectric Reach. **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for redband trout in the long term.**

Bull Trout

Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir Similar to the Proposed Action, under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative bull trout upstream of J.C. Boyle Reservoir could be affected by increased predation from reintroduced salmonids, but this loss might be offset by an increase in available food sources (e.g., eggs, fry, and juveniles of reintroduced salmonids) (Buchanan et al. 1997).

Based on the restricted distribution of bull trout, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less than significant impact on bull trout in the short- and long term.

Eulachon

Lower Klamath River: Downstream of Iron Gate Dam Under this alternative, suspended sediment conditions and effects on eulachon in the lower Klamath River would be similar to those described for the Proposed Action, but of slightly lesser magnitude. Short-term decreases in water quality might also be associated with this alternative and would affect adults and larvae in the mainstem Klamath River. As with SSCs, these effects could be muted by tributary inputs.

Estuary Similar to the Proposed Action, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect estuarine habitat.

Based on short duration of poor water quality during reservoir drawdown in the estuary, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate

Alternative would have a less-than-significant effect on eulachon in the short-and long term.

Longfin Smelt The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would release dam-stored sediment downstream to the lower Klamath River, but would not be expected to reach the area potentially used by longfin smelt. Longfin smelt using the lower Klamath River after January 2020 could be exposed to high SSCs for a portion of their migration period. SSCs would decrease in the downstream direction from Iron Gate Dam due to dilution from tributaries, so the magnitude of the effect would likely be low. Short-term decreases in water quality could also affect adults and larvae in the mainstem Klamath River. As with SSCs, these effects could be muted by tributary inputs.

<u>Estuary</u> Similar to the Proposed Action, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative is not expected to substantially change or affect estuarine habitat.

Based on short duration of poor water quality during reservoir drawdown in the estuary, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have a less-than-significant effect on longfin smelt in the short- and long term.

Introduced Resident Species
<u>Upper Klamath River: Upstream of the Influence of J.C. Boyle Reservoir</u> Introduced resident species upstream of J.C. Boyle Reservoir would not be affected by the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative.

<u>Hydroelectric Reach: from Upstream End of J.C. Boyle Reservoir to Iron Gate Dam</u>
Similar to the Proposed Action, implementation of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would eliminate reservoir habitat associated with the two largest reservoirs Copco 1 and Iron Gate Dam, but would retain the habitat associated with the smaller J.C. Boyle and Copco 2 reservoirs. This would be detrimental to nonnative fishes upstream of Iron Gate Dam. Abundance of these species would decline substantially as the majority of their preferred reservoir habitat would be eliminated (Buchanan et al.2011a).

The Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would reduce habitat for introduced resident species in the Hydroelectric Reach. **Because these species were introduced and they occur in other nearby water bodies, their loss would not be considered important from a biological perspective, and would benefit native species. This impact would be less than significant from a biological perspective. Their loss would, however, decrease opportunities for recreational fishing for these species, as discussed in Section 3.20, Recreation.**

Freshwater Mussels
<u>Suspended Sediment Concentrations</u> Most stored sediment that would affect downstream Klamath River resources is stored in Iron Gate Reservoir, and SSCs resulting from

implementation of this alternative would be the same as, or very similar to, those levels described previously for the Proposed Action. Therefore, SSCs resulting from the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would have the same effects on freshwater mussels, as previously described for the Proposed Action.

Changes in Bed Elevation Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, free-flowing river conditions would be restored through most of the mainstem Klamath River. The release of sediment currently stored behind Iron Gate and Copco 1 Dams would occur and changes in streambed elevation downstream of Iron Gate Dam would be similar, but slightly smaller in magnitude than those of the Proposed Action because the J.C. Boyle and Copco 2 Dams would remain in place and the sediment stored behind them would not be removed. Therefore, the effects of this alternative on bedload elevation changes would be similar, but perhaps slightly smaller in magnitude, than those associated with the Proposed Action.

Changes in Bed Substrate Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, changes in bed substrate would be similar as those described for the Proposed Action. Therefore, this alternative would have similar effects on freshwater mussels in the mainstem Klamath River as the Proposed Action.

Based on substantial reduction in the abundance of multiple year classes in the short term and the slow recovery time of freshwater mussels, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for freshwater mussels in the short term.

Based on increase in habitat availability, the effects of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial to freshwater mussels in the long term.

Benthic Macroinvertebrates

Suspended Sediment Concentrations Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, the release of sediment currently stored behind Iron Gate and Copco 1 Dams would occur. The effects of SSCs on BMIs would be the same as, or very similar to, those described for the Proposed Action.

Changes in Bed Elevation Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, the effects on BMIs resulting from bedload elevation changes are expected to be similar, if not the same as, those associated with the Proposed Action.

Changes in Bed Substrate Under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, the effects on BMIs resulting from changes in bed substrate in the mainstem Klamath River would be similar to those described for the Proposed Action.

As described for the Proposed Action, the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative could alter SSCs and bedload sediment transport and deposition and affect benthic macroinvertebrates. **Based on substantial reduction in the abundance of a year class in the short term, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be significant for macroinvertebrates in the short term.**

As described for the Proposed Action, in the long term, removal of dams under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative, could result in alterations in habitat availability, flow regime, water quality, and temperature variation, which could affect macroinvertebrates. While a large proportion of their populations in the Hydroelectric Reach and in the mainstem Klamath River downstream of Iron Gate Dam would be affected, their populations would be expected to recover quickly because of the many sources for recolonization and their rapid dispersion through drift or aerial movement of adults. **Based on increased habitat availability and improved habitat quality, the effect of the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative on macroinvertebrates would be beneficial in the long term.**

Trap and Haul – Programmatic Measure

Implementation of trap and haul measures could affect aquatic species. The trap and haul measures around Keno Impoundment and Link River would have the same impacts under the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative as the Fish Passage at Four Dams Alternative. **Based on access to additional, historical habitat and the anticipated improvements in fish health, implementation of trap and haul measures in the Fish Passage at J.C. Boyle and Copco 2, Remove Copco 1 and Iron Gate Alternative would be beneficial for fall-run Chinook salmon.**

3.3.4.4 Mitigation Measures

AR-1: Protection of Mainstem Spawning

It is anticipated that short-term effects of the Proposed Action (SSCs and bedload movement) will result in up to 100% mortality of fall Chinook and coho salmon embryos and pre-emergent alevin within redds that were constructed in the mainstem in the fall of 2019. In addition, any steelhead or Pacific lamprey migrating within the mainstem Klamath River after December 30th could be directly affected. As described in Appendix E, around 4,600 fall-Chinook salmon redds are predicted to be affected, and around 13 redds from the Upper Klamath River Population Unit for coho salmon.

Deleterious short-term effects of the Proposed Action on mainstem spawning could be reduced by capturing migrating adult fish (Chinook, coho, steelhead, or Pacific lamprey) in the mainstem Klamath River and relocating them to suitable habitat. Capture of adult fish could be accomplished with the use of an Alaskan-style weir and box trap, similar to that currently used at the Willow Creek and Trinity River site. The most suitable location for the trap appears to be directly upstream of the Shasta River, where the mainstem Klamath River is small enough to effectively trap, and would ensure that fish returning to key tributaries downstream of, and including the Shasta River would not be interrupted. The weir would be installed at the beginning of the fall migration and continue past the initial dam drawdown period until high flows require the trap to be dismantled. Captured fish would periodically be transported to receiving tributaries. Fish could be released either in under-seeded tributaries downstream of Iron Gate Dam (e.g., Scott River), or in tributaries upstream of Iron Gate Dam if that were consistent with post-dam removal management goals. The relocated fish would then spawn naturally in the tributary streams and their progeny would not be affected by the SSCs and bedload movement during the dam removal process. In addition, the trap would only be operated periodically, so that some violotional passage upstream of the Shasta River would occur, allowing fish to return to Bogus Creek and the hatchery during 2019.

Additional surveys in the mainstem downstream of Shasta River could be conducted to locate coho salmon spawning in the mainstem. Any identified adult coho, Chinook, steelhead, or Pacific lamprey could be captured using dip-nets, electrofishing, or seines and transported to tributary habitat. Surveys should be conducted in December 2019, immediately prior to the first release of sediment associated with facilities removal.
A detailed plan describing capture techniques, release locations, and monitoring methods would be developed by the Dam Removal Entity (DRE) prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

The effectiveness of the measure will depend on how effectively adults can be captured with the weir. Based on operation of similar traps in other rivers, it is anticipated that when operational the trap could capture nearly all upstream migrants. However, it is the intention to allow a portion of the adult to migrate violitionally to access Bogus Creek or the hatchery. Therefore it is assumed some fall Chinook salmon will continue to spawn within the mainstem during 2019. Depending on the condition of captured adults, some may be injured during transport, or may not spawn when released. However, the progeny of these adults is predicted to suffer 100% mortality if they spawn in the mainstem, so relocation is considered worth the risk of reduced spawning success. Overall effectiveness of the adult relocation operation would be measured by using radio-tagged individuals to track the -tagged fish to determine spawning success and location.

AR-2: Protection of Outmigrating Juveniles

It is anticipated that short-term effects of the Proposed Action (SSC) will result in mostly sublethal, and in some cases lethal impacts to a portion of the juvenile Chinook, coho, steelhead, and Pacific lamprey that are outmigrating from tributary streams to the Klamath River upstream of Orleans during late winter and early spring of 2020 (Appendix E).

Deleterious short term effects on outmigrating juveniles could be reduced by capturing juveniles outmigrating from tributaries prior to their entry into the mainstem. This measure includes the installation of downstream migrant traps on up to 13 key tributary streams downstream of Iron Gate Dam including Bogus Creek, Dry Creek, Walker Creek, Shasta River, Seiad Creek, Oneil Creek, Scott River, Grider Creek, Tom Martin Creek, Horse Creek, Beaver Creek, Cottonwood Creek, and Humbug Creek. Results of spawning surveys in fall 2019 could be used to focus trapping efforts within these or other tributaries. Trapping on all of these streams is proposed to help preserve the genetic integrity and varied life history tactics that are represented by this group of streams that have a high diversity with respect to size, channel types, water temperature regimes, geographic distribution, and other attributes.

The trapping would involve the standard CDFG/USFWS rotary screw trap/fyke net/pipe trap methods currently in use. However, placement of a second trap downstream of the first would increase the number of captures. Captured fish could then be placed in aerated tank trucks and transported to a release site downstream of the Trinity River or other locations that have suitable water quality.

The procedures of trapping, handling, trucking, and releasing outmigrating salmonids could result in harm or mortality to some individuals, and releasing fish at downstream locations could reduce natal cues and increase stray rates. Therefore fish will be captured and transported only if conditions within the mainstem are as poor as predicted. Due to the uncertainties with suspended sediment modeling, water quality monitoring during spring 2020 would be used to trigger the initiation and cessation of the capture program and inform suitable release locations. Release locations should be varied to prevent predators from congregating at release locations. Alternatively, in a portion of tributaries juveniles could be held in temporary facilities within tributaries and released when SSC in the mainstem were non-stressful. This would prevent any decrease in the natal cue, as well as any potential associated effects of fish transport.

A detailed plan describing trapping techniques, release locations, and monitoring methods would be developed by the DRE prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

The effectiveness of this measure depends on the efficiency of trapping efforts. Trap efficiency varies with species and tributary. Current trapping efforts in the Shasta River and Scott River typically have trap efficiencies between around 5 and 30 percent, averaging around 15 percent (Underwood et al. 2010). It is anticipated that trapping efficiency could be increased over current efforts by more aggressive trapping efforts using either multiple traps and/or increased weir panels. However, not all tributaries with outmigrating juveniles will be trapped, and within trapped tributaries some individuals will avoid traps and migrate to the mainstem (particularly during high flows). Overall, it is assumed 50 percent of juveniles outmigrating to the mainstem could be captured. Current predictions of mortality estimate a total of 2,668 to 6,536 smolts for an impact of 9 to 22 percent from the upper Klamath River, mid-Klamath River, Scott River, and Shasta River population units depending on a most-likely-to-occur or worst case scenario. Assuming 50 percent capture efficiency this mitigation measure would reduce mortality a total of 1,334 to 3,268 smolts for an impact of 4 to 11 percent depending on a most-likely-to-occur or worst-case scenario. To evaluate the effectiveness of the mitigation measure, the trapping procedures would need to assess trap efficiency that would lead to the development of estimates of stream production and numbers of fish assumed missed by trapping effort.

AR-3: Fall Flow Pulses

It is anticipated that short-term effects of the Proposed Action (SSC) will result in sublethal effects for green sturgeon adults remaining in the mainstem Klamath River during fall 2019, mortality for mainstem spawning fall-run Chinook salmon, mortality for migrating adult winter steelhead, and sublethal effects for adult coho salmon remaining in mainstem prior to entering tributaries.

Deleterious short-term effects on adults could be reduced by augmented flows during fall 2019 prior to dam removal. It has been observed that fall pulse flows result in the downstream migration of post-spawned green sturgeon out of the Klamath River (Benson et al. 2007), and increased flows during fall prior to dam removal may increase the rate and proportion of fall-run Chinook salmon, steelhead, and coho salmon spawning in tributaries, and thus reducing the proportion of the population spawning in the mainstem or being exposed to SSC in the mainstem during migration (Stillwater Sciences 2009a).

Water releases in the fall prior to dam removal should mimic the natural hydrograph that would have existed in the Klamath River during a “wet year” prior to the Reclamation project, consistent with recommendations in NRC (2004). However, if the water year during dam removal is dry, managers will need to balance the benefits of increased flows during fall with the risk of impacts to the basin if less water is available during the following spring (during smolt outmigration). Increases in fall flows would likely be most successful if conducted synchronously with increased flows in unregulated tributaries, to help create enough of a pulse of water to encourage migration. Doing so will also ensure that adults that are attracted up the mainstem by increasing fall flows are not blocked from accessing their natal streams due to natural low flow conditions.

A detailed plan describing target flows and monitoring methods would be developed by the DRE prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

It is anticipated that this measure will be effective for reducing deleterious short-term effects on adult green sturgeon during fall 2019. Benson et al. (2007) reported that the majority of adult green sturgeon outmigrating during the first major flow event of the fall. Analysis of the mainstem natural spawner fraction versus flow suggests that, generally, increased numbers of naturally produced fall-run Chinook salmon adults spawn in the mainstem during years when fall flows are low (Stillwater Sciences 2009a). The minimum proportion of fall-Chinook salmon spawning in the mainstem is 5.3%, suggesting that if fall-pulse flows are successful at increasing tributary spawning the proportion of fall-run Chinook salmon spawning in the mainstem could be reduced to this level.

Currently on average less than 4 percent of coho salmon migrate into monitored tributaries after December 15th, and in many years no fish are observed migrating after this date (Appendix E). Migration of coho salmon adults into tributaries also appears to be affected by flow, with earlier tributary entrance times observed in Blue Creek, Shasta River, Bogus Creek and other tributaries during years with high flows during fall (Stillwater Sciences 2009a). A fall pulse-flow is anticipated to be effective at ensuring nearly all adult coho salmon migrate into tributaries prior to initiation of reservoir drawdown on December 15. The effectiveness of the measure could be monitored with spawning surveys during 2019. The proportion of steelhead migrating upstream after December 15th is highly variable (USFWS 1998). Although no analysis has been conducted, it is possible that increased fall flows could result in a greater proportion of steelhead migrating upstream and into tributaries prior to dam removal, as is observed in some years (USFWS 1998).

AR-4: Hatchery Management

It is anticipated that short-term effects of the Proposed Action (SSC) will result in mostly sublethal, and in some cases lethal impacts to a portion of the juvenile Chinook, coho, and steelhead smolts outmigrating from tributary streams to the Klamath River upstream of Orleans during late winter and early spring of 2020 (Appendix E).

Deleterious short-term effects on outmigrating hatchery Chinook and coho salmon smolts could be reduced by adjustments to hatchery management. Hatchery managers could adjust the timing of hatchery releases during spring 2020. Although it would be out of synch with natural life history timing, if smolts are released later in the spring (e.g., mid-May), survival is anticipated to be higher based on current conditions (Beeman et al. 2008), as well as avoiding the peak in spring release of sediment in the year following dam removal.

An alternative to adjusting the hatchery release timing would be to allow the sub-yearling and yearling smolts to imprint at the hatchery and then truck them to release locations downstream where SSC effects may be muted by tributary accretion flow. Trucking could be accomplished during the normal releasing timing period.

The implementation of this mitigation measure is dependent on the hatchery remaining open and having a suitable water supply. A detailed plan describing adjustments to hatchery management would be developed by the DRE prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

It is anticipated that this measure will effectively reduce short-term lethal effects on hatchery released smolts to sublethal effects.

AR-5: Pacific lamprey Capture and Relocation

Based on predictions of low dissolved oxygen and the analysis of SSC that was conducted (Appendix E), high rates of mortality are predicted in the short term as a result of the Proposed Action. An action to mitigate this deleterious short term effect would be to salvage and relocate lamprey ammocoetes from preferred habitat areas where dissolved oxygen levels would be particularly low, including pools, alcoves, backwaters, and channel margins that experience low water velocities and sand and silt deposition (Streif 2009) from areas downstream of Iron Gate Dam. The focus of relocation efforts would be within 3 km of Iron Gate Dam, where SSC is predicted to be highest, and dissolved oxygen levels the lowest. However, the density of lamprey within this reach is not known, and reconnaissance surveys should be conducted prior to the implementation of this measure to assess if enough ammocoetes are present to warrant mitigation.

The salvage operation, if implemented, would be conducted by first identifying preferred (and high risk) areas and then utilize a specialized electrofisher to capture ammocoetes. Collection of lamprey ammocoetes has been demonstrated in the Klamath River (Karuk Tribe and USFWS unpublished data). Captured individuals would be transported to suitable locations (with current low occurrences of lamprey) within tributaries upstream or upstream of Keno Dam. A detailed plan describing lamprey capture and relocation would be developed by the DRE prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

It is expected that implementation of this mitigation measure would reduce dissolved oxygen and SSC-related stress or mortality for a proportion of lamprey ammocoetes. An unknown number of lamprey ammocoetes remaining in the mainstem Klamath River downstream of Iron Gate Dam would still experience stress and mortality resulting from elevated SSC and bedload movement. Mitigation effectiveness monitoring would consist of reporting the number of individuals captured, release location, and their condition upon release.

AR-6: Sucker Rescue and Relocation

It is anticipated that short-term effects of the Proposed Action will result in mostly sublethal, and in some cases lethal impacts to Lost River and shortnose suckers within reservoirs in Hydroelectric Reach. Under this measure adult Lost River and shortnose suckers in reservoirs downstream of Keno Dam could be captured and relocated to Upper Klamath Lake (Buchanan et al. 2011a).

If deemed feasible in 2019 prior to dam removal, Klamath smallscale suckers will be collected directly downstream of J.C. Boyle Dam and terminating approximately 2 miles downstream in the approximate area of the current powerhouse. Fish will be collected using electro- fishing techniques. Salvaged Klamath smallscale sucker will be relocated to Spencer Creek immediately downstream of the Spencer Creek hook up road (upper limits for sucker in Spencer creek). Smallscale suckers will not be relocated upstream of Keno Dam.

Lost River and shortnose suckers can also be captured using electrofishing and trammel nets. It is recommended that these and other approved capture techniques be utilized for this relocation effort. Captured Lost River and shortnose suckers could then be placed in aerated tank trucks and transported to suitable release sites in Upper Klamath Lake. A detailed plan describing sucker rescue and relocation would be developed by the DRE prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

It is expected that implementation of this mitigation measure would reduce the deleterious short-term effects from the Proposed Action. However, it is not known how many suckers inhabit the Hydroelectric Reach reservoirs, therefore it is unknown what proportion of the population would be captured and successfully relocated. Those Lost River and shortnose suckers not relocated to the Upper Basin would likely be lost, but with little or no successful reproduction (Buettner et al. 2006), and no connection to upstream populations, the individuals downstream of Keno Dam contribute minimally to conservation goals or recovery (Hamilton et al. 2011).

AR-7: Freshwater Mussel Relocation

Freshwater mussels in the Hydroelectric Reach and in the lower Klamath River, downstream of Iron Gate Dam, are likely to be deleteriously affected by prolonged SSCs and bedload movement during the later part of reservoir drawdown and subsequent dam removal. Freshwater mussels cannot move to avoid these impacts, and some species are very long lived, and may not reproduce successfully (or at all) each year. An action to mitigate this effect is to relocate freshwater mussels prior to drawdown. Freshwater mussels could be relocated to tributary streams or upstream of the Hydroelectric Reach, then moved back to their approximate location or to other suitable habitat in the river after dam removal has been completed.

Freshwater mussel relocation success depends on a variety of factors including the availability of suitable habitat (for juveniles, adults, reproduction, feeding, growth, and host fish), population density at the relocation site, and handling during relocation (Hamilton et al. 1997; Bolden and Brown 2002). While many (and still unknown) factors influence the survival and reproduction of freshwater mussels in their natural environment, relocation adds an additional stress. Thus, the variables associated with the characteristics of freshwater mussel habitat at the source and destination sites as well as with the relocation methods should be as similar as possible for all life stages (Cope and Waller 1995; Cope et al. 2003). Previous studies indicate varied success of freshwater mussel relocation projects, with most mortality observed within one year (Thomas 2008). Habitat selection is important for success, as changes in habitat (e.g., substrate size) from the original site appear to influence mortality (Cope and Waller 1995; Bolden and Brown 2002). As such, the presence of existing freshwater mussel populations should guide site selection. Cope et al. (2003) found that proper handling and transport and selection of suitable habitat improved survivorship of relocated freshwater mussels.

Luzier and Miller (2009) developed some general guidelines for freshwater mussel relocation projects, including 1) an initial evaluation of freshwater mussel populations to identify species, estimate abundance, and sex ratio and age distribution (if possible), 2) site evaluation for relocation to determine (among other factors) habitat quality and presence of appropriate fish hosts, 3) careful and quick transport to minimize stress, and 4) monitoring relocated populations to determine initial survival, recruitment, and persistence through the range of environmental conditions at the site. Following these guidelines, prior to drawdown (e.g., fall 2019 or before) surveys would be conducted to evaluate current freshwater mussel species and habitat below Iron Gate Dam and to identify potential sites for relocation. Freshwater mussels would be relocated to suitable habitats and monitored over the duration of high SSCs. After dissipation of effects, original locations could be resurveyed to determine habitat suitability. If suitable, then the relocated freshwater mussels could be returned to their source location. Most relocation projects are conducted during warm periods when reproductive stress is presumably low for most species, and their metabolic rates are sufficient for burrowing in the substrate (Cope and Waller 1995).

If suitable in-stream habitat cannot be found for the time period of increased SSCs, it may be possible to temporarily house relocated freshwater mussels in fish hatchery raceways at facilities near to the removal sites. This was apparently performed on the Elwha during dam removal (no citation available) using river water so they could filter feed. However, many freshwater mussels need to burrow to reduce the energy needs of holding their valves closed for extended periods. Thus, such artificial holding areas should not be used for long periods. Aquaculture ponds have sometimes been used as well (Cope et al. 2003).

This mitigation measure would benefit from a pilot program prior to initiation, to assess the success and potential levels of mortality associated with relocation. Relocation should also consider the potential for transmission of disease or interbreeding between genetically distinct populations. A detailed plan describing freshwater mussel rescue and relocation would be developed by the DRE prior to 2019.

Effectiveness of Mitigation in Reducing Impacts

With the proposed mitigation, these impacts freshwater mussels would be reduced.

Summary of Mitigation Measures

The DRE would be responsible for implementation of Mitigation Measures AR-1 through AR-7. Although all proposed mitigation measures would reduce short-term deleterious effects of the Proposed Action, significant effects would continue to occur for some species, as described in detail in the Proposed Action Species-Specific impacts analysis provided in Section 3.3.4.3 and detailed in Tables 3.3-11 through 3.3-18.

Table 3.3-11. Comparison of Short-term SSC Effects from the Proposed Action with and without Mitigation Measures; Most-likely Scenario (i.e., 50%Exceedance Probabilities) for Fall- and Spring-Chinook and Coho Salmon.

Species/Run	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Fall Chinook Salmon	**Proposed Action**				
	No effects	Up to 100% mortality of the progeny of mainstem spawners (about 8% of escapement)	No juvenile progeny anticipated rearing in mainstem due to impacts during incubation. Most other juveniles assumed to rear in tributaries prior to outmigration.	N/A	**Type I:** Major stress and reduced growth for Type I fry (about 60% of production) **Type II:** No effects **Type III:** Major stress, reduced growth, and up to 20% mortality for Type III outmigrants (less than 1% of production)
	Proposed Action with Mitigation Measures AR-1, 2, 3, and 4				
	Increased escapement into tributaries due to augmented attraction flows	Reduced effects due to increased hatchery production, trapping and relocation of adult spawners and additional redds being constructed in tributaries	Reduced effects due to mainstem progeny now rearing in hatchery and tributary streams.	N/A	**Type I:** Major stress on smolts not rescued and relocated; Growth-related effects for non-hatchery smolt; reduced effects on hatchery smolts due to delayed release **Type II:** Same as above for naturally spawned progeny. Reduced effects for hatchery-reared fish due to release timing modification. Reduced effects for rescued and relocated smolts. **Type III:** Major stress, reduced growth, and up to 20% mortality for Type III outmigrants. Reduced effects for rescued and relocated smolts.

Table 3.3-11. Comparison of Short-term SSC Effects from the Proposed Action with and without Mitigation Measures; Most-likely Scenario (i.e., 50%Exceedance Probabilities) for Fall- and Spring-Chinook and Coho Salmon.

<table>
<tr><th rowspan="2">Species/Run</th><th colspan="5">Life History Stage</th></tr>
<tr><th>Adult migration</th><th>Spawning through fry emergence</th><th>Age 0+ rearing</th><th>Age 1+ rearing</th><th>Outmigration</th></tr>
<tr><td rowspan="8">Spring Chinook Salmon</td><td colspan="5">Proposed Action</td></tr>
<tr><td rowspan="3">Spring Migration:
Major stress, impaired homing for adults returning to Salmon R. (about 5% of run)
Summer Migration:
No effects</td><td rowspan="3">Most spawning takes place in tributaries; no effects predicted</td><td rowspan="3">Juveniles primarily rear in tributaries; no effects predicted</td><td rowspan="3">Juveniles primarily rear in tributaries; no effects predicted</td><td>Type I: Major stress for Type I fry from Salmon R. (about 80% of Salmon R. production)</td></tr>
<tr><td>Type II: Major to moderate stress for 1 to 3 days</td></tr>
<tr><td>Type III: Major stress, reduced growth, but no mortality</td></tr>
<tr><td colspan="5">Proposed Action with Mitigation Measures AR- 2 and 3</td></tr>
<tr><td rowspan="3">Spring Migration:
Same as above
Summer Migration:
Same as above</td><td rowspan="3">Same as above</td><td rowspan="3">Same as above</td><td rowspan="3">Same as above</td><td>Type I: Major stress on smolts not rescued and relocated</td></tr>
<tr><td>Type II: Same as above for non-rescued and relocated fish.</td></tr>
<tr><td>Type III: 20-40% mortality (about 31 smolts)</td></tr>
</table>

Table 3.3-11. Comparison of Short-term SSC Effects from the Proposed Action with and without Mitigation Measures; Most-likely Scenario (i.e., 50%Exceedance Probabilities) for Fall- and Spring-Chinook and Coho Salmon.

<table>
<tr><th rowspan="2">Species/Run</th><th colspan="5">Life History Stage</th></tr>
<tr><th>Adult migration</th><th>Spawning through fry emergence</th><th>Age 0+ rearing</th><th>Age 1+ rearing</th><th>Outmigration</th></tr>
<tr><td rowspan="7">Coho Salmon</td><td colspan="5">Proposed Action</td></tr>
<tr><td rowspan="2">Major stress and impaired homing</td><td rowspan="2">Up to 100% mortality of progeny of mainstem spawners (typically <1% of run)</td><td rowspan="2">Age 0+ summer: Reduced growth for age 0+ from 2020 cohort in upper mainstem (<50% of fry).
No effect on juveniles rearing in tributaries</td><td rowspan="2">Age 1+ winter: Major stress, reduced growth, and up to 60% mortality for age 1+ juveniles from 2019 cohort in mainstem (assume <1% of juveniles). No effect on juveniles rearing in tributaries</td><td>Early spring outmigration: Major stress, reduced growth, and up to 20% mortality for smolts coming from tributaries in upper mainstem in early spring (about 44% of production)</td></tr>
<tr><td>Late spring outmigration: Major stress and reduced growth for smolts coming from tributaries in the upper mainstem in late spring (about 56% of production)</td></tr>
<tr><td colspan="5">Proposed Action with Mitigation Measure AR-2 and 3</td></tr>
<tr><td rowspan="2">Same as above</td><td rowspan="2">Reduced effects due to relocation of adult spawners and additional redds being constructed in tributaries upstream of Hydroelectric reach</td><td rowspan="2">Age 0+ summer: Same as above</td><td rowspan="2">Age 1+ winter: Same as above</td><td>Early spring outmigration: Major stress, reduced growth, and up to 4% mortality; Reduced mortality</td></tr>
<tr><td>Late spring outmigration: Major stress and mortality on smolts not rescued and relocated; Growth-related effects</td></tr>
</table>

Table 3.3-12. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Most-likely scenario (i.e., 50% Exceedance Probabilities) for Steelhead and Pacific Lamprey.

Species/Run	**Life History Stage**					
	Adult migration	**Runbacks/Half-pounder residency**	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Summer and Winter Steelhead	**Proposed Action**					
	Summer run: Major stress and impaired homing for fish spawning in mid- and upper-Klamath tributaries (about 45% of escapement) Winter run: Major stress, impaired homing, and up to 36% mortality for fish spawning in mid- and upper-Klamath tributaries (about 1,008 adults)	Adult runbacks: Major stress; depending on time spent in mainstem Half-pounder residency: Most assumed to remain in tributaries; major stress for any remaining in mainstem	Most spawning takes place in tributaries; no effects predicted	Major stress resulting in reduced growth and up to 100% mortality for juveniles in that migrate from tributaries to the mainstem	Age 1+ rearing: Major stress, reduced growth, and up to 100% mortality for juveniles in that migrate from tributaries to the mainstem Age 2+ rearing: Reduced growth and up to 60% mortality for juveniles in mainstem	Major stress and reduced growth; about 57% outmigrate from Trinity R. and would have less exposure

Table 3.3-12. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Most-likely scenario (i.e., 50% Exceedance Probabilities) for Steelhead and Pacific Lamprey.

Species/Run	Life History Stage					
	Adult migration	**Runbacks/Half-pounder residency**	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
	Proposed Action with Mitigation Measure AR-2					
Summer and Winter Steelhead	Summer run: Same as above Winter run: Same as above	Adult runbacks: Same as above Half-pounder residency: Same as above	Same as above	Reduced effects for those migrating fish that are captured and relocated. Same effects as above for non-relocated fish.	Age 1+ rearing: Reduced effects for those migrating fish that are captured and relocated. Same effects as above for non-relocated fish. Age 2+ rearing: Reduced effects for those migrating fish that are captured and relocated. Same effects as above for non-relocated fish.	Major stress and reduced growth for that portion of the population not captured by the outmigrant rescue program.

Table 3.3-12. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Most-likely scenario (i.e., 50% Exceedance Probabilities) for Steelhead and Pacific Lamprey.

Species/Run	Life History Stage					
	Adult migration	**Runbacks/Half-pounder residency**	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Pacific Lamprey	**Proposed Action**					
	Major stress, reduced growth, and up to 36% mortality; later-returning adults and those returning to lower tributaries would have less exposure	N/A	See adult migration	**Ammocoete rearing*:*** Major stress, reduced growth, and up to 52% mortality for multiple year classes of ammocoetes in mainstem; majority rear in tributaries and would not suffer mortality		**Spring outmigration*:*** Major stress **Fall and winter outmigration*:*** Moderate stress
	Proposed Action with Mitigation Measure AR-5					
	Same as above	N/A	Same as above	**Ammocoete rearing*:*** Reduced effects for ammocoetes that are captured and relocated. Major stress, reduced growth, and up to 52% mortality for lamprey not captured and relocated.		**Spring outmigration*:*** Same as above **Fall and winter outmigration*:*** Same as above

Table 3.3-13. Comparison of Short-term SSC Effects from the Proposed Action with and without Mitigation Measures; Most-Likely Scenario (i.e., 50% Exceedance Probabilities) for Green Sturgeon and Suckers.

Species/Run	Life History Stage			
	Adult migration	**Adult Post-spawning Holding**	**Spawning through larvae**	**Juvenile Rearing (year-round) and Outmigration**
Green Sturgeon	**Proposed Action**			
	Major stress; 75% of adults not expected to migrate in 2020	No effects	76% mortality for all mainstem production; about 30% that spawn in Trinity R. would be unaffected (based on salmonid literature; effects likely overestimated)	Reduced growth and up to 20% mortality; about 30% of juveniles rear in Trinity R. and would be unaffected (based on salmonid literature; effects likely overestimated)
	Proposed Action with Mitigation Measure AR-4			
	Reduced effects due to fall flow pulse moving adults downstream; 75% of adults not expected to migrate in 2020.	Same as above	Same as above	Same as above
Suckers (spp)	**Proposed Action**			
	NA	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach.
	Proposed Action with Mitigation Measure AR-6			
	NA	Beneficial in upper Klamath Lake due to more habitat area. Loss of all adults within the Hydroelectric Reach that were not captured and relocated.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach since larvae and juveniles will not be captured and relocated.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach since larvae and juveniles will not be captured and relocated.

Table 3.3-14. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measure AR-8 for Freshwater Mussels.

Species/Run	Adults	Spawning	Larvae
Freshwater mussels	**Proposed Action**		
	Major physiological stress and substantial mortality	Major physiological stress and substantial mortality during the spawning season	Major adult physiological stress and mortality will significantly reduce larval production. No information on effects of SSC on larvae. Larvae produced in downstream reaches or tributaries may contribute to population recovery.
	Proposed Action with Mitigation Measure AR-8		
	Major physiological stress and substantial mortality. Some individuals would be relocated and would assist in reseeding the population.	Major physiological stress and substantial mortality during the spawning season. Relocated individuals may spawn in upstream reaches.	Major adult physiological stress and mortality will significantly reduce larval production. No information on effects of SSC on larvae. Larvae produced by relocated individuals, in downstream reaches, or in tributaries may contribute to population recovery.

Table 3.3-15. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-Case Scenario (10% Exceedance Probabilities) for Fall- and Spring-run Chinook Salmon.

Species/Run	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Fall-run Chinook Salmon	**Proposed Action**				
	No effect	Up to 100% mortality of the progeny of mainstem spawners (about 8% of escapement)	No juvenile progeny anticipated rearing in mainstem due to impacts during incubation. Most other juveniles assumed to rear in tributaries prior to outmigration.	N/A	**Type I:** Major stress and reduced growth for the about 40% of fry entering mainstem in April/May
					Type II: Moderate to major stress for the about 60% of Type II juveniles entering mainstem in Sept/Nov
					Type III: Major stress, reduced growth, and up to 71% mortality for about 0.18% of all juveniles entering mainstem in Feb-April
	Proposed Action with Mitigation Measures AR-1, 2, 3, and 4				
	Increased escapement into tributaries due to augmented attraction flows	Reduced effects due to increased hatchery production, relocation of adult spawners and additional redds being constructed in tributaries	Reduced effects due to mainstem progeny now rearing in hatchery and tributary streams	N/A	**Type I:** Major stress on smolts not rescued and relocated; Growth-related effects for non-hatchery smolt; reduced effects on hatchery smolts due to delayed release
					Type II: Same as above for naturally spawned progeny. Reduced effects for hatchery-reared fish due to release timing modification.
					Type III: Major stress, reduced growth, and up to 60% mortality***; Reduced mortality***

Table 3.3-15. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-Case Scenario (10% Exceedance Probabilities) for Fall- and Spring-run Chinook Salmon.

Species/Run	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Spring-run Chinook Salmon	**Proposed Action**				
	Spring Migration: Major stress and impaired homing Summer Migration: Impaired homing	Most spawning takes place in tributaries; no effects predicted	Juveniles primarily rear in tributaries; no effects predicted	Juveniles primarily rear in tributaries; no effects predicted	Type I: Major stress for Type I fry from Salmon R. (about 80% of Salmon R. production)
					Type II: Moderate stress for Type II juveniles from Salmon R. (about 20% of Salmon R. production)
					Type III: Major stress for Type III juveniles from Salmon R. (<1% of Salmon R. production)
	Proposed Action with Mitigation Measure s AR- 2				
	Spring Migration: Same as above Summer Migration: Same as above	Same as above	Same as above	Same as above	Type I: Reduced impacts for those fish that are rescued and relocated. Same impacts as above for fish not rescued.
					Type II: Reduced impacts for those fish that are rescued and relocated. Same impacts as above for fish not rescued.
					Type III: Reduced impacts for those fish that are rescued and relocated. Same impacts as above for fish not rescued.

Table 3.3-16. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-Case Scenario (10% Exceedance Probabilities) for Coho Salmon and Steelhead.

Species/Run	Life History Stage					
	Adult migration	**Runbacks/Half-pounder residency**	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Coho Salmon	**Proposed Action**					
	Major stress and impaired homing	N/A	Up to 100% mortality of progeny of mainstem spawners (typically <1% of run)	**Age 0+ summer:** No growth for 2020 cohort rearing in upper mainstem (< 50% of fry). No effect on juveniles rearing in tributaries	**Age 1+ winter:** Major stress, reduced growth and up to 52% mortality for 2018 age-1+ cohort in mainstem (assume <1% of juveniles). No effect on juveniles rearing in tributaries	**Early spring outmigration:** Major stress, reduced growth, and up to 49% mortality for smolts coming from Upper Klamath, Mid-Klamath, Shasta River, and Scott River populations during early spring (approximately 44% of the run outmigrates in early spring). (Mortality for approximately 8% of total population)
						Late spring outmigration: Major stress and reduced growth for smolts coming from tributaries in the upper mainstem in late spring (about 56% of production)
	Proposed Action with Mitigation Measures AR-2 and 3					
	Same as above	N/A	Same as above	**Age 0+ summer:** Same as above	**Age 1+ winter:** Same as above	**Early spring outmigration:** Major stress, reduced growth, and up to 11% mortality***; Reduced mortality***
						Late spring outmigration: Reduced impacts for those fish that are rescued and relocated.

Table 3.3-16. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-Case Scenario (10% Exceedance Probabilities) for Coho Salmon and Steelhead.

Species/Run	Life History Stage					
	Adult migration	**Runbacks/Half-pounder residency**	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Summer and Winter Steelhead	**Proposed Action**					
	Summer run: Major stress, impaired homing, and up to 20% mortality (From 0 to 130 adults, or from 0 to 9 percent of the basin-wide escapement). Winter run: Major stress, impaired homing, and up to 71% mortality. The proportion migrating prior to January would not be affected. (Up to 1,988 adults, or up to 28 percent of the basin-wide escapement).	Adult runbacks: Major stress; exposure dependant on time it takes runbacks to return to sea Half-pounder residency: Major stress and reduced growth for any in mainstem; Most assumed to remain in tributaries;	Most spawning takes place in tributaries; no effects predicted	Major stress and reduced growth for age 0+ juveniles in mainstem (about 60% of juveniles)	Age 1+ rearing: Stress, reduced growth, and up to 71% mortality Up to 11,207 juveniles or around 19% of total age 1 production). Age 2+ rearing: Stress, reduced growth and up to 71% mortality (Up to 9,412 juveniles or around 18% of total age 2 production).	Major stress resulting in reduced growth, about 57% outmigrate from Trinity R. and will have less exposure
	Proposed Action with Mitigation Measures AR-2					
	Summer run: Same as above Winter run: Same as above	Adult runbacks: Same as above Half-pounder residency: Same as above	Same as above	Same as above	Age 1+ rearing: Same as above Age 2+ rearing: Same as above	Major stress and reduced growth for that portion of the population not captured by the outmigrant rescue program.

Table 3.3-17. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-case Scenario (10% Exceedance Probabilities) for Pacific Lamprey, Green Sturgeon, and Suckers.

Species	Life History Stage				
	Adult migration	Spawning through fry emergence	Age 0+ rearing	Age 1+ rearing	Outmigration
Pacific Lamprey	**Proposed Action**				
	Major stress, reduced growth, and up to 71% mortality; later-returning adults and those returning to lower tributaries would have less exposure	See adult migration	**Ammocoete rearing:** Major stress, reduced growth, and up to 71% mortality for multiple year classes of ammocoetes in mainstem; majority rear in tributaries and would not suffer mortality		**Spring outmigration:** Moderate to major stress and reduced growth **Fall and winter outmigration:** Major stress
	Proposed Action with Mitigation Measure AR-5				
	Same as above	Same as above	**Ammocoete rearing:** Same as above for any ammocoetes not captured and relocated		**Spring outmigration:** Same as above **Fall and winter outmigration:** Same as above

Table 3.3-17. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-case Scenario (10% Exceedance Probabilities) for Pacific Lamprey, Green Sturgeon, and Suckers.

Species	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Green Sturgeon	**Proposed Action**				
	Major stress; about 25% of adults expected to be exposed in 2020	**Adult Post-spawning Holding:** Short period (<1 wk) of relatively low SSCs, not expected to result in deleterious effects; about 75% of adults hold in mainstem after spawning; remainder return to ocean	95% mortality for all mainstem production; about 30% that spawn in Trinity R. would be unaffected (based on salmonid literature; effects likely overestimated)	**Juvenile Rearing (year-round) and Outmigration:** Reduced growth and up to 36% mortality; about 30% of juveniles rear in Trinity R. and would be unaffected	N/A
	Proposed Action with Mitigation Measure AR-3				
	Reduced effects due to fall flow pulse moving adults downstream	**Adult Post-spawning Holding:** Reduced effects due to fall flow pulse moving adults downstream	Same as above	**Juvenile Rearing (year-round) and Outmigration:** Same as above	N/A

Table 3.3-17. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-case Scenario (10% Exceedance Probabilities) for Pacific Lamprey, Green Sturgeon, and Suckers.

Species	Life History Stage				
	Adult migration	**Spawning through fry emergence**	**Age 0+ rearing**	**Age 1+ rearing**	**Outmigration**
Suckers (spp)	**Proposed Action**				
	NA	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach.	NA
	Proposed Action with Mitigation Measure AR-6				
	NA	Beneficial in upper Klamath Lake due to more habitat area. Loss of all adults within the Hydroelectric Reach that will not be captured and relocated.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach since larvae and juveniles will not be captured and relocated.	Beneficial in upper Klamath Lake due to more habitat area. Loss of all individuals within the Hydroelectric Reach since larvae and juveniles will not be captured and relocated.	NA

Table 3.3-18. Comparison of Short-term SSC effects from the Proposed Action with and without Mitigation Measures; Worst-Case Scenario (i.e., 10% Exceedance Probabilities) for Freshwater Mussels.

Species	Adults	Spawning	Larvae
Freshwater mussels	**Proposed Action**		
	Major physiological stress and substantial mortality	Major physiological stress and substantial mortality during the spawning season	Major adult physiological stress and mortality will significantly reduce larval production. No information on effects of SSC on larvae. Larvae produced in downstream reaches or tributaries may contribute to population recovery.
	Proposed Action with Mitigation Measure AR-8		
	Major physiological stress and substantial mortality. Some individuals would be relocated and would assist in reseeding the population.	Major physiological stress and substantial mortality during the spawning season. Relocated individuals may spawn in upstream reaches.	Major adult physiological stress and mortality will significantly reduce larval production. No information on effects of SSC on larvae. Larvae produced by relocated individuals, in downstream reaches, or in tributaries may contribute to population recovery.

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