UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
777 Sonoma Avenue, Room 325
Santa Rosa, California 95404-4731

December 17, 2021 **Refer to NMFS No:** WCRO-2021-01946

Kimberly D. Bose, Secretary
Federal Energy Regulatory Commission
888 First Street NE, Room 1A
Washington, D.C. 20426

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Surrender and Decommissioning of the Lower Klamath Hydroelectric Project No. 14803-001, Klamath County, Oregon and Siskiyou County, California

Dear Secretary Bose:

Thank you for the Federal Energy Regulatory Commission letter of August 2, 2021, requesting initiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for the surrender and decommissioning of the Lower Klamath Hydroelectric Project No. 14803-001 (Lower Klamath Project). The Lower Klamath Project is located on the Klamath River in Klamath County, Oregon and Siskiyou County, California.

NMFS also reviewed the likely effects of the proposed action on essential fish habitat (EFH), pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1855(b)), and concluded that the action would adversely affect the EFH of Pacific Coast Salmon, Pacific Coast groundfish, and coastal pelagic EFH. Therefore, we have included the results of that review in Section 3 of this document.

This letter transmits NMFS' final biological opinion pertaining to the proposed action. This biological opinion is based on information provided and considered throughout the consultation, including the Federal Energy Regulatory Commission's August 2, 2021 transmittal letter and biological assessment, as revised and clarified by subsequent letters; discussions between NMFS and Klamath River Renewal Corporation staff; and other sources of the best scientific and commercial data available.

In the biological opinion, NMFS concludes that the proposed action is not likely to jeopardize the continued existence of the Southern Oregon/Northern California Coast (SONCC) coho salmon Evolutionarily Significant Unit (ESU), Southern Resident Killer Whale (SRKW) Distinct Population Segment (DPS), and Southern DPS eulachon, or destroy or adversely modify designated critical habitat for the SONCC coho salmon ESU, SRKW, or Southern DPS eulachon. However, NMFS anticipates non-jeopardizing incidental take of SONCC coho salmon, SRKW, and Southern DPS eulachon. An incidental take statement with reasonable and prudent measures and terms and conditions is included with the enclosed biological opinion. In addition, NMFS concurs with the Federal Energy Regulatory Commission's determination that the proposed action is not likely to adversely affect Southern DPS green sturgeon or its critical habitat, thereby concluding informal consultation for this species and its critical habitat.

Please contact Jim Simondet, Northern California Office, Arcata, at (707) 825-5171, or via email at Jim.Simondet@noaa.gov if you have any questions concerning this consultation, or if you require additional information.

Sincerely,

Alecia Van Atta
Assistant Regional Administrator
California Coastal Office

Enclosure

cc: Diana Shannon, Ecologist, Federal Energy Regulatory Commission, OEP-Division of Hydropower Administration and Compliance, Diana.Shannon@ferc.gov
Mark Bransom, Chief Executive Officer, Klamath River Renewal Corporation, mark@klamathrenewal.org
e-file ARN 151422WCR2021AR00150

Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response

Surrender and Decommissioning of the Lower Klamath Hydroelectric Project No. 14803-001, Klamath County, Oregon and Siskiyou County, California

NMFS Consultation Number: WCRO-2021-01946

Action Agency: Federal Energy Regulatory Commission

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	Is Action Likely To Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	Is Action Likely To Destroy or Adversely Modify Critical Habitat?
Southern Oregon/Northern California Coast (SONCC) coho salmon (*Oncorhynchus kisutch)* ESU	Threatened	Yes	No	Yes	No
Southern DPS eulachon (*Thaleichthys pacificus*)	Threatened	Yes	No	Yes	No
Southern Resident DPS Killer Whale (*Orcinus orca*)	Endangered	Yes	No	Yes	No
Southern DPS green sturgeon (*Acipenser medirostris*)	Threatened	No		No	

Essential Fish Habitat and NMFS' Determinations:

Fishery Management Plan That Identifies EFH in the Project Area	Does Action Have an Adverse Effect on EFH?	Are EFH Conservation Recommendations Provided?
Pacific Coast Salmon	Yes	No
Pacific Coast groundfish	Yes	No
Pacific Coast pelagics	Yes	No

Consultation Conducted By: National Marine Fisheries Service, West Coast Region

Issued By:

Alecia Van Atta
Assistant Regional Administrator
California Coastal Office

Date: December 17, 2021

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ABBREVIATIONS	MEANING
ATWG	Aquatic Technical Work Group
ARG	Aquatic Resources Group
BA	Biological Assessment
BDA	beaver dam analogue structure
BLM	Bureau of Land Management
BMI	benthic macroinvertebrates
BMP	Best Management Practice
BOD	biological oxygen demand
BRT	Biological Review Team
BPA	Bonneville Power Administration
CA	California
CARB	California Air Resources Board
CCE	California Current Ecosystem
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife (previously CDFG)
CFPR	California Forest Practice Rules
CHERP	Conservation and Habitat Enhancement and Restoration Program
cfs	cubic feet per second
CNFHC	California/Nevada Fish Heath Center
CSWRCB	California State Water Resources Control Board
CWR	Center for Whale Research
CWT	coded wire tags
DDT	dichlorodiphenyltrichloroethane
DFO	Fisheries and Oceans Canada
DO	dissolved oxygen
DOI	Department of the Interior
DPS	Distinct Population Segment
DQA	Data Quality Act
DRA	Dam Removal Alternative
DSOD	California Division of Safety of Dams
DQA	Data Quality Act
EEC	expected environmental concentration
EEZ	United States Exclusive Economic Zone
EFH	essential fish habitat
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FCH	Fall Creek Hatchery
FERC	Federal Energy Regulatory Commission
fps	feet per second
FMP	Fishery Management Plan
GEEC	generic estimated environmental concentration
GSI	genetic stock information
HAPC	Habitat Areas of Particular Concern
HCP	Habitat Conservation Plan

Abbreviations	Meaning
HGMP	Hatchery and Genetic Management Plan
HLFM	habitat limiting factors model
IEV	invasive and exotic vegetation
IFRMP	Klamath Basin Integrated Fisheries Restoration and Monitoring Plan
IGH	Iron Gate Hatchery
IOD	immediate oxygen demand
IOP	Interim Operations Plan
IP	Intrinsic Potential
IPCC	Intergovernmental Panel on Climate Change
ISAB	Independent Scientific Advisory Board
ITS	incidental take statement
KBRA	Klamath Basin Restoration Agreement
KHP	PacifiCorp's Klamath Hydroelectric Project
KHSA	Klamath Hydroelectric Settlement Agreement
KNF	Klamath National Forest
KRRC	Klamath River Renewal Corporation (Renewal Corporation)
LOEC	lowest acute or chronic effect concentration
LWD	Large Woody Debris
MOA	Memorandum of Agreement
MSA	Magnuson–Stevens Fishery Conservation and Management Act
MWCD	Montague Water Conservation District
MWAT	maximum weekly average temperature
MWMT	maximum weekly maximum temperature
NAA	No Action Alternative
NAS	National Academy of Sciences
NCRWQCB	North Coast Regional Water Quality Control Board
NFP	Northwest Forest Plan
NFWF	National Fish and Wildlife Foundation
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOEC	no observable effect concentration
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
NTU	Nephelometric Turbidity Units
NRKW	Northern Resident killer whale
NWFSC	Northwest Fisheries Science Center
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OEHHA	Office of Environmental Health Hazard Assessment
OHWM	ordinary high-water mark
OR	Oregon
PAH	Polycyclic Aromatic Hydrocarbon
PBDEs	polybrominated diphenyl ether flame retardants
PBFs	physical or biological features
PCE	primary constituent element

ABBREVIATIONS	MEANING
PCSRF	Pacific Coast Salmon Restoration Fund
PFMC	Pacific Fishery Management Council
POI	Prevalence of infection
POP	Persistent organic pollutant
PST	Pacific Salmon Treaty
ppb	parts per billion
RAMP	Reservoir Area Management Plan
RM	River Miles
RPM	reasonable and prudent measure
RQ	risk quotient
RRVID	Rogue River Valley Irrigation District
S3	Stream Salmonid Simulator Model
SEAK	Southeast Alaska
SEV	Severity of Ill Effects
SHA	Safe Harbor Agreement
SI	Sacramento Index
SOF	South of Falcon
SONCC	Southern Oregon/Northern California Coast
SR^3	Sealife Response, Rehabilitation, and Research
SRKW	Southern resident killer whales
SSC	suspended sediment concentration
SVOC	semi-volatile organic compounds
SWFSC	Southwest Fisheries Science Center
SWPPP	Stormwater Pollution Prevention Plan
SWRCB	State Water Resources Control Board
TEA	Triclopyr triethylamine salt
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorous
TRH	Trinity River Hatchery
TWG	Technical Work Group
UKL	Upper Klamath Lake
USACE	United States Army Corps of Engineers
USDOI	United States Department of the Interior
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	Unites States Geological Survey
VOC	volatile organic compound
VSP	viable salmonid population
WDFW	Washington Department of Fish and Wildlife
WSL	water surface level
YTEP	Yurok Tribe Environmental Program

1 INTRODUCTION

This Introduction section provides information relevant to the other sections of this document and is incorporated by reference into Sections 2 and 3 below.

1.1 Background

NOAA's National Marine Fisheries Service (NMFS) prepared the biological opinion (opinion) and incidental take statement (ITS) portions of this document in accordance with section 7(b) of the Endangered Species Act (ESA) of 1973 (16 U.S.C. 1531 et seq.), as amended, and implementing regulations at 50 CFR part 402.

We also completed an essential fish habitat (EFH) consultation on the proposed action, in accordance with section 305(b)(2) of the Magnuson–Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801 et seq.) and implementing regulations at 50 CFR part 600.

We completed pre-dissemination review of this document using standards for utility, integrity, and objectivity in compliance with applicable guidelines issued under the Data Quality Act (DQA) (section 515 of the Treasury and General Government Appropriations Act for Fiscal Year 2001, Public Law 106-554). The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. A complete record of this consultation is on file at California Coastal NMFS office.

This Opinion and determinations are based on information provided in the Federal Energy Regulatory Commission (FERC) Final Biological Assessment (BA) (FERC 2021a), including appendices, which was provided by the Klamath River Renewal Corporation (KRRC or Renewal Corporation); associated errata sheet and cover letter (KRRC 2021b); and other sources of the best scientific and commercial data available.

The Klamath Basin's hydrologic system consists of a complex of interconnected rivers, lakes, marshes, dams, diversions, wildlife refuges, wilderness areas, other federal and state lands, and private lands. Alterations to the natural hydrologic system began in the late 1800s and accelerated in the early 1900s. Currently, there is a complex network of water uses in the Klamath Basin, including the operation of several hydroelectric dams by the privately owned PacifiCorp (Section 1.1.1 below), the United States Bureau of Reclamation (Reclamation)'s Klamath Project (Section 1.1.2 below), and additional diversions by private users.

1.1.1 PacifiCorp's Klamath Hydroelectric Project

PacifiCorp's Klamath Hydroelectric Project (KHP) (FERC Project No. 2082) was constructed between 1911 and 1962. The KHP included eight developments: the East and West Side power facilities, Keno, J.C. Boyle, Copco No. 1, Copco No. 2, Fall Creek, and Iron Gate. Link River Dam and Upper Klamath Lake (UKL) are not part of the KHP. Although Reclamation's Link River Dam and PacifiCorp's Keno Dam currently have fish ladders that will pass anadromous fish, Iron Gate, Copco No. 1, Copco No.2, and J.C Boyle developments were not constructed with adequate fish ladders. As a result, anadromous fish have been blocked from accessing the upper reaches of the Klamath basin since the start of construction of Copco No. 1 Dam in 1911. A 50-year FERC license for the KHP was issued in 1954, prior to enactment of the ESA. Beginning in 1956, Iron Gate Dam (the most downstream mainstem dam) flow releases were generally governed by guidelines outlined in the FERC license, commonly referred to as "FERC minimum flows." In 2004, PacifiCorp filed an application with FERC for a new 50-year license for the KHP (FERC 2007; NMFS 2007a). PacifiCorp's application did not include provisions for volitional fish passage. PacifiCorp operated the KHP under the 50-year license issued by FERC in 1954 until the license expired in 2006. PacifiCorp continues to operate the KHP under annual licenses based on the terms of the previous license. Under their Federal Power Act authorities, NMFS and the United States Department of the Interior (USDOI) issued modified mandatory prescriptions for fishways and recommended certain fishery protection, mitigation and enhancement measures in the FERC relicensing proceeding in 2007 (NMFS 2007a; USDOI 2007). The mandatory fishway prescriptions provide for volitional fish passage around KHP developments as described therein. Therefore, FERC would be required to include the fishway prescriptions in a new license to PacifiCorp for the KHP. As it became clear that installation of volitional fish passage facilities would be very costly, PacifiCorp began settlement discussions with a diverse group of stakeholders in parallel with the FERC relicensing process. The settlement discussions culminated in a settlement agreement in 2010, which is further described in Section 1.1.3 below.

1.1.2 Reclamation's Klamath Project

Separate from the KHP and located upriver, Reclamation's Klamath Project is a water-management project intended to supply irrigation water for agricultural uses in the Upper Klamath Basin. Reclamation's Klamath Project also supplies water to the Tule Lake National Wildlife Refuge and the Lower Klamath National Wildlife Refuge.

NMFS and the U.S. Fish and Wildlife Service (USFWS; collectively, NMFS and USFWS are referred to as the Services) have issued several biological opinions regarding the effects of Reclamation's Klamath Project operations on ESA-listed species and critical habitat for those species over the past approximately 20 years. Among other biological opinions, in 2001 and 2002, the Services issued biological opinions on the effects of Reclamation's Klamath Project operations, and concluded that the Klamath Project operations would jeopardize two sucker species in the UKL (USFWS 2001; USFWS 2002) and the Southern Oregon/Northern California Coast (SONCC) coho salmon (*Oncorhynchus kisutch*) Evolutionarily Significant Unit (ESU) (NMFS 2001a; NMFS 2002).

Subsequently, USFWS (2008) and NMFS (2010b), issued new biological opinions on the effects of Reclamation's Klamath Project on listed suckers and coho salmon and critical habitat designated for listed coho salmon. Reclamation developed a new operation plan, and NMFS and USFWS issued a new joint biological opinion in 2013 (NMFS and USFWS 2013). More recently, Reclamation's Klamath Project operations that were affected by a 2017 court-ordered injunction[1], which required Reclamation to implement flushing flows and emergency dilution flows intended to reduce and mitigate the effects of *Ceratonova shasta* (*C. shasta*) on coho salmon in the Klamath River (NMFS 2019a). In 2017, Reclamation (2017) sent a letter to NMFS clarifying that Reclamation had reinitiated formal consultation with NMFS and USFWS on the effects of Klamath Project operations to address the exceedance of incidental take of coho salmon associated with disease infection rates that occurred during 2014 and 2015. Based on information provided in Reclamation's Final BA and subsequent addenda and clarifications, among other sources of the best scientific and commercial data available, NMFS and USFWS issued biological opinions on Reclamation's Klamath Project operations in 2019 (NMFS 2019a; USFWS 2019).

Later in 2019, the Yurok Tribe and commercial fishing organizations filed an action in United States District Court that, as amended and among other things, challenged NMFS' (2019a) biological opinion (Yurok Tribe *et al*. vs. Reclamation and NMFS 2019b; 2019a). In addition, later in 2019, Reclamation and the Services reinitiated formal consultation on Klamath Project operations based on new information that revealed effects of Klamath Project operations on ESA-listed species and critical habitat in a manner or to an extent not previously considered (NMFS 2019d; Reclamation 2019a; Reclamation 2019b). In 2020, Reclamation transmitted a proposed Interim Operations Plan (IOP) to the Services, which specifies certain deviations from Reclamation's operations plan analyzed in the Services' 2019 biological opinions under certain conditions to provide additional flows in the Klamath River for listed species (Reclamation 2020a; Reclamation 2020b). Reclamation proposed that the IOP will be in effect until the earlier of September 30, 2022, or the completion of reinitiated consultation on a modified or new proposed operation plan. NMFS agreed with Reclamation's conclusion that implementation of the proposed IOP is expected to result in reduced effects from those previously analyzed in NMFS' 2019 biological opinion and, therefore, is expected to be consistent with NMFS' determinations that Klamath Project operations are not likely to jeopardize the continued existence of SONCC coho salmon or destroy or adversely modify its designated critical habitat (NMFS 2020c). In addition, implementation of the proposed IOP is not expected to cause an effect to listed species or critical habitat that was not considered in NMFS' 2019 biological opinion. USFWS issued a biological opinion on the proposed IOP (USFWS 2020).

In April 2021, based on critically dry and extraordinary hydrologic conditions, and after coordination with the Services and other interested parties, Reclamation proposed temporary operating procedures, which would remain in effect through September 30, 2021, when Reclamation would revert to the IOP, which will remain in effect until the earlier of September 30, 2022, or the completion of ESA Section 7 consultations on a new proposed Klamath Project operations plan (Reclamation 2021a; Reclamation 2021b). In June 2021, Reclamation proposed adjustment to those temporary operating procedures (Reclamation 2021c). The Services responded to these proposals acknowledging that Reclamation had taken actions to closely

[1] *Hoopa Valley Tribe v. U.S. Bureau of Reclamation, et al.*, 2017 WL 6055456, at *1 (N.D. Cal. 2017) (order modifying injunction); *Yurok Tribe, et al. v. U.S. Bureau of Reclamation, et al.*, No. 3:16-cv-06863, at 1 (N.D. Cal. March 24, 2017)(order modifying injunction); *Hoopa Valley Tribe v. National Marine Fisheries Service, et al.,* 230 F.Supp.3d 1106, 1146 (N.D. Cal. 2017) (order granting motion for partial summary judgment and issuing preliminary injunction); *Yurok Tribe, et al. v. U.S. Bureau of Reclamation, et al.,* 231 F.Supp.3d 450, 490 (N.D. Cal. 2017) (order granting motion for partial summary judgment and issuing preliminary injunction), *appeal dismissed*, 2018 WL 7917110 (9th Cir 2018).

coordinate with the Services consistent with the processes outlined in specific terms and conditions of the Services' most recent biological opinions (NMFS 2021d; NMFS 2021c; USFWS 2021a; USFWS 2021b). Reclamation is coordinating with the KRRC to ensure its operations plans and dam removal will work together.

1.1.3 Klamath Hydroelectric Settlement Agreement

1.1.3.1 Klamath Hydroelectric Settlement Agreement, 2010

Stakeholders began efforts to reach agreement on the multifaceted issues in the Klamath Basin in the early 2000s, and the efforts to reach a settlement increased in 2001 and 2002, following the water-related farming and fisheries crises experienced in the Klamath Basin during those years. Because of a severe drought in 2001 and jeopardy biological opinions (NMFS 2001a; USFWS 2001), Reclamation restricted Klamath Project water deliveries in 2001 to agricultural users and the national wildlife refuges. However, Reclamation provided full water deliveries to irrigators in 2002 as the drought continued. In 2002, at least 33,000 returning adult Chinook salmon perished in the mainstem Klamath River due to high water temperatures, crowded conditions, and disease (Guillen 2003; Belchik et al. 2004; CDFG 2004). The likelihood that such widely traumatic cycles would continue, coupled with changes PacifiCorp would need to make in order to continue operating their hydroelectric project, led basin stakeholders and Tribes to begin collaborative discussion with the goal of developing a mutually beneficial agreement as a sustainable option for solving many of the basin's natural resource problems related to water supplies, water use, and water infrastructure.

Beginning in 2005, these collaborative discussions by a diverse group of stakeholders, including federal agencies, the States of California and Oregon, Indian tribes, counties, farming organizations, and conservation and fishing groups led to the Klamath Hydroelectric Settlement Agreement (KHSA)(KHSA 2010) and the associated Klamath Basin Restoration Agreement (KBRA)(KBRA 2010). Both the KHSA and KBRA were signed in February 2010[2] The KHSA provided a process for the Secretary of the Interior to make a determination (Secretarial Determination) whether removal of the four Facilities on the Klamath River (i.e., Iron Gate, Copco Nos. 1 and 2, and J.C. Boyle dams and appurtenant works as defined in the KHSA) would: 1) advance restoration of the salmonid fisheries of the Klamath Basin, and 2) would be in the public interest, which includes but is not limited to consideration of potential impacts on affected local communities and Tribes. As part of the Secretarial Determination process, the Department of the Interior released an overview report (USDOI 2013) that concluded that there was a high degree of certainty, based on available science, and the lack of contrary conclusions, that coho salmon and other anadromous salmonids would benefit from dam removal. As established in Section 1.1 and Section 1.2 of the KHSA, many of the parties to the settlement maintained that facilities removal would help restore many Klamath Basin resources, and the parties agreed that the purpose of the KHSA was resolving among them the pending FERC relicensing proceeding by establishing a process for potential removal of the four facilities and operation of the KHP until that time.

[2] The Federal agencies did not sign the KBRA.

1.1.3.2 Amended Klamath Hydroelectric Settlement Agreement, 2016

When Congress did not ratify the KBRA and certain provisions of the KHSA, and the KBRA expired in December 2015, parties reconvened to amend the KHSA (KHSA Signatory Parties 2016) to generate satisfactory outcomes for the Klamath Basin in the absence of the KBRA. The KHSA was amended in April 2016 (KHSA 2016), which included a process for potential removal of the four facilities through FERC's existing authority under the Federal Power Act, and the KRRC was formed to serve as the dam removal entity. The KRRC is a private, independent nonprofit 501(c)(3) organization formed by signatories of the KHSA. KRRC's work is funded by PacifiCorp customer surcharges and California Proposition 1 water bond funds, and is further supported by the states of California and Oregon (KRRC 2021d).

1.1.3.3 FERC License Transfer and Surrender

Pursuant to Sections 7.1.5 and 7.1.7 of the KHSA, on September 23, 2016, PacifiCorp and the KRRC filed a "Joint Application for Approval of License Amendment and License Transfer" (Transfer Application)(PacifiCorp and KRRC 2016) seeking a separate license for the J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate developments (the Lower Klamath Project), and to transfer the license for the Lower Klamath Project from PacifiCorp to the KRRC. Concurrent with this filing, the KRRC filed an Application for Surrender of License for Major Project and Removal of Project Works (Surrender Application)(KRRC 2016), seeking FERC's approval of an application to surrender the license for the Lower Klamath Project.

FERC issued a notice of the Transfer Application and the Surrender Application on November 10, 2016. FERC initiated informal consultation with (a) the USFWS and NMFS under Section 7 of the ESA and the joint agency implementing regulations at 50 CFR Part 402; and (b) NMFS under Section 305(b) of the MSA and implementing regulations at 50 CFR Part 600.920. FERC also designated PacifiCorp and the KRRC as the non-federal representatives for carrying out informal consultation, pursuant to Section 7 of the ESA and Section 305(b) of the MSA (FERC 2016).

On March 15, 2018, FERC amended the KHP license, which created the Lower Klamath Project (FERC Project No. 14803), consisting of J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate developments (FERC 2018c). On June 21, 2018, FERC stayed the effectiveness of the license amendment for the Lower Klamath Project pending its final action on the transfer application (FERC 2018a). On July 16, 2020, FERC approved a partial transfer of license to the KRRC. FERC required PacifiCorp to remain as co-licensee following KRRC's acceptance of such transfer through license surrender (FERC 2018b). On November 17, 2020, PacifiCorp and the KRRC filed an Amended License Surrender Application (PacifiCorp and KRRC 2020a). This application included the Definite Decommissioning Plan (PacifiCorp and KRRC 2020b), which is the KRRC's comprehensive plan to physically remove the Lower Klamath Project and achieve a free-flowing condition and volitional fish passage, site remediation and restoration, and avoidance of adverse downstream impacts; and a Memorandum of Agreement (MOA) (PacifiCorp and KRRC 2020c), which was reached among PacifiCorp, the states of California and Oregon, the KRRC, and the Yurok and Karuk Tribes.

A joint license transfer application was filed on January 13, 2021 (PacifiCorp et al. 2021), that incorporated provisions from both the FERC's July 15 partial transfer of license order as well as the MOA. The application proposed that the states will be co-licensees (rather than PacifiCorp) with the KRRC for purpose of license surrender. On February 25, 2021, the KRRC filed with FERC final decommissioning design specifications and sixteen management plans establishing the resource protection measures (KRRC 2021e). On June 17, 2021, FERC issued an order approving transfer of the license for the Lower Klamath Project from PacifiCorp to the KRRC and the states of California and Oregon (FERC 2021d). On the same date, FERC issued a notice of intent to prepare an environmental impact statement for the proposed Lower Klamath Project surrender and removal, which included a list of permits and authorizations that are anticipated to be required for the proposed surrender and removal, including consultation under ESA Section 7 with NMFS (FERC 2021e).

1.1.4 Additional Relevant ESA Consultations and Permits

In accordance with Section 10(a)(1)(B) of the ESA, PacifiCorp finalized two Habitat Conservation Plans (HCPs) for interim operation of the KHP prior to the potential removal of the four hydroelectric developments as part of the KHSA or prior to implementation of mandatory fishways that would be required under any new license for the KHP if the KHSA was terminated for any reason. The HCP for coho salmon was finalized in 2012 (PacifiCorp 2012), and the HCP for Lost River and shortnose suckers was finalized in 2013 (PacifiCorp 2013). NMFS and USFWS issued associated incidental take permits for coho salmon and Lost River and shortnose suckers, respectively. Under the HCPs, PacifiCorp is responsible for implementing several extensive conservation measures, as described in the HCPs.

In 2012, Reclamation requested early consultation with NMFS and USFWS and a preliminary biological opinion pursuant to Section 7(a)(3) of the ESA and the EFH provisions of the MSA for the proposed removal of the four hydroelectric developments. On November 19, 2012, NMFS and the USFWS issued a joint preliminary biological opinion, and NMFS issued a MSA EFH consultation response, based on Reclamation's proposed action for dam removal (NMFS and USFWS 2012).

On October 31, 2014, NMFS issued a permit to the California Department of Fish and Wildlife (CDFW) in accordance with ESA section 10(a)(1)(A) for scientific and enhancement purposes (NMFS 2014b), which authorizes take of SONCC coho salmon associated with implementation of the Hatchery and Genetic Management Plan (HGMP) for the Iron Gate Hatchery (IGH) coho salmon program (CDFW 2014).

1.1.5 United States Fish and Wildlife Service ESA Listed Species

Federally-listed species, and in some cases their associated critical habitat, that fall under the jurisdiction of the USFWS that are also affected by FERC's proposed action include Lost River sucker (*Deltistes luxatus*), shortnose sucker (*Chasmistes brevirostris*), bull trout (*Salvelinus confluentus*), Northern Spotted Owl (*Strix occidentalis*), Oregon Spotted Frog (*Rana pretiosa*) and Franklin's bumble bee (*Bombus franklini*). The USFWS is preparing a separate, but coordinated, opinion regarding the effects of the proposed action on these species and affected critical habitat.

1.2 Consultation History

The following items describe important activities that are relevant to, and including, initiation of consultation on the proposed action:

The removal of the four Klamath dams was previously evaluated in the Reclamation (2012b) BA and the NMFS and USFWS joint preliminary biological opinion (NMFS and USFWS 2012). While the proposed action is largely the same as the action evaluated in the Reclamation (2012b) BA and in the NMFS and USFWS (2012) joint preliminary biological opinion, there are important changes to the proposed action requiring a new consultation. These changes include: FERC, not Reclamation, acting as the federal action agency as per the revised process for dam removal described in the amended KHSA (Section 1.1.3.2 above); updated information related to listed species and designated critical habitat under the ESA; and updated information related to environmental baseline conditions. The consultation history that occurred between January 26, 2011 and November 2, 2012 is described in the NMFS and USFWS (2012) joint preliminary biological opinion.

Between 2012 and 2017, stakeholder discussions and other activities related to dam removal continued (see Background Section 1.1.3, KHSA, above). As described above, FERC issued a notice of the Transfer Application and the Surrender Application on November 10, 2016, in which FERC initiated informal consultation with (a) the USFWS and NMFS under Section 7 of the ESA and the joint agency implementing regulations at 50 CFR Part 402; and (b) NMFS under Section 305(b) of the MSA and implementing regulations at 50 CFR Part 600.920. FERC also designated PacifiCorp and the KRRC as the non-federal representatives for carrying out informal consultation, pursuant to Section 7 of the ESA and Section 305(b) of the MSA (FERC 2016).

On April 28, 2017, a Lower Basin Agency Meeting included an overview of proposed 2017 project activities, including schedule, review and discussion of mitigation measures previously included in the NMFS and USFWS (2012) joint preliminary biological opinion, U.S. Department of the Interior and California Department of Fish and Game 2012 Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (2012 EIS/EIR) (DOI and CDFG 2012), and a Detailed Plan specific to threatened and endangered species identified in the 2012 project action area was held. Attendees included the KRRC, NMFS, USFWS, and CDFW.

On May 23, 2017, the KRRC met with representatives of federal and state agencies and Tribes to discuss the proposed action and kick off the consultation and coordination processes for ESA Section 7 compliance and for compliance with other applicable laws and regulations. As part of this consultation, the KRRC convened an Aquatic Technical Work Group (ATWG) composed of agency and tribal fisheries scientists to review and update the aquatic resource mitigation measures included in the 2012 EIS/EIR (DOI and CDFG 2012).

On May 23, 2017, the Aquatic and Terrestrial Resource Meeting included discussion of concerns specific to aquatic resource relocation and potential mortality rates of spawning and juvenile species, analysis of coho salmon effects in the BA, and proposed mitigation measures. This meeting also included a discussion on proposed survey plans and potential minimization measures for terrestrial species, including northern spotted owl and listed plants. USFWS and NMFS provided input on the listed species and potential effects to be included in the evaluation presented in the BA. Attendees included the KRRC, NMFS, USFWS, CDFW, Oregon Department of Environmental Quality (ODEQ), North Coast Regional Water Quality Control Board (NCRWQCB), State Water Resources Control Board (SWRCB); and the Hoopa Valley, Yurok, Karuk, and Klamath tribes.

On June 13, 2017, the Aquatic Resources Measures Planning Meeting included discussion of the 2012 Aquatic Resource Mitigation Measures, development and implementation of an effectiveness monitoring plan, and revised Aquatic Resource Measures Specific to Mainstem Spawning, Outgoing Juveniles, and Pacific Lamprey. Attendees included the KRRC, NMFS, USFWS, CDFW, and the Hoopa Valley, Yurok, and Karuk tribes.

August 15, 2017, Aquatic Resources Measures Planning Meeting – ongoing discussions pertaining to refinements to the 2012 Aquatic Resource Mitigation Measures, development and implementation of an effectiveness monitoring plan, and revised Aquatic Resource Measures Specific to Mainstem Spawning, Outgoing Juveniles, and Pacific Lamprey. Attendees included the KRRC, NMFS, USFWS, CDFW, Oregon Department of Fish and Wildlife (ODFW), ODEQ, SWRCB, and the Hoopa Valley, Yurok, and Karuk tribes.

October 26, 2017, Aquatic Resources Measures Planning Meeting – proposed monitoring periods, laboratory experiments for turbidity and suspended sediments, evaluation of spawning habitat, and salmonid behavioral response to high sediment loads. Attendees included the KRRC, NMFS, USFWS, CDFW, ODFW, and the Hoopa Valley and Yurok tribes.

On December 6, 2017, Section 7 Informal Consultation Meeting – Discussion of needed updates to the BA, including project and baseline changes, schedule, action area, and new species. Attendees included the KRRC, USFWS, and NMFS.

On February 8, 2018, Section 7 Informal Consultation Call – provided updates on progress on the BA, reviewed the action area, species lists, and schedule. Attendees included the KRRC, NMFS, and USFWS.

On March 6, 2018, Section 7 Informal Consultation Call – provided an update on the progress on the BA, follow up on items from the previous meeting, and a request for clarification from the Services on the action area definition. Attendees included the KRRC, NMFS, and USFWS.

On March 30, 2018, Section 7 Informal Consultation Call – provided an update on progress on the BA, discussed hatchery considerations, current status of orca, cumulative effects analysis, and ongoing coordination with Reclamation. Attendees included the KRRC, NMFS, and USFWS.

On May 3, 2018, Section 7 Informal Consultation Call – discussion of dam removal hydrology. Attendees included the KRRC, NMFS, and USFWS.

On May 18, 2018, Section 7 Informal Consultation Meeting – review and discussion of the first three sections of the BA, schedule updates, and field survey updates. Attendees included the KRRC, NMFS, and USFWS.

On June 14, 2018, Section 7 Informal Consultation Call – discussion of flood-proofing projects and United States Army Corps of Engineers (USACE) jurisdiction. Attendees included the Renewal Corporation, USACE, and NMFS.

On November 1, 2018, Section 7 Informal Consultation Call – webinar providing an overview of the Draft BA. Attendees included the KRRC, USFWS, and NMFS.

On May 8, 2019, Section 7 Informal Consultation Meeting – review schedule for project and consultation. Attendees included the KRRC, USFWS, NMFS, and PacifiCorp.

On September 24, 2019, Section 7 Informal Consultation Meeting – review and discussion of the 30% design, introduction to the project design-build team, schedule updates, and field survey updates. Attendees included the KRRC, Kiewit Team, NMFS, USFWS, and USACE.

On October 4, 2019, Meeting of the ATWG – presented 2019 data collection results, reviewed aquatic resource measures, and presented preliminary aquatic organism salvage plans. Attendees included the KRRC, Kiewit Team, NMFS, USFWS, ODFW, CDFW, and Yurok and Karuk tribes.

On October 18, 2019, Agency Visit to Project Site – site visit with a focus on proposed in-water work activities below Iron Gate Dam prior to reservoir drawdown, with discussion of potential minimization measures. Attendees included the KRRC, NMFS, CDFW, and PacifiCorp.

On November 15, 2019, Section 7 Informal Consultation Call – discussion of approaches to evaluate effects on Southern Resident killer whale. Attendees included the KRRC, NMFS, USFWS, and U.S. Geological Survey.

On March 20, 2020, Section 7 Informal Consultation Call - discussion regarding drafting of the BA, change in project regulatory lead, and drawdown engineering design advancement. Attendees included the KRRC, USFWS, and NMFS. NMFS recommended that a Technical Work Group (TWG) be established for review, coordination, and input on the reservoir drawdown effects analysis.

On April 4 through July 2, 2020, TWG meetings –nine meetings were held with a TWG to review engineering design advancements associated with reservoir drawdown. The TWG included members of NMFS, USFWS, ODFW, CDFW, Reclamation, Yurok Tribe, Karuk Tribe, and the KRRC. Meetings reviewed hydraulic modeling results, updated suspended sediment modeling results, reviewed the approach to the effects analysis for the BA, results, and the planned Aquatic Resource Measures to minimize and reduce impacts.

On April 24, 2020, TWG meeting – TWG meeting with the SWRCB and Stillwater Sciences to review the California Clean Water Act Section 401 Certification and Final Environmental Impact Report drawdown and suspended sediment analysis approach and assumptions. The TWG included members of NMFS, USFWS, ODFW, CDFW, Reclamation, Yurok Tribe, Karuk Tribe, and the Renewal Corporation.

On April 24 through June 23, 2020, Section 7 Informal Consultation Coordination Calls – five Section 7 Informal Consultation coordination calls were held to coordinate on the TWG agenda and development of the BA, including discussion and guidance on the approach to the effects analysis, results, document format, and project description. Attendees included NMFS, USFWS, and the KRRC.

On August 13, 2020, Section 7 Informal Consultation – update for NMFS on the status of the BA, document organization, and NMFS comment resolution. Attendees included NMFS and the KRRC.

On August 21, 2020, Draft BA Coordination Call – update agencies on status of the BA, discussion of areas of overlap between the agencies. Attendees included NMFS, USFWS, and the KRRC.

On August 27, 2020, TWG Meeting – meeting to discuss juvenile salmonid and Pacific lamprey rescue and relocation plan. Attendees included NMFS, USFWS, CDFW, Yurok Tribe, Karuk Tribe, SWRCB, ODFW, SWRCB, and the KRRC.

On September 16, 2020, Fish Passage Criteria Meeting – discussion about criteria for fish passage following dam removal. Attendees included ODFW, CDFW, NMFS, and the KRRC.

On October 7, 2020, Section 7 Informal Consultation – update for agencies on the project description section of the BA. Attendees included NMFS, USFWS, and the KRRC.

On October 8, 2020, TWG Meeting – discussed fish passage monitoring approach taken in the BA. Attendees included NMFS, USFWS, ODFW, CDFW, Karuk Tribe, Yurok Tribe, and the KRRC.

On October 20, 2020, Section 7 Informal Consultation – updated for agencies on the bull trout effects analysis section of the BA. Attendees included USFWS, NMFS, and the KRRC.

On January 7, 2021, Technical Working Group Meeting – established timeline for finalizing the BA, as well as the process for moving the document forward. Attendees included NMFS, USFWS, CDFW, ODFW, Yurok Tribe, Karuk Tribe, and the KRRC.

Between January 15 and March 19, 2021, TWG Meetings – eleven TWG weekly meetings were held to work toward finalization of the BA. Attendees included NMFS, USFWS, CDFW, ODFW, Yurok Tribe, Karuk Tribe, Klamath Tribe, and the KRRC. Between each weekly meeting, technical Biological Assessment calls were held with USFWS and NMFS to review and address comments for the species and effects analysis covered in the Biological Assessment.

On April 1, 2021 – 100% Design dam removal presentation and 60% restoration design presentation by KRRC Team. Attendees included NMFS, USFWS, ACOE, Bureau of Land Management (BLM), SWRCB, NCRWQCB, CDFW, ODFW, ODEQ, Yurok Tribe, Karuk Tribe, Klamath Tribes, and the KRRC.

On August 24, 2021 – Reservoir Area Management Plan (RAMP) agency comment resolution call. - Attendees included: NMFS, USFWS, CDFW, ODFW, BLM, SWRCB, and the KRRC.

On August 31 and September 9, 2021 – Aquatic Resource Management Plan agency comment resolution calls on agency provided comments for the subplans contained within the Aquatic Resource Management Plan. Attendees included: NMFS, USFWS, CDFW, ODFW, BLM, SWRCB, and the KRRC.

On October 1, 2021 – NMFS and KRRC held a call to discuss Biological Assessment questions from NMFS.

On October 6 and 7, 2021 – Copco 2 Bypass/Wards Canyon site visit. Qualitative assessment of the habitat conditions and fish passage compatibility of the reach. Attendees included: NMFS, ODFW, Yurok, Karuk, and the KRRC

On October 12, 2021 – NMFS and KRRC held a call to discuss recreation sites.

On August 2, 2021, FERC sent a letter to NMFS and USFWS requesting formal consultation on the proposed action (FERC 2021c), and transmitted the BA.

On August 16, 2021, KRRC transmitted an errata sheet and cover letter (KRRC 2021b) providing clarification on the effects determinations included in the BA for Southern Resident Killer Whale and critical habitat for this species.

On August 19, 2021, NMFS transmitted a letter to FERC indicating that the BA and associated materials provide sufficient information to initiate formal consultation and providing clarifications regarding effects determinations in the BA and its appendices (NMFS 2021e).

On October 13, 2021, FERC transmitted a letter responding to NMFS' August 19, 2021 letter, in which FERC acknowledged that NMFS did not concur with FERC's effects determinations on Southern Resident Killer Whales or their designated critical habitat, and FERC agreed with NMFS' proposed course of action to formally consult on effects to this species and critical habitat (FERC 2021b). In addition, FERC acknowledged that it is FERC's intent to consult with NMFS pursuant to both the EFH provisions in Section 305(b) of the MSA, as well as section 7 of the ESA (FERC 2021b).

On October 18, 2021, NMFS and KRRC held a call to discuss springs and habitat at Copco Lake.

On December 3, 2021, NMFS and KRRC held a call to discuss draft terms and conditions and Biological Opinion progress update.

On December 10, 2021, NMFS held a call with KRRC and CDFW to provide an update on the draft Biological Opinion and to discuss hatchery operations and monitoring post dam removal.

On December 14, 2021, NMFS held a call with KRRC to provide an update on the draft Biological Opinion, including draft terms and conditions.

On December 15, 2021 NMFS met with representatives from the Yurok Tribe, Karuk Tribe, and Hoopa Tribe to coordinate on the analysis and findings of this biological opinion.

On December 17, 2021, NMFS met with representatives from the KRRC to provide an update on the draft Biological Opinion, including draft terms and conditions.

1.3 Proposed Federal Action

Under the ESA, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies (50 CFR 402.02). Under the MSA, "Federal action" means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal agency (see 50 CFR 600.910). In this case, FERC has designated the KRRC as the non-federal representative for consultation on the license surrender and decommissioning of the Lower Klamath Project. The Renewal Corporation proposes to completely remove dams and other facilities at four developments (J.C. Boyle, Copco No.1, Copco No. 2, and Iron Gate) as detailed in the BA (FERC 2021a). This will include the complete removal of the dams, power generation facilities, water intake structures, canals, pipelines, ancillary buildings, and dam foundations. The Proposed action also includes the restoration of the areas formerly inundated by reservoirs, reconnecting tributary streams to the mainstem, stabilizing lands disturbed by the dam facilities, closing IGH, and upgrading and temporarily operating Fall Creek Hatchery (FCH).

1.3.1 Proposed Action Summary

The Renewal Corporation proposes to remove hydroelectric dams and other facilities at four developments (J.C. Boyle, Copco No.1, Copco No. 2, and Iron Gate) on the mainstem Klamath River as described in the BA (FERC 2021a). Broadly described, the proposed action is comprised of preparing the facilities for dam removal, including road improvements, dam and gate improvements, and general infrastructure modifications. When that work has been completed, the reservoirs can be drawn down in preparation for the removal of the dams themselves. Once the reservoirs are drawn down, the restoration of the former reservoir footprints and tributary reconnections will commence. Figure 1 shows the location of the dams in the context of the Klamath River watershed. Note that Copco No. 1 and No. 2 dams are part of the same facility without a considerable reservoir pool between the two dams. Therefore, reservoir restoration actions described in Section 1.3.5 below apply to the three reservoirs that will leave a significant footprint when dewatered, J.C. Boyle, Copco No. 1, and Iron Gate.

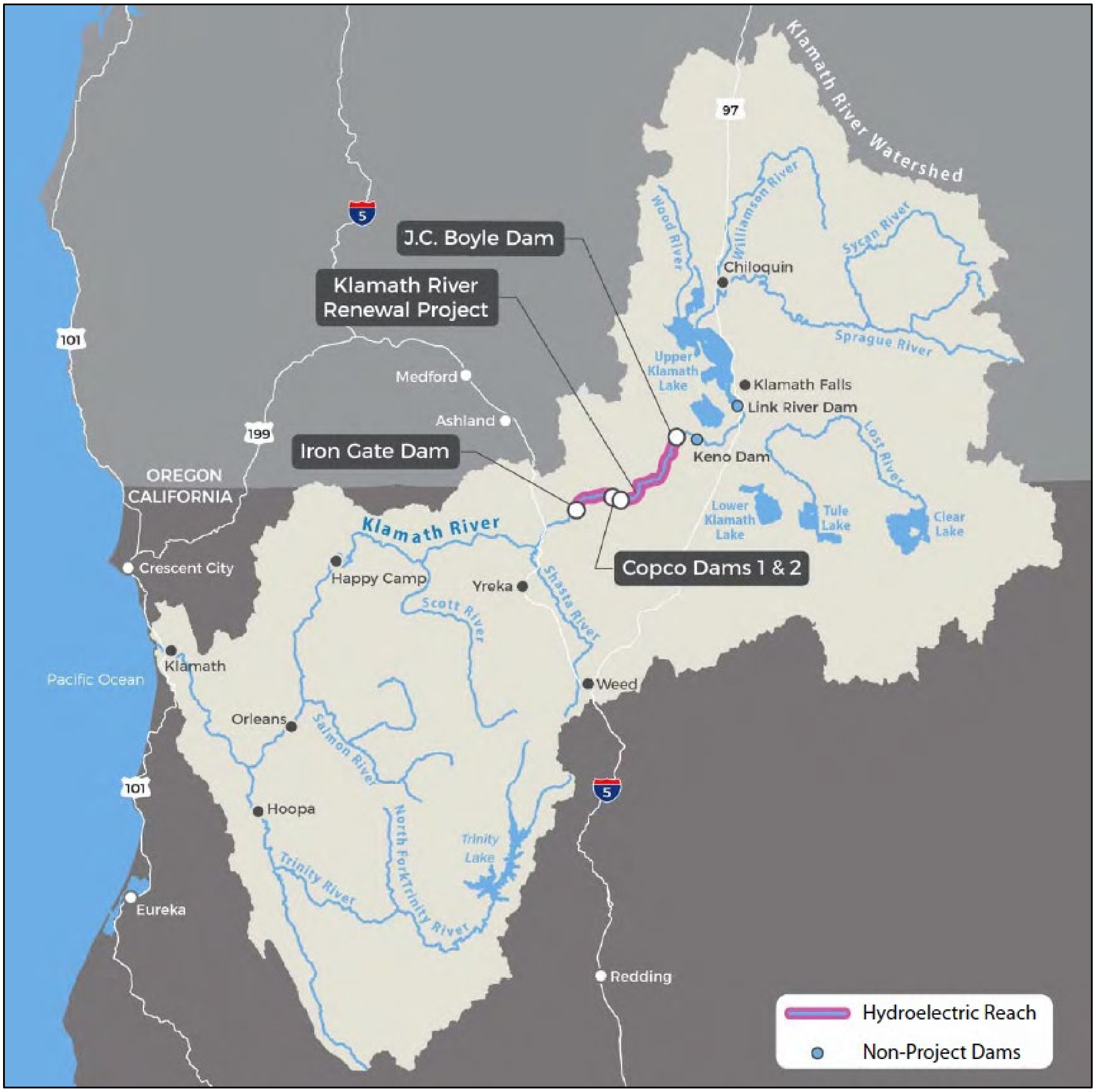

Figure 1. Klamath River watershed and facilities locations (FERC 2021a)

In order to remove the four dams, each of the reservoirs will be drawn down prior to dam removal so that the majority of the sediment can be flushed downstream during a time when high flows and increased turbidity would occur under normal ecological settings (winter). Drawdown will begin on January 1st and is expected to be completed sometime in spring. After the reservoirs are drawn down, demolition of all four dams will commence simultaneously. If possible, Copco No. 2 may be removed earlier than the other three dams. Copco No. 2 is a relatively small dam and sits just downstream from Copco No. 1. This alternative is described further in Section 1.3.4.3.

The Renewal Corporation plans to have all four dams removed by the end of the summer following drawdown, with the final breach occurring at Iron Gate Dam on or about October 1st.

This final breach will allow upstream fish migration into the Hydroelectric Reach (i.e., the reach of the Klamath River, from Iron Gate Dam to the upstream extent of J.C. Boyle Reservoir, that encompasses the four dams and associated facilities to be removed), and in the Upper Klamath Basin above the Hydroelectric Reach, for the first time in more than a hundred years.

Post drawdown and dam removal, crews will be working to actively restore the exposed reservoir footprints and tributary mouths that flow into the former reservoirs. To reduce elevated suspended sediment concentrations (SSCs), the Renewal Corporation will take active measures to flush sediment from the reservoirs during drawdown and then immediately begin stabilizing remaining sediment after drawdown has been completed. Revegetation, channel construction, and placement of habitat features such as logs and boulders will minimize erosion and allow passable channels to form in preparation of fish presence.

The IGH currently sits and the base of Iron Gate Dam and will need to be decommissioned during dam removal. However, in the KHSA, the parties agreed to continue some level of hatchery production for eight years post dam removal. Therefore, a currently closed hatchery that is located just upstream of Iron Gate Reservoir, called Fall Creek, will be upgraded and re-opened temporarily.

The implementation of the dam removal components of the proposed action is expected to occur over an approximate 20-month period while longer term monitoring and restoration actions will extend another five years beyond dam removal (see Table 1). Much of the construction associated with dam removal will occur upstream of Iron Gate Dam prior to fish having access to the upstream reaches. In this Opinion, we describe only the aspects of the proposed action that are relevant to understand the proposed action's effects on listed species and designated critical habitat. A full description of the proposed action can be found in Chapter 2 of the BA (FERC 2021a).

In this section, the proposed action is broken down into key components and organized in the relatively sequential order they are expected to occur. Table 1 outlines the components of the proposed action that may impact listed species and a simplified timeline. The following sections describe each component in more detail. Table 2 provides the position of key locations that are referenced throughout this Opinion.

Table 1. Components of the proposed action.

Proposed Action Component	Approximate Dates[1]	Related Actions
Infrastructure modifications to support drawdown and decommissioning	April 2022 to Jan 2023	1. Bridge repair/replacement, 2. Construction of temporary access roads, 3. Additional infrastructure improvements (long term).
Reservoir drawdown	Planned for January 2023 to June 2023	1. Increase of flow at dam outlet, 2. Channel construction for fish passage, 3. Controlled breach of cofferdam.
Dam and facilities removal	June 2023 to October 2023	1. Construction access and staging, 2. Disposal of waste materials.
Reservoir restoration	June 2023 to December 2028	1. Riparian revegetation, 2. Invasive exotic vegetation management, 3. Restoration of volitional fish passage, 4. Construction of instream habitat features.
Utilization of FCH	November 2022 to December 2030	1. Improvements to hatchery, 2. Operation of hatchery.

[1]The Renewal Corporation proposes that the dam and facilities removal component of the proposed action will occur during the summer to fall of 2023 as described in this table. The dates presented in this table may change if dam removal is delayed. If a delay occurs, the entire schedule will shift later by one year as drawdown must begin on January 1st of the dam removal year.

Table 2. Position of key locations on the Klamath River described in River Miles (RM)

Location	River Mile (RM)
Hydroelectric Reach	193.1 to 234.1
Link River Dam	260.5
Keno Dam	239.2
Spencer Creek	233.4
J.C. Boyle Dam	230.6
Shovel Creek	212
Copco 1 Dam	202.2
Copco 2 Dam	201.8
Fall Creek	199.8
Jenny Creek	197.4
Camp Creek	195.2
Iron Gate Dam	193.1
Bogus Creek	192.6
Willow Creek	188
Cottonwood Creek	185.1
Shasta River	179.3
Kinsman Screw Trap	147.6
Scott River	145.1
Salmon River	66.3
Orleans	59
Trinity River	43.4
Omogar Creek	10.5
Lower Estuary	0.5

1.3.2 Infrastructure modifications and construction activities

At each dam, infrastructure may need to be modified to facilitate drawdown and other dam removal activities. For example, temporary access roads will need to be built, and at Iron Gate Dam the existing diversion tunnel will need to be modified. These and other activities to facilitate dam removal are described below and locations shown in Figure 2. Construction activities that occur at locations upstream of Iron Gate Dam, including the removal of Copco Nos. 1 and 2 Dams and J.C. Boyle Dam, are not described in this section as listed species will not be able to access those locations during those actions[3], and critical habitat for NMFS's listed species has not been designated upstream of Iron Gate Dam. Complete descriptions of construction activities occurring upstream of Iron Gate Dam prior to dam removal can be found in the BA (FERC 2021a) while a summary of actions occurring at the upstream dams can be found in Table 6 of Section 1.3.8 below.

[3] Construction activities to decommission and remove these dams will occur when Iron Gate Dam still blocks listed species from accessing aquatic habitat at these dams. However, listed species and critical habitat will be exposed to the results of these construction activities, as described in the Effects of the Action section below.

1.3.2.1 Iron Gate Dam

Prior to reservoir drawdown, modifications to Iron Gate Dam will need to be completed. The following list identifies activities that will be completed near or in the water where coho salmon could be exposed, followed by a more detailed description of those activities.

1. Construction of an access road at the base of Iron Gate Dam. The road will extend from the right bank (looking downstream) across to the fish collection facilities.

2. Construction of a temporary bridge adjacent to Lakeview Road.

3. Installation of tunnel outlet erosion protection measures (e.g., armoring the existing left bank access road).

4. Construction of fire access ramp adjacent to Lakeview Road Bridge.

5. Removal of temporary access roads.

The Renewal Corporation will partially line the existing diversion tunnel as reinforcement for its use during the controlled reservoir drawdown. Additionally, a horizontal vent will be added to the tunnel. These actions will help support the large volumes of water expected to pass through the tunnel during drawdown. To complete this preliminary work, the Renewal Corporation will construct a temporary access road that approaches the site. The temporary road will start at the right bank (looking downstream) staging area and extend upstream below the spillway outlet and the diversion tunnel outlet to the fish collection facilities and the powerhouse on the left bank. Figure 2 shows the portions of the access road (in light green) that will be constructed in-water. Seepage flows from the spillway will be passed through the road with drainage culverts. This road will be extended to the diversion tunnel outlet using a small bridge to cross the existing IGH fish ladder. Use of the temporary access road requires that at least three of the six fish collection ponds be decommissioned in the pre-drawdown construction year.

The Renewal Corporation will construct the temporary access road starting July 15 of the year before drawdown and will complete the road in approximately 20 days. Approximately 1,500 cubic yards of rock fill will be placed below the ordinary high-water mark (OHWM) to support the road. Fish will be excluded from the in-water work area. The Renewal Corporation will decommission the temporary road just prior to the start of drawdown, starting on December 15 of the pre-drawdown year. The temporary access road will take approximately 10 days to remove and during this time fish will be excluded from the area of active road removal.

The Renewal Corporation will construct a fire access ramp just downstream of the current Lakeview Road Bridge. The ramp will be constructed during the in-water work window and at a similar time as the access road is being constructed at the base of Iron Gate Dam. The work will consist of minimal grading, placement of crushed rock base and steel support rails. A series of pre-cast concrete panels will be placed to create a 40-foot long by 20-foot long wide ramp. Best Management Practices (BMPs), including fish exclusion measures, will be implemented as described in Section 1.3.7.5

1.3.2.2 Construction Access and Long-term Infrastructure Improvements

The Renewal Corporation will undertake various improvements to provide adequate access and haul routes associated with construction activities. Due to the amount of truck traffic during construction and changing environment after drawdown, a number of bridges and culverts will need to be replaced or reinforced throughout the action area. The Renewal Corporation will complete nearly all of these improvements prior to drawdown and dam removal when listed species cannot be exposed to impacts. However, two Copco Road crossings will require new culverts at Camp and Scotch creeks. These new crossings will be constructed post-dam removal when coho salmon have access to those sites. Camp and Scotch creeks currently drain into Iron Gate Reservoir and will likely adjust their channel elevation post drawdown. NMFS requested the Renewal Corporation replace these culverts at least one year after drawdown so the new culverts are designed for the restored or historic channel elevation.   The Renewal Corporation will design the culverts to meet NMFS' fish passage criteria and use fish exclusion methods and BMPs described in Appendix C of the Reservoir Area Management Plan, which is Appendix C of the BA (FERC 2021a), during the replacement of these culverts.

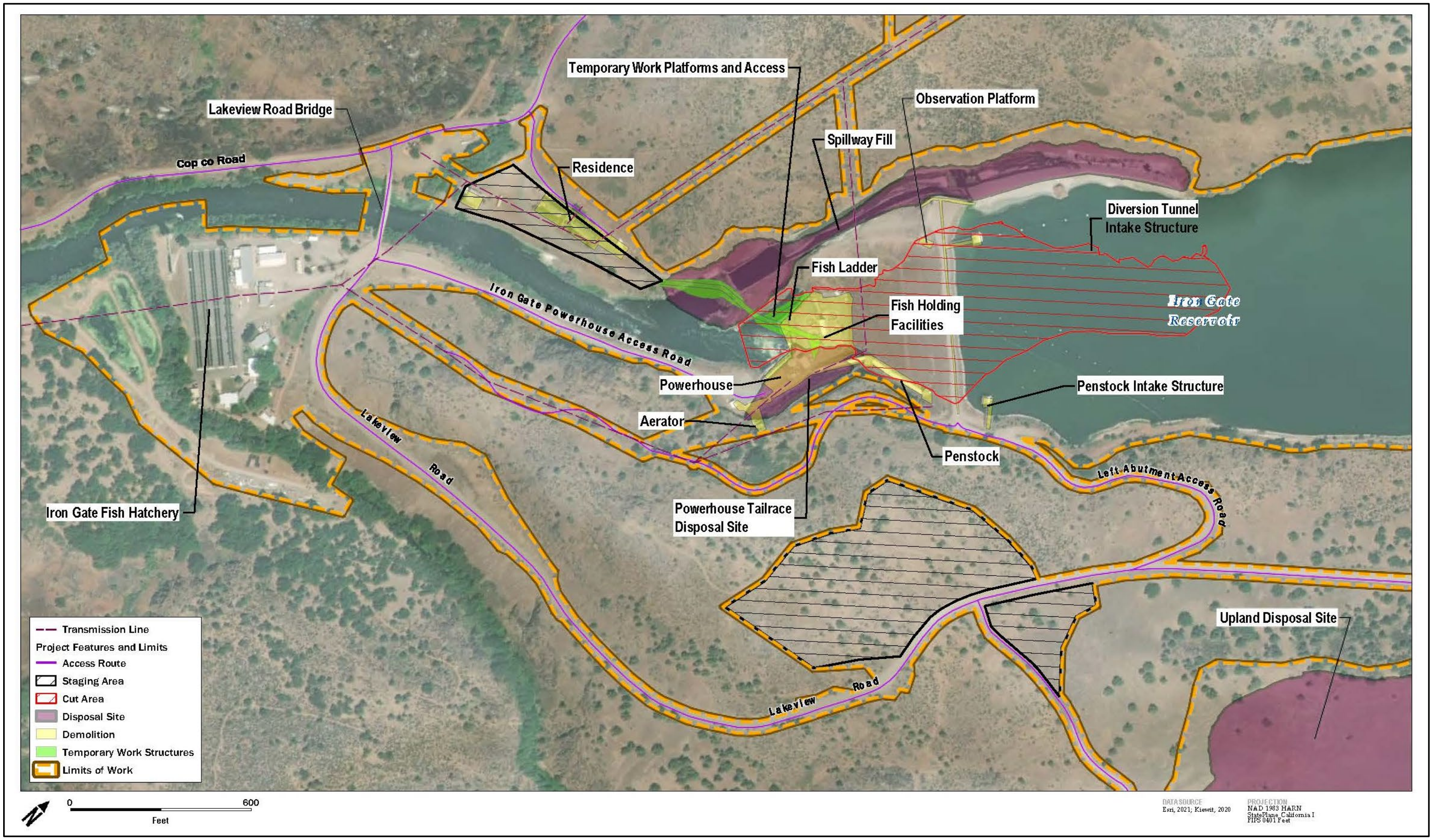

Figure 2. Iron Gate Dam Removal Features and Construction Footprint (FERC 2021a)

1.3.3 Reservoir Drawdown

Prior to drawdown, PacifiCorp will use the facilities' existing structures to bring water elevations at the reservoirs to or near their minimum allowable operating levels. Then, starting January 1 of the drawdown year (Year 1), reservoir drawdown and associated sediment release will be accomplished through regulated releases to draw down all reservoirs in a controlled manner. The regulated release will occur through the existing diversion tunnels at each of the dams. The Renewal Corporation has a target drawdown rate of five feet per day decrease in water surface level (WSL) at each reservoir. The Renewal Corporation will make use of historic cofferdams at each site that were originally constructed at low elevations to keep water out of the work area during dam construction. As the dams are deconstructed, the historic cofferdams will be used to direct water through the diversion channels and around the dams. Drawdown will continue until the reservoir levels stabilize at the elevation of the cofferdams. Details of the drawdown and diversion procedure for each facility can be found in the Renewal Corporation's 100% Design Report Rev C and the Reservoir Drawdown and Diversion Plan (Kiewit 2020). After reservoir drawdown is complete, and the natural river flow is running through the diversion tunnels, the dam deconstruction will be completed through the summer. The last step of dam removal is the breeching of the cofferdam, allowing the river to be connected to its historic channel.

In the months prior to and through dam removal, the Renewal Corporation will coordinate closely with Reclamation as Reclamation manages water supply to meet many of the Klamath Basin's competing needs while continuing to follow the terms and conditions of the incidental take statements attached to NMFS and USFWS biological opinions (NMFS 2019a; USFWS 2020). The fall/winter period is focused on refilling UKL to meet the needs of suckers in UKL, to provide flows downstream for coho salmon, and to provide water to the Klamath Irrigation Project the following spring/summer. Reclamation's process of refilling UKL will intermittently affect and/or reduce discharge rates from Keno Dam to the J.C. Boyle Reservoir. Peak spring runoff will most likely follow the initial reservoir drawdown and, depending on actual hydrology, partial reservoir refilling may result, followed by subsequent periods of drawdown. Historically, the spring freshet ends by early June. Reclamation operates Upper Klamath Lake (UKL) as described in the NMFS (2019a) and USFWS (2020) biological opinions, for which Reclamation is the action agency. Reclamation has limited flexibility in meeting specific lake threshold elevations at UKL and specific river flows downstream of Iron Gate Dam described in these biological opinions over the period of drawdown. Reclamation's operational flexibility and ability to control the WSL and maintain desired rates of reservoir drawdown will largely be dictated by storage constraints in UKL and the actual basin hydrology experienced (including magnitude, duration and frequency of inflow events) over the drawdown period. The Renewal Corporation will coordinate closely with Reclamation and the Services to ensure public health and safety are maintained, and effects to listed species are minimized to the greatest extent practicable during the drawdown period.

Drawdown start timing, sequence, and rate will be implemented based on conditions during the drawdown year to achieve the goals of maximizing sediment evacuation and providing fish passage by October following dam removal. Evaluated scenarios of riverflow conditions that would facilitate, or hinder, the drawdown schedule will help steer and determine timeline of reservoir drawdown actions. The projected water year, evaluated drawdown scenario, and projected drawdown schedule based on year of conditions will be communicated to resource agencies including FERC, California Division of Safety of Dams (DSOD), NMFS, USFWS, and other agencies.

The Renewal Corporation expects that final drawdown to historic WSL (defined as the top of the historical cofferdams) will be achieved between mid-January and mid-April in most water years. This minimum elevation will be maintained by additional water releases should reservoirs partially refill due to high inflow events.

1.3.4 Dam and Facilities Removal and Disposal

The proposed action includes the removal of dams (except for buried features that will not impact flow characteristics), power generation facilities and transmission lines, water intake structures, canals, pipelines, and ancillary buildings. The Renewal Corporation will remove hazardous materials from each dam site and from any structural components left in place, per the Abatement Specifications for each of the four developments (FERC 2021a). The Renewal Corporation will also follow these standard practices: detailed assessment of the material, identification of required abatement and special handling (if required) for each type of hazardous material, and compliance with legal disposal and transportation rules per local, state, and federal regulations. Any remaining structures will not impact flow characteristics below the 100-year flood elevation. The Renewal Corporation will conduct monitoring activities five years post-dam removal to ensure no buried structures emerge in the channel over time.

All disposal sites are located outside of the 100-year flood plain except where specifically noted. Concrete rubble and other artificial materials will not be disposed of within channel defined by the OHWM.

1.3.4.1 J. C. Boyle

J.C. Boyle Dam is located in a narrow canyon on the Klamath River. Minimum requirements for a free- flowing condition and for volitional fish passage on the Klamath River through the J.C. Boyle Dam site include partial removal of the embankment section and concrete cutoff wall beneath the embankment to the bedrock foundation to ensure long-term stability of the site and to prevent the potential development of a fish barrier at the site in the future.

Active dam deconstruction will begin in June of the drawdown year, with the objective of a volitional fish passage channel completed by October 1st of the drawdown year. The Renewal Corporation plans to breach the historical cofferdam to establish a volitional fish passage channel by the end of September, and additional channel restoration will take place afterward. The completed Klamath River channel will include fringe roughness (i.e., placement of boulders to aid fish passage) and grade slope protection to stabilize soils.

1.3.4.2 Copco No. 1

Copco No. 1 Dam is located in a narrow canyon on the Klamath River. The Copco No. 1 development consists of a dam and power plant. Minimum requirements for a free-flowing condition and volitional fish passage through the Copco No. 1 Dam site include the removal of the concrete dam between the left abutment rock contact and the concrete intake structure on the right abutment to an appropriate elevation to ensure future scour and migration of the riverbed does not expose foundational concrete that could create a fish barrier.

The Renewal Corporation plans to demolish the portions of existing roads that are on PacifiCorp property and will provide erosion protection during and post-construction. The Renewal Corporation will build a new temporary access road by pushing coarse rockfill into the river from the powerhouse or dry river access to the spillway plunge pool for a work platform at the base of the spillway. The plunge pool at the base of the dam will need to be filled and graded to match the appropriate channel elevation. The pool will be filled with clean, native-sourced rock. The material used for temporary access roads and work pads will likely be removed and used to cap disposal sites outside of the floodplain.

1.3.4.3 Copco No. 2

Copco No. 2 Dam is located in a narrow canyon on the Klamath River approximately 0.4 miles downstream of Copco No. 1 Dam with no significant reservoir pool between the two dams. If timing of permits allow, Copco No. 2 may be removed during the year prior to drawdown which would afford additional flexibility for the removal of the remaining three dams post drawdown. If timing does not allow, dam removal will occur in a similar manner but after the reservoir drawdown has been completed.

There is an opportunity to remove Copco No. 2 early because it is a much smaller dam and is located immediately downstream of Copco No. 1. Currently, PacifiCorp has the ability to dry the reach between Copco No. 1 and No. 2 for maintenance purposes. Therefore, the Renewal Corporation could dry the reach for a short period of time to accomplish removal of Copco No. 2 in advance of the other dams. Iron Gate Reservoir provides enough storage for the required downstream environmental flows during this period. If the option to remove Copco 2 the year prior to drawdown is approved, the Renewal Corporation will proceed directly to remove the entire concrete diversion dam and portion of the intake structure to the final excavation limits. The Renewal Corporation would also remove the historical cofferdam and would complete the final channel restoration at this time.

1.3.4.4 Iron Gate Dam

Iron Gate Dam is located in a narrow canyon on the Klamath River and is the downstream-most dam in the Hydroelectric Reach. Minimum requirements for a free- flowing condition and for volitional fish passage on the Klamath River through the Iron Gate Dam site require the removal of the earth-fill embankment, concrete cutoff walls, and removal of fish trapping and holding facilities located on fill downstream of the dam between the rock abutments to the bedrock foundation.

Figure 2 shows the details of the Iron Gate Dam work site. Detailed designs including temporary access roads, disposal sites, final channel design, and other dam removal features can be found in Appendix A of the BA (FERC 2021a).

During pre-drawdown, The Renewal Corporation will construct a temporary access road as described in Section 1.4.1.2. The Renewal Corporation will start excavation of the embankment section at Iron Gate Dam in early summer of the drawdown year and will complete excavation by early October. The Renewal Corporation anticipates flow rates in the Klamath River to decrease (via the normal hydrologic cycle) throughout the dam removal period, which will result in low river flows around the time of the final cofferdam breach. The Renewal Corporation will notch the remaining embankment and will progressively downcut the embankment to provide a controlled release of the remaining reservoir. This process will restore natural flows in the Klamath River channel and allow for final embankment removal and closure of the diversion tunnel.

Additionally, the Renewal Corporation will deconstruct all remaining fish facilities from IGH, including collection ponds, the fish ladder, water supply lines, holding tanks, and the spawning building that were not removed during pre- drawdown construction.

1.3.5 Reservoir Restoration

1.3.5.1 Expected Reservoir Conditions Following Dam Removal

The restoration actions within the reservoir footprints are described in the Reservoir Area Management Plan (Appendix C in FERC 2021a) and updated with information from the 100% Design Report Rev C (Kiewit 2020).

The Renewal Corporation will simultaneously drawdown the J.C. Boyle, Copco No. 1, and Iron Gate reservoirs and allow the accumulated sediment to naturally erode and evacuate from the reservoir areas. The accumulated sediment is predominantly silt, clay, and organic material that is more than 80 percent water, and highly erodible (Reclamation 2011b). Reclamation used both one-dimensional (1D) and two-dimensional (2D) sediment transport models to predict likely sediment transport and river conditions in the reservoirs after dam removal. Reclamation estimated that approximately 50 percent of the stored sediment in the reservoirs will be eroded during drawdown for a median water year with a range of 41 percent to 65 percent for dry and wet years, respectively (Reclamation 2011b).

The Reservoir Area Management Plan (Appendix C in FERC 2021a) summarizes the previous hydraulic modeling completed by Reclamation and the anticipated responses of the reservoir areas to drawdown. Anticipated responses include erosion of reservoir deposits; slumping of saturated sediment deposits toward the river channel due to limited shear strength and draining of water from the pore spaces of the deposits; and drying, consolidation, cracking, and hardening of remaining deposits. During development of the 100% design Rev C, the Renewal Corporation used updated (2018) topographic and reservoir bathymetric surveys to estimate post-drawdown topography. The Renewal Corporation used a variety of survey data to estimate topography of the reservoirs after drawdown and estimated residual sediment thickness in the restored Klamath River channel and in high-priority tributaries.

Each reservoir has distinct features and characteristics. For instance, Copco No. 1 Reservoir has a large floodplain and meandering historical river planform, while the historical channel in the lower reaches of J.C. Boyle Reservoir was confined to a narrow canyon. Reservoir restoration projects described below are tailored to the specific landscapes of each reservoir.

1.3.5.2 Restoration Strategy and Priorities

Primary reservoir restoration actions for J.C. Boyle, Copco No. 1, and Iron Gate will be the following as described above: (1) reservoir drawdown, (2) sediment evacuation, and (3) dam removal. The Renewal Corporation will perform additional restoration actions to provide volitional fish passage, selectively stabilize residual sediments, and encourage native plant establishment. In addition, the Renewal Corporation will take supplemental restoration actions to enhance aquatic habitat in prioritized locations. The Reservoir Area Management Plan (Appendix C of FERC 2021a) describes measures for restoration implementation, monitoring, and adaptive management of the exposed reservoir bottoms and surrounding areas disturbed as part of the proposed action. The majority of in-water restoration work will be conducted in the year after dam removal when the river has had a year to stabilize post-drawdown.

The Reservoir Area Management Plan (Appendix C of FERC 2021a) defines the restoration elements, establishes restoration performance criteria, and specifies monitoring and adaptive management approaches for river geomorphology and associated riparian and upland revegetation. The sections below provide a summary of the reservoir restoration approach and actions.

Restoration actions described herein include multiple options the Renewal Corporation will apply based on existing information, and during subsequent restoration design iterations that will be based on observed and measured post-drawdown conditions. These include the following:

- Implementing measures to encourage sediment evacuation during drawdown.
- Reconstructing a geomorphically appropriate channel through the former dam footprints.
- Selective post-drawdown grading of mainstem near-channel areas and priority tributaries as needed to provide volitional fish passage, remove large, unstable residual sediment deposits, and where cost-effective and feasible, improve hydrologic connectivity to off-channel and floodplain areas to establish and sustain native riparian vegetation and enhance aquatic habitat.
- Installing large wood and boulder clusters to enhance habitat.
- Installing willow baffles to provide floodplain roughness and to encourage vegetation establishment and selectively stabilize sediments.
- Revegetating formerly inundated areas primarily through seeding to slow erosion and re-establish native plant communities.
- Selectively planting and irrigating locally salvaged and/or nursery-sourced plants, including wetland sod, willow cuttings, bare root trees and shrubs, and acorns.
- Controlling high-priority invasive and exotic vegetation (IEV) prior to, during, and following construction (2021-2024) where cost-effective and feasible.

- Fencing select locations to protect restored reservoir areas from trampling and herbivory by cattle and wild horses.

The restoration strategy for reservoir footprints is designed to be flexible and adaptive based on observed conditions post-drawdown. The Renewal Corporation will review channel response within the mainstem Klamath River and priority tributaries following drawdown, and information obtained during the monitoring process will be used to inform decisions regarding design for active restoration (construction) or continued monitoring of channel response. The adaptive management process is described in FERC's (2021a) BA, Appendix C, Section 6. Restoration priorities are driven by the primary project goals of volitional fish passage, residual sediment stabilization, native plant establishment, and the secondary goal of enhancing native fish habitat.

1.3.5.3 Management of Remaining Reservoir Sediment and Vegetation Establishment

The Renewal Corporation describes a detailed plan for sediment stabilization, revegetation, and erosion control post drawdown. However, much of the effort will occur pre-dam removal and in upland locations where fish and instream habitat will not be exposed to potential adverse effects. Additional details can be found in FERC's (2021a) BA, Appendix C.

Stabilization of remaining reservoir sediment will be achieved through revegetation at the three reservoirs with significant footprints (i.e., Iron Gate, Copco No. 1, and J.C. Boyle). Vegetation restoration focuses on control of IEV species and revegetation of the reservoir areas with native grasses, shrubs, and trees as the primary method for sediment stabilization and riparian, wetland, and upland restoration. To implement this plan and manage the remaining reservoir area sediments, the Renewal Corporation will use a two-pronged approach that consists of revegetation and active habitat restoration with monitoring and adaptive management. As part of this approach, the Renewal Corporation will conduct selective grading to remove unnatural erosion-resistant deposits that create fish passage barriers and to stabilize un-evacuated sediment at vulnerable high-sediment yield locations.

The Renewal Corporation will implement two primary strategies for IEV treatment: eradication and containment. The Renewal Corporation will adaptively manage treatments through a robust quantitative monitoring program. Treatments will require a combination of methods including mechanical (grubbing, mowing) and chemical. The Renewal Corporation will minimize chemical treatments for use only on species that are not effectively treated mechanically. The Renewal Corporation will not use helicopter or other mechanical sprayers. It is anticipated that a 10 to 50- foot buffer along up to 49 miles of access roads that includes the area around Iron Gate to Copco Lake and J.C. Boyle Powerhouse to the upper extent of J.C. Boyle Reservoir will be treated for IEV. Section 1.3.7.4 summarizes the BMPs to be implemented during IEV treatment. Additional details can be found in the Reservoir Area Management Plan (Section 5.3.3 of Appendix C of FERC 2021a).

Monitoring associated with restoration of the reservoir areas is designed to measure progress toward achieving the project goals, inform potential adaptive management needs, and provide feedback into river and reservoir area conditions to evaluate whether sites are trending towards or away from achieving the goals of the proposed action. The Renewal Corporation has identified physical site characteristics as appropriate monitoring metrics using standard field techniques to produce data compatible with standard protocols derived from previously developed dam removal monitoring and adaptive management plans. Monitoring strategies will include use of photo points, aerial photos, and LiDAR data. The Reservoir Area Management Plan (Appendix C of FERC 2021a) provides monitoring parameters that include stability of remaining reservoir sediments, fish passage, IEV, native plant revegetation, and restoration of natural ecosystem processes.

1.3.5.4 Restoration of Klamath River Channel and Tributaries within the Reservoir Footprint

The Renewal Corporation expects that the Klamath River in the reservoir areas will re-occupy the historical channel alignment due to geological constraints and the erosion of fine sediments accumulated in the reservoir bottoms during and immediately following drawdown. This conclusion was reached from both a geomorphic evaluation and a two-dimensional hydraulic modeling analysis by Reclamation (2012b). Because the Klamath River channel has not been altered since construction of the dams, the Renewal Corporation expects that the river will return to a natural gravel/cobble-bed river and behave similarly to pre-dam conditions. One exception is that riparian vegetation, primarily willows, may not be established on the banks, but will be planted with the revegetation efforts. The Renewal Corporation will implement the detailed riparian revegetation plan in the Reservoir Area Management Plan (Appendix C of FERC 2021a) to restore the Klamath River in the reservoir areas and restart natural river processes.

Habitat restoration on the floodplains and tributaries that flow into the Klamath River in the reservoir areas is critical to restoring natural ecosystem processes to the Hydroelectric Reach. The Renewal Corporation will complete most all of the instream restoration projects in the year after dams are removed. Localized instream work may be necessary for maintenance in the years following dam removal when guided by monitoring results. Post dam removal maintenance activities are described below in Section 1.3.5.5. The Renewal Corporation will implement the following restoration techniques in the reservoir areas as appropriate.

Tributary Connectivity:

After the reservoirs have been drawn down, tributaries that enter the reservoir footprint will carve new channels through remaining sediment before reaching the newly established Klamath River channel. The Renewal Corporation will work to ensure tributaries and their confluences with the Klamath River stabilize quickly and avoid fish passage barriers. The Renewal Corporation will use light equipment and manual labor to move materials and enhance access and longitudinal connectivity of the tributaries with the mainstem Klamath River. In addition, the Renewal Corporation will add large wood to tributaries either in the channel or on the floodplain/terrace to promote habitat and complexity and connectivity. Table 3 describes the key tributaries that will be restored and anticipated lengths of their channels to be restored.

Table 3. Tributary Restoration Lengths

Tributary	Anticipated Length (ft)
Spencer Creek	106
Beaver Creek	501
Jenny Creek	885
Scotch Creek	1204
Camp Creek	6181

Wetlands, Floodplain, and Off-Channel Habitat Features:

The Renewal Corporation will incorporate floodplain features into exposed floodplains, including wetlands, floodplain swales, and side channels. Restoration of these features are described as follows:

- Wetland restoration strategies for the reservoir areas include preservation of existing non-reservoir-dependent wetlands, hydrologic connection of off-channel wetlands with the river, or creation of new wetlands at lower elevations corresponding to the post-dam removal surfaces and hydrologic regime.

- Floodplain swales are small depressional areas incorporated into the floodplain that provide microsites where floodplain vegetation can establish at slightly lower elevations (closer to the water table) than adjacent floodplain surfaces. To maximize diversity, floodplain swales vary in size and depth, but do not extend below the anticipated baseflow elevation.

- Side channel restoration strategies include modifying inlet and outlet hydraulics, improving hydraulic complexity with structures or realignment, and delivery of water to higher floodplain surfaces.

Floodplain Roughness:

The Renewal Corporation will apply floodplain roughness as a strategy in exposed areas where frequent interaction with the river channel is anticipated. Floodplain roughness is created using equipment to roughen the floodplain surface and partially bury brush, limbs, and wood in the soil. Brush, limbs, and wood in the soil will increase moisture retention, create protective microsites for establishing seed and plants, and promote soil development by introducing organic material. The Renewal Corporation anticipates using willow baffles and large wood to create floodplain flow obstructions that promote sediment re-working and reduce floodplain flow velocities.

Riverbank Stability and Channel Fringe Complexity:

The Renewal Corporation will introduce channel fringe complexity through the riparian revegetation and strategic addition of bank complexity (i.e., vegetation, rootwads, etc.), large wood, and boulders to create velocity shadows, improve bank stability, and reduce unnatural erosion. Boulder clusters will be locally sourced, oversized boulders (approximately 2 to 6 feet in diameter) at select locations along high-priority tributaries to enhance habitat. The number and size of boulders will vary depending on location and function.

Large Wood Habitat Features:

The Renewal Corporation will use large wood to improve habitat and promote reservoir area conditions that restore natural ecosystem processes and protect vegetation during the initial years of establishment. Large wood feature design and implementation will emulate natural river processes to allow all wood to be dynamic and provide long-term complexity. The Renewal Corporation will strategically place each large wood feature based on post-drawdown topographic and hydraulic conditions. The Renewal Corporation will not use any artificial anchoring (duckbill anchors, cables, pins, bolts, etc.) to ballast wood elements. The placement of large wood habitat features will primarily be in tributaries and will consist of several rootwad logs or trees placed in strategic arrangements or complexes.

The Reservoir Area Management Plan (Appendix C of FERC 2021a) contains detailed descriptions of the restoration approach, design information, maps, and additional information on reservoir area restoration with these techniques and applicable locations for implementation.

1.3.5.5 Maintenance and Monitoring Post Dam Removal

After restoration work is complete at the end of the construction period, some additional grading work may be needed at tributary locations during the maintenance period (anticipated over a five-year period following the construction period). Additional in-water work that may occur during the maintenance period could include maintenance actions focused on ensuring fish passage, stopping or limiting headcut migration, and removing residual reservoir sediment. The Renewal Corporation expects in-water work to be minimized but could occur at different locations over time in accordance with the fish passage monitoring, maintenance activities, and adaptive management detailed in the Reservoir Area Management Plan (Appendix C of FERC 2021a), Section 6.0., conservation measures to exclude fish from in-water work sites, will be implemented post dam removal when coho salmon may be present.

1.3.5.6 Fish Hatcheries

The existing IGH facilities, operated by CDFW, are part of the Lower Klamath Project. With the removal of Iron Gate Dam, the Renewal Corporation will also remove the water intake and fish capture, holding, and spawning facilities at the hatchery. The Renewal Corporation will move the hatchery operations to the Fall Creek Fish Hatchery which requires significant upgrades and construction to support proposed operations.

Under the KHSA, PacifiCorp will fund 100 percent of hatchery operations and maintenance necessary to fulfill annual mitigation goals developed by CDFW in consultation with NMFS. PacifiCorp's funding will be provided for hatchery operations to meet mitigation requirements and will continue for 8 years following the decommissioning of Iron Gate Dam. Therefore, hatchery operations at Fall Creek are temporary.

In this section, we describe the components of the hatchery plan that involve impacts to listed species and habitat due to facility modification and construction as well as changes in hatchery production numbers as it relates to long term population viability and prey resources for Southern Resident Killer Whales. Although the Renewal Corporation is responsible for construction of the hatchery and PacifiCorp is primarily responsible for the funding for eight years after dam removal, CDFW will manage and operate the hatchery in a manner consistent with what already occurs at the Iron Gate Hatchery. The impacts to coho salmon as a result of these hatchery operations have been analyzed during the ESA Section 7 consultation relating to issuance to issuance of ESA Section 10(a)(1)(A) Permit 15755 to CDFW for enhancement and scientific purposes for implementation of an HGMP for the coho salmon program at the Iron Gate Hatchery. Operations already analyzed include broodstock collection, hatchery releases, water quality impacted by hatchery operations, and monitoring and evaluation of the program. NMFS, in coordination with CDFW, is evaluating the current HGMP to determine the extent of modifications necessary to update the HGMP and permit as a result of the planned relocation of hatchery operations to Fall Creek. The revised HGMP would evaluate operations over the planned eight-year term of the Fall Creek hatchery. Therefore, in this opinion, NMFS describes aspects of the proposed action, such as the initial construction actions at Fall Creek, that may impact listed species that have not already been considered in the existing HGMP and associated ESA Section 7 consultation.

During the initial construction required to modify Fall Creek hatchery, listed species will not be impacted. All modifications will be completed prior to dam removal so that fish can be relocated from IGH prior to drawdown. Although hatchery operations will commence at Fall Creek, NMFS expects wild salmonids to repopulate Fall Creek post dam removal.

Figure 3 shows the general layout of the re-designed FCH. The hatchery is located toward the upstream limit of anadromy on Fall Creek for fish that will repopulate Fall Creek post dam removal. Two existing dams (Dam A and B) are located just upstream of the hatchery and have the potential to impact coho salmon that return to Fall Creek post dam removal. The adult trap used to capture broodstock is downstream of the dams. Dam A is located in an artificial channel called the "tailrace" where fish repopulating Fall Creek will have access. Dam B is just upstream of the tailrace channel on Fall Creek and just below the falls which are a barrier to anadromy. Both dams will be modified as part of the FCH modification process.

1.3.5.7 Fall Creek Barrier Construction

Fall Creek is currently used by both PacifiCorp for hydroelectric power generation and by the City of Yreka for a municipal water supply. Hatchery upgrades and operations need to work around existing infrastructure supporting PacifiCorp and the City of Yreka. This section describes how listed species moved to the hatchery or repopulating Fall Creek post dam removal will be protected from existing infrastructure operations in Fall Creek. Figure 3 provides a layout of the proposed FCH and other infrastructure.

The primary Fall Creek diversion that supports the City of Yreka is called Dam A. Dam A is located in the tailrace of the PacifiCorp Fall Creek powerhouse, and consists of a low concrete dam with spillway notch and sluice gate. A secondary diversion point on Fall Creek is used whenever the power plant is shut down. This diversion, called Dam B, supplies water through a pipeline to the headworks structure at Dam A and then to the Yreka water supply pipeline.

The Renewal Corporation will improve both Dams A and B with velocity aprons to ensure no fish can pass either of the dams where little to no suitable habitat is present upstream. The existing fish screens at the intake near Dam A do not meet current NMFS criteria for anadromous fish and pose a threat of entrainment. Additionally, Dam A is located on an artificial tail race channel and is not blocking access to natural habitat. Dam B is located within natural habitat but does not have a fish screen. However, Dam B is approximately 80 feet downstream of the Fall Creek falls with a steep gradient and no suitable spawning or rearing habitat upstream of the dam. Therefore, The Renewal Corporation will enhance the barriers to ensure juvenile and adult fish are not exposed to the City of Yreka's intake structures upstream of the dams.

To supply water to the FCH, CDFW may divert up to 10 cubic feet per second (cfs) of water from PacifiCorp's hydro- generation tailrace canal supplied from the pool behind Dam A or from a supplemental supply location on Fall Creek above Dam B. Water will be gravity-fed and plumbed to each rearing location. During periods when the powerhouse tailrace is not flowing, hatchery water will be diverted from Dam B to Dam A to ensure the tailrace canal is not dewatered and can support any fish that may repopulate Fall Creek and may be rearing in the tailrace channel.

Additionally, the Renewal Corporation will construct a removable fish exclusion picket barrier adjacent to the fish ladder (just downstream of the Fall Creek bridge) that will guide fish to the fish ladder entrance pool and ultimately up to the trap. The weir will be in place only during spawning months. Adult fish will be collected to meet broodstock and production goals for the hatchery. Any additional adult fish will be released to Fall Creek for spawning. The picket barrier system will consist of a set of aluminum pickets with 1-inch-maximum clear spacing that will be installed on a permanent concrete sill and removed each year at the beginning and end of the trapping season. The 1-inch spacing is expected to allow fish passage for upstream rearing juveniles.

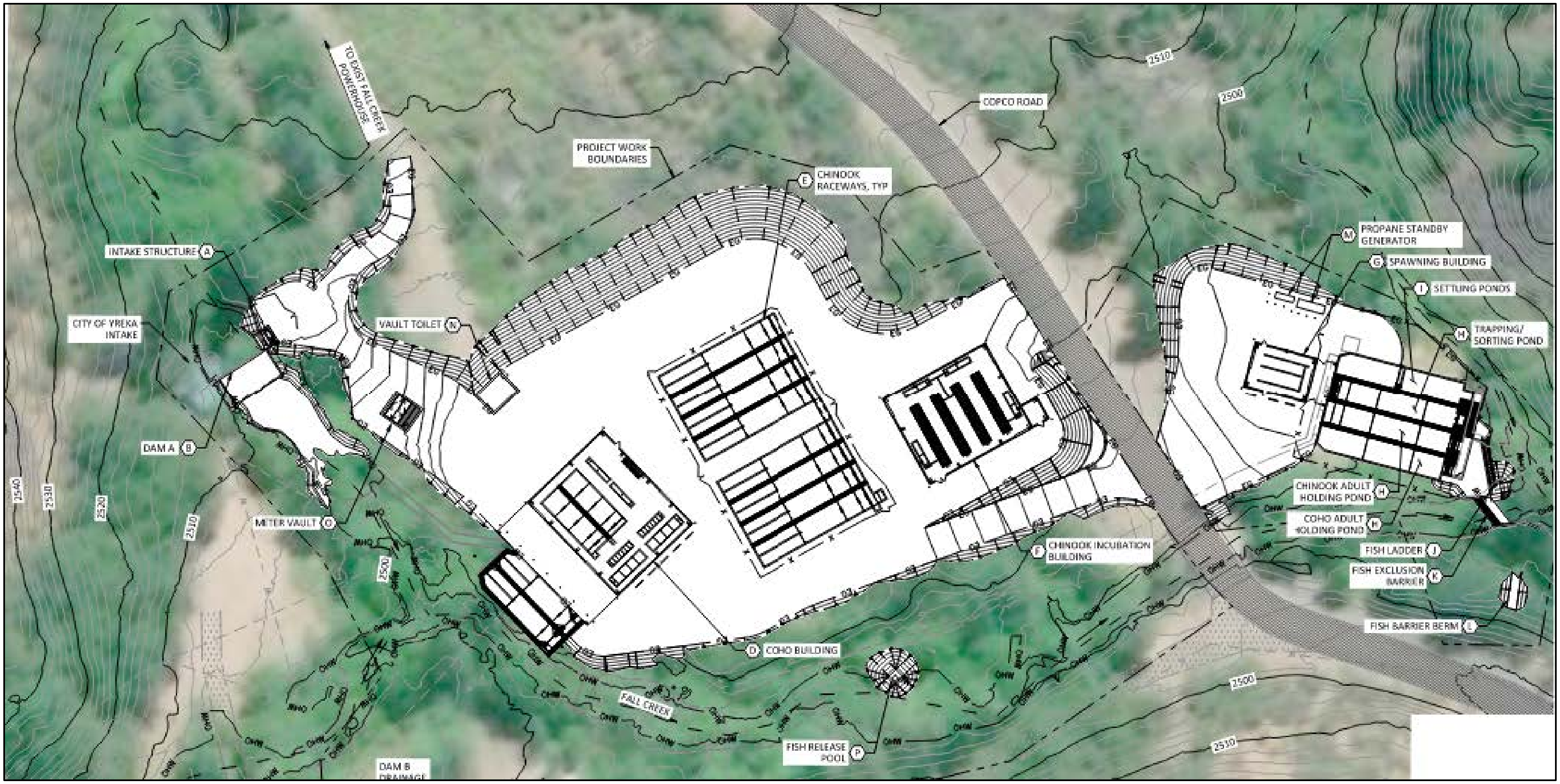

Figure 3. General site layout for proposed Fall Creek Hatchery (FCH)(FERC 2021a)

1.3.5.8 Hatchery Production Goals

The Renewal Corporation developed new hatchery production goals in consultation with NMFS and CDFW that prioritize fish production goals during the 8-year period following dam removal. As a state- and federally listed species in the Klamath River, coho salmon production is the highest priority for NMFS and CDFW, followed by Chinook salmon, which support tribal, sport, and commercial fisheries. Chinook salmon are also a valuable prey source for listed Southern Resident Killer Whales. Steelhead production is the lowest priority. Due to limited water availability and rearing capacities at the two facilities and recent low hatchery steelhead returns, NMFS and CDFW have recommended that steelhead production be discontinued.

Table 4 summarizes the NMFS and CDFW recommendations for fish production. The production goal for coho salmon, which are the highest priority for hatchery production due to their ESA listed status, will remain the same. However, due to limited production capacity at FCH relative to IGH, the production goal of Chinook salmon will be reduced post-dam removal. The production goal for steelhead will be eliminated; the steelhead program has not produced steelhead since 2012 due to a lack of adults returning to IGH. The reduction of Chinook salmon production is part of the proposed action considered in this biological opinion.

Table 4. Comparison of Hatchery Mitigation Requirements and NMFS/CDFW Production Recommendation

Species / Life Stage	**Current Production Goal (at IGH)**	**Production Goal Post-Dam Removal (at FCH)**	**Release Dates**
Coho Yearlings	75,000	Minimum of 75,000	March 15 – May 1
Chinook Yearlings	900,000	Minimum of 250,000	Oct 15 – Nov 20
Chinook Smolts	5,100,000	Up to 3,000,000	April 1 – June 15
Steelhead	200,000	0	N/A

Non-consumptive water diversion from Fall Creek will support hatchery operations using the existing CDFW water right on Fall Creek; the water will return to the creek at the fish ladder on the eastern side of Fall Creek.

1.3.6 Recreational Facilities

A number of recreational facilities that are associated with the reservoirs (e.g., boat ramps, day use facilities) will be removed as part of the proposed action and overall restoration of the reservoir footprints. The Renewal Corporation proposes additional recreation sites to access the newly formed river channel in the Hydroelectric Reach. These sites will provide recreational access for boats. The states of Oregon and California will ultimately construct and maintain the proposed recreational sites. Construction of the sites will occur post drawdown, up to 5 years after dam removal depending on funding. Table 5 describes the new sites that require in-water work.

Table 5. Proposed Recreation Sites with In-Water Work Requirements

Site Name	Reservoir Footprint	In-Water Construction
Pioneer Park West	J.C. Boyle	New Boat Ramp
Moonshine Falls	J.C. Boyle	New Boat Ramp
Copco Valley	Copco	New Boat Ramp
Iron Gate Recreation Facility	Iron Gate	New Boat Ramp

The boat ramps will likely be constructed after dam removal when listed coho salmon may be present in the work area. Figure 4, a plan view of the proposed Iron Gate Fire Access Ramp site, shows an example of how boat ramp construction will appear at the other sites. Only a small part of the river's edge will be impacted during construction, allowing fish migration around the work zone. Listed below are some key BMPs associated with boat ramp construction that are designed to minimize impacts to aquatic species. More detailed BMPs for in-water construction work are found in the Reservoir Area Management Plan (Appendix C of FERC 2021a).

- Construction will take place during the in-water work window (June 15 - Oct 31).

- Disturbance to existing riparian vegetation and channel banks will be minimized to the extent feasible. It is likely that no living riparian vegetation will be present as the sites will be in the Reservoir footprints.

- Water pollution control scheduling and methods will be specified in the contractor's Storm Water Pollution Prevention Plan. Contractor will follow specific methods that are indicated in Caltrans' Construction Site Best Management Practices (BMP) Manual (Caltrans 2017) to the extent practicable. Most of these measures are standard practices that have proven efficacy.

- Invasive species control measures will be followed to minimize potential transport of aquatic invasive species.

- The work area at water's edge will be isolated to prepare for grading and concrete. Only a small portion of the migration channel will be isolated, allowing migration around the work area.

- A qualified fisheries biologist will perform fish rescue, relocation, and exclusion actions as described in the Reservoir Area Management Plan. Fish will be placed outside of the work area in habitat adjacent to the isolated work zone.

- The isolated work zone will be dewatered and prepped for grading and concrete and remain dewatered until concrete is completely cured to prevent low pH impacts to water quality.

- Pouring concrete will only occur in dry conditions to prevent runoff into the adjacent water way.

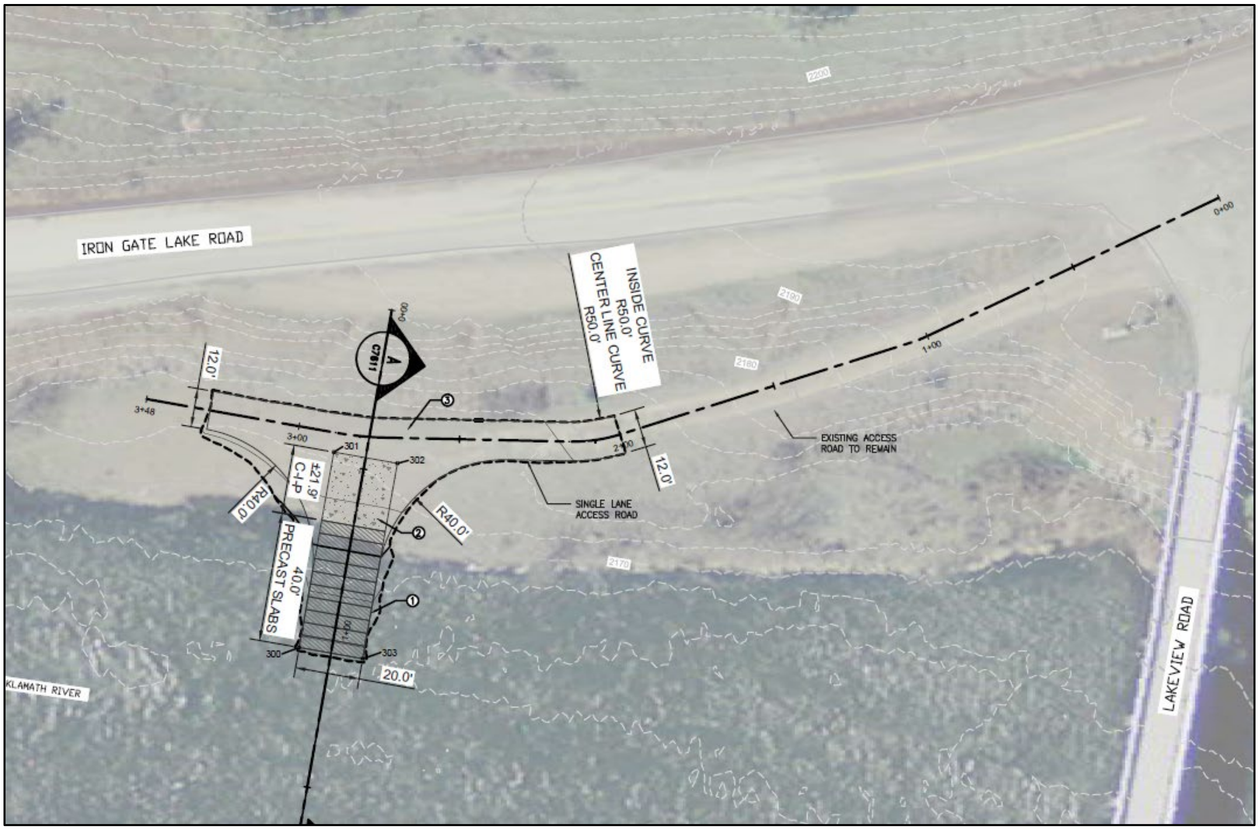

Figure 4. Iron Gate Fire Access Ramp. Plan view provides example of boat ramp construction for other sites (FERC 2021a)

1.3.7 Conservation, Avoidance, and Minimization Measures

The Renewal Corporation will implement conservation, avoidance, and minimization measures, along with numerous BMPs, during the proposed action to comply with federal and state permits, including the USACE CWA Section 404 permit, the SWRCB and ODEQ Clean Water Act Section 401 Water Quality Certifications (ODEQ 2018; CSWRCB 2020a), National Pollutant Discharge Elimination System (NPDES) permits for Oregon and California, and others.

During the years of discussions with key agencies and stakeholders, the Renewal Corporation convened an ATWG. This group consisted of state, federal, and Tribal resource agency staff. The following conservation measures described in this section were developed by the Renewal Corporation in close coordination with the ATWG. Upon FERC's issuance of a License Surrender Order, the Renewal Corporation will assemble an Aquatic Resources Group (ARG) for the purpose of coordinating on implementing the Aquatic Resources Management Plan. This work group will include members of the Renewal Corporation's team, and federal, state, and Tribal resource agency staff. Each member will designate a lead who will represent at ARG meetings and serve as its primary contact for all ARG-related matters.

Because the proposed action requires a significant amount of adaptive management, field-fit restoration projects post dam removal, and rapid decision making during key moments of construction, the Renewal Corporation will remain in close communication with the ARG through the periods of construction, monitoring, and maintenance. Many of the conservation measures require consultation with the ARG so that decision making will be effective and minimize impacts to listed species.

The Renewal Corporation has established specific management plans to address all conservation, avoidance and minimization measures. In this section, we describe specific management plans and practices that aim to protect NMFS' ESA listed species or might otherwise affect them. Although there are numerous plans included in the BA and associated appendices, we describe in the following sections only the plans that contain conservation, avoidance, and minimization measures that pertain to NMFS' ESA listed species. Additional conservation plans have been developed to meet USFWS ESA listed species, and to meet various state permitting requirements. Below we will focus specifically on the following plans:

- Aquatic Resources Management Plan[4] (Appendix D of FERC 2021a) which includes:
  - Spawning and Habitat Availability Report and Plan (Appendix A)
  - Tributary-Mainstem Connectivity Plan (Appendix D)
  - Juvenile Salmonids and Pacific Lamprey Rescue and Relocation Plan (Appendix E)
- Erosion and Sediment Control Plan (to be developed under state requirements)
- Reservoir Area Management Plan (Appendix C of FERC 2021a) which includes:
  - Best Management Practices (Appendix C)
  - Geomorphology Monitoring/Adaptive Management Field References (Appendix G)
  - Native Revegetation and Invasive Exotic Vegetation Treatment (Appendix H)

1.3.7.1 Adult Passage and Spawning

The Renewal Corporation expects short-term effects of the proposed action (SSCs and bedload) to result in high mortality of fall Chinook salmon and coho salmon embryos and pre-emergent alevins in mainstem redds. The Renewal Corporation will implement monitoring and adaptive management measures to reduce effects of the proposed action on mainstem spawning. Bedload transport and deposition may also contribute to passage barriers at tributary mouths or specific mainstem locations. Additional information regarding the monitoring and restoration actions summarized below can be found in FERC's (2021a) BA, Appendix D.

<u>Tributary-Mainstem Connectivity Plan</u> (Appendix D of FERC 2021a): The Renewal Corporation will evaluate tributary-mainstem confluences to ensure adult salmonids can enter tributaries where quality spawning habitat is located. Monitoring will include four sites in the

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[4] The Renewal Corporation filed an amended Aquatic Resources Management Plan with FERC on December 14, 2021 (FERC 2021f). The Renewal Corporation communicated the changes in the amended Aquatic Resources Management Plan to NMFS prior to the conclusion of this consultation, and those changes have been incorporated in this opinion.

Hydroelectric Reach and five sites in the 8-mile reach from Iron Gate Dam (RM 193.1) downstream to Cottonwood Creek (RM 185.1), for two years beginning with the start of reservoir drawdown. Monitoring frequency will be variable based on the season and year. Additionally, a 5-year flow event (a flow event that is expected to be equal or exceeded on an average of once in 5 years) will trigger a monitoring effort. If tributary confluence blockages are identified during monitoring, necessary means will be employed to remove the obstructions to ensure volitional passage for adult salmonids. The Renewal Corporation will meet with the ARG periodically during the two-year monitoring period to review monitoring frequency to ensure volitional passage is maintained between the Klamath River and selected tributaries (Appendix D of FERC 2021a).

Spawning Habitat Availability Report and Plan (Appendix D of FERC 2021a): The Renewal Corporation will complete a spawning habitat evaluation in the Hydroelectric Reach and newly accessible tributaries following reservoir drawdown and dam removal. The Renewal Corporation will evaluate newly available spawning habitat upstream of the dams, post removal, to ensure enough quality spawning gravels are made available to adult fish to offset the impacts to lost fall Chinook salmon and steelhead redds during the year of drawdown. If spawning gravel availability is less than the target values following reservoir drawdown, the Renewal Corporation and the ARG will convene to design, and the Renewal Corporation will implement, spawning gravel augmentation projects.

1.3.7.2 Outmigrating Juveniles

The Renewal Corporation will undertake a number of actions to reduce the overall effect of elevated SSCs on outmigrating juveniles as summarized below.

FERC (2021a) Aquatic Resource Measure Action 1: The Renewal Corporation will complete sampling and salvage of overwintering juvenile coho salmon from the Klamath River between Iron Gate Dam and the Trinity River confluence downstream prior to reservoir drawdown. Sampling and salvage sites will focus primarily on alcoves, side channels, and backwater floodplain features adjacent to the mainstem Klamath River. The Renewal Corporation expects up to 1,000 juvenile coho salmon to be caught and relocated to off-channel ponds by the Renewal Corporation to protect this small, but important, life history strategy in the ESA-listed coho salmon population. A technical memorandum identifying target capture locations and methods for salvage of overwintering juvenile coho salmon will be provided to NMFS six months prior to the salvage.

FERC (2021a) Aquatic Resource Measure Action 2: The Renewal Corporation will monitor mainstem-tributary connectivity as described above in Section 1.3.7.1. Monitoring that supports adult passage at tributary junctions will similarly support juvenile downstream migration.

FERC (2021a) Aquatic Resource Measure Action 3: The Renewal Corporation prepared and will implement a Juvenile Salmonid and Pacific Lamprey Rescue and Relocation Plan (Appendix D of FERC 2021a) for 13 key tributary confluences between Iron Gate Dam and the Trinity River. This action will only be necessary in the rare circumstance that outmigrating fish in tributaries become trapped in warming tributary waters when the mainstem is too turbid for them to enter. Tributaries to be monitored include Bogus Creek, Dry Creek, Cottonwood Creek, Shasta River, Humbug Creek, Beaver Creek, Horse Creek, Scott River, Tom Martin Creek, O'Neil Creek, Walker Creek, Grider Creek, and Seiad Creek. Water temperatures in tributary streams will be monitored from March 1 to July 1 of the drawdown year. SSCs will be measured continuously following drawdown at water quality stations in the mainstem Klamath River, including Iron Gate Dam, Seiad Valley, and Orleans. If tributary water temperatures reach 17 ºC (7-day average of the daily maximum values) and Klamath River SSCs remain elevated above 1,000 mg/L, the ARG will convene to organize the logistics for juvenile salvage and relocation efforts. If the tributary water temperature trigger of 19°C (7-day average of the daily maximum values) and Klamath River SSC trigger of 1,000 mg/L (7-day sustained daily maximum) are met, the Renewal Corporation will complete a salvage effort. The salvage effort would include capturing fish using seines, dip nets, and other methods from tributary confluence areas, loading them to aerated transport trucks, and relocating them to cool water tributaries or off-channel ponds including, but not limited to, the Seiad Creek complex.

1.3.7.3 Water Quality

The Erosion and Sediment Control Plan is a best management approach to address potential impacts associated with implementing the proposed action and is required by the ODEQ and SWRCB. The Renewal Corporation will establish erosion and sediment control BMPs to minimize pollution from sediment erosion caused by facilities removal and restoration activities. Examples of the erosion control measures to be included are:

- grading to fit existing topography; minimize length and steepness of slopes by benching, terracing or constructing diversion structures;
- minimization of soil exposure during the rainy season;
- retaining natural vegetation whenever possible;
- vegetating and mulching denuded areas to protect from seasonal rains;
- trapping sediment-laden runoff in basins to allow soil particles to settle out before flows are released to receiving waters;
- inspecting sites frequently to ensure control measures are working properly, and correct problems as needed.

1.3.7.4 Instream Habitat Restoration within Reservoir Footprints

The Reservoir Area Management Plan (Appendix C of FERC 2021a) includes all components to be implemented for restoration activities, monitoring, and adaptive management. The Reservoir Area Management Plan provides a detailed description of proposed restoration activities and a preliminary map identifying proposed locations for those activities.

The Reservoir Area Management Plan details BMPs related to upland restoration, infrastructure, IEV, and in-water work for significant interventions (maintenance actions). BMPs at upland restoration sites include grading and recontouring slopes to match the natural neighboring slopes and implementing site-specific temporary and permanent sediment and erosion control BMPs per the Stormwater Pollution Prevention Plan (SWPPP), including revegetation with regionally appropriate upland native seed mixes. Infrastructure-related restoration associated with bridge sites and culverts will include temporary and permanent sediment and erosion control BMPs per the site-specific SWPPP, including revegetation.

To manage the spread of IEVs into disturbed areas, the Renewal Corporation will closely monitor the movement of people and equipment while restoration activities are being performed. IEV cleaning stations will be included at each staging area for vehicle washing and boot cleaning. Fencing can prevent seed from entering the reservoirs from cattle movements, but wildlife capable of jumping over fencing is expected to move seed into restoration areas. Additional BMPs related to IEV management include:

- Maintaining a 50-foot-wide buffer free of IEV species around access roads, trails, and staging areas.
- Thoroughly cleaning clothing and gear following site visits.
- Checking clothing and gear for soil, seeds, and plant materials.
- Inspecting and cleaning equipment upon entering and exiting the limits of work.
- Inspecting and cleaning vehicles upon entering and exiting the limits of work.
- Training staff, including contractors, on weed identification and methods to avoid the unintentional spread of invasive plants.
- Managing vegetation using methods that reduce the spread of invasive species and encourage desirable vegetation.

The Renewal Corporation's Reservoir Area Management Plan (Appendix C of FERC 2021a) includes a detailed revegetation plan that describes how and when herbicides may be used as part of IEV management. Herbicides will only be used for species that are not well controlled by mechanical removal techniques such as grubbing, mowing, cutting or solarization. The Renewal Corporation will not use aerial (i.e., helicopter) or other mechanical sprayers, but will rely mainly on spot spraying with hand held wands or broadcast applications with wands or other hand held devices.

Eradicating pioneering IEV species within the former footprint of the reservoirs will be the highest priority to promote establishment of native species. At the J.C. Boyle site approximately 248 acres will be seeded with native herbaceous and woody species upland mixes as well as planting of bare root trees and shrubs. Similar actions will take place at the Copco site over approximately 845 acres, and 98 acres may be irrigated to promote riparian area establishment. At the Iron Gate site approximately 874 acres will be seeded or planted with upland species, and 109 acres may be irrigated to promote riparian area establishment.

The list of chemicals described in Section 5.3.3.2 of the Reservoir Area Management Plan (Appendix C of FERC 2021a) were proposed in consultation with NMFS staff. A glyphosate product (AquaNeat® - approved for use in or near water by the EPA) is the only product proposed in the main text of the Reservoir Area Management Plan for use close to water. Table C.2 in an appendix for the Reservoir Area Management Plan clarifies that it is proposed to be spot sprayed or hand applied (e.g., cutting and painting applications) up to the waterline of perennial streams or wetlands, or for intermittent streams and roadside ditches with water present. Broadcast applications under these circumstances will have a 100-foot buffer between application areas and waterbodies. The Renewal Corporation proposes that for intermittent streams, wetlands or roadside ditches that are dry at the time of application, no buffer is necessary for spot spraying or hand applications of this product and a 50-foot buffer will be applied for broadcast applications.

The Renewal Corporation proposes to also use the following list of herbicides but does not define a buffer for most of these products to prevent exposure to coho salmon or their habitat. The herbicides proposed for use are: glyophosate, aminopyralid, chlorosulfuron, aminocyclopyrachlor + chlorosulfuron, triclopyr, imazapyr, and dicamba. Table C.2 does propose buffers for "aquatic glyphosate", "aquatic imazapyr", and dicamba, and NMFS analyzed these herbicides with the proposed buffers. An additional herbicide (metsulfuron-methyl) listed in table C.2 that is not on the above list was not analyzed due to lack of information on how and where this herbicide would be used. Additional herbicides not listed above or uses may be proposed by the Renewal Corporation during the implementation period of the Reservoir Area Management Plan. These proposals will be considered individually at that time to determine if their use requires reinitiation of consultation.

The Renewal Corporation proposes numerous BMPs in order to prevent or minimize exposure of coho salmon and their habitat to the herbicides and any adjuvants used during an application. Table C.1 in the Reservoir Area Management Plan (Appendix C of FERC 2021a) contains the full list. The most pertinent to our analysis include:

- Implement an herbicide safety/spill response plan to reduce the likelihood of spills, misapplication, reduce potential for unsafe practices, and to take remedial actions in the event of spills.
- Mix herbicides more than 150 feet from any natural waterbody to minimize the risk of an accidental discharge. Wash spray tanks further than 300 feet away from surface water. Check that all hauling and application equipment is free from leaks and operating as intended.
- Have trained applicators apply herbicides under direct supervision of a Qualified Applicator Licensee (Oregon and California applicator license).
- Keep records of each application, including the active ingredient, formulation, application rate, date, time, and location.

- The only surfactants and adjuvants permitted are those allowed for use on aquatic sites, as listed by the Washington State Department of Ecology: http://www.ecy.wa.gov/programs/wq/pesticides/regpesticides.html.[5]
- The surfactants R-11, POEA, and herbicides that contain POEA (e.g., Roundup) will not be used.
- Herbicide carriers (solvents) are limited to water or specifically labeled vegetable oil.
- Broadcast spraying using booms mounted on ground-based vehicles, with the following restrictions:
    - Do not broadcast spray within 100 feet of open water when wind velocity exceeds 5 miles per hour (mph).
    - Do not broadcast spray when wind velocity exceeds 10 mph.
    - Do not spray if precipitation is occurring or is imminent (within 24 hours).
    - Do not spray if air turbulence is sufficient to affect the normal spray pattern.
- Dyes or colorants, (e.g., Hi-Light, Dynamark) will be used as needed to assist in treatment assurance and minimize overspraying within 100 feet of water.
- Do not spray when wind speeds exceed 10 miles per hour to reduce the likelihood of spray/dust drift. Winds of 2 mph or less are indicative of air inversions. The applicator must confirm the absence of an inversion before proceeding with the application whenever the wind speed is 2 mph or less.
- Be aware of wind directions and potential for herbicides to affect aquatic habitat area downwind.
- Keep boom or spray as low as possible to reduce wind effects.
- Avoid or minimize drift by using appropriate equipment and settings (e.g., nozzle selection, adjusting pressure, drift reduction agents). Select proper application equipment (e.g., spray equipment that produces 200- to 800-micron-diameter droplets).
- Follow herbicide label directions for maximum daytime temperature permitted.
- Do not spray during periods of adverse weather conditions (snow or rain imminent, fog, etc.).
- Herbicides shall not be applied when the soil is saturated or when a precipitation event likely to produce direct runoff to fish-bearing waters from a treated site is forecasted within 48 hours following application.

[5] When this opinion was being completed this website was no longer active. NMFS and the Renewal Corporation coordinated to confirm that the list of permitted surfactants and adjuvants that the applicant is permitted to use is consistent with the list of Spray Adjuvants Registered for Use on Aquatic Sites in Washington, Revised May 15, 2017 (WSAD 2017).

1.3.7.5 In-water Work Best Management Practices

The Renewal Corporation will apply in-water work BMPs to work related to reservoir restoration activities. These BMPs are specific to the restoration activities conducted during the Construction Period and Maintenance and Monitoring Period of the project. These BMPs for in-water work are part of the overall adaptive management approach that includes proactive monitoring and surveys for fish passage and tributary connectivity blockages, as described in the Reservoir Area Management Plan (Appendix C of FERC 2021a), and Aquatic Resources Management Plan (Appendix D of FERC 2021a).

Significant adaptive management interventions involve in-water work and the need for work zone isolation measures. The Renewal Corporation will implement the following BMPs for significant interventions that require in-water work:

1. The ARG will be notified a minimum of 48-hours before start of work.
2. Unless under the guidance of ARG, in-water work activities will occur during the in-water work window, expected to be June 15 to October 31.
3. A biologist will evaluate the in-water habitat to determine if salmonids occur in the limits of work.
    a) If salmonid or protected fish are or are assumed to be present in the in-water work area, fish rescue, relocation, and exclusion will occur under the direction of a qualified fisheries biologist.
        (1) General conditions for fish capture and relocation activities: Exclusion will include the use of block nets, or similar, to isolate the work area from fish access. The fisheries biologist will evaluate the upstream and downstream extent of the fish exclusion and relocation efforts, which will be based on the minimal amount of wetted channel where salmonids may experience potential injury or mortality from the in-water activity. Fish relocation will be performed using seine nets, dip nets, and/or electrofishing as determined appropriate and effective by the fisheries biologist. The duration and extent of fish relocation actions will be determined by the fisheries biologist. Once the work area is determined to be cleared of salmonids, in-water work activities will be cleared to begin.
            i. Electrofishing: All electrofishing will be conducted in accordance with the NMFS Guidelines for Electrofishing Waters Containing Salmonids Listed under the Endangered Species Act (NMFS 2000)
            ii. Salmonid Handling and Relocation: NOAA Restoration Center's Programmatic Approach to ESA/EFH Consultation Streamlining for Fisheries Habitat Restoration Projects (NMFS 2017b), Section 2.4.1.E – Guidelines for Relocation of Salmonids, will guide relocation work.
    b) If no salmonids or protected fish occur in the work area, a biologist will monitor the in-water work actions to ensure that there is no change in

conditions that would require fish exclusion or relocation. The biologist will document and report the completion of the in-water work activity to NMFS as described below.

4. The Renewal Corporation will minimize disturbance to existing riparian vegetation and channel banks to the extent feasible to complete the required restoration or maintenance action.
5. In the tributary restoration areas, the Renewal Corporation will use cofferdam and flow diversion around the work area if channel bed adjustments are required.
6. The Renewal Corporation will use and store petroleum-powered equipment in a manner to prevent the potential release of petroleum materials into waters.
7. Areas for fuel storage, refueling, and servicing of construction equipment will be located in an upland location.
8. Oil absorbent and spill containment materials will be on site when mechanical equipment is in operation within 100 feet of the proposed watercourse crossings. If a spill occurs, no additional work shall commence in-channel until the following occurs: (1) the mechanical equipment is inspected by the Renewal Corporation, and the leak has been repaired; (2) the spill has been contained; and (3) the ARG is contacted and have evaluated the impacts of the spill.
9. The Renewal Corporation will follow invasive species control measures to minimize potential transport of aquatic invasive species.
10. Documentation and Reporting: The Renewal Corporation will provide photographs of the in-water work location, summary of actions including any fish relocation, and notification of completion of the in-water work to the ARG within one week of the completion of in-water work.

1.3.8 Summary and Schedule of Proposed In-Water Work

As described in the previous sections, much of the proposed work will occur outside of the channel on upper slopes or prior to Iron Gate dam being removed. Listed species under NMFS' jurisdiction will have no exposure to the immediate construction related effects of those types of actions. In this Opinion we focus on components of the proposed action that may occur or for which exposure from effects may occur in-stream either downstream of Iron Gate Dam where listed species are currently present or upstream of Iron Gate after the dams have been removed and allow listed species to access the work sites.

Table 6, Table 7, and Table 8 summarize the proposed action in the context of when and where the specific actions will take place to help guide the eventual effects analysis in Section 2.5.1 (Effects of the Action, SONCC coho salmon).

Table 6. Proposed in-water work occurring upstream of Iron Gate Dam prior to dam removal

Location	Action
J. C. Boyle	Develop new boat ramp for retained recreation area at edge of new channel
J.C. Boyle	Remove Timber Bridge, demolish power house, backfill tailrace, remove earth-fill dam and cofferdam, place rock for channel roughness to aid fish passage
Copco 1	Dredging and open water disposal from barge, installation of access road and work pads, powerhouse removal, removal of concrete dam with some in-water blasting, filling of plunge pool at base of dam, final channel shaping, placement of rock for channel roughness
Copco 2	Install access roads and work pads, remove spillway and work pad, remove existing cofferdam and dam structure, plug diversion tunnel intake structure, install temporary bridge upstream of Daggett Road bridge, remove temporary bridge
Fall Creek	FCH improvements include fish ladder[6], diversion dam modifications, settling tank outfall, erosion control pad
Fall Creek	Replace existing culverts at Daggett Road crossing to improve passage for all life stages of salmonids
Fall Creek	Install temporary pipeline crossing for Yreka water supply at Daggett Road bridge
Iron Gate Reservoir	Replace existing pipeline for Yreka water supply under Klamath River

Table 7. Proposed in-water work occurring at or downstream of Iron Gate Dam prior to removal

Location	Action
Iron Gate Dam (IGD)	Construct access road and workpad on downstream side of Iron Gate Dam
Iron Gate Dam	Construction of a temporary bridge adjacent to Lakeview Road
Iron Gate Dam	Construct fire access ramp adjacent to Lakeview Road Bridge
Iron Gate Dam	Installation of tunnel outlet erosion protection measures (e.g., armoring the existing left bank access road)
Iron Gate Dam	Removal of access road and workpad on downstream side of IGD
Iron Gate Dam	Fill tailrace area with concrete rubble and rock

[6] Operationoperation of the fish ladder is analyzed in the Section 7 consultation associated with the HGMP.

Table 8. Proposed in-water work occurring after dam removal

Location	**Action**
Spencer Creek	Re-grading of stream channel and confluence for volitional fish passage - includes channel, floodplain, delta, and sediment stabilization grading; placement of boulder clusters, willow baffles, and large wood structures with ground-based equipment and helicopters.
Copco 2	Construction of new boat ramp at Copco Cove at new river channel edge
Beaver Creek	Re-grading of stream channel and confluence for volitional fish passage - includes channel, floodplain, delta, and sediment stabilization grading; placement of boulder clusters, willow baffles, and large wood structures with ground-based equipment and helicopters.
Camp Creek	Replace existing culvert with new culvert that meets NMFS' fish passage criteria
Scotch Creek	Replace existing culvert with new culvert that meets NMFS' fish passage criteria
Jenny Creek	Re-grading of stream channel and confluence for volitional fish passage - includes channel, floodplain, delta, and sediment stabilization grading; placement of boulder clusters, willow baffles, and large wood structures with ground-based equipment and helicopters.
Camp Creek	Re-grading of stream channel and confluence for volitional fish passage - includes channel, floodplain, delta, and sediment stabilization grading; placement of boulder clusters, willow baffles, and large wood structures with ground-based equipment and helicopters.
Long Creek	Removal of three historical crossing structures over Long Creek
Mainstem Klamath; tributary confluences	Fish passage maintenance (would only occur if monitoring suggests a blockage): Removal of reservoir-related sediment or debris blockages at tributary confluences, minor grading at the mainstem confluences using equipment or hand crews

1.3.9 Consequences of Other Activities Caused by the Proposed Action

We considered, under the ESA, whether or not the proposed action would cause any consequences of other activities based on the regulatory definition of "*Effects of the action*" in 50 CFR 402.02, which provides:

> *Effects of the action* are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. (See § 402.17).

We specifically considered whether the consequences of the following activities should be considered as effects of the action for this proposed action: (1) relocating the location where Klamath River flows are measured for Reclamation's Klamath Project operations from Iron Gate Dam to Keno Dam, (2) Fall Creek Hatchery operations beyond eight years after dam removal, and (3) active reintroduction of hatchery origin spring-run Chinook salmon into the Oregon portion of the Klamath Basin. We determined that consequences of these activities should not be considered as effects of the action for this proposed action for the following reasons, and we determined that the proposed action would not cause any other activities the consequences of which should be considered as effects of the action for this proposed action.

As described in section 1.1.2, NMFS issued a biological opinion on Reclamation's Klamath Project operations in 2019. In that biological opinion we stated, "given the potential that decommissioning of the four developments described above will occur within the lifespan of this Opinion, Reclamation indicated that they will coordinate with NMFS to identify a methodology to back calculate flow requirements measured at Iron Gate Dam to what the flow requirements would need to be as measured at Keno Dam to ensure consistency with this Opinion prior to decommissioning" (NMFS 2019a). In addition, as described in section 1.1.2, later in 2019, Reclamation reinitiated consultation with the Services on Reclamation's Klamath Project operations. That reinitiated consultation is ongoing and will include discussion of whether the location where Klamath River flows are measured for Reclamation's Klamath Project operations should be relocated as a result of the proposed action addressed in this Opinion and any consequences of doing so. Until reinitiated consultation on Reclamation's Klamath Project operations is completed, NMFS expects Reclamation to operate and manage flow releases to the Klamath River consistent with those described in the 2019 biological opinion on Reclamation's Klamath Project and the IOP described in section 1.1.2.

As described above in section 1.3.5.6, under the KHSA, PacifiCorp will fund 100 percent of hatchery operations and maintenance necessary to fulfill annual mitigation goals developed by CDFW in consultation with NMFS. PacifiCorp's funding will be provided for hatchery operations to meet mitigation requirements and will continue for 8 years following the decommissioning of Iron Gate Dam. Therefore, hatchery operations at Fall Creek as part of the proposed action are temporary. Beyond eight years after dam removal, any hatchery production at this facility would be based on the potential for the investment of resources by state regulatory agencies and Tribal partners, and other factors related to natural production of anadromous fish, which are not necessarily caused by the proposed action. Therefore, the potential for hatchery production at this facility beyond eight years after dam removal is discussed further in section 2.6.2, Southern Resident Killer Whales (Cumulative Effects).

Oregon Department of Fish and Wildlife (ODFW) and the Klamath Tribes of Oregon have prepared a draft Implementation Plan for the Reintroduction of Anadromous Fishes into the Oregon Portion of the Upper Klamath Basin (reintroduction plan)(ODFW and Klamath Tribes 2021). This reintroduction plan includes active reintroduction (outplanting of hatchery juveniles into areas currently above the dams) of spring-run Chinook salmon, which are not listed under the ESA, into the Oregon portion of the basin. ODFW has made significant progress to secure funding and staff for purposes of implementing the reintroduction plan; thus, NMFS concludes that it is reasonably certain to occur. Therefore, NMFS expects that this active reintroduction as part of the reintroduction plan is reasonably certain to occur. However, active reintroduction and the reintroduction plan are not part of the proposed action. In addition, active reintroduction as part of a reintroduction plan was considered even before the proposed action (KBRA 2010, Section 11) and could be done in conjunction with the Services' mandatory prescription for fishways under FERC relicensing if the proposed action did not proceed (NMFS 2007a; USDOI 2007). Therefore, active reintroduction as part of the reintroduction plan would likely be considered regardless of whether the proposed action occurs. The potential effects of active reintroduction as part of the reintroduction plan are described in the Cumulative Effects section of this opinion.

2 ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS, and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provide an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

FERC determined the proposed action is not likely to adversely affect the southern Distinct Population Segment (DPS) of North American green sturgeon (*Acipenser medirostris*) or its critical habitat (FERC 2021a). Our concurrence is documented in the "*Not Likely to Adversely Affect" Determinations* section (Section 2.12).

2.1 Analytical Approach

This biological opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "jeopardize the continued existence of" a listed species, which is "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This biological opinion also relies on the regulatory definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species" (50 CFR 402.02).

The designations of critical habitat for the SONCC coho salmon ESU, Southern Resident Killer Whale DPS, Southern DPS eulachon, and Southern DPS green sturgeon use the term primary constituent element (PCE) or essential features. The 2016 final rule (81 FR 7414; February 11, 2016) that revised the critical habitat regulations (50 CFR 424.12) replaced this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

The ESA Section 7 implementing regulations define effects of the action using the term "consequences" (50 CFR 402.02). As explained in the preamble to the final rule revising the definition and adding this term (84 FR 44976, 44977; August 27, 2019), that revision does not change the scope of our analysis, and in this opinion, we use the terms "effects" and "consequences" interchangeably.

We use the following approach to determine whether a proposed action is likely to jeopardize listed species or destroy or adversely modify critical habitat:

- Evaluate the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Evaluate the environmental baseline of the species and critical habitat.
- Evaluate the effects of the proposed action on species and their critical habitat using an exposure–response approach.
- Evaluate cumulative effects.
- In the integration and synthesis, add the effects of the action and cumulative effects to the environmental baseline, and, in light of the status of the species and critical habitat, analyze whether the proposed action is likely to: (1) directly or indirectly reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species; or (2) directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.
- If necessary, suggest a reasonable and prudent alternative to the proposed action.

2.1.1 Overview of NMFS' Assessment Framework

NMFS uses a series of sequential analyses to assess the effects of federal actions on endangered and threatened species and designated critical habitat. The first analysis identifies those physical, chemical, or biotic aspects of the proposed action that are likely to have an individual or interactive effect on the environment (NMFS uses the term "potential stressors" for these aspects of an action). As part of this step, NMFS identifies the spatial extent of any potential stressors and recognizes that the spatial extent of those stressors may change with time (the spatial extent of these stressors is the "action area" for a consultation) within the action area.

The second step of the analyses starts by determining whether a listed species is likely to occur in the same space and at the same time as these potential stressors. If NMFS concludes that such co-occurrence is likely, NMFS then estimates the nature of that co-occurrence (these represent the exposure analyses). In this step of the analyses, NMFS identifies the number and age (or life stage) of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent.

Once NMFS identifies which listed species and its life stage(s) are likely to be exposed to potential stressors associated with an action and the nature of that exposure, NMFS determines whether and how those listed species and life stage(s) are likely to respond given their exposure (these represent the *response analyses*). The final steps of NMFS' analyses are establishing the risks those responses pose to listed species and their life stages.

2.1.1.1 Risk Analyses for Endangered and Threatened Species

NMFS' jeopardy determination must be based on an action's effects on the continued existence of the listed species, which, depending on how a species is listed under the ESA, could be focused on true biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (that is, the probability of extinction or probability of persistence) of listed species depends on the viability of the populations that comprise the species. Similarly, the continued existence of populations is determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

NMFS' risk analyses reflect these relationships between listed species and the populations that comprise them, and the individuals that comprise those populations. NMFS identifies the probable risks that actions pose to listed individuals that are likely to be exposed to an action's effects. NMFS then integrates those individuals' risks to identify consequences to the populations those individuals represent. NMFS' analyses conclude by determining the consequences of those population-level risks to the species those populations comprise.

NMFS measures risks to listed individuals using the individual's reproductive success which integrates survival and longevity with current and future reproductive success. In particular, NMFS examines the best available scientific and commercial data to determine if an individual's probable response to stressors produced by an action would reasonably be expected to reduce the individual's current or expected future reproductive success by one or more of the following: increasing the individual's likelihood of dying prematurely, having reduced longevity, increasing the age at which individuals become reproductively mature, reducing the age at which individuals stop reproducing, reducing the number of live births individuals produce during any reproductive bout, reducing the number of times an individual is likely to reproduce over its reproductive lifespan (in animals that reproduce multiple times), or causing an individual's progeny to experience any of these phenomena (Stearns 1992; McGraw and Caswell 1996; Newton and Rothery 1997; Brommer et al. 1998; Clutton-Brock 1998; Brommer 2000; Brommer et al. 2002; Roff 2002; Oli and Dobson 2003; Turchin 2003; Kotiaho et al. 2005; Coulson et al. 2006).

When individuals of a listed species are expected to have reduced future reproductive success or reductions in the rates at which they grow, mature, or become reproductively active, NMFS would expect those reductions, if many individuals are affected, to also reduce the abundance, reproduction rates, and growth rates (or increase variance in one or more of these rates) of the populations those individuals represent (see Stearns 1992).

NMFS also considers species distribution when evaluating extinction risk. It is important to take into account spatial structure for two main reasons: 1) because there is a time lag between changes in spatial structure and species-level effects, overall extinction risk at the 100-year time scale may be affected in ways not readily apparent from short-term observations of abundance and productivity, and 2) population structure affects evolutionary processes and may, therefore, alter a population's ability to respond to environmental change (McElhany et al. 2000).

Reductions in one or more of the above described variables (or one of the variables NMFS derive from them) is a necessary condition for increasing a population's extinction risk, which is itself a necessary condition for increasing a species' extinction risk.

NMFS equates the risk of extinction of the species with the "likelihood of both the survival and recovery of a listed species in the wild" for purposes of conducting jeopardy analyses under section 7(a)(2) of the ESA because survival and recovery are conditions on a continuum with no bright dividing lines. Similar to a species with a low likelihood of both survival and recovery, a species with a high risk of extinction does not equate to a species that lacks the potential to become viable. Instead, a high risk of extinction indicates that the species faces significant risks from internal and external processes and threats that can drive a species to extinction. Therefore, NMFS' jeopardy assessment focuses on whether a proposed action appreciably increases extinction risk, which is a surrogate for appreciable reduction in the likelihood of both the survival and recovery of a listed species in the wild.

On the other hand, when listed species exposed to an action's effects are not expected to experience adverse effects, NMFS would not expect the action to have adverse consequences on the extinction risk of the populations those individuals represent or the species those populations comprise (Mills and Beatty 1979; Stearns 1992; Anderson 2000).

2.1.1.2 Effects Analysis for Listed Fishes

For Pacific salmon, steelhead, and certain other species, we commonly use four "viable salmonid population" (VSP) parameters (McElhany et al. 2000) to assess the viability of the populations that, together, constitute the species. When these parameters are collectively at an appropriate level, they maintain a population's capacity to adapt to various environmental conditions and allow it to sustain itself in the natural environment. Although McElhany et al. (2000) specifically addresses viable populations of salmonids, NMFS believes that the concepts and viability parameters in McElhany et al. (2000) can also be applied to listed eulachon due to the general similarity in life cycle and freshwater/ocean use. Therefore, in this Opinion, NMFS applies the viability parameters (McElhany et al. 2000) in its characterization of the status of the species, environmental baseline, and analysis of effects of the action to Southern DPS eulachon.

For the SONCC coho salmon ESU, the effects analysis is based on a bottom-up hierarchical organization of individual fish at the life stage scale, population, diversity stratum, and ESU (Figure 5). The guiding principle behind this effects analysis is that the viability of a species (e.g., ESU) is dependent on the viability of the diversity strata that compose that species; the viability of a diversity stratum is dependent on the viability of most independent populations that compose that stratum and the spatial distribution of those viable populations; and the viability of the population is dependent on the fitness and survival of individuals at the life stage scale. The salmonid life cycle includes the following life stages and behaviors, which will be evaluated for potential effects resulting from the proposed action: adult migration, spawning, embryo incubation, juvenile (sub-yearling and yearling) rearing, and outmigration. Although life-history stage terminology is somewhat different for eulachon compared to salmonids, they are also anadromous (i.e., spawn in freshwater and migrate to the ocean), and, therefore, a similar analysis is applied to eulachon.

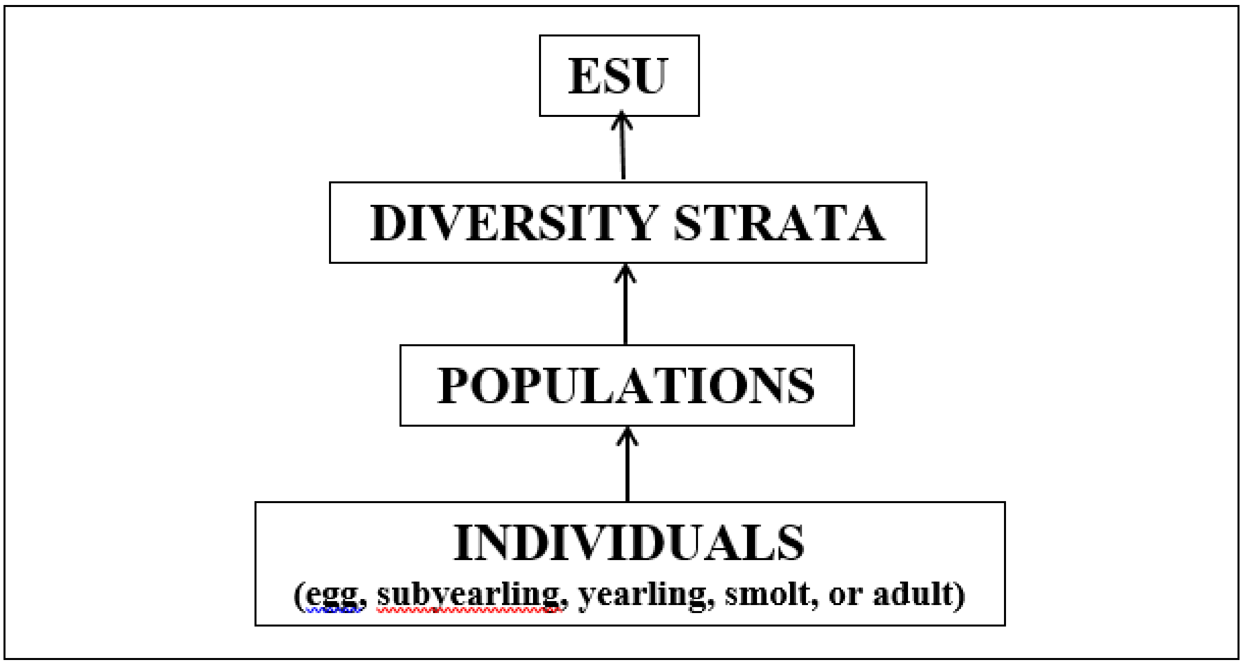

Figure 5. Conceptual model of the hierarchical structure that is used to organize the jeopardy risk assessment for the SONCC coho salmon ESU.

2.1.1.3 Viable Salmonid Populations Framework for salmonids and eulachon

In order to assess the status, trend, and recovery of any species, a guiding framework that includes the most appropriate biological and demographic parameters is required. For Pacific salmon, McElhany et al. (2000) defined a VSP as an independent population that has a negligible probability of extinction over a 100-year time frame. The VSP concept provides guidance for estimating the viability of populations and larger-scale groupings of Pacific salmonids such as an ESU or DPS. Four VSP parameters form the key to evaluating population and ESU/DPS viability: (1) abundance; (2) productivity (i.e., population growth rate); (3) population spatial structure; and (4) diversity (McElhany et al. 2000). Therefore, these four VSP parameters were used to evaluate the extinction risk of the listed SONCC coho salmon and Southern DPS eulachon included in this opinion.

Population size provides an indication of the type of extinction risk that a population faces. For instance, smaller populations are at a greater risk of extinction than large populations because the processes that affect populations operate differently in small populations than in large populations (McElhany et al. 2000). One risk of low population sizes is depensation. Depensation occurs when populations are reduced to very low densities and per capita growth rates decrease as a result of a variety of mechanisms [e.g., failure to find mates and, therefore, reduced probability of fertilization, failure to saturate predator populations (Liermann and Hilborn 2001)]. While the Allee effect (Allee et al. 1949) is more commonly used in general biological literature, depensation is used here because this term is most often used in fisheries literature (Liermann and Hilborn 2001). Depensation results in negative feedback that accelerates a decline toward extinction (Williams et al. 2008a).

The productivity of a population (i.e., production over the entire life cycle) can reflect conditions (e.g., environmental conditions) that influence the dynamics of a population and determine abundance. In turn, the productivity of a population allows an understanding of the performance of a population across the landscape and habitats in which it exists and its response to those habitats (McElhany et al. 2000). In general, declining productivity can lead to declining population abundance. Understanding the spatial structure of a population is important because the spatial structure can affect evolutionary processes and, therefore, alter the ability of a population to adapt to spatial or temporal changes in the species' environment (McElhany et al. 2000).

Diversity, both genetic and behavioral, is critical to success in a changing environment. Salmonids express variation in a suite of traits, such as anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smelting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, and physiology and molecular genetic characteristics. The more diverse these traits (or the more these traits are not restricted), the more diverse a population is, and the more likely that individuals and, therefore, the species, would survive and reproduce in the face of environmental variation (McElhany et al. 2000). However, when diversity is reduced due to loss of entire life history strategies or to loss of habitat used by fish exhibiting variation in life history traits, the species is in all probability less able to survive and reproduce given environmental variation.

Because some of the VSP parameters are related or overlap, the evaluation is at times unavoidably repetitive. Viable ESUs are defined by some combination of multiple populations, at least some of which exceed "viable" thresholds, and that have appropriate geographic distribution, resiliency from catastrophic events, and diversity of life histories and other genetic expression (McElhany et al. 2000).

NMFS evaluates the current status of the species to diagnose how near, or far, the species is from a viable state because it is an important metric indicative of a self-sustaining species in the wild. However, NMFS also considers the ability of the species to recover in light of its current condition and the status of the existing and future threat regime. Generally, NMFS folds this consideration of current condition and ability to recover into a conclusion regarding the "risk of extinction" of the population or species.

NMFS uses the concepts of VSP as an organizing framework in this opinion to systematically examine the complex linkages between the proposed action effects and VSP parameters while also considering and incorporating natural risk factors such as climate change and ocean conditions. These VSP parameters are important to consider because they are predictors of extinction risk, and the parameters reflect general biological and ecological processes that are critical to the growth and survival of fish (McElhany et al. 2000). These four parameters are consistent with the "reproduction, numbers, or distribution" criteria found within the regulatory definition of "jeopardize the continued existence of" (50 CFR 402.02) and are used as surrogates for reproduction, numbers, and distribution. The fourth VSP parameter, diversity, relates to all three jeopardy criteria. For example, reproduction, numbers, and distribution are all affected when genetic or life history variability is lost or constrained, resulting in reduced population resilience to environmental variation at local or landscape-level scales.

2.1.1.4 Application of the Analytical Approach to Critical Habitat Analyses

The basis of the destruction or adverse modification analysis is to evaluate whether the proposed action affects the quantity or quality of the PBFs in the designated critical habitat for a listed species and, especially in the case of unoccupied critical habitat, whether the proposed action has any impacts to the critical habitat itself. Based on the definition of "*Destruction or adverse modification*" in 50 CFR 402.02, NMFS will conclude that a proposed action is likely to destroy or adversely modify the designated critical habitat for the ESU or DPS if the action results in a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species.

NMFS bases critical habitat analysis on the affected areas and functions of critical habitat essential for the conservation of the species, and not on how individuals of the species will respond to changes in habitat quantity and quality. If an area encompassed in a critical habitat designation is likely to be exposed to the consequences of the proposed action on the natural environment, NMFS analyzes if PBFs included in the designation that give the designated critical habitat value for the conservation of the species are likely to respond to that exposure. In particular, NMFS is concerned about responses that are sufficient to reduce the quantity or quality of those PBFs or otherwise reduce the value of critical habitat for the conservation of the species.

To conduct this analysis, NMFS follows the basic analytical steps related to exposure, response, and risk described above. We recognize that the value of critical habitat for the conservation of the species is a dynamic property that changes over time in response to changes in land use patterns, climate (at several spatial scales), ecological processes, the dynamics of biotic components of the habitat, etc. For these reasons, some areas of critical habitat might respond to an exposure when others do not. We also consider how the PBFs of designated critical habitat are likely to respond to any interactions with and synergisms between effects of baseline conditions and proposed action stressors or benefits.

2.1.1.4.1 Hierarchical Construct

At the heart of the analysis is the basic premise that the value of an overall critical habitat designation for the conservation of the species is the sum of the values of the components that comprise the habitat. The value of the PBFs that comprise the critical habitat designated within a population is the sum the value of the critical habitat for that population, and this is also true in a similar manner at the diversity stratum, and ESU/DPS level. Therefore, the value of listed salmonid or eulachon critical habitat for the conservation of the species is determined by the value of the watersheds or other areas that make up the total designated area of critical habitat for that species. In turn, the value of the watersheds or other areas focuses on the quantity or quality of PBFs of critical habitat. Reductions in the quantity or quality of any PBFs of critical habitat may reduce the value of the exposed area (e.g., basin or sub-basin) for the conservation of the species, which in turn may reduce the value of the overall critical habitat designation for the conservation of the species.

2.1.1.5 Approach Specific to Southern Resident Killer Whales (SRKW)

The Overview of the Assessment Framework and Application of the Analytical Approach to Listed Species and Critical Habitat Analyses described above also applies to NMFS' approach for Southern resident killer whales (SRKW). The primary impact to SRKW as a result of the proposed action evaluated is potential reductions to the SRKW prey base, an important PBF of SRKW critical habitat. Chinook salmon, which are not listed under the ESA in the Klamath Basin, are the preferred prey of SRKW. Thus, an accompanying analysis of impacts to Chinook salmon will be performed using an analytical approach similar to that for listed fishes to support assessment of effects on the SRKW prey base PBF. This analysis of effects to SRKW relies on the expected impacts of the proposed action on the abundance and availability of Chinook salmon for prey and how any expected changes in prey availability will affect the fitness, and ultimately the abundance, reproduction, and distribution, of the SRKW. Given the similar nature of these effects' pathways to the effects pathways relative to the prey PBF for SRKW critical habitat, the analysis of the proposed action's effects on the value of SRKW critical habitat as a whole relies heavily on the effects analysis of the impacts on abundance and availability of Chinook salmon for SRKW prey.

The analysis of the effects of the proposed action on SRKWs identifies and examines certain time periods when the anticipated effects are distinct from each other from the perspective of individual SRKWs. The analysis of the effects on SRKW prey considers the short term effects of dam removal (up to two years after dam removal) on Chinook salmon, consistent with the analyses for other ESA-listed species in the biological opinion. In addition, the effects analysis considers changes in Chinook salmon hatchery production that are proposed as well as changes in the survival and productivity of Chinook salmon in the Klamath River that are expected after the dams are removed. The analysis includes an eight-year time period after dam removal when hatchery production is proposed to be modified from current hatchery production operations, as well as a long term horizon beyond eight years after dam removal when hatchery production is no longer proposed by the applicant to occur. This perspective of the variable phases of effects is unique to SRKWs in this opinion, given how consequences from the proposed action extend through any/all Chinook salmon affected by the proposed action to individual SRKWs in a variable manner based on how SRKWs ultimately interact with prey resources that are available (or not available) in the future. The terminology for the timeline of the effects analysis is further described in Section 2.1.5.4, Short Term, Mid Term, and Long Term Impacts.

2.1.2 Approach to Analysis: Suspended Sediment Concentrations

In this section of the Opinion, we describe an outline of the approach we used to evaluate the impacts of suspended sediment as a result of the proposed action. NMFS staff worked closely with The Renewal Corporation to guide and develop the approach to SSC impact analysis that would support this consultation. The analysis provides information at a scale that quantifies impacts to the affected coho salmon populations and describes individual responses. We have determined that of all the impacts resulting from the proposed action, elevated SSCs are expected to be the most severe. Therefore, this section provides sufficient detail to support the effects analysis in Section 2.5 and integration and synthesis in Section 2.7. Additionally, we considered the KRRC's similar, but scaled down version of this analysis for Southern DPS eulachon and Southern DPS green sturgeon. Impacts to Chinook salmon were also considered using the described approach to support the SRKW effects analysis in this Biological Opinion. Additional detail on the SSC analysis can be found in the FERC (2021a) BA and associated Appendix H, "Suspended Sediment Effects on Coho Salmon Populations".

The Renewal Corporation completed a robust SSC effects analysis in close coordination with NMFS staff during the technical assistance phase of consultation. The analysis included a number of steps and use of modeling data to describe exposure and severity of response (i.e., impacts) to coho salmon. Below is a simplified outline and flow chart (Figure 6) of the analysis followed by a more detailed description. Further details can be found in the FERC (2021a) BA and associated Appendix H, "Suspended Sediment Effects on Coho Salmon Populations".

The SSC analysis:

- Utilized Reclamation's (2011b) sediment transport model;
- Updated model results with revised drawdown rates;
- Utilized suspended sediment data collected at a range of locations downstream of Iron Gate Dam to estimate exposure of different populations and attenuation of SSCs;
- Utilized flow data during the 48-year period of record (1961 – 2008) that is consistent with Reclamation's (2011b) model;
- Modeled predicted daily SSCs for each year in the period of record;
- Utilized the Newcombe and Jensen (1996) Severity of Ill Effects (SEV) indices to sum the impacts individuals would experience during each water year in the period of record. This step utilized life history data to determine exposure periods and duration in a given year;
- Identified "median impact year" and "severe impact year" based on the summed SEV scores across all life stages during the water year;
- Used "severe impact year" modeling results to estimate maximum extent of take of each life stage of coho salmon across all life stages in a year based on the period of record.

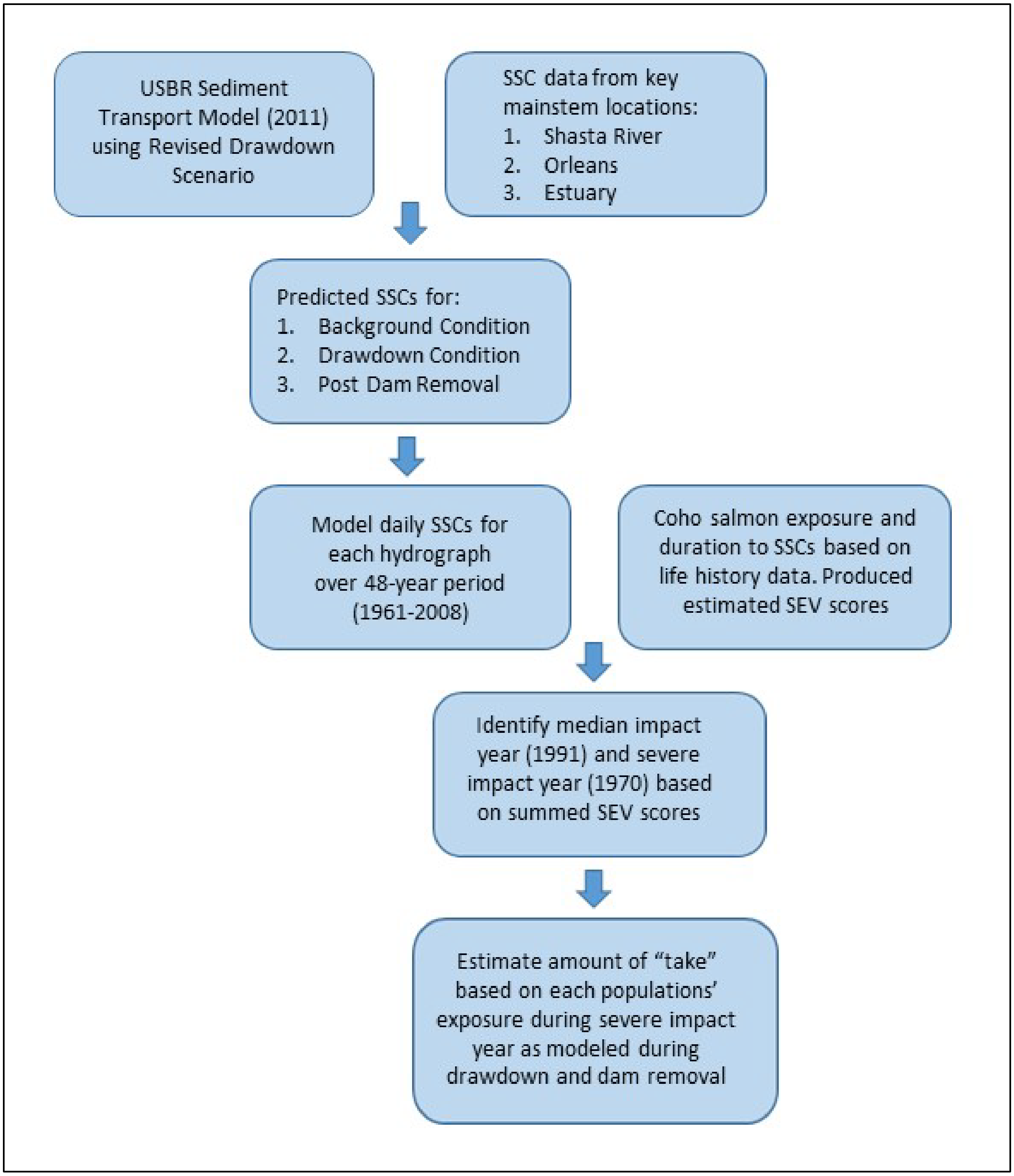

Figure 6. Flow chart representing model steps to develop SSC exposure-response data during drawdown and dam removal

The Renewal Corporation began their analysis by using Reclamation's previously developed SRH-1D 2.4 sediment transport model (Sedimentation and River Hydraulics, One Dimension Version 2.4) (Reclamation 2011b) hereafter referred to as "the model." The results from this model were used in NMFS' preliminary Biological Opinion analyzing effects of dam removal

(NMFS and USFWS 2012). Since 2012, the drawdown scenario first modeled has been revised by the Renewal Corporation. The now proposed drawdown rate is limited by the capacity of the diversion tunnels at Iron Gate Dam (Appendix I of FERC 2021a). Additionally, NMFS requested that the Renewal Corporation consider SSCs at different locations of the mainstem Klamath River to better evaluate the impacts to different coho salmon populations, as the severity of the impact would vary through the extent of the Klamath River. For example, the Upper Klamath River coho salmon population[7] will experience the most severe impacts, as those fish occupy habitat immediately downstream of Iron Gate Dam. The Lower Klamath River population, on the other hand, will experience a more minimized impact as concentrations of suspended solids are attenuated downstream. The model uses suspended sediment data collected by the United States Geological Survey (USGS) at three key gage locations downstream of Iron Gate Dam: (1) Shasta River near Yreka, (2) Klamath River near Orleans, and (3) Klamath River at Klamath (near the mouth) to estimate daily SSCs (in milligrams per liter [mg/L]) as a function of discharge (cfs). This approach provides a more accurate representation that, for example, will show individuals in the Lower Klamath are exposed to less severe impacts of SSC than those near Iron Gate Dam.

The SSCs were modeled daily for all water years between 1961 and 2008 using both a "dams in" scenario (background conditions) and dam removal scenario (proposed action). The life stage of each focal species (coho salmon, Chinook salmon, and eulachon) was then overlaid with the modeling results to determine extent of exposure to the elevated SSCs. With an understanding of anticipated SSCs in the Klamath River, life-stage travel times, and concomitant SSC exposure durations, the Newcombe and Jensen (1996) method was used to assess impacts of SSC on the different focal species. Newcombe and Jensen (1996) reviewed and synthesized 80 published reports of fish responses to suspended sediment in streams and estuaries, and established a set of equations to calculate "severity of ill effect" indices (SEV scores) for various species and life stages based on the duration of exposure and concentration of suspended sediment present.

The Renewal Corporation prepared a more detailed description and analysis for two representative years within the 48-year record that include the calculated median and most severe impact years (based on SEV scores) for each focal species. This allows us to evaluate a median impact scenario and a severe impact scenario using actual hydrographs from past years. To calculate the median impact year, the Renewal Corporation chose the year with the highest SEV score of the median 2 years to represent the median impact year.[8] The selected median and severe impact years vary depending on the species impacted.

[7] The terms used in this opinion for SONCC coho salmon populations, and Klamath River Basin geography, are similar, but denote different geographic areas. SONCC coho salmon populations in the action area are defined as used in the NMFS (2014) SONCC coho salmon Recovery Plan: the Upper Klamath River Population (IGD at RM 193.1 downstream to the mouth of Portuguese Creek at RM 128), the Middle Klamath River Population (the mouth of Portuguese Creek downstream to the Trinity River confluence at RM 43.4), and the Lower Klamath River Population (Trinity River confluence downstream to Klamath River mouth). Klamath River Basin areas are defined as used in the FERC (2021) BA: Upper Klamath Basin (Upper Klamath Lake and its tributaries downstream to Keno Dam at RM 239.2), Middle Klamath Basin (Keno Dam downstream to the Trinity River confluence) and Lower Klamath Basin (Trinity River confluence downstream to the Klamath River Mouth). This discrepancy was necessary to account for the area upstream of Iron Gate Dam that will become accessible to anadromous fish with the removal of the four dams.

[8] Because there are an even number of years within the hydrologic period, there are two median values.

The modeled period of record (1961-2008) was the only available suspended sediment model for removal of the four dams and represents the best available scientific information for analyzing the effects of SSCs. Although the model does not include the most recent years, we believe the modeled period to be sufficient to cover impacts of climate change that have influenced local hydrologic conditions. Later in this Opinion, we describe the effects of climate change in the action area (Section 2.4.1.2.1). Climate change has resulted in more rain, less snow pack, lower summer base flows, and more frequent, high intensity storms. The identification of a median impact and severe impact year are not tied specifically to a dry or wet hydrologic year. Instead, the analysis relied on the timing and duration of various flow events that co-occur with key life history events. We believe the results of the analysis include a wide range of flow events and timing so that, for example, the severe-impact year is representative of extreme flow events related to our changing climate that may occur in the near term (approximately 2022-2024, Table 1).

Predictions of mortality at high SSCs and exposure durations are considered more certain than the predictions of sublethal effects. For the current application of the Newcombe and Jensen framework, sublethal effects resulting from exposure to lower concentrations are also important to consider because sublethal SSC impacts may be magnified when sublethal concentrations occur in conjunction with the already stressed condition of some species and life stages from water temperature, low dissolved oxygen, and disease. Minor stress, such as alarm reactions or temporary avoidance response do not rise to the level of sublethal impacts (Newcombe and Jensen 1996) and are, therefore, not considered as an adverse effect to individuals.

Results of our SSC impact analysis show a range of potential mortality for the median and severe impact years. As explained below (Section 2.1.5.2, Variation in Behavioral Responses), we believe that in many cases fish will not experience the highest levels of mortalities predicted due to local conditions that allow for avoidance of the highest SSCs. However, elevated SSC will coincide with low dissolved oxygen concentrations during reservoir drawdown. Effects related to dissolved oxygen are expected to be sub-lethal, except when in the presence of high SSCs. Therefore, we do not expect additional mortality as a result of low DO, but instead assume that estimated morality associated with SSC exposure is likely to result in mortality that is at the upper extent of the estimated range.

2.1.3 Approach to Analysis: Dissolved Oxygen Concentrations

Dissolved oxygen levels are expected to be impacted by the short-term immediate oxygen demand (IOD) associated with water releases needed to accomplish the dam drawdowns. These water releases are likely to cause the rapid depletion of water column dissolved oxygen by releasing or re-suspending anoxic sediments.[9] Biological oxygen demand (BOD) refers to the amount of oxygen needed by aquatic microbes to metabolize organic matter and oxidize reduced nitrogen species such as ammonia, as well as to oxidize reduced mineral species such as ferrous iron (Stillwater Sciences 2011). While IOD exerts short-term pressure on dissolved oxygen concentrations, BOD is typically exerted more slowly over time.

[9] The sediments are anoxic due to reduced metals and chemicals in the sediments (Stillwater Sciences 2011).

The Renewal Corporation analyzed the short-term effects (<2 years) of the proposed action on dissolved oxygen levels by updating an existing numerical model (Stillwater Sciences 2011) to predict short-term dissolved oxygen levels in the Klamath River downstream of Iron Gate Dam. The model uses an approach similar in concept to the Streeter and Phelps (1958) equation to incorporate the oxygen-demand offsets of tributary dilution and reaeration in evaluating the different short-term oxygen demand parameters.

The model input parameters are bounded by a range of potential conditions at Iron Gate Dam as well as other inputs downstream of the dam. Initial condition inputs include BOD and IOD, initial oxygen saturation, flow, SSCs, and water temperature. Flow, SSCs, and water temperature data are also included for other downstream model nodes to represent the influence of tributary dilution. The dilution ratios for each month for each tributary are calculated as the total tributary inflow for the month divided by the total mainstream flow volume downstream of the tributary confluence during the first water year of dam removal.

Initial oxygen concentrations are based on either high initial saturation conditions (80% saturation) or low initial saturation conditions (0% saturation). The Renewal Corporation used 80% saturation as a conservative but reasonable estimate for high saturation conditions based on PacifiCorp sonde data for existing conditions (Raymond 2010; PacifiCorp 2018) and Karuk Tribe (https://waterquality.karuk.us:8080/) data collected downstream of Iron Gate Dam. Because the IOD/BOD model results are sensitive to initial dissolved oxygen concentrations (Stillwater Sciences 2011), and because initial percent saturation is uncertain during drawdown conditions where SSCs and IOD/BOD generated from J.C. Boyle and Copco drawdowns may reduce initial dissolved oxygen concentrations, the Renewal Corporation also simulated 0% saturation initial conditions in the model to represent worst-case initial conditions. The results bracket the range of dissolved oxygen conditions that could be expected in the Klamath River downstream of Iron Gate Dam during the reservoir drawdown.

The mean daily discharge on the same day of each peak SSC was used as the mainstem discharge input to the model. Water temperatures were unchanged from the Stillwater Sciences (2011) model and are monthly averages derived from a HEC5Q water temperature model (Bartholow 2005).

Oxygen depletion rates are scaled to the level of suspended sediments expected under median impact year and severe impact year scenarios developed for juvenile coho salmon (1991 and 1970, respectively) and juvenile Chinook salmon (1991 and 1973, respectively) based on Reclamation's hydrology and sediment transport model updated for the revised drawdown (Reclamation 2011b; Appendix I of FERC 2021a). Model output was synthesized for the peak daily SSC value for each month from October prior to the drawdown year through September of the drawdown year. Summary output includes anticipated minimum dissolved oxygen levels and the location, extent, and duration of anoxic conditions.

As a result of pre-consultation discussions with NMFS, the Renewal Corporation used dissolved oxygen thresholds of 7 mg/L and 5 mg/L to determine the potential downstream distances of dissolved oxygen impairment that will be expected under each impact year scenario and for each initial dissolved oxygen saturation scenario. NMFS uses 7 mg/L as a dissolved oxygen concentration that has no expected impairment on aquatic habitat for salmonids. Laboratory studies have demonstrated that dissolved oxygen concentrations of 7.0 mg/L or greater result in little to no population impairment for salmonids (Davis 1975; EPA 1986; Carter 2005). The

Renewal Corporation also presented the 5 mg/L dissolved oxygen threshold to provide consistency with previous Klamath River dam removal dissolved oxygen analyses (Stillwater Sciences 2011; Reclamation 2012a; CSWRCB 2020b) that used 5 mg/L as a minimum value below which short-term fish effects are likely to be acute and may cause harm or mortality (Stillwater Sciences 2011).

2.1.4 Approach to Analysis: Bedload Deposition

Because the River's bedload can affect fish passage, the Renewal Corporation analyzed SRH-1D bed sediment and bedload modeling output provided by Reclamation to assess the proposed action's effect on bedload sediment transport and deposition in the near term. Updated modeling output reflects the proposed action's drawdown approach and schedule, which results in a slower average drawdown rate and later reservoir sediment evacuation in the Hydroelectric Reach reservoirs than previously modeled by Reclamation (2012a).

Reclamation dam removal simulations were divided into two modeling domains: the Hydroelectric Reach or "US Reach" from Keno Dam to approximately 0.5 miles downstream of Iron Gate Dam, and the downstream reach or "DS Reach" from below Iron Gate Dam to the mouth of the Klamath River. A full description of the model is provided in Reclamation's Report (Reclamation 2011b). For some analyses, the Renewal Corporation analyzed the results by subreach, as defined by dam locations and the upstream limits of reservoirs in the US Reach, and by major tributary confluences in the DS Reach. The modeling output is in monthly and 28-day timesteps for the DS Reach and US Reach, respectively, both covering a period of two water years beginning on October 1 of the pre-drawdown year and ending on September 30 in the post-drawdown year. Depositional analysis beyond that timeframe is too difficult to predict in the modeling given the range of flows and water year types that may occur over that time.

The Renewal Corporation analyzed bed elevation and sediment thickness as well as sediment texture output data for reference locations over monthly time steps for the three representative water years. The selected years, 1976, 1984, and 2001, represent median, wet, and dry hydrologic conditions, respectively. By utilizing different water year types in the analysis that bound the range of results, NMFS assumes the approach is sufficient to cover impacts of climate change in the near term that may have influenced local hydrologic conditions (e.g., more frequent occurrence of dry water year types). For example, hydrologic conditions in 2001 are representative of recent dry hydrologic conditions in the upper Klamath Basin (e.g. 2020 and 2021conditions). Output data included reach-averaged changes in channel bed elevation and sediment thickness, and sediment texture.

2.1.5 Critical Assumptions

2.1.5.1 Exposure to Proposed Action

The proposed action describes the decommissioning and removal of four hydroelectric dams on the mainstem Klamath River. The instream construction activities at each of the dam sites will be completed simultaneously during the summer of dam removal. Iron Gate is the downstream most dam and currently the upstream limit of anadromy. Therefore, any instream construction activities that occur upstream of Iron Gate Dam (e.g., removal of Copco Dams and J.C. Boyle) will occur prior to anadromous fish being present in the action area. Only once all four dams have been removed and the final cofferdam is breached at Iron Gate in October, will fish have access to upstream reaches.

NMFS' effects analysis only considers impacts to individuals when exposure to the action is likely. Although listed species will not be present for much of the upstream construction activities such as drawdown of reservoirs, construction of access roads, dam removal, channel restoration etc., some upstream activities will impact fish that are present downstream of Iron Gate Dam. For example, during drawdown of the four reservoirs, sediment will be evacuated and moved downstream. Listed species downstream of Iron Gate Dam will be exposed to elevated suspended sediment as a result of upstream drawdown activities. NMFS' effects analysis includes impacts of SSCs that result from reservoir drawdown.

2.1.5.2 Variation in Behavioral Responses

Much of NMFS' analysis relies on modeling results provided by Reclamation and the Renewal Corporation. The Renewal Corporation performed a literature review to determine critical variables that were needed to model impacts of elevated SSCs. For example, the Renewal Corporation made assumptions regarding exposure times of each life stage to mainstem instream conditions and physical response to that exposure. The assumptions made during the modeling exercises are based on laboratory experiments or averages derived from field observations. However, salmonids respond to their environment in variable and sometimes unpredictable ways. In the Klamath River, coho salmon movement is often linked to environmental cues including water temperatures, smolt growth rates, and flow events (Wallace 2004; Witmore 2014). Additionally, elevated SSCs as a result of drawdown presents a unique environmental condition that exposes fish to turbid conditions in the mainstem Klamath River but does not impact tributaries. Due to the distribution of tributaries throughout the Klamath River, refugia areas containing higher water quality will be available to migrating and rearing salmonids to reduce exposure to elevated SSCs. Individual behavioral responses and utilization of refugial areas could not be modeled for the purposes of our analysis. Therefore, modeling results likely over estimate population impacts to an unknown degree.

2.1.5.3 Critical Habitat Analysis for Coho Salmon

Critical habitat for SONCC coho salmon overlaps with the action area in the Klamath River from Iron Gate Dam to the Pacific Ocean. Critical habitat for SONCC coho salmon is not designated upstream of Iron Gate Dam (50 CFR 226.210). However, post dam removal, coho salmon are expected to re-populate their historic range that includes tributary and mainstem habitat upstream of Iron Gate Dam, inclusive of Spencer Creek in Klamath County Oregon (Hamilton et al. 2005; ODFW 2021). NMFS' critical habitat analysis will not include impacts to habitat upstream of Iron Gate Dam. However, NMFS' effects analysis of coho salmon individuals within the Upper Klamath SONCC coho salmon population will consider effects of the proposed action to habitat upstream of Iron Gate Dam.

2.1.5.4 Short Term, Mid Term, and Long Term Impacts

In this Opinion NMFS will evaluate the effects of the proposed action in terms of short-term and long-term impacts for listed fish species and their designated critical habitat, and short-term, mid-term, and long-term impacts for SRKW and their designated critical habitat. The proposed action will have short-term impacts to fish species and their critical habitat as a result of facility demolition, sediment release, and instream restoration actions. For ESA listed fish species and their designated critical habitat, NMFS will evaluate both the short term impacts (less than two years) and long term impacts (two years or more), including anticipated beneficial impacts, to ESA listed species and critical habitat as a result of the proposed action. For SRKW and their critical habitat, NMFS will evaluate short term impacts (less than two years), mid-term impacts (two to eight years), and long-term impacts (beyond eight years), including anticipated beneficial impacts. The reason for the difference in the timeline for effects analysis between fish species and SRKW is predominantly because hatchery production targets for coho salmon for eight years post dam removal are expected to remain the same under the proposed action, while hatchery production targets for Chinook salmon, who are SRKW prey, are reduced under the proposed action. In addition, effects to SRKW resulting from impacts to their prey are delayed until their prey have matured to be large enough to be suitable prey, so the effects of the proposed action will continue into the future beyond eight years. The analytical approach to the effects analysis for SRKW is further described in Section 2.1.1.5, Approach Specific to Southern Resident Killer Whales (SRKW). The Integration and Synthesis (Section 2.7) will describe this evaluation as we look at impacts and benefits to populations of listed species and their critical habitat affected by the proposed action.

2.2 Rangewide Status of the Species and Critical Habitat

This opinion examines the status of each species that is likely to be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" for the jeopardy analysis. The opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the function of the PBFs that are essential for the conservation of the species.

2.2.1 Southern Oregon/Northern California Coast (SONCC) coho salmon

2.2.1.1 Species Description and General Life History

The SONCC ESU of coho salmon is listed as threatened and is described as naturally spawned coho salmon originating from coastal streams and rivers between Cape Blanco, Oregon, and Punta Gorda, California. Also, the SONCC ESU includes coho salmon from the following artificial propagation programs: The Cole Rivers Hatchery Program; TRH Program; and the IGH Program (50 CFR 223.102(e)). SONCC coho salmon have a generally simple three-year life history. The adults typically migrate from the ocean and into bays and estuaries towards their freshwater spawning grounds in late summer and fall, and spawn by mid-winter. Adults die after spawning. The eggs are buried in nests, called redds, in the rivers and streams where the adults spawn. The eggs incubate in the gravel until fish hatch and emerge from the gravel the following spring as fry. Individual fish produced during the same year are considered from the same "year class" or cohort. Fish typically rear in freshwater for about 15 months before migrating to the ocean. The juveniles go through a physiological change during the transition from fresh to salt water called smoltification. Coho salmon typically rear in the ocean for two growing seasons, returning to their natal streams as three-year old fish to renew the cycle.

2.2.1.2 Status of SONCC coho salmon and their Critical Habitat

As described in more detail in the Analytical Approach section above, NMFS assesses four population viability parameters to help us understand the status of each species and their ability to survive and recover. These population viability parameters are: abundance, population productivity, spatial structure, and diversity (McElhany et al. 2000). While there is insufficient information to evaluate these population viability parameters in a thorough quantitative sense, NMFS has used existing information, including the Recovery Plan for SONCC Coho Salmon (NMFS 2014a) and the most recent status review for SONCC coho salmon (Williams et al. 2016a) to determine the general condition of each population and factors responsible for the current status of the ESU. We use these population viability parameters as surrogates for reproduction, numbers, and distribution; the criteria found within the regulatory definition of "jeopardize the continued existence of" (50 CFR 402.02). This Opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the PBFs that help to form that conservation value.

2.2.1.2.1 Status of SONCC Coho Salmon

SONCC Coho Salmon Abundance and Productivity: Although long-term data on coho salmon abundance are scarce, the available evidence from short-term research and monitoring efforts indicate that spawner abundance has declined since the previous status review (Williams et al. 2011) for populations in this ESU (Williams et al. 2016a). In fact, most of the 30 independent populations in the ESU are at high risk of extinction because they are below or likely below their depensation threshold, which can be thought of as the minimum number of adults needed for survival of a population. No populations are at low risk of extinction and all core populations are thousands short of the numbers needed for recovery (Williams et al. 2016a).

SONCC Coho Salmon Spatial Structure and Diversity: The distribution of SONCC coho salmon within the ESU is reduced and fragmented, as evidenced by an increasing number of previously occupied streams from which SONCC coho salmon are now absent (NMFS 2001b; Good et al. 2005; Williams et al. 2011; Williams et al. 2016a). Extant populations can still be found in all major river basins within the ESU (70 FR 37160 (June 28, 2005)). However, extirpations, loss of brood years, and sharp declines in abundance (in some cases to zero) of SONCC coho salmon in several streams throughout the ESU indicate that the SONCC coho salmon's spatial structure is more fragmented at the population-level than at the ESU scale. The genetic and life history diversity of populations of SONCC coho salmon is likely very low. The SONCC coho salmon ESU is currently considered likely to become endangered within the foreseeable future in all or a significant portion of its range, and there is heightened risk to the persistence of the ESU as VSP parameters continue to decline and no improvements have been noted since the previous status review in 2011 (Williams et al. 2016a).

2.2.1.2.2 Status of SONCC Critical Habitat

Critical habitat for SONCC coho salmon is designated to include all river reaches accessible to listed coho salmon between Cape Blanco, Oregon, and Punta Gorda, California. Critical habitat consists of the water, substrate, and adjacent riparian zone of estuarine and riverine reaches (including off-channel habitats) in hydrologic units and counties identified in Table 6 of 50 CFR Part 226. Accessible reaches are those within the historical range of the ESU that can still be occupied by any life stage of coho salmon. Inaccessible reaches are those above specific dams identified in Table 6 of 50 CFR Part 226 or above longstanding, naturally impassable barriers (i.e., natural waterfalls in existence for at least several hundred years) (50 CFR 226.210(b)). Tribal lands are specifically excluded from critical habitat for this ESU (50 CFR Part 226, Table 6, note 2). The condition of SONCC coho salmon critical habitat, specifically its ability to provide for their conservation, has been degraded from conditions known to support viable salmonid populations. NMFS has determined that currently depressed population conditions are, in part, the result of the following human induced factors affecting critical habitat: overfishing, artificial propagation, logging, agriculture, mining, urbanization, stream channelization, dams, wetland loss, and water withdrawals (including unscreened diversions for irrigation). Impacts of concern include altered stream bank and channel morphology, elevated water temperature, lost spawning and rearing habitat, habitat fragmentation, impaired gravel and wood recruitment from upstream sources, degraded water quality, lost riparian vegetation, and increased erosion into streams from upland areas (Weitkamp et al. 1995; 70 FR 37160 (June 28, 2005); 64 FR 24049 (May 5, 1999)). Diversion and storage of river and stream flow has dramatically altered the natural hydrologic cycle in many of the streams within the ESU. Altered flow regimes can delay or preclude migration, dewater aquatic habitat, and strand fish in disconnected pools, while unscreened diversions can entrain juvenile fish.

2.2.1.2.3 Factors Related to the Decline of Species and Degradation of Critical Habitat

The factors that caused declines include hatchery practices, ocean conditions, habitat loss due to dam building, degradation of freshwater habitats due to a variety of agricultural and forestry practices, water diversions, urbanization, over-fishing, mining, climate change, and severe flood events exacerbated by land use practices (Good et al. 2005; Williams et al. 2016b). Sedimentation and loss of spawning gravels associated with poor forestry practices and road building are particularly chronic problems that can reduce the productivity of salmonid populations. Late 1980s and early 1990s droughts and unfavorable ocean conditions were identified as further likely causes of decreased abundance of SONCC coho salmon (Good et al. 2005). From 2014 through 2016, the drought in California reduced stream flows and increased temperatures, further exacerbating stress and disease. Drought conditions returned to the Klamath Basin in 2020 (Reclamation 2020c), and the state of Oregon declared a state of drought emergency in the upper Klamath River Basin in early 2021 due to unusually low snow pack and lack of precipitation (Oregon 2021). Reduced flows can cause increases in water temperature, resulting in increased heat stress to fish and thermal barriers to migration.

One factor affecting the range wide status and aquatic habitat at large is climate change. The best available information suggests that the earth's climate is warming, and that this could significantly impact ocean and freshwater habitat conditions, and thus the survival of species subject to this consultation. Recent evidence suggests that climate and weather is expected to become more extreme, with an increased frequency of drought and flooding (IPCC 2019). Climate change effects on stream temperatures within Northern California are already apparent. For example, in the Klamath River, Bartholow (2005) observed a 0.5ºC per decade increase in water temperature since the early 1960's and model simulations predict a further increase of 1-2 ºC over the next 50 years (Perry et al. 2011). Heavier winter rainstorms from warming may lead to increased flooding and high-flow events that result in scouring of riverbeds, smothering redds, and increasing suspended sediment in systems. In the summer, decreased stream flows and increased water temperature can reduce salmon habitat and impede migration (Southern Resident Orca Task Force 2019).

In coastal and estuarine ecosystems, the threats from climate change largely come in the form of sea level rise and the loss of coastal wetlands. Sea levels will likely rise exponentially over the next 100 years, with possibly a 43-84 cm rise by the end of the 21st century (IPCC 2019). This rise in sea level will alter the habitat in estuaries and either provide an increased opportunity for feeding and growth or in some cases will lead to the loss of estuarine habitat and a decreased potential for estuarine rearing. Marine ecosystems face an entirely unique set of stressors related to global climate change, all of which may have deleterious impacts on growth and survival while at sea. In general, the effects of changing climate on marine ecosystems are not well understood given the high degree of complexity and the overlapping climatic shifts that are already in place (e.g., El Niño, La Niña, and Pacific Decadal Oscillation) and will interact with global climate changes in unknown and unpredictable ways. Overall, climate change is believed to represent a growing threat, and will challenge the resilience of SONCC coho salmon.

2.2.2 Southern Resident Killer Whales (SRKWs)

The Southern Resident killer whale DPS (SRKW or SRKWs), described as killer whales from the J, K and L pods, is listed as endangered under the ESA (50 CFR 224.101(h)). A 5-year review under the ESA completed in 2016 concluded that SRKWs should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2016e). NMFS considers SRKWs to be currently among nine of the most at-risk species as part of NMFS' Species in the Spotlight initiative because of their endangered status, declining population trend, and because they are high priority for recovery based on conflict with human activities and recovery programs in place to address threats (NMFS 2019b). The population has relatively high mortality and low reproduction, unlike other resident killer whale populations, which have generally been increasing since the 1970s (Carretta et al. 2021).

The limiting factors described in the final recovery plan include reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS 2008). This section summarizes the status of SRKWs throughout their range and summarizes information taken largely from the recovery plan (NMFS 2008), most recent 5-year review (NMFS 2016e), the Pacific Fishery Management Council (PFMC) SRKW Ad Hoc Workgroup's report (PFMC 2020b), as well as new data that became available more recently.

2.2.2.1 Status of SRKWs

2.2.2.1.1 Abundance, Productivity, and Trends

Killer whales, including SRKWs, are a long-lived species and sexual maturity can occur at age 10 (NMFS 2008). Compared to Northern Resident killer whales (NRKWs), which are a resident killer whale population with a sympatric geographic distribution ranging from coastal waters of Washington State and British Columbia north to Southeast Alaska, SRKWs females appear to have reduced fecundity (Ward et al. 2013; Velez-Espino et al. 2014), and all age classes of SRKWs have reduced survival compared to other fish-eating populations of killer whales in the Northeast Pacific (Ward et al. 2013).

Since the early 1970s, annual summer censuses in the Salish Sea using photo-identification techniques have occurred (Bigg et al. 1990; CWR 2019). At present, the SRKW population size[10] has declined to near historically low levels (Figure 7). The July 2021 census number reported by the CWR was 74 whales.[11]

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[11]As of December 10, 2021, one whale has been reported as missing since the July 2021 census; https://www.whaleresearch.com/orca-population.

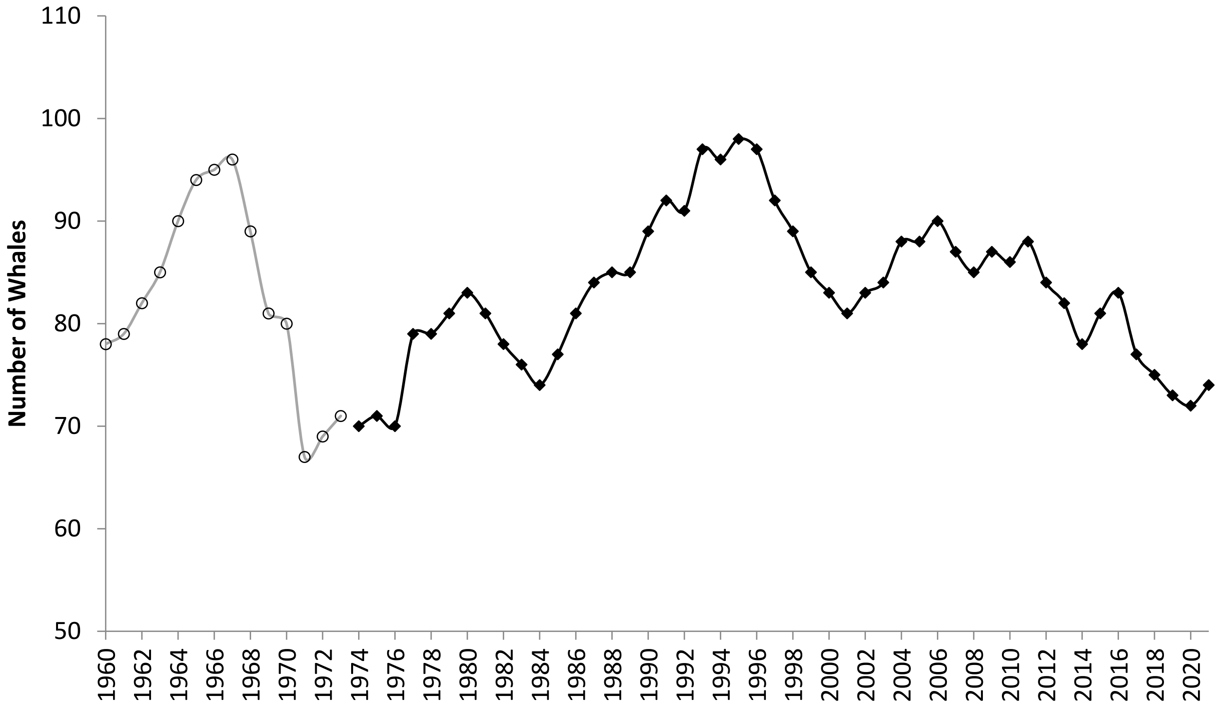

Figure 7. Population size and trend of SRKWs, 1960-2021. Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of *(Olesiuk et al. 1990)*. Data from 1974-2021 (diamonds, black line) were obtained through photo-identification surveys of the three pods (J, K, and L) in this community and were provided by the Center for Whale Research (2021 unpublished data) and NMFS (2008). Data for these years represent the number of whales present at the end of each calendar year.

The NMFS Northwest Fisheries Science Center (NWFSC) continues to evaluate changes in fecundity and mortality rates, and has updated the population viability analyses conducted for the 2004 Status Review for SRKWs and the 2011 science panel review of the effects of salmon fisheries (Krahn et al. 2004; Hilborn et al. 2012; Ward et al. 2013). Following from that work, population estimates including data from the last 5 years (2017-2021) project a downward trend over the next 25 years (Figure 8). The declining trend is in part due to the changing age and sex structure of the population (the sex ratio at birth was estimated at 55% male and 45% female following current trends), but also related to the relatively low fecundity rate observed over the period from 2017 to 2021 (when the same analyses are applied to Fisheries and Oceans Canada's (DFO's) NRKW data, a similar trend of declining fecundity is also present in that population). Though these fecundity rates are declining, average SRKW survival rates estimated by the NWFSC have been slowly increasing since the late 1990s. The population projection is most pessimistic if future fecundity rates are assumed to be similar to the last 5 years, and higher but still declining if average fecundity and survival rates over all years (1985-2021) is used for the projections (Figure 8). The projection using the highest fecundity and survival rates (1985-1989) shows some stability and even a slight increase over the next decade before severely declining. Only 25 years were selected for projections because as the model projects out over a longer time frame (e.g., 50 years), there is increased uncertainty around the estimates. This limitation is also discussed in Hilborn et al. (2012).

The scenario using the most recent (2017-2021) survival and fecundity rates may be a more reliable estimation if current levels of survival and poor reproduction continue. This predicted downward trend in the model is driven by the current age and sex structure of young animals in the population, as well as the number of older animals. The analysis does not link population growth or decline to any specific threat, but reflects the combined impacts of all of the threats in the past. One assumption shared across all scenarios presented here is that female reproduction will be similar to average (given the age of animals and time period). As many reproductive aged females have not produced a calf in the last decade, we would expect the SRKW population size to decline even more rapidly if the number of females not reproducing continues to increase, or these females continue to fail to produce calves.

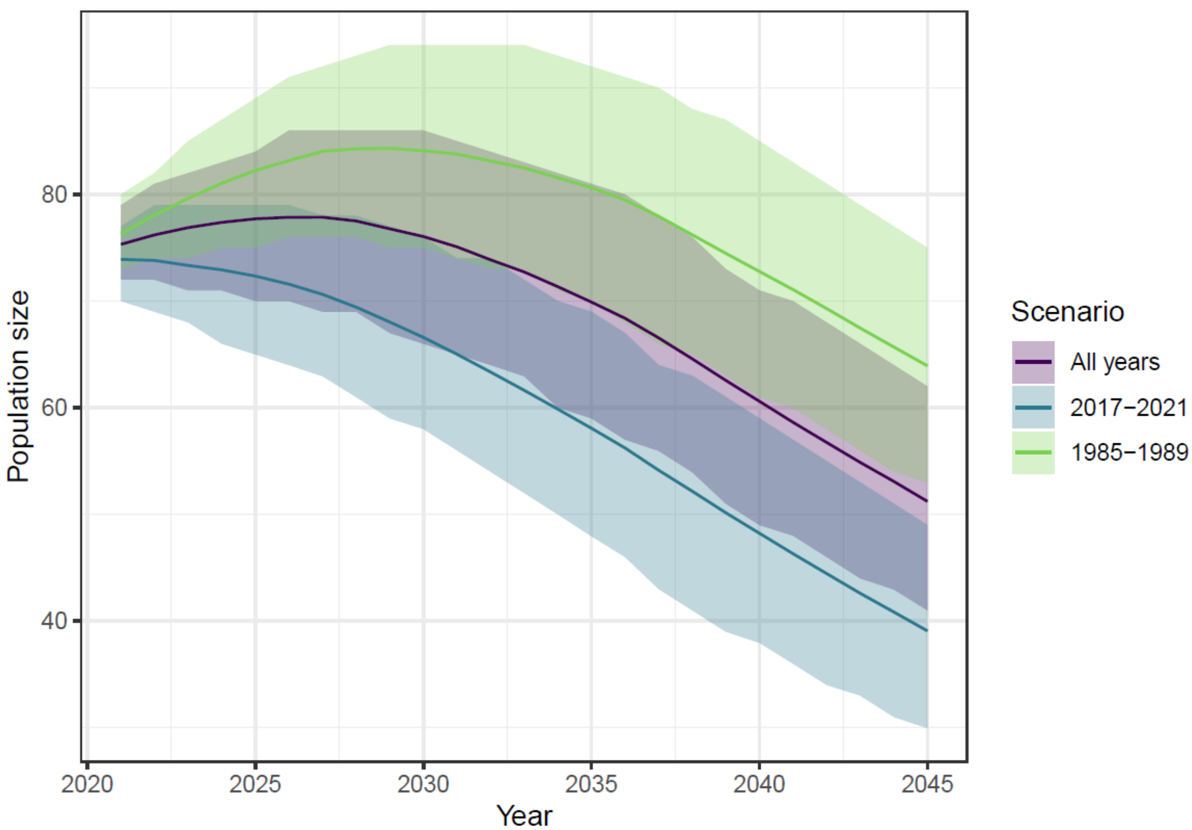

Figure 8. Southern Resident killer whale population size projections from 2020 to 2045 using 3 scenarios: (1) projections using fecundity and survival rates estimated over the entire time series, (2) projections using rates estimated over the last 5 years (2017-2021), and (3) projections using the highest survival and fecundity rates estimated, during the period 1985-1989 (NMFS in prep.).

Because of this population's small abundance, it is susceptible to increased risks of demographic stochasticity – randomness in the pattern of births and deaths among individuals in a population. Several sources of demographic variance (e.g., differences between individuals or within individuals) can affect small populations and contribute to variance in a population's growth and increased extinction risk. Sources of demographic variance can include environmental stochasticity, or fluctuations in the environment that drive changes in birth and death rates, and demographic heterogeneity, or variation in birth or death rates of individuals because of differences in their individual fitness (including sexual determinations). In combination, these and other sources of random variation combine to amplify the probability of extinction (Gilpin and Michael 1986; Fagan and Holmes 2006; Melbourne and Hastings 2008). The larger the population size, the greater the buffer against stochastic events and genetic risks.

2.2.2.1.2 Geographic Range and Distribution

SRKWs occur throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (Figure 9) (NMFS 2008; Hanson et al. 2013; Carretta et al. 2017; Ford et al. 2017; Carretta et al. 2021; NMFS 2021h). A comprehensive review of SRKW use of coastal waters is available in the Final Biological Report on SRKW critical habitat (NMFS 2021h). SRKWs are highly mobile and can travel up to 86 miles (160 km) in a single day (Erickson 1978; Baird 2000), with seasonal movements likely tied to the migration of their primary prey, salmon. During the spring, summer, and fall months, the whales have typically spent substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Bigg 1982; Ford et al. 2000; Krahn et al. 2002; Hauser et al. 2007). During fall and early winter, SRKWs, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum, coho, and Chinook salmon runs (Osborne 1999; Hanson et al. 2010; Ford et al. 2016). Although seasonal movements are somewhat predictable, there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall, with late arrivals and fewer days present in recent years (Hanson and Emmons 2010; NMFS 2021f).

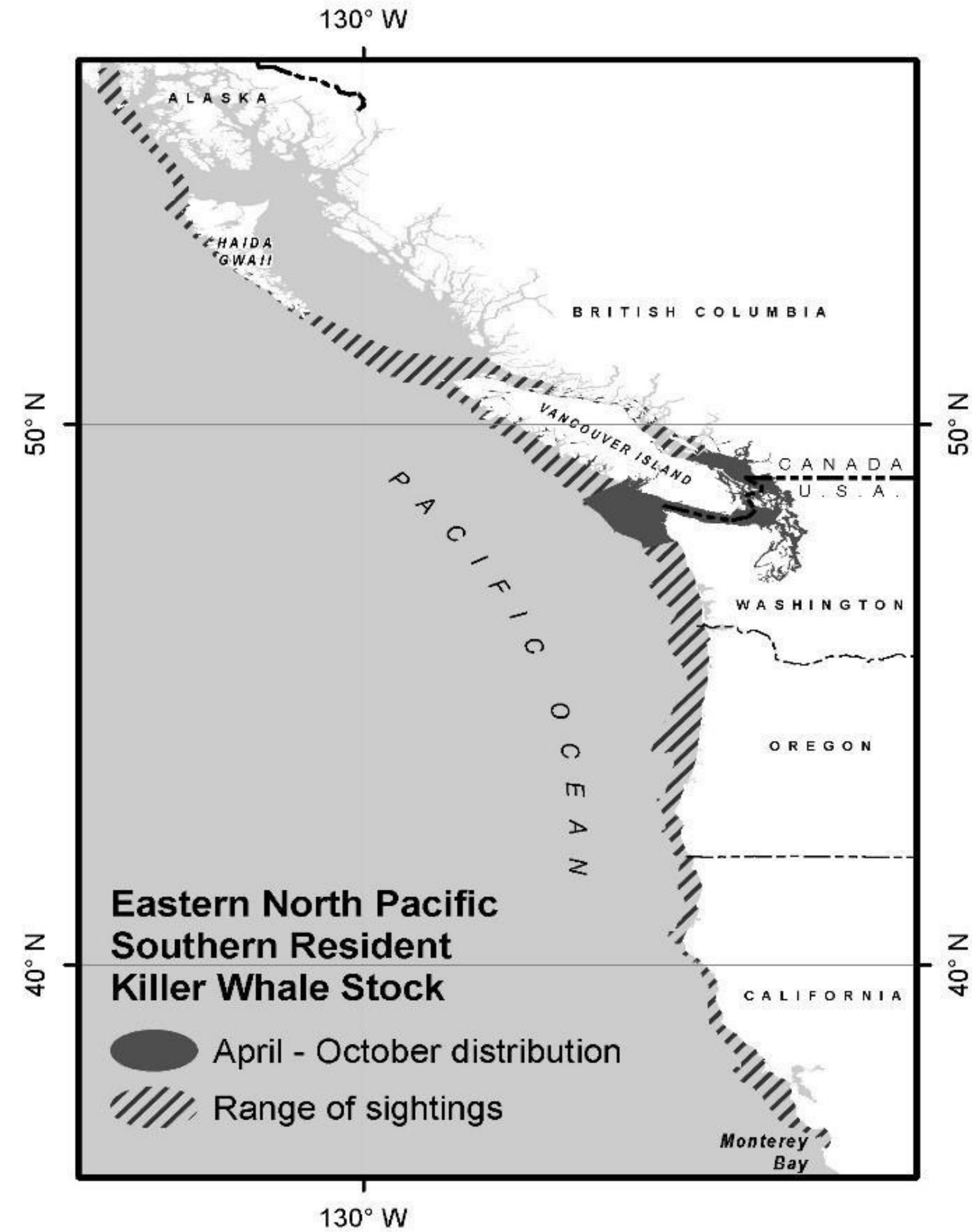

Figure 9. Geographic range of SRKWs (reprinted from Carretta et al. 2021)

As part of a collaborative effort between NWFSC, Cascadia Research Collective, and the University of Alaska, satellite-linked tags were deployed on eight male SRKWs (three tags on J pod members, two on K pod, and three on L pod) from 2012 to 2016 in Puget Sound or in the coastal waters of Washington and Oregon. Over the course of the study, the eight satellite tags deployed were monitored for a range of signal contact durations from 3 days to 96 days depending on the tag, with deployment from late December to mid-May. The winter locations of the tagged whales included inland and coastal waters. The inland waters range occurs across the entire Salish Sea, from the northern end of the Strait of Georgia and Puget Sound, and coastal waters from central west coast of Vancouver Island, British Columbia to northern California

(Hanson et al. 2017). J pod spends more time during the winter and spring in the inland waters of Washington and B.C. compared to K and L pods who spend the majority of their time in coastal waters during these seasons (Hanson et al. 2017).

Passive acoustic recorders were deployed off the coasts of California, Oregon and Washington in most years since 2006 to assess SRKW seasonal uses of these areas via the recording of stereotypic calls of the SRKWs (Hanson et al. 2013; Emmons et al. 2019). There were acoustic detections off Washington coast in all months of the year, with greater than 2.4 detections per month from January through June and a peak of 4.7 detections per month in both March and April, indicating that the SRKW may be present in Washington coastal waters at nearly any time of year, more often than previously believed (Hanson et al. 2017). Acoustic recorders were deployed off Newport, Fort Bragg, and Port Reyes between 2008 through 2013 and SRKW were detected 28 times (Emmons et al. 2019). For areas off the coast of Oregon and California, the data available suggest considerable year-to-year variation in SRKW occurrence with their presence (K and L pod primarily) expected to be most likely during the winter and spring (NMFS 2021h).

2.2.2.2 Limiting Factors and Threats

Several factors identified in the final recovery plan for SRKWs may be limiting recovery. The recovery plan identifies three major threats including (1) quantity and quality of prey, (2) toxic chemicals that accumulate in top predators, and (3) impacts from sound and vessels (NMFS 2008). Oil spills and disease as well as the small population size are also risk factors. It is likely that multiple threats are acting together to impact the whales. Modeling exercises have attempted to identify which threats are most significant to survival and recovery (e.g., Lacy et al. 2017) and available data suggests that all of the threats are potential limiting factors (NMFS 2016e).

2.2.2.2.1 Quantity and Quality of Prey

SRKWs consume a variety of fish species (22 species) and one species of squid (Ford et al. 1998; Ford et al. 2000; Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016) but salmon are identified as their primary prey. The best available information suggests an overall preference for Chinook salmon (*Oncorhynchus tshawytscha)* during the summer and fall. Chum (*O. keta)*, coho (*O. kisutch)*, and steelhead (*O. mykiss*) may also be important in the SRKW diet at particular times and in specific locations. Rockfish (*Sebastes* spp.), Pacific halibut (*Hippoglossus stenolepis*), and Pacific herring (*Clupea pallasi*) were also observed during predation events (Ford and Ellis 2006); however, these data may underestimate the extent of feeding on bottom fish (Baird 2000). A number of smaller flatfish, lingcod (*Ophiodon elongatus*), greenling (*Hexagrammos* spp.), and squid have been identified in stomach content analysis of resident whales (Ford et al. 1998).

SRKW diet studies are the subject of ongoing research, the majority of which has occurred during summer months in inland waters of Washington State and British Columbia, Canada, and have involved direct observation, scale and tissue sampling of prey remains, and fecal sampling. The diet data suggest that SRKWs are consuming mostly larger (i.e., generally age 3 and up) Chinook salmon. Chinook salmon is their primary prey despite the much lower abundance in comparison to other salmonids in some areas and during certain time periods. Factors of potential importance include the Chinook salmon's large size, high fat and energy content, and year-round occurrence in the whales' geographic range. Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (kilocalorie/kilogram (kcal/kg)) (O'Neill et al. 2014). For example, in order for a killer whale to obtain the total energy value of one Chinook salmon, they would need to consume on average approximately 2.7 coho, 3.1 chum, 3.1 sockeye, or 6.4 pink salmon (O'Neill et al. 2014). The degree to which killer whales are able to or willing to switch to non-preferred prey sources (i.e., prey other than Chinook salmon) is also largely unknown, and likely variable depending on the time and location.

Recent stable isotope analyses of opportunistically collected fish scale samples (from prey remains and whale fecal samples (Warlick et al. 2020) continue to support and validate previous diet studies (Ford et al. 2016) and what is known of SRKW seasonal movements (Olson et al. 2018; see below), but highlight temporal variability in isotopic values. Warlick et al. (2020) continued to find that Chinook salmon is the primary prey for all pods in summer months followed by coho salmon and then other salmonids. Carbon signatures in samples varied by month, which could indicate variation in Chinook and coho salmon consumption between months and/or differences in carbon signatures across salmon runs and life histories. Peaks in carbon signatures in samples varied between K/L pod and J pod. Though Chinook salmon was the primary prey across years, there was inter-annual variability in nitrogen signature in samples, which could indicate variation in Chinook salmon nitrogen content from year to year or greater Chinook salmon consumption in certain years versus others and/or nutritional stress in certain years, but this is difficult to determine.

Scale and tissue sampling from May to September in inland waters of Washington and British Columbia, Canada, indicate that the SRKW's diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90%) (Hanson et al. 2010; Ford et al. 2016). Genetic analysis of the Hanson et al. (2010) samples from 2006 – 2010 indicate that when SRKWs are in inland waters from May to September, they primarily consume Chinook salmon stocks that originate from the Fraser River, and to a lesser extent consume stocks from Puget Sound, the Central British Columbia Coast and West and East Vancouver Island. Prey remains and fecal samples collected in inland Washington waters during October through December indicate Chinook and chum salmon are primary contributors of the whales' diet (Hanson et al. 2021).

Collection of prey and fecal samples have also occurred in coastal waters in the winter and spring months, as well as observations of SRKWs overlapping with salmon runs (Wiles 2004; Zamon et al. 2007; Krahn et al. 2009). Results indicate that, as is the case in inland waters, Chinook salmon are the primary species detected in diet samples on the outer coast, although steelhead, chum salmon, and Pacific halibut were also detected in samples. Foraging on chum and coho salmon, steelhead, Big skate (*Rana binoculata*) and lingcod was also detected in recent fecal samples (Hanson et al. 2021). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al. 2013). Chinook salmon genetic stock identification from samples collected in winter and spring in coastal waters from California through Washington included 12 U.S. west coast stocks, and showed that over half the Chinook salmon consumed originated in the Columbia River (Hanson et al. 2021). Columbia River, Central Valley, Puget Sound, and Fraser River Chinook salmon collectively comprised over 90% of Chinook salmon prey samples for which genetic stock origin was determined for SRKWs in coastal areas. As noted, most of the Chinook salmon prey samples opportunistically collected in coastal waters were determined to have originated from the Columbia River basin, including Lower Columbia Spring, Middle Columbia Tule, and Upper Columbia Summer/Fall. In general, we would expect to find these stocks given the diet sample locations (Figure 10). However, the Chinook salmon stocks included fish from as far north as the Taku River (Alaska and British Columbia stocks) and as far south as the Central Valley California (Hanson et al. 2021).

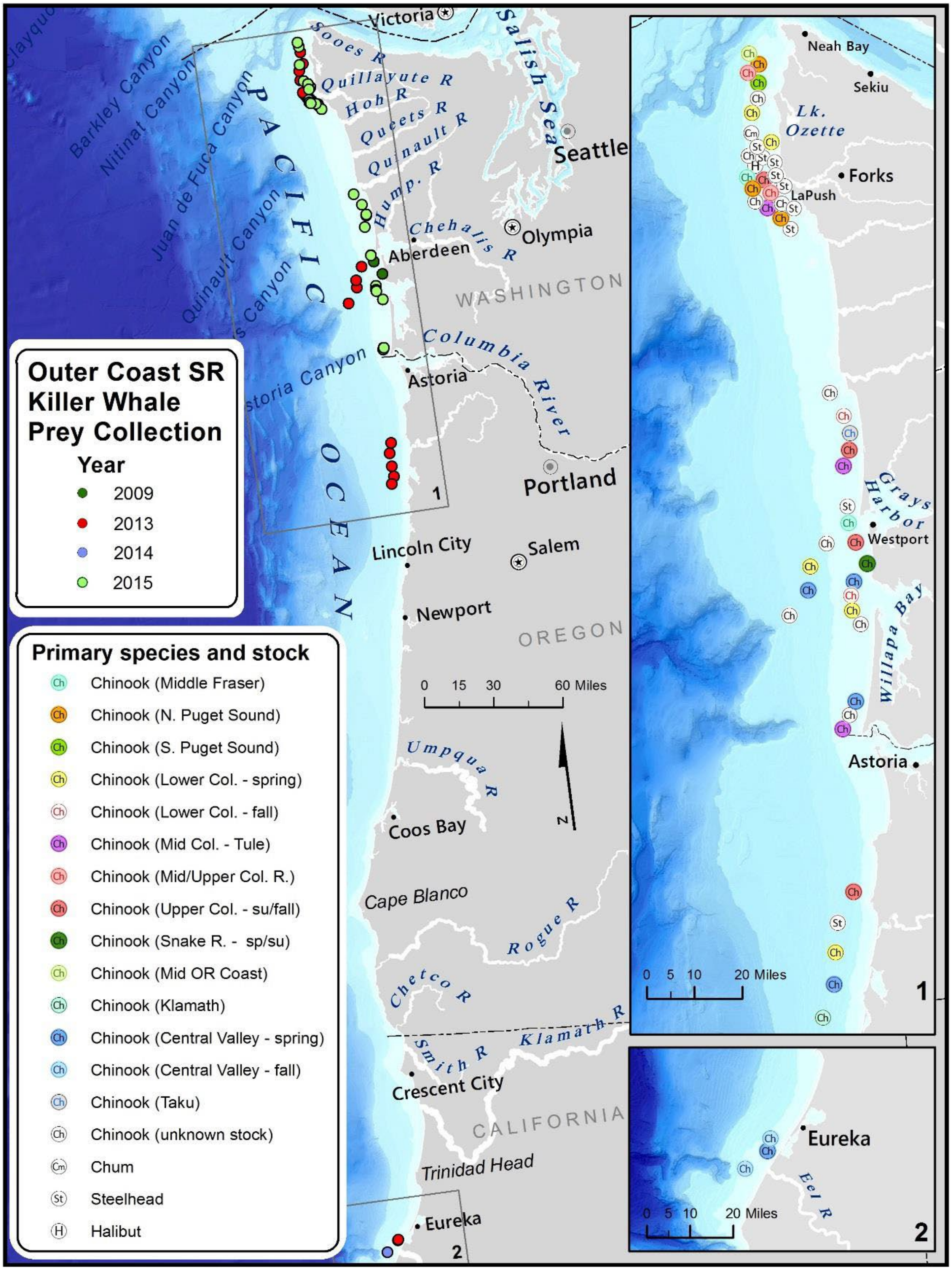

Figure 10. Location and species for scale/tissue samples collected from SRKW predation events in outer coastal waters (stock IDs are considered preliminary)(NMFS 2021h).

Currently, there are over 300 hatchery programs in Oregon, Washington, Idaho, and California that release hundreds of millions of juvenile salmon annually. Hatchery production is a significant component of the salmon prey base returning to watersheds within the range of SRKWs (Barnett-Johnson et al. 2007; NMFS 2008). The release of hatchery fish has not been identified as a threat to the survival or persistence of SRKWs and there is no evidence to suggest the whales prefer wild salmon over hatchery salmon. Increased Chinook salmon abundance, including hatchery fish, benefit this endangered population of whales by enhancing prey availability to SRKWs, and hatchery fish often contribute significantly to the salmon stocks consumed (Hanson et al. 2010). Currently, hatchery fish play a mitigation role of helping sustain Chinook salmon numbers while other, longer term, recovery actions for natural fish are underway. Although hatchery production has contributed to offset some of the historical declines in the abundance of natural-origin salmon within the range of the whales, hatcheries also pose risks to natural-origin salmon populations (Nickelson et al. 1986; Ford 2002; Levin and Williams 2002; Naish et al. 2007).

In an effort to prioritize recovery efforts such as habitat restoration and help inform efforts to use fish hatcheries to increase the whales' prey base, NMFS and Washington Department of Fish and Wildlife (WDFW) developed a priority stock report identifying the Chinook salmon stocks along the West Coast (NOAA and WDFW 2018) . The priority stock report was created by using observations of Chinook salmon stocks found in scat and prey scale/tissue samples, observations of the killer whale body condition through aerial photographs, and estimating the spatial and temporal overlap with Chinook salmon stocks ranging from Southeast Alaska to California. Extra weight was given to the salmon runs that support the SRKWs during times of the year when the whales' body condition is more likely reduced and when Chinook salmon may be less available, such as in winter months. Table 9 is a summary of those stock descriptions. However, it important to note, this priority stock report will continue to get updated over time as new data become available. Given this was designed to prioritize recovery actions and there are no abundance estimates for each stock that are factored in, it is currently not designed to assess prey availability within any given area.

Table 9. Summary of the priority Chinook salmon stocks for prioritizing recovery actions (adapted from NOAA and WDFW 2018).

Priority	ESU/Stock Group	Run Type	Rivers or Stocks in Group
1	North Puget Sound	Fall	Nooksack, Elwha, Dungeness, Skagit, Stillaguamish, Snohomish, Nisqually, Puyallup, Green, Duwamish, Deschutes, Hood Canal Systems
	South Puget Sound		
2	Lower Columbia	Fall	Fall Tules and Fall Brights (Cowlitz, Kalama, Clackamas, Lewis, others), Lower Strait (Cowichan, Nanaimo), Upper Strait (Klinaklini, Wakeman, others), Fraser (Harrison)
	Strait of Georgia		
3	Upper Columbia & Snake	Fall	Upriver Brights, Spring 1.3 (Upper Pitt, Birkenhead; Mid & Upper Fraser; North and South Thompson) and Spring 1.2 (Thompson, Louis Creek, Bessette Creak); Lewis, Cowlitz, Kalama, Big White Salmon
	Fraser	Spring	
	Lower Columbia	Spring	
4	Middle Columbia	Fall	Fall Brights
5	Snake River	Spring/summer	Snake, Salmon, Clearwater, Nooksack, Elwha, Dungeness, Skagit (Stillaguamish, Snohomish)
	Northern Puget Sound	Spring	
6	Washington Coast	Spring and Fall	Hoh, Queets, Quillayute, Grays Harbor
7	Central Valley	Spring	Sacramento and tributaries
8	Middle/Upper Columbia	Spring/Summer	Columbia, Yakima, Wenatchee, Methow, Okanagan
9	Fraser	Summer	Summer 0.3 (South Thompson, Lower Fraser, Shuswap, Adams, Little River, Maria Slough) and Summer 1.3 (Nechako, Chilko, Quesnel, Clearwater River)
10	Central Valley	Fall and late Fall	Sacramento, San Joaquin, Upper Klamath, and Trinity
	Klamath River	Fall and Spring	
11	Upper Willamette	Spring	Willamette
12	South Puget Sound	Spring	Nisqually, Puyallup, Green, Duwamish, Deschutes, Hood Canal systems
13	Central Valley	Winter	Sacramento and tributaries

Priority	ESU/Stock Group	Run Type	Rivers or Stocks in Group
14	North/Central Oregon (OR) Coast	Fall	Northern (Siuslaw, Nehalem, Siletz) and Central (Coos, Elk, Coquille, Umpqua)
15	West Vancouver Island	Fall	Robertson Creek, West Coast Vancouver Island (WCVI) Wild
16	Southern OR & Northern CA Coastal	Fall and Spring	Rogue, Chetco, Smith, Lower Klamath, Mad, Eel, Russian

2.2.2.2.2 Nutritional Limitation and Body Condition

When prey is scarce or in low density, SRKWs likely spend more time foraging than when prey is plentiful or in high density. Increased energy expenditure and prey limitation can cause poor body condition and nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources, and as a chronic condition, can lead to reduced body size of individuals and to lower reproductive and survival rates in a population (Trites and Donnelly 2003). During periods of nutritional stress and poor body condition, cetaceans lose adipose tissue behind the cranium, displaying a condition known as “peanut-head” in extreme cases (Pettis et al. 2004; Bradford et al. 2012; Joblon et al. 2014). Between 1994 and 2008, 13 SRKWs were observed from boats to have a pronounced “peanut-head”; all but two subsequently died (Durban et al. 2009; Center for Whale Research 2021 unpublished data). None of the whales that died were subsequently recovered, and, therefore, definitive cause of death could not be identified. Both females and males across a range of ages were found in poor body condition.

Since 2008, NOAA’s Southwest Fisheries Science Center (SWFSC) has used aerial photogrammetry to assess the body condition and health of SRKWs, initially in collaboration with the Center for Whale Research and, more recently, with the Vancouver Aquarium and marine wildlife health and wellness non-profit Sealife Response, Rehabilitation, and Research (SR^3). Aerial photogrammetry studies have provided finer resolution for detecting poor condition, even before it manifests in “peanut heads” that are observable from boats. Annual aerial surveys of the population from 2013-2017 (with exception of 2014) have detected declines in condition before the death of seven SRKWs (L52 and J8 as reported in Fearnbach et al. (2018); J14, J2, J28, J54, and J52 as reported in Durban et al. (2017)), including five of the six most recent mortalities (Trites and Rosen 2018). These data have provided evidence of a general decline in SRKW body condition since 2008, and documented members of J pod being in poorer body condition in May compared to September of the previous year (at least in 2016 and 2017) (Trites and Rosen 2018). Stewart et al. (2021) measured the condition of the majority of all three pods in each September of seven years between 2008 and 2019 to understand interannual body condition changes. Using a measurement of the eye patch ratio (which indicates the amount of adipose fat stored behind the cranium), the body condition of individual whales was categorized into five body condition categories. Whales that were determined to be in poor body condition had two to three times higher mortality probabilities than whales in better body condition

(Stewart et al. 2021). Other pods could not be reliably photographed in both seasonal periods. Furthermore, hormone analysis conducted by Ayres et al. (2012) from fecal samples collected in 2007-2009, suggests that prey availability may be a greater physiological stressor on SRKW than vessel presence (due to differences in concentrations of two hormones) but that also there could be cumulative physiological effects of prey availability and vessel presence, and also with pollutants.

Information collated on strandings for all killer whale ecotypes by Raverty et al. (2020) as well as data collected from three SRKW strandings in recent years, have also contributed to our knowledge of the health of the population and the impact of the threats to which they are exposed. Across the Northeast Pacific, causes of death for stranded killer whales of various ages and ecotypes have included: congenital defects, malnutrition and emaciation, infectious disease, bacterial infections, and blunt force trauma (Raverty et al. 2020). The authors examined cause of death for 53 stranded whales, 22 of which had a definitive diagnosis. They reported on both proximate (process, disease, or injury that initiated process that led to death) and ultimate (final process that led to death) causes of death. Of the 22 stranded killer whales where a definitive diagnosis could be determined, nutritional causes were identified in 11 whales as either the proximate (n = 5) or ultimate cause of death (n = 6) (Raverty et al. 2020), though none of these whales were identified as SRKWs (some unknown but in unlikely locations for SRKW). However, this does highlight that nutritional causes of mortality occur in killer whales.

2.2.2.2.3 Toxic Chemicals

Various adverse health effects in humans, laboratory animals, and wildlife have been associated with exposures to persistent pollutants. These pollutants have the ability to cause endocrine disruption, reproductive disruption or failure, immunotoxicity, neurotoxicity, neurobehavioral disruption, and cancer (Reijnders 1986; Subramanian et al. 1987; de Swart et al. 1996; Bonefeld-Jørgensen et al. 2001; Reddy et al. 2001; Schwacke et al. 2002; Darnerud 2003; Legler and Brouwer 2003; Viberg et al. 2003; Ylitalo et al. 2005; Fonnum et al. 2006; Viberg et al. 2006; Darnerud 2008; Legler 2008). SRKWs are exposed to a mixture of pollutants, some of which may interact synergistically and enhance toxicity, influencing their health and reproduction. Relatively high levels of these pollutants have been measured in blubber biopsy samples from SRKWs compared to other resident killer whales in the North Pacific (Ross et al. 2000; Krahn et al. 2004; Krahn et al. 2007; Krahn et al. 2009; Lawson et al. 2020). More recently, these pollutants were measured in fecal samples collected from SRKWs, and fecal toxicants matched those of blubber samples (Lundin et al. 2016a; Lundin et al. 2016b).

2.2.2.2.4 Disturbance from Vessels and Sound

Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals. While in inland waters of Washington and British Columbia, SRKWs are a principal target species for the commercial whale watch industry

(Hoyt 2001; O'Connor et al. 2009)) and encounter a variety of other vessels in their urban environment (e.g., recreational, fishing, ferries, military, shipping). Several main threats from vessels include direct vessel strikes, the masking of echolocation and communication signals by anthropogenic sound, and behavioral changes (NMFS 2008). There is a growing body of evidence documenting effects from vessels on small cetaceans and other marine mammals (NMFS 2010c; NMFS 2016e; NMFS 2018b). Research has shown that the whales spend more time traveling and performing surface active behaviors and less time foraging in the presence of all vessel types, including kayaks, and that noise from and/or presence of motoring vessels up to 400 meters away has the potential to affect the echolocation abilities of foraging whales and their foraging dives and success (Holt 2008; Lusseau et al. 2009; Noren et al. 2009; Williams et al. 2010; Holt et al. 2021). Models of SRKW behavior states showed that both males and females spent less time in foraging states, with fewer prey-capture dives and shorter dives, when vessels were near (within 400 yards on average), but also that females were more likely to switch from deep and intermediate dive foraging behaviors to travel/respiration when vessels were near (Holt et al. 2021). Individual energy balance may be impacted when vessels are present because of the combined increase in energetic costs resulting from changes in whale activity with the decrease in prey consumption resulting from reduced foraging opportunities (Williams et al. 2006a; Lusseau et al. 2009; Noren et al. 2009; Noren et al. 2012). Ayres et al. (2012) examined glucocorticoid and thyroid hormone levels in fecal samples collected from SRKWs in inland waters and their results suggest that the impacts from vessel traffic on hormone levels are lower than the impacts from reduced prey availability.

Federal vessel regulations were established in 2011 to prohibit vessels from approaching killer whales within 200 yards (182.9 m) and from parking in the path of the whales within 400 yards (365.8 m). These regulations apply to all vessels in inland waters of Washington State with exemptions to maintain safe navigation and for government vessels in the course of official duties, ships in the shipping lanes, research vessels under permit, and vessels lawfully engaged in commercial or treaty Indian fishing that are actively setting, retrieving, or closely tending fishing gear (76 FR 20870, April, 14, 2011). In December 2017, NMFS completed a technical memorandum evaluating the effectiveness of regulations that concluded some indicators suggested the regulations have benefited SRKWs by reducing impacts without causing economic harm to the commercial whale-watching industry or local communities, whereas some indicators suggested that vessel impacts continue and that some risks may have increased (Ferrara et al. 2017). In 2019, Washington state regulations were updated to increase vessel viewing distances from 200 to 300 yards to the side of the whales and reduce vessel speed within ½ nautical mile of the whales to seven knots over ground (see RCW 77.15.740). In 2021, Washington implemented a Commercial Whale Watch Licensing Program requiring commercial operators to maintain a commercial whale watching license in order to view SRKWs in Washington waters.

In addition to vessels, underwater sound can be generated by a variety of other human activities, such as dredging, drilling, construction, seismic testing, and sonar (Richardson et al. 1995; Gordon and Moscrop 1996; NRC 2003). Impacts from these sources can range from serious injury and mortality to changes in behavior. In other cetaceans, hormonal changes indicative of stress have been recorded in response to intense sound exposure (Romano et al. 2003). Chronic stress is known to induce harmful physiological conditions, including lowered immune function in terrestrial mammals, and likely does so in cetaceans (Gordon and Moscrop 1996).

2.2.2.2.5 Oil Spills

In the Northwest, SRKWs are the most vulnerable marine mammal population to the risks imposed by an oil spill due to their overall small population size, strong site fidelity to areas with high oil spill risk, large groups of individuals together, late reproductive maturity, low reproductive rate, and specialized diet, among other attributes (Jarvela Rosenberger et al. 2017). Oil spills have occurred in the range of SRKWs in the past, and there is potential for spills in the future. Oil can be discharged into the marine environment in any number of ways, including shipping accidents, refineries and associated production facilities, and pipelines. Despite many improvements in spill prevention since the late 1980s, much of the region inhabited by SRKWs remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers.

Repeated ingestion of petroleum hydrocarbons by killer whales likely causes adverse effects; however, long-term consequences are poorly understood. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion and disease, pneumonia, liver disorders, neurological damage, adrenal toxicity, reduced reproductive rates, and changes in immune function (Geraci and Aubin 1990; Schwacke et al. 2013; Venn-Watson et al. 2015; de Guise et al. 2017; Kellar et al. 2017), as well as potentially death and long-term effects on population viability (Matkin et al. 2008; Ziccardi et al. 2015). Previous Polycyclic Aromatic Hydrocarbon (PAH) exposure estimates suggested SRKWs can be occasionally exposed to concerning levels (Lachmuth et al. 2011). More recently, Lundin et al. (2018) measured PAHs in whale fecal samples collected in inland waters of Washington between 2010 and 2013 and found low concentrations of the measured PAHs (<10 parts per billion (ppb), wet weight). However, PAHs were as high as 104 ppb in the first year of their study (2010) compared to the subsequent years. Although the cause of this trend is unclear, higher levels were observed prior to the 2011 vessel regulations that increased the distance vessels could approach the whales. In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may adversely affect SRKWs by reducing food availability.

2.2.2.2.6 Climate Change

The potential impacts of climate and oceanographic change on whales and other marine mammals would likely involve effects on habitat availability and food availability. Although few predictions of impacts on the SRKWs have been made, it seems likely that any changes in weather and oceanographic conditions resulting in effects on salmon populations would have consequences for the whales. Increases in temperature may affect salmon habitat and populations. Heavier winter rainstorms from warming may lead to increased flooding and high-flow events that result in scouring of riverbeds, smothering redds, and increasing suspended sediment in systems. In the summer, decreased stream flows and increased water temperature can reduce salmon habitat and impede migration (Southern Resident Orca Task Force 2019). All of this would lead to fewer salmon available for the SRKWs to consume. In the marine system, warming of the ocean and resulting decreases in dissolved oxygen would affect the base of the food web, ultimately decreasing the amount of prey available to SRKWs. All of this may lead SRKWs to shift their distribution in response to climate-related changes in their salmon prey.

Climate change may also result in an increase in contaminant levels of the SRKWs. Increased high flow events lead to more instances of overflowing at sewage treatment facilities and increased runoff from roads, which further pollute marine and freshwater systems (Southern Resident Orca Task Force 2019). Increases in pollution in the surrounding systems would lead to increased contaminant levels in SRKW prey and the whales themselves. Persistent pollutant bioaccumulation may also change because of changes in the food web (e.g., Alava et al. 2018).

2.2.2.3 Status of Southern Resident Killer Whale DPS Critical Habitat

Critical habitat for SRKWs includes inland waters of Washington in three specific areas: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca. In addition, critical habitat for SRKWs includes coastal marine waters along the U.S. West Coast that includes six specific marine areas along the coasts of Washington, Oregon, and California: 1) the Coastal Washington/Northern Oregon Inshore Area; 2) Coastal Washington/Northern Oregon Offshore Area; 3) Central/Southern Oregon Coast Area; 4) Northern California Coast Area; 5) North Central California Coast Area; and 6) Monterey Bay Area. Critical habitat for SRKWs does not include 19 specific areas controlled by the Department of Defense (50 CFR 226.206; all of these areas are described in more detail in this regulation). NMFS identified the following PBFs for critical habitat for SRKWs: (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 (50 CFR 226.206).

Critical habitat for the SRKWs was first designated on November 29, 2006 (71 FR 69054), which included approximately 2,560 square miles of inland water of Washington in the three specific areas described above. On September 19, 2019, NMFS proposed to revise the critical habitat designation for the SRKWs under the ESA by designating six new areas (covering approximately 15,626 square miles) along the U.S. West Coast from the U.S.-Canada border to Point Sur, California (84 FR 49214; September 19, 2019). The final rule on revised critical habitat was published on August 2, 2021 (86 FR 41668) and went into effect on September 1, 2021. The revised critical habitat added approximately 15,910 square miles to the previous designation, including marine waters between the 6.1-meter and 200-meter depth contours from the U.S.-Canada border to Point Sur, California (Figure 11). The areas added are occupied and contain the three PBFs that were previously identified and included in the 2006 critical habitat designation.[12]

[12] Further information on the revised SRKW critical habitat is available at: https://www.fisheries.noaa.gov/west-coast/endangered-species-conservation/critical-habitat-southern-resident-killer-whales.

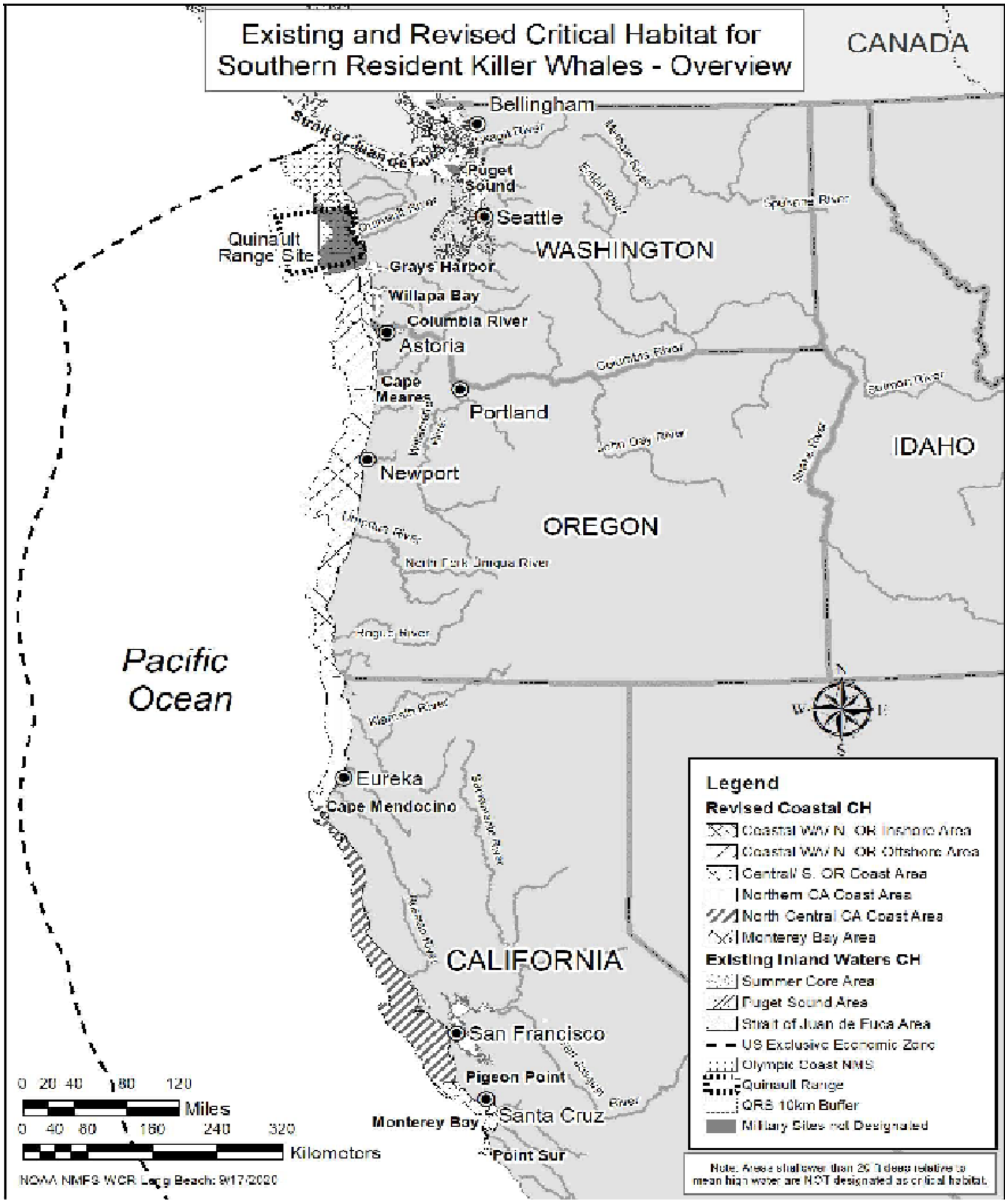

Figure 11. Designated SRKW Critical Habitat. This includes critical habitat designated in 2006 and 2021. Detailed information on the designated areas is described in the Final Biological report (NMFS 2021h).

Water quality to support growth and development is a PBF, given the whales' present contamination levels, small population numbers, increased extinction risk caused by any additional mortalities, and geographic range (and range of their primary prey) that includes highly populated and industrialized areas. Water quality is especially important in high-use areas where foraging behaviors occur and contaminants can enter the food chain. The absence of contaminants or other agents of a type and/or amount that would inhibit reproduction, impair immune function, result in mortalities, or otherwise impede the growth and recovery of the SRKW population is an important habitat feature for the species' recovery. Exposure to oil spills also poses additional direct threats as well as longer-term population level impacts; therefore, the absence of these chemicals is of the utmost importance to SRKW conservation and survival.

Prey species of sufficient quantity, quality and availability to support individual growth, reproduction, and development, as well as overall population growth, is a PBF as SRKWs need to maintain their energy balance all year long to support daily activities (foraging, traveling, resting, socializing), as well as gestation, lactation, and growth. Most wild salmon stocks throughout the whales' geographic range are at fractions of their historic levels, and 28 ESUs and DPSs of salmon and steelhead throughout the whales' geographic range are listed as threatened or endangered under the ESA. Historically, overfishing, habitat losses, and hatchery practices were major causes of decline for these salmonids. Poor ocean conditions over the past two decades have reduced populations already weakened by the degradation and loss of freshwater and estuary habitat, fishing, hydropower system management, and hatchery practices. In addition to sufficient quantity of prey, fish need to be accessible and available to the whales, which can be related to the density and distribution of salmon, and competition from other predators and fisheries. Vessels and sound may reduce the effective zone of echolocation and also reduce availability of fish for the whales in their critical habitat (Holt 2008). As mentioned above, contaminants and pollution also affect the quality of SRKW prey in Puget Sound and in coastal waters of Washington, Oregon, and California. The size of Chinook salmon is also an important aspect of prey quality (i.e., SRKWs primarily consume large Chinook salmon), so changes in Chinook salmon size (for instance as shown by Ohlberger et al. 2018) may affect the quality of this PBF of critical habitat.

Finally, passage conditions to allow for migration, resting, and foraging is a PBF because SRKWs require open waterways that are free from obstruction (e.g., physical, acoustic) to move within and migrate between important habitat areas throughout their range, communicate, find prey, and fulfill other life history requirements. In particular, vessels may present both physical and/or acoustic obstacles to whale passage, causing the whales to swim further and change direction more often, which can increase energy expenditure for whales and impacts foraging behavior (review in NMFS 2010c; Ferrara et al. 2017). This PBF may be less likely to be impacted in coastal ocean waters compared to the more geographically constricted inland waters because the whales may be able to more easily navigate around potential obstructions in the open ocean, but these passage conditions are still a PBF in such waters.

Human activities managed under a variety of legal mandates have the potential to affect the PBFs of SRKWs, including those that could increase water contamination and/or chemical exposure; decrease the quantity, quality, or availability of prey; or inhibit safe, unrestricted passage between important habitat areas to find prey and fulfill other life history requirements. Examples of these types of activities include (but are not limited to), in no particular order: (1)

salmon fisheries and bycatch; (2) salmon hatcheries; (3) offshore aquaculture/mariculture; (4) alternative energy development; (5) oil spills and response; (6) military activities; (7) vessel traffic; (8) dredging and dredge material disposal; (9) oil and gas exploration and production; (10) mineral mining (including sand and gravel mining); (11) geologic surveys (including seismic surveys); and (12) activities occurring adjacent to or upstream of critical habitat that may affect PBFs, labeled "upstream activities" (including activities contributing to point-source water pollution, power plant operations, liquefied natural gas terminals, desalinization plants; see NMFS 2021h).

2.2.3 Southern DPS Eulachon

The southern DPS eulachon is listed as a threatened species, which is described as eulachon originating from the Skeena River in British Columbia south to and including the Mad River in northern California (50 CFR 223.102(e)). NMFS reaffirmed this threatened status conclusion in its most recent 5-year status review (NMFS 2016c). NMFS designated critical habitat for the southern DPS eulachon in 16 specific areas in California, Oregon, and Washington, but excluding Indian lands for four Federally-recognized Tribes in the States of California, Oregon and Washington (50 CFR 226.222). More information on the biology, ecology, and status of this species can be found in the recovery plan (NMFS 2017d). Table 10 summarizes listing and recovery plan information, status summary, and threats for eulachon.

Table 10. Status review and summary of threats to the viability of Southern DPS eulachon.

Status Summary	Threats (BRT Ratings)
The southern DPS of eulachon comprises fish that spawn in rivers south of the Nass River in British Columbia to, and including, the Mad River in California. Four "subpopulations" are considered in NMFS' recovery plan as a minimum set of "populations" that are needed to meet biologically based and threats-based delisting criteria: the Klamath River, the Columbia River, the Fraser River, and the British Columbia coastal rivers. Starting in 1994, there was an abrupt decline in the abundance of eulachon returning to all subpopulations, including the Columbia River. Despite a brief period of improved returns in 2001 to 2003, the returns and associated commercial landings were at low levels from the mid-1990s through the 2000s. Eulachon abundance in monitored rivers improved in the 2013 to 2015 return years, before declining again in 2016 through 2019, most likely due to recent poor ocean conditions. However, for 2020 the run in the Columbia River has improved moderately likely due to favorable ocean conditions.	High: climate change impacts on ocean conditions High–Moderate: ocean fisheries bycatch Moderate: climate change impacts on freshwater habitat Moderate: predation Moderate–Low: water quality Moderate–Very Low: dams and water diversions Moderate–Very Low: shoreline construction Moderate–Very Low: dredging

2.2.3.1 Range and Distribution

Eulachon are smelt native to eastern North Pacific waters from the Bering Sea to Monterey Bay, California, or from 61º N to 31º N (Hart and McHugh 1944; Odemar 1964; Hay and McCarter 2000). Adult eulachon are found in coastal and offshore marine habitats possibly to 2,000 feet deep, but more frequently between 50 and 600 feet deep (Allen and Smith 1988; Hay and McCarter 2000; Willson et al. 2006). The southern DPS eulachon comprises eulachon originating from the Skeena River in British Columbia south to and including the Mad River in northern California (Figure 12)(50 CFR 223.102(e)). However, eulachon may have historically occurred in the Sacramento River system and even farther south along the California and Baja California coast, in areas where they may have been extirpated (Willson et al. 2006).

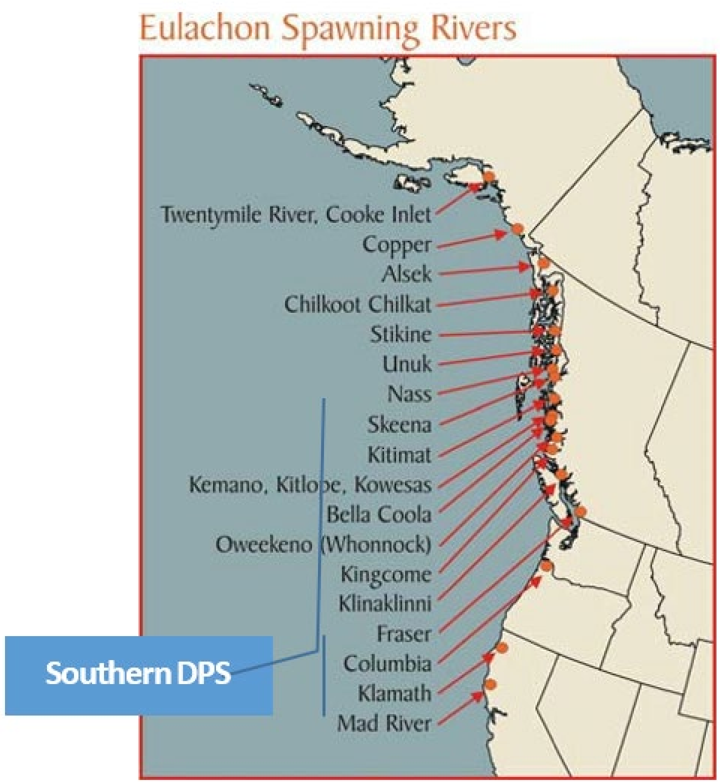

Figure 12. Map of historical spawning rivers for eulachon and the southern DPS critical habitat area.

Four subpopulations—the Klamath River, the Columbia River, the Fraser River, and the British Columbia coastal rivers—are considered in NMFS' recovery plan as a minimum set of "populations" that are needed to meet biologically based (abundance, productivity, spatial distribution, and genetic and life-history diversity) and threats-based delisting criteria (NMFS 2017d).

Adult eulachon have been observed in California's Humboldt Bay, Klamath, Mad, Russian, and Sacramento rivers as well as Redwood Creek; the Umpqua and Rogue rivers in Oregon, and Washington's Puget Sound, Hood Canal, Bear, Naselle, Nemah, Wynoochee, Quinault, Queets, and Nooksack rivers (Odemar 1964; Emmett et al. 1991; Jennings 1996; Larson and Belchik 1998; Wright 1999; Musick et al. 2000; WDFW and ODFW 2001; Moyle 2002). Spawning has been documented in the Elwha River and the Strait of Juan de Fuca, but sightings or spawning in these Oregon and Washington rivers is very limited or unknown (McElhany et al. 1999; Shaffer et al. 2007). For southern DPS eulachon, most spawning is believed to occur in the Columbia River and its tributaries (Grays, Skamokawa, Elochoman, Kalama, Lewis, and Sandy rivers), with less production from the Mad and Klamath rivers, as well as sporadic production in other Oregon and Washington rivers (Emmett et al. 1991; Musick et al. 2000; WDFW and ODFW 2001).

On the Klamath River of northwest California, eulachon are of great importance to the Yurok Tribe but runs have diminished in the past few decades. The last noticeable runs of eulachon were observed in 1988 and 1989 by Tribal fishers, many of whom remember past magnitudes of runs so great, "…. that a continuous mass of fish lined the banks and as many fish as one could physically manage was pulled onto the river's bank in dip nets." (Larson and Belchik 1998).

2.2.3.1.1 Life History

Eulachon are semelparous and anadromous, spending most of their lives in marine environments before returning to freshwater to spawn once and die. Because larvae exit the freshwater systems almost immediately, they likely retain homing only to the estuarine system that their natal river drains to. Based upon this, the smallest stock unit is likely the estuary that natal streams drain (Hay and McCarter 2000; Beacham et al. 2005). Specific spawning rivers within the natal system are likely selected based upon environmental conditions at the time of return (Hay and Beacham 2005).

Maximum known lifespan is 9 years of age, but 20 to 30 percent of individuals live to 4 years and most individuals survive to 3 years of age, although spawning has been noted as early as 2 years of age (Wydoski and Whitney 1979; Barrett et al. 1984; Hay and McCarter 2000). Eulachon generally die following spawning (Scott and Crossman 1973; Clarke et al. 2007). The age distribution of spawners varies between river and from year-to-year (Willson et al. 2006). Eulachon from southern rivers generally spawn at a younger age than eulachon from more northern rivers (Clarke et al. 2007).

2.2.3.1.2 Timing of Spawning

Spawn timing depends upon the river system (Willson et al. 2006). In the Columbia River and further south, spawning occurs from late January to May, although river entry occurs as early as December (Hay and McCarter 2000). The peak of eulachon runs in Washington State is from February through March. Fraser River spawning is significantly later, in April and May (Hay and McCarter 2000). In northern California, in rivers such as the Klamath, eulachon spawning migrations were similar to the Columbia's runs and peak between March and April (Larson and Belchik 1998).

The timing of eulachon entry into spawning rivers is likely tied to water temperature and tidal cycles (Ricker et al. 1954; Bishop et al. 1989; Lewis et al. 2002; Spangler 2002). Spawning normally occurs when water temperature is between 4 and 10º C (WDFW and ODFW 2001; Hay et al. 2003), but can occur below 4 °C in some rivers. Adults may migrate up to 100 miles upstream to reach spawning grounds (Hart and McHugh 1944). Males tend to arrive on spawning grounds earlier than females and tend to stay longer, making them more susceptible to commercial and recreational fisheries (Hart and McHugh 1944). However, males outnumber females by a roughly 2:1 margin. Eulachon sperm is viable for only minutes and a key factor of eulachon spawning may be male grouping en mass to broadcast their sperm. Once milt reaches downstream females, each female releases 7,000 to 31,000 eggs (in the Columbia River) at which time fertilization occurs (WDFW and ODFW 2001). Females lay eggs over sand, course gravel, or detrital substrate. This reproductive strategy requires high eulachon density to ensure fertilization. Eggs attach to gravel or sand and incubate for 30 to 40 days after which larvae drift to estuaries and coastal marine waters (Wydoski and Whitney 1979) and after three to five years, adults migrate back to natal basins to spawn.

2.2.3.1.3 Feeding Habits

Following hatching in freshwater, larvae and juveniles become thoroughly mixed in coastal waters generally less than 50 feet deep and move deeper as they grow (Barraclough 1967; Hay and McCarter 2000). Larval and post larval eulachon prey upon phytoplankton, copepods, copepod eggs, mysids, barnacle larvae, worm larvae, and other eulachon larvae until they reach adult size (WDFW and ODFW 2001). The primary prey of adult eulachon are copepods and euphausiids, including *Thysanoessa* spp., unidentified malacostracans, and cumaceans (Smith and Saalfeld 1955; Barraclough 1967; Wydoski and Whitney 1979; Sturdevant et al. 1999; Hay and McCarter 2000).

2.2.3.2 Status of the Species

The southern DPS of eulachon is listed as threatened under the Endangered Species Act (50 CFR 223.102(e)). Eulachon are threatened by decreased abundance, natural predation, commercial and recreational fishing pressure (directed and bycatch), and loss of habitat. Population decline is anticipated to continue as a result of climate change and bycatch in commercial shrimp fisheries. However, as highly fecund fish, eulachon have the ability to rebound quickly if given the opportunity, a feature that is likely necessary to withstand significant predation pressure and high mortality likely experienced by pelagic larvae (Bailey and Houde 1989).

Eulachon formerly experienced widespread, abundant runs and have been a staple of Native American diets for centuries along the northwest coast. However, these robust runs that were formerly present in several California rivers as late as the 1960s and 1970s (i.e., Klamath River, Mad River, and Redwood Creek) are thought to no longer occur (Larson and Belchik 1998). This decline likely began in the 1970s and continued, with the most recent observed and recorded Klamath River run in 1999 (Moyle 2002), after which there have not been consistent surveys conducted on the Klamath River. Two eulachon were identified in a Coastal Longfin identification project in 2020 for the Mad River (ICF 2020, unpublished data). Sampling effort has been low (Moyle 2002) for the Mad River and Redwood Creek since the mid 1990's and eulachon presence has not been detected.

2.2.3.2.1 Factors Responsible for Current Status of Eulachon

Starting in 1994, southern DPS eulachon experienced an abrupt decline in abundance throughout its range. Eulachon abundance in monitored rivers improved in the 2013 to 2015 return years, but recent poor conditions in the northeastern Pacific Ocean appear to have driven sharp declines in the river systems in 2016 and 2017.

No reliable fishery-independent, historical abundance estimates exist for eulachon. From 2000 through 2019, mean spawning stock biomass estimates in the Columbia River ranged from a low of about 783,000 fish in 2005 to a high of nearly 186 million fish in 2014, and in 2021 an estimated abundance of 100.7 million fish (Robert Anderson, NMFS, personal communication[13]). Spawning stock biomass estimates in the Fraser River (1995 to 2019) ranged from a low of about 110,000 to 150,000 fish in 2010 to a high of about 42 million to 56 million fish in 1996 (NMFS 2017d). Fishery-independent estimates are not available for the Klamath River or British Columbia coastal rivers (NMFS 2017d).

The NMFS Biological Review Team (BRT) rated climate change impacts on ocean conditions as the highest threat to the persistence of eulachon subpopulations, followed by bycatch in coastal shrimp fisheries. The latter was likely reduced in recent years with the addition of lights and excluder devices to shrimp gear, developed specifically to reduce eulachon bycatch (Lomeli et al. 2018). Dams and water diversions, climate change impacts on freshwater habitat, predation, water quality, shoreline construction, and dredging were all rated as having moderate impacts for at least one subpopulation (NMFS 2017d).

Habitat Degradation and Loss

Habitat loss and degradation threaten eulachon, particularly in the Columbia River basin. Hydroelectric dams block access to historical eulachon spawning grounds and affect the quality of spawning substrates through flow management, altered delivery of coarse sediments, and siltation. The release of fine sediments from behind a U.S. Army Corps of Engineers' sediment retention structure on the Toutle River has been negatively correlated with Cowlitz River eulachon returns three to four years later and is thus implicated in harming eulachon in this river system, though the exact cause of the effect is undetermined. Dredging activities in the Cowlitz and Columbia rivers during spawning runs may entrain and kill fish or otherwise result in decreased spawning success.

Commercial Fisheries

In the Pacific Ocean, there is currently no ban on commercial fishing for eulachon. Eulachon can be harvested year-round using any method otherwise authorized to harvest food fish in the open ocean. Bycatch of eulachon in commercial marine fisheries poses a moderate threat to eulachon in Oregon, Washington and California. Eulachon bycatch, specifically in the pink shrimp trawls, was also identified as a high threat to the species. Regulations passed in 2018 required LED lights on shrimp trawls to reduce their bycatch, and it appears to be having an effect. Research into the LED lights showed a 90 percent reduction in eulachon bycatch (Lomeli et al. 2018; 2020). The recent implementation of LED lights may be having a positive effect on survival of those fish out at sea, leading to larger runs in river. In the past, protection of forage fishes has not been a priority when developing ways to reduce shrimp fishing bycatch. Eulachon

[13] Email from Robert Anderson (NMFS) to Heather Wiedenhoft (NMFS), September 2, 2021

are particularly vulnerable to capture in shrimp fisheries in the United States and Canada as the marine areas occupied by shrimp and eulachon often overlap. In Oregon, the bycatch of various species of smelt (including eulachon) has been as high as 28 percent of the total catch of shrimp by weight (Hay and McCarter 2000; Hannah and Jones 2007).

Climate Change

Changing ocean conditions in the Pacific Northwest, caused by global climate change, present a potentially severe threat to eulachon survival and recovery. Increases in ocean temperatures have already occurred and will likely continue to impact listed fish and their habitats. In coastal and estuarine ecosystems, the threats from climate change largely come in the form of sea level rise and the loss of coastal wetlands. Sea levels will likely rise exponentially over the next 100 years, with possibly a 43-84 cm rise by the end of the 21st century (IPCC 2019). In addition, changes in climate along the entire Pacific Coast and along the northern California and southern Oregon coasts will further change hydrologic patterns and ultimately pose challenges to eulachon spawning because of decreased snowpack, increased peak flows, and decreased base flow. Low river flow decreases river plume volumes and increases water temperatures, disrupting the distribution of larvae into the marine environment (Morrison et al. 2002).

In the marine environment, eulachon rely upon cool or cold ocean regions and the prey communities therein (Willson et al. 2006). As with El Niño and La Niña events, warming ocean temperatures will likely alter these communities, making it more difficult for eulachon and their larvae to locate or capture prey (Roemmich and McGowan 1995; Zamon and Welch 2005). Warmer waters could also allow for the northward expansion of eulachon predator and competitor ranges, increasing an already high predation pressure on the species (Rexstad and Pikitch 1986; McFarlane et al. 2000; Phillips et al. 2007). A change to a warm-water regime in the ocean creates larger areas of hypoxia or annoxia because warmer water holds less dissolved oxygen. This shifts more species into shallower waters where atmospheric oxygen mixes more freely into the water column (Meyer-Gutbrod et al. 2021) and could have future impacts on eulachon predation and feeding in the nearshore environment.

2.2.3.3 Status of Critical Habitat

In 2011, NMFS designated critical habitat for the southern DPS of Pacific eulachon. NMFS designated approximately 539 miles of riverine and estuarine habitat in California, Oregon, and Washington within the geographical area occupied by the southern DPS of eulachon. The designation includes 16 rivers and creeks extending from and including the Mad River, California to the Elwha River, Washington, and all of these areas are considered migration and spawning habitat for this species. In the Klamath River, critical habitat is designated from the mouth of the Klamath River upstream to the confluence with Omogar Creek at approximately RM 10.5 from the mouth; however, critical habitat does not include any tribal lands of the Yurok Tribe or the Resighini Rancheria (76 FR 65324, October 20, 2011, codified at 50 CFR 226.222). Lands of the Resighini Rancheria overlap with approximately 0.5 km (0.3 mi), or 3 percent, of the areas occupied by eulachon in the Klamath River. The boundaries of the Yurok Indian Reservation encompass the entire 17.5 km (10.9 mi) of the areas occupied by eulachon in the Klamath River. However, land ownership within the reservation boundary includes a mixture of

Federal, state, Tribal, and private ownerships. Exclusion from critical habitat designation only applies to Native- owned lands (76 FR 65324, 65344-45, October 20, 2011). The PBFs for southern DPS eulachon critical habitat are: (1) freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, (2) freshwater and estuarine migration corridors free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted, and (3) nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival (50 CFR 226.222(b)).

Continued persistence and strength of eulachon runs in the Klamath River may be influenced by climate change effects and/or commercial fisheries as suitable spawning habitat in the Lower Klamath River does not seem to be limited.

2.2.3.3.1 Factors affecting southern DPS eulachon critical habitat.

Except for commercial fisheries, the same factors responsible for the current status of southern DPS of Pacific eulachon (Table 10) also affect their critical habitat. Compared to historical conditions, most watersheds with PBFs for eulachon are currently degraded, at least to some extent, by human activities, climate change impacts to the ocean and freshwater habitat, urbanization and rural residential development, transportation corridors, industry, predation (by nonindigenous species), water quality, dams and water diversions, shoreline construction (e.g., pile dikes, jetties, bank armoring, and levies), and dredging (NMFS 2017d).

Dams and water diversions are moderate threats to eulachon in the Columbia and Klamath rivers where hydropower generation and flood control are major activities. Degraded water quality is common in some areas occupied by southern DPS eulachon. In the Columbia and Klamath river basins, large-scale impoundment of water has increased winter water temperatures, potentially altering the water temperature during eulachon spawning periods. Numerous chemical contaminants are also present in spawning rivers, but the exact effect these compounds have on spawning and egg development is unknown (Gustafson et al. 2010; Lee et al. 2016).

2.3 Action Area

"Action area" means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action (50 CFR 402.02).

The proposed action is located in the Klamath River Basin of northern California and southern Oregon. For the purposes of this Opinion, the Klamath River Basin includes all headwaters of tributaries to the Klamath River (e.g., Williamson, Sprague, Lost, and Trinity rivers) downstream to the mouth of the Klamath River. The Klamath River Basin is typically divided into three geographic areas: Upper Klamath Basin, Middle Klamath Basin, and Lower Klamath Basin. The Upper Klamath Basin includes Upper Klamath Lake and its tributaries downstream to Keno Dam. The Middle Klamath Basin is defined as the portion of the Klamath River watershed between Keno Dam and the Trinity River confluence. The Lower Klamath Basin includes the Trinity River confluence to the confluence with the Pacific Ocean.

For the purposes of this Opinion, the action area consists of the geographic extent anticipated for potential effects of the removal activities and the resulting free-flowing river condition on all evaluated listed species. Effects in the action area would vary according to species, because the population distribution and the specific effects may vary among species. Therefore, the analysis in other sections of this opinion will focus on different areas for different listed species, depending on their distribution or expected distribution, as explained further in other sections. For example, once dams are removed under the proposed action, the upstream extent of anadromy for SONCC coho salmon in the Klamath Basin is expected to extend to Spencer Creek (RM 233.4), while the upstream extent of anadromy for Chinook salmon (preferred prey of SRKWs) in the Klamath Basin is expected to extend further upstream into the tributaries above UKL (see footnote 13 below). The distribution of Southern DPS eulachon in the Klamath River only extends upstream to the confluence with Omogar Creek (RM 10.5).

The Action Area (Figure 13) includes:

- Upper Klamath Lake and its fish-bearing tributaries, up to the limit of anadromy[14] (FERC 2021a);
- The Klamath River from Upper Klamath Lake downstream to the mouth of the Klamath River estuary;
- All fish-bearing tributaries of the Klamath River upstream of Iron Gate Dam, up to the limit of anadromy. Anticipated limits of anadromy are based on current watershed conditions;
- The area within 1.5 miles of the overall project construction limits in the Hydroelectric Reach (four developments and their reservoirs), which contains the four dams proposed for removal and encompasses the extent of fish passage actions on the main tributaries as well as the entire construction footprint. This 1.5-mile buffer is a conservative buffer to encompass potential effects related to noise from all construction activities including blasting activities at the dams, restoration work in tributaries, work at disposal sites, road work, and hauling;
- The 100-year floodplain[15] from Link River Dam to the mouth of the Klamath River;

[14] Upstream of the hydroelectric reach, Reclamation's Link River Dam and the Keno Dam currently have fish ladders that will pass anadromous fish. Although coho salmon are only expected to utilize mainstem and tributary habitat up to and including Spencer Creek (Hamilton et al. 2005; ODFW 2021) for an estimated 76 miles of additional habitat, the additional habitat for Chinook salmon, steelhead, and lamprey is estimated to be over 300 miles (Huntington 2004; Dunsmoor and Huntington 2006), and potentially over 420 miles (Hamilton et al. 2011; USDOI 2013). The difference in the amount of habitat that coho salmon and Chinook salmon are expected to utilize post dam removal is due to morphometric and life history differences (e.g., adult run timing) between the two species, and is based on historical studies (Huntington 2004; Hamilton et al. 2005; Dunsmoor and Huntington 2006; ODFW 2021)(Hamilton et al. 2011; USDOI 2013).

[15] The inclusion of the bank of the river up to the 100-year flood plain is included in the action area as a precautionary approach to be inclusive of potential sediment impacts in the case of a flood, and to include the footprints of any restoration projects, as described in Appendix C of FERC (2021a), the Reservoir Area Management Plan.

- The Pacific Ocean 1.5 miles north, south, and west of the mouth of the Klamath River. This 1.5-mile buffer is a conservative estimate for the distance that sediment mobilized during the proposed action could extend; and
- Tule Lake Sump 1A and the Lost River from Anderson-Rose Dam to Tule Lake Sump 1A to account for the effects of translocated suckers on existing suckers in Tule Lake Sump 1A and the Lost River reach.

The action area also includes the Pacific Ocean where there is species overlap between Klamath River Chinook salmon and Southern Resident killer whale. The exact boundaries of this area cannot be precisely defined based on current information; however, it includes coastal waters ranging from northern California through central Oregon up to the mouth of the Columbia River.

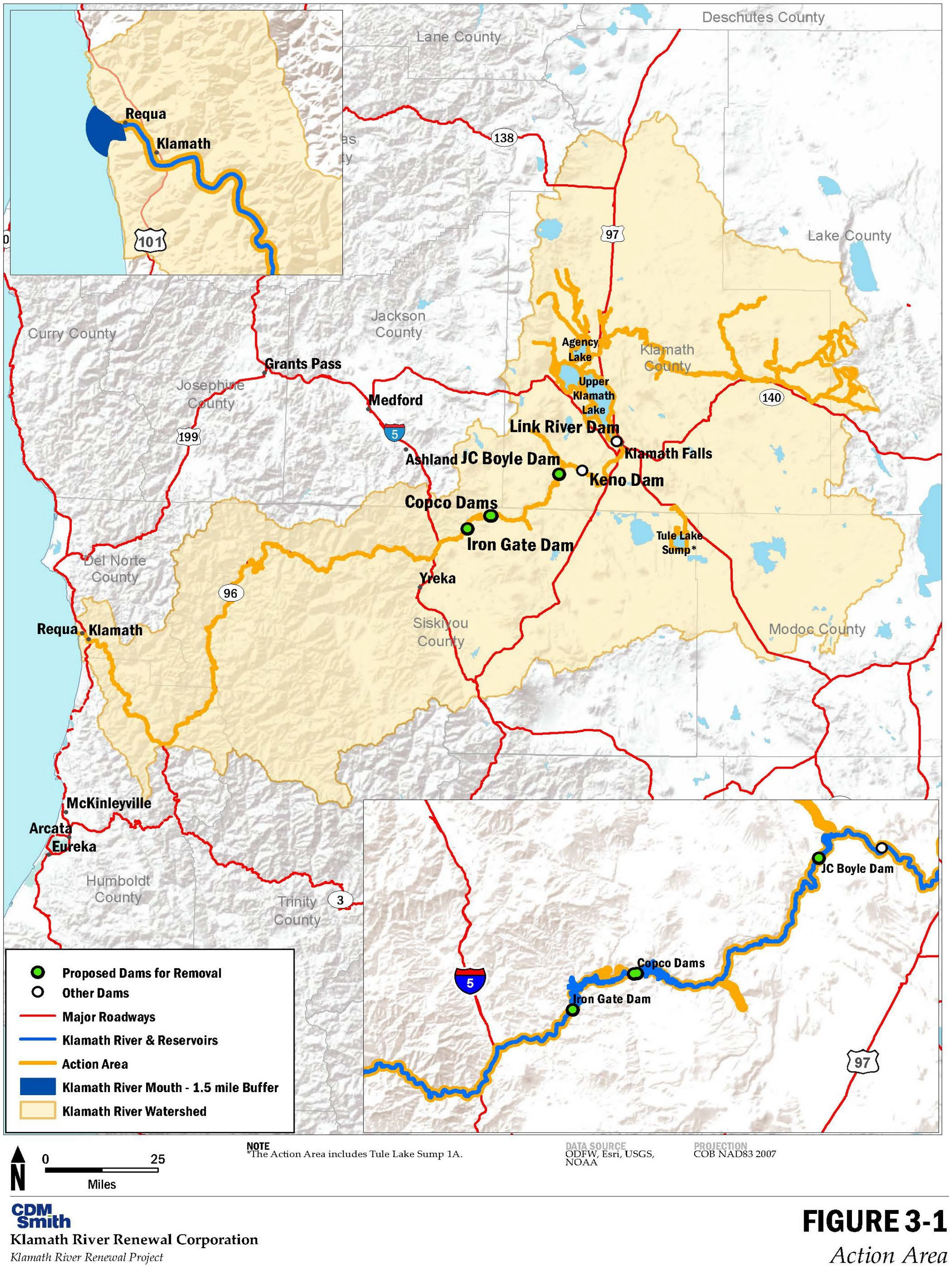

Figure 13. Action Area, except for the Pacific Ocean where there is species overlap between Klamath River Chinook salmon and Southern Resident killer whale (FERC 2021a; KRRC 2021c).

2.4 Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultations, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 CFR 402.02).

The following subsections describe the environmental baseline for SONCC coho salmon (Section 2.4.1), SRKW (Section 2.4.2), and eulachon (Section 2.4.3) and their critical habitats.

2.4.1 SONCC coho salmon

While the *Status of SONCC coho salmon* section (Section 2.2.1.2.1) discussed the viability of the SONCC coho salmon ESU as a whole, this section will focus on the condition of SONCC coho salmon and their critical habitat in the action area, and factors affecting their condition within the action area. Although the overall action area in the FERC (2021a) BA, which accounts for potential overlap with USFWS listed species, includes all fish-bearing tributaries to Upper Klamath Lake (e.g., Wood, Williamson, Sprague), up to the limit of anadromy, the effects of the proposed action on SONCC coho salmon would only occur within the action area where coho salmon currently occur or are expected to occur, which includes the 100-year floodplain of the mainstem Klamath River between Spencer Creek and the Pacific Ocean. Because this Environmental Baseline section refers to the condition of the species and habitat without the consequences of the proposed action, the primary focus of this section will be on the habitat within their current range (i.e., the Klamath Basin downstream of Iron Gate Dam). However, because the proposed action is anticipated to provide access to historic habitat above Iron Gate Dam to at least as far upstream as Spencer Creek (Hamilton et al. 2005), the current conditions of some habitat factors above Iron Gate Dam are also discussed in this Section. In addition, some populations of coho salmon (e.g., tributary populations) spawn in areas that are not expected to be directly impacted by the proposed action, but then migrate through areas that will be impacted; the baseline conditions for those populations are also discussed in this section.

Coho salmon were once numerous and widespread within the Klamath River Basin (Snyder 1931). Today, due to migration barriers (Figure 14), habitat degradation, and other factors, the populations that remain occupy a fraction of their historical area, in limited habitat within the tributary watersheds (e.g., Bogus Creek, Shasta River, Scott River, Salmon River, Trinity River, and miscellaneous smaller tributaries) and the mainstem Klamath River just downstream of Iron Gate Dam (NRC 2004; NMFS 2014a). Since 1962, the upper limit to anadromous migration on the Klamath River has been the Iron Gate Dam. Dwinnell Dam on the Shasta River, a major tributary to the Klamath River downstream of Iron Gate Dam, was completed in 1928 and blocked access to portions of the upper Shasta River. The Lewiston water diversion dam on the Trinity River, completed in 1963, has prevented access of coho salmon to their historical spawning grounds upstream of the dam (Reclamation and CDFW 2017). In recent years, the highest recorded escapement of adult coho salmon in the Klamath Basin has been to either the Trinity River or Scott River sub-basins. The extent and quality of coho salmon habitat in each sub-basin is discussed in greater detail below.

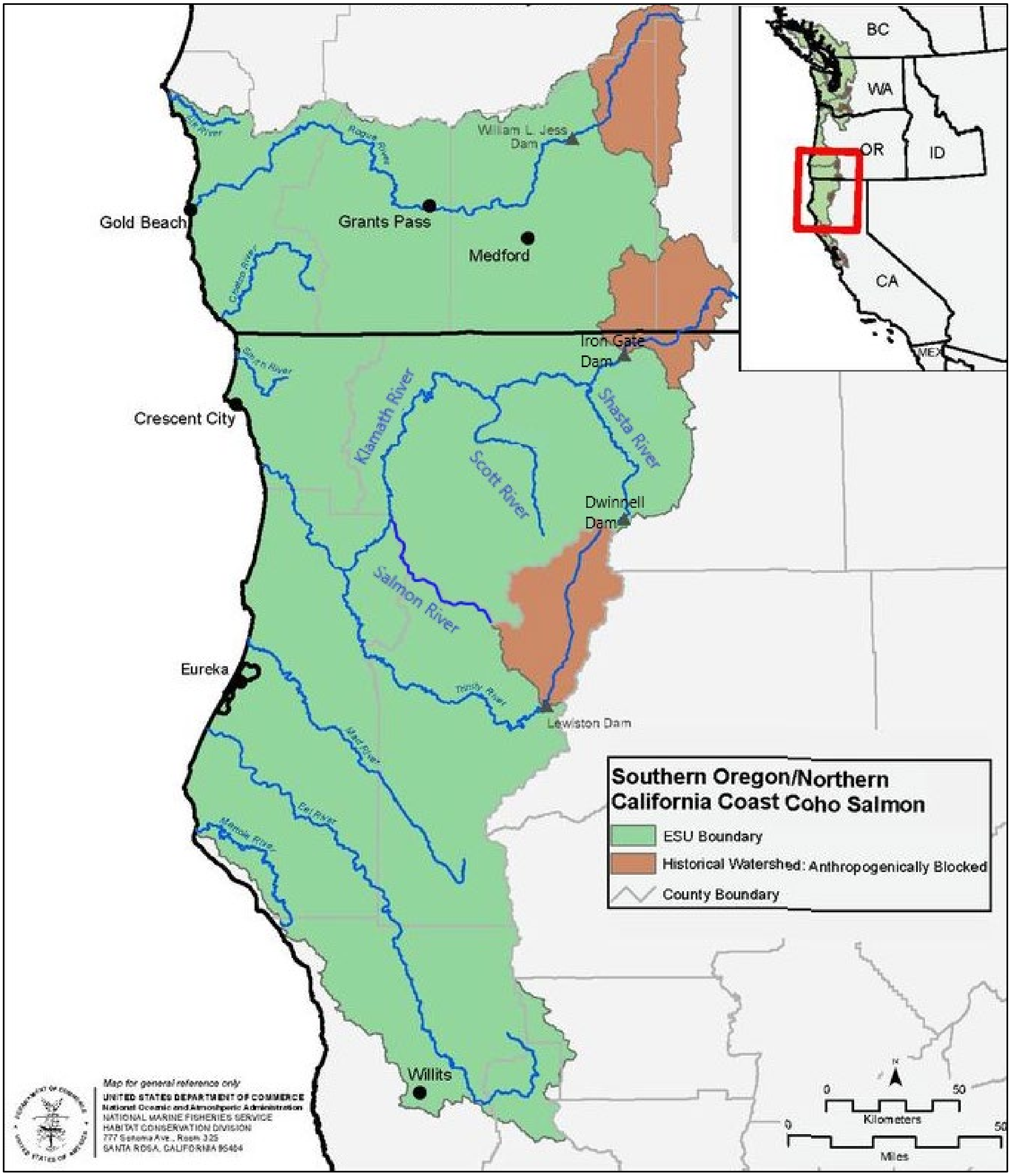

Figure 14. Map showing the SONCC coho ESU boundary and major barriers including Iron Gate Dam on the Klamath River, and Lewiston Dam on the Trinity River.

Coho salmon potentially affected by the proposed action currently occupy temperate coastal regions and arid inland areas stretching an approximated 193 RM from Iron Gate Dam downstream to the estuary, in addition to tributaries that join along that length of the Klamath River. Coho salmon potentially affected by the proposed action belong to three (i.e., the Interior Klamath, the Central Coastal, and the Interior Trinity) of the seven diversity strata that comprise the SONCC coho salmon ESU. All five populations of the Interior Klamath Diversity Stratum, one population of the Lower Klamath River Diversity Stratum, and all three populations in the Interior Trinity Diversity Stratum, would be affected by the proposed action (Section 1.3). Populations affected by the proposed action include: the Upper Klamath River (historically comprised of tributaries and mainstem Klamath River from the mouth of Portuguese Creek at RM 128 upstream to Spencer Creek at RM 233 excluding the Shasta and Scott Rivers), the Middle Klamath River (comprised of tributaries and mainstem Klamath River from the Trinity River confluence at RM 43 upstream to the mouth of Portuguese Creek excluding the Salmon River), the Lower Klamath River (comprised of tributaries and mainstem Klamath River downstream of the Trinity River confluence to the Klamath River mouth at RM 43), all three populations in the Trinity River (RM 43), the Salmon River (RM 66), the Scott River (RM 145), and the Shasta River (RM 179)(Table 2; Figure 15).

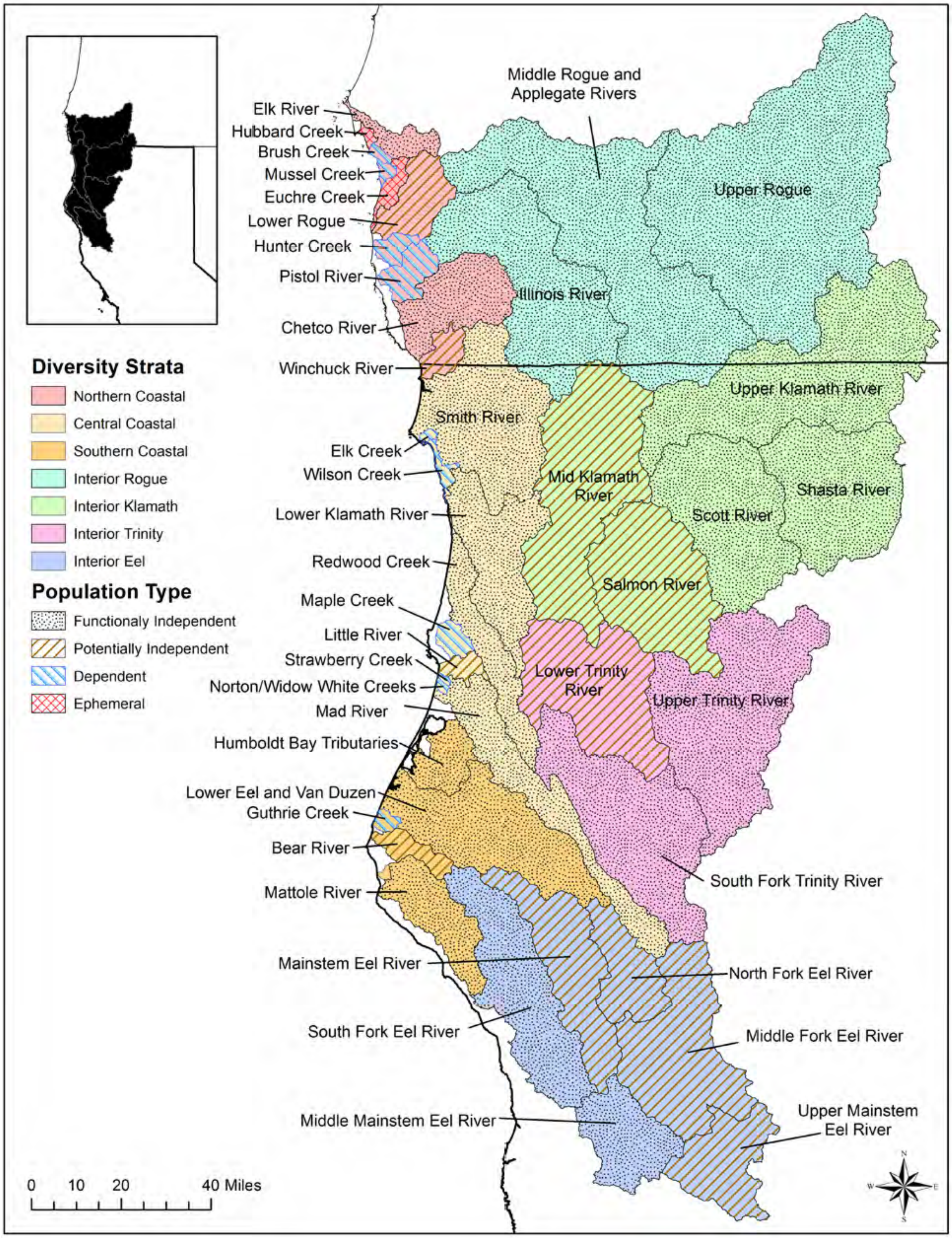

Figure 15. Historic population structure of the SONCC coho salmon ESU, including populations and diversity strata, as described in NMFS (2014a).

2.4.1.1 Status of Habitat in the Klamath Basin, including the Action Area

The habitat in the action area, and in the locations adjacent to the action area that SONCC coho salmon affected by the proposed action also utilize, is a patchwork of designated critical habitat and habitat that is not designated as critical habitat. For example, the habitat above Iron Gate Dam that is expected to be re-populated by coho salmon following the proposed action is not designated as critical habitat. However, the status of that habitat is relevant to our analysis of the effects of the proposed action. In addition, the tributaries downstream of Iron Gate Dam (e.g., Shasta, Scott, Salmon, and Trinity rivers), while mostly designated as critical habitat, are not included in the action area. However, because some of the coho salmon migrating through or otherwise utilizing the action area that may be affected by the proposed action will then utilize the habitat in those tributaries, the status of the habitat conditions in those tributaries is also relevant to our analysis of the effects of the proposed action. The status of the habitat conditions in those areas is summarized in this section. The threats and stressors that impact designated critical habitat and habitat that SONCC coho salmon utilize that is not designated as critical habitat are similar, so they are only described once in this section. However, for the purposes of the analysis of effects to SONCC coho salmon critical habitat, we identify in this section which habitat is designated as critical habitat, and which habitat is not.

Critical habitat for SONCC coho salmon in the Klamath River Basin that overlaps with the action area consists of the water, substrate, and adjacent riparian zone from the Iron Gate Dam (RM 193.1) to the Klamath River mouth at the Pacific Ocean, excluding the Yurok Reservation, Karuk Reservation, and Resighini Rancheria (64 FR 24049, 24058; May 5, 1999), which includes the Klamath River downstream of the confluence with the Trinity River. Again, the area upstream of Iron Gate Dam (RM 193.1) that is expected to be re-populated by coho salmon following the proposed action, which is believed to be at least as far upstream as Spencer Creek (confluence at RM 233.4) (Hamilton et al. 2005), is not designated as critical habitat. In addition, the tributaries to the Klamath River downstream of Iron Gate Dam, including the Shasta, Scott, Salmon, and Trinity (excluding the Hoopa Valley Reservation) rivers are designated critical habitat. As described above, the habitat in these areas, while not part of the action area, is relevant to the analysis of the effects of the proposed action.

The four dams to be removed, and their associated reservoirs, influence the habitat in the action area, not only in the hydroelectric reach, but on the Klamath River habitat downstream of Iron Gate Dam to the Pacific Ocean. The water temperature in the Klamath River downstream of Iron Gate Dam, which is affected by the reservoirs, is warmer in the summer and fall and colder in the spring than it would be without the four dams (Dunne et al. 2011; CSWRCB 2020b). Nutrients and associated algae, which flourish in the reservoirs, impact DO concentrations and otherwise impact water quality downstream of Iron Gate Dam (Asarian and Kann 2013). The dams disrupt sediment transport processes, thereby impacting both suspended sediment and larger diameter sediment (e.g., spawning gravel) conditions downstream of Iron Gate Dam (Reclamation 2011b). Many of these factors (i.e., temperature, nutrients, sediment transport) play an important role in determining fish disease conditions in the river downstream of Iron Gate Dam, which is increasingly identified as a major threat to SONCC coho salmon in the Klamath River (NMFS 2014a). Therefore, the status of these factors that affect SONCC coho salmon habitat associated with various life stages that will be affected by the proposed action are described in the following section for each population.

2.4.1.1.1 Water Quality Conditions

Much of the Klamath Basin is currently listed as water-quality impaired under section 303(d) of the Clean Water Act (Table 11). Water temperature within both mainstem and tributary reaches are often stressful to juvenile and adult coho salmon during late spring, summer, and early fall months. In addition, increased nutrient loading and organic enrichment with associated depletion of dissolved oxygen (DO) are recognized to be stressors for coho salmon in much of the Klamath Basin (NMFS 2014a).

Table 11: Water bodies listed as water-quality impaired under section 303(d) of the Clean Water Act and stressors for locations that contain SONCC coho salmon populations that may be affected by the proposed action (adapted from DOI and CDFG 2012; FERC 2021a).

Water Body	Water Temperature	Sedimentation	Organic Enrichment/Low Dissolved Oxygen	Nutrients
Klamath River: Spencer Creek mouth to Oregon-California State Line (not designated critical habitat)	x		x	
Klamath River: Oregon-California State line to Iron Gate Dam (not designated critical habitat)	x		x	x
Klamath River: Iron Gate Dam to Scott River mouth* (critical habitat)	x		x	x
Klamath River: Scott River mouth to Trinity River mouth** (critical habitat)	x		x	x
Klamath River: Trinity River mouth to Pacific Ocean (not designated critical habitat)	x	x	x	x
Shasta River (critical habitat)	x		x	
Scott River (critical habitat)	x	x		
Salmon River (critical habitat)	x			
Trinity River (critical habitat where not overlapping with Hoopa Valley Reservation)		x		

x – Indicates water bodies (row) listed as water quality impaired for a specific stressor (column).
*Selected minor tributaries that are impaired for sediment and sedimentation include Beaver, Cow, Deer, Hungry, and West Fork Beaver creeks (USEPA 2010).
**Minor tributaries that are impaired for sediment and sedimentation include China, Fort Golf, Grider, Portuguese, Thompson, and Walker creeks (USEPA 2010).

2.4.1.1.2 Water Temperature

Unsuitable water temperature is one of the most widespread and significant stresses in the SONCC coho salmon ESU (Williams et al. 2016a), and is a recognized stressor seasonally throughout the action area. Optimal, sub-optimal, and lethal water temperatures for coho salmon are lifestage specific (DWR 2004; Carter 2005). Stenhouse et al. (2012) reviewed water temperature thresholds and optima for coho salmon in the action area and identified an optimal water temperature range for rearing juvenile coho salmon to be 8°C to 15.6°C. Temperatures above this optimal range are associated with higher disease incidence and increased predation. NMFS (2014a) identifies 19°C as the upper limit for coho salmon suitability and 25°C as the lethal threshold for juvenile coho salmon.

Water temperatures in the Klamath Basin vary seasonally and by location, but water temperatures in the Klamath River regularly exceed temperatures optimal for coho salmon. Daily mean temperature (averaged over 2001 to 2011) exceeded 21°C from early July to late August in the Klamath River downstream of Iron Gate Dam (Asarian and Kann 2013). In 2017, an "extremely wet year", using the EPA guidelines, migrating adult salmon and rearing juvenile salmon temperature criteria were exceeded for between three months and four summer months at all focal monitoring locations in Klamath basin (Romberger and Gwozdz 2018). Water temperatures in the Klamath Hydroelectric Reach are influenced by the facilities for the four hydroelectric developments in the Lower Klamath Project. The relatively shallow depth and short hydraulic residence time in J.C. Boyle Reservoir do not support thermal stratification, and this reservoir does not directly provide a source of cold water to downstream reaches during summer (NRC 2004). During daily peaking operations at J.C. Boyle Powerhouse, warm reservoir discharges are diverted from the bypass reach, allowing cold groundwater to dominate flows in the river (PacifiCorp 2006). Water temperatures in the bypass reach can decrease by 5 to 15°C (9 to 27°F) when peaking operations are underway (Kirk et al. 2010).

The temporal water temperature pattern of the Hydroelectric Reach is repeated in the Klamath River immediately downstream from Iron Gate Dam, where water released from the Iron Gate Reservoir, when compared with modeled conditions without the dams, is 1 to 2.5 °C cooler in the spring, potentially just below optimal temperatures in some years, and 2 to 10 °C warmer in the summer and fall, well above optimal temperatures in most years (PacifiCorp 2004a; Dunsmoor and Huntington 2006; NCRWQCB2010; Risley et al. 2012). Immediately downstream of Iron Gate Dam, daily water temperatures are also less variable than those documented farther downstream in the Klamath River (Karuk Tribe of California 2009; 2010; 2011; 2013).

Farther downstream, the presence of the four dams exerts less influence; water temperatures are more influenced by the natural heating and cooling regime of ambient air temperatures and tributary inputs of surface water. Once the water has reached the Salmon River confluence, the effects of the dams on water temperature are not discernible (FERC 2021a). Downstream of the Salmon River, summer water temperatures begin to decrease slightly with distance as coastal meteorology (i.e., fog and lower air temperatures) reduces longitudinal warming and cool water tributary inputs increase the overall flow volume in the river (Magneson and Chamberlain 2015). Supplemental flows from the Trinity River, which are cold water releases from Trinity Reservoir intended to help manage water temperature, have been successful at keeping temperatures below 23°C in the Klamath River just below the Trinity River confluence and above the mouth in most years when supplemental flows have occurred (David and Goodman 2017; Romberger and Gwozdz 2018; Romberger and Daley 2021). However, daily maximum summer water temperatures have been measured at values greater than 26°C just upstream of the confluence with the Trinity River, decreasing to around 22°C to 24°C near Terwer Creek (Asarian and Kann 2013; YTEP 2016).

Water temperatures in the Klamath River estuary are linked to temperatures and flows entering the estuary, salinity of the estuary and resulting density stratification, and the timing and duration of the formation of a sand berm across the estuary mouth. When the estuary mouth is open, denser saltwater from the ocean sinks below the less dense fresh river water, resulting in a saltwater wedge that moves upstream and downstream in the estuary with the daily tides (Wallace 1998; Hiner 2006). Input of cool ocean water and fog along the coast minimizes extreme water temperatures much of the time (Scheiff and Zedonis 2011). Water temperatures in wetlands and tributaries near the estuary ranged from 10°C to 16°C during March to November of 2013 through 2015 (YTEP 2016).

2.4.1.1.3 Dissolved Oxygen

As with temperature, optimal and sub-optimal levels of DO are life stage specific for coho salmon (Carter 2005). During summer, the reservoirs in the Hydroelectric Reach exhibit varying degrees of dissolved oxygen supersaturation (i.e., >100 percent saturation) in surface waters (due to high rates of internal photosynthesis by algae) and hypolimnetic oxygen depletion in bottom waters (due to microbial decomposition of dead algae). At J.C. Boyle Reservoir, seasonal variations in dissolved oxygen are observed at its discharge due to conditions in the upstream reach from Link River Dam. Copco No. 1 and Iron Gate reservoirs thermally stratify beginning in April/May and do not mix again until October/November (FERC 2007). Dissolved oxygen in Copco No. 1 and Iron Gate reservoirs and surface waters during summer months is generally at, or in some cases greater than, saturation, while levels in hypolimnetic waters reach minimum values near 0 mg/L by July (Raymond 2010)

Generally, DO concentrations in the Klamath River downstream of Iron Gate Dam exceed minimum DO requirements for salmonids and other coldwater species (Asarian and Kann 2013). However, annual minimum DO concentrations from 2001 – 2011 were as low as 3.5 mg/L at Iron Gate Dam, with a general upward trend from 2001 – 2011 (Asarian and Kann 2013). Asarian and Kann (2013) indicated that the lowest DO concentrations (daily minimum DO, averaged over 2001 – 2011) occur from mid-July through late August, with Klamath River minima (7.3 to 7.0 mg/L when averaged over 2001 to 2011) occurring between Iron Gate Dam and RM ~100 (approximately the location of Happy Camp, CA). Similarly, PacifiCorp (2018) indicated that seasonal minima (approaching 5 mg/L) occurred in August and mid-September within one river mile downstream of Iron Gate Dam; DO concentrations at all other monitored Klamath River sites were above 8 mg/L during calendar year 2017 (PacifiCorp 2018). PacifiCorp engages in turbine venting at the Iron Gate Dam powerhouse, which involves forced aeration to increase the dissolved oxygen of water passing through the powerhouse turbines. Preliminary data from pilot testing indicate that turbine venting can increase downstream dissolved oxygen by around 2 mg/L (PacifiCorp 2011). Since completion of the pilot tests, PacifiCorp has initiated turbine venting at the Iron Gate Dam powerhouse whenever DO saturation levels fall to 87 percent or lower in the Klamath River downstream of Iron Gate Dam (PacifiCorp 2011).

Farther downstream in the mainstem Klamath River, near Seiad Valley, dissolved oxygen concentrations increase relative to the reach immediately downstream of Iron Gate Dam, but continue to exhibit variability, with mean daily values ranging from approximately 6.5 mg/L to supersaturated concentrations of approximately 11.0 mg/L, from June through November (Karuk Tribe of California 2002; 2003; 2009; 2010; 2011; 2013). Discrete sampling measurements at Seiad Valley indicate that dissolved oxygen values fluctuate between around 8 mg/L and 12 mg/L from March through December, with the lowest values occurring in summer (Watercourse Engineering 2019). Continuous sonde sampling collected at Seiad Valley from 2001 to 2011 indicate that around 50 percent of measurements fell below 8 mg/L during July and August of those years, but DO very rarely fell below 6 mg/L at any location or any time of year (Asarian and Kann 2013).

Measured concentrations of dissolved oxygen in the mainstem Klamath River downstream of Seiad Valley continue to increase with increasing distance from Iron Gate Dam. Dissolved oxygen concentrations near Orleans continue to be variable, with typical daily values ranging from approximately 6.5 mg/L to supersaturated concentrations of 11.5 mg/L (NCRWQCB 2010; Asarian and Kann 2013; Karuk Tribe of California 2013; Watercourse Engineering 2019). Farther downstream, near the confluence with the Trinity River and at the Terwer gage, minimum dissolved oxygen concentrations below 8 mg/L have been observed for extended periods of time during late summer/early fall (YTEP 2012; YTEP 2013b; YTEP 2014a; YTEP 2016).

Dissolved oxygen concentrations in the Klamath River estuary vary both temporally and spatially; concentrations in the deeper main channel of the estuary are generally greater than 6 to 7 mg/L throughout the year (Hiner 2006). Discrete dissolved oxygen measurements taken monthly from 2009- 2014 by the Yurok Tribe in the lower estuary generally range from 7.5 mg/L to 11.5 mg/L (YTEP 2012; YTEP 2013b; YTEP 2014a; YTEP 2016). Low dissolved oxygen concentrations (<1 to 5 mg/L) have been observed during summer months in the relatively shallow, heavily vegetated south slough (Wallace 1998; Hiner 2006).

2.4.1.1.4 Nutrients

Primary nutrients, including nitrogen and phosphorus, are affected by the geology of the surrounding watershed of the Klamath River, upland productivity and land uses, and a number of physical processes affecting aquatic productivity within reservoir and riverine reaches. An overabundance of these nutrients in the water annually leads to toxic algal blooms and reduced dissolved oxygen levels.

On an annual basis, nutrients typically decrease through the Hydroelectric Reach due to dilution from the springs downstream of J.C. Boyle Reservoir and settling of particulate matter and associated nutrients in Copco No. 1 and Iron Gate reservoirs (CSWRCB 2020b). In a 2005 to 2008 study of nutrient dynamics in the Klamath River during May through December, nutrients followed a decreasing longitudinal pattern, with the highest concentrations (approximately 0.1 to 0.5 mg/L total phosphorous [TP] and 1 to 4 mg/L total nitrogen [TN]) measured in the Klamath River downstream of Keno Dam (Asarian et al. 2010). On a seasonal basis, TP, and to a lesser degree TN, can increase in this reach due to the release (export) of dissolved forms of phosphorus (orthophosphate) and nitrogen (ammonium) from reservoir sediments during periods of summer and fall hypolimnetic anoxia. The seasonal nutrient releases can occur during periods of in- reservoir algal growth or can be transported downstream to the lower Klamath River, where they may stimulate periphyton growth.

These elevated nutrient levels also result in annual blooms of toxigenic cyanobacteria (a blue-green algal species) in the reservoirs and one of these species (*Microcystis aeruginosa*) often produces the toxin microcystin. Microcyctins are hepatotoxins and have been shown to cause problems with hatching, developmental defects (e.g., yolk sac effects, curved body and tail, heart rate perturbations), osmoregulatory imbalance, liver damage (enlargement, lesions), kidney lesions, and/or increased mortality in several species of fish including rainbow trout and particularly in embryo and fry lifestages (Kotak et al. 1996; Best et al. 2003; Malbrouck and Kestemont 2006; OEHHA 2009; Pavagadhi and Balasubramanian 2013). The FERC (2021a) BA notes local studies that determined microcystins can bioaccumulate in aquatic biota and were found in 85% of fish and mussel tissues sampled in the Klamath River in 2007 including in Iron Gate and Copco No. 1 reservoir (Kann 2008). Bioaccumulation has also been confirmed in studies elsewhere (Schmidt et al. 2013).

When the cyanobacteria dies, the cell walls burst and release the toxin into the water. Microcystins are very stable and resist common chemical breakdown pathways such as hydrolysis or oxidation under conditions commonly found in water bodies. OEHHA (2009) notes that in many circumstances necessary bacterial proteases are not present in natural water bodies and the toxin may persist in the water column for months under the right conditions resulting in its transport downstream in systems such as this one.

Downstream of Iron Gate Dam, TP values typically range from 0.1 to 0.25 mg/L in the Klamath River between Iron Gate Dam and Seiad Valley, with the highest values occurring just downstream of the dam (Asarian and Kann 2013). TN concentrations in the river downstream of Iron Gate Dam generally range from <0.1 to 2.0 mg/L and are generally lower than those in upstream reaches due to reservoir retention and dilution from springs in the Hydroelectric Reach (Asarian et al. 2009; Asarian and Kann 2013). Further decreases in TN occur in the mainstem river due to a combination of tributary dilution, alluviation on river banks following high water in spring and early summer, and in-river nitrogen removal processes such as denitrification and/or storage related to biomass uptake (Asarian et al. 2010). Ratios of nitrogen to phosphorus measured in the Klamath River downstream of Iron Gate Dam suggest the potential for nitrogen limitation of primary productivity, with some limited periods of co-limitation by both nitrogen and phosphorus. However, concentrations of both nutrients are high enough that other factors (i.e., light, water velocity, or available substrate) may be more limiting to primary productivity than nutrients, particularly in the vicinity of Iron Gate Dam (FERC 2007; Asarian et al. 2010; HTEPA 2013; CSWRCB 2020b). This is particularly important with regard to factors controlling periphyton growth in the Klamath River between Iron Gate Dam and the Scott River (Asarian et al. 2009).

Downstream of the confluence with the Salmon River, nutrient concentrations continue to decrease in the Klamath River compared with those measured farther upstream due to tributary dilution and seasonal nutrient retention in upstream reaches. Data collected by various tribes and agencies from 2001 to 2011 indicate that TP concentrations are generally 0.01 to 0.2 mg/L from the mouth of the Salmon River to the mouth of the Trinity River, with peak values occurring in September and October (Asarian et al. 2010; Asarian and Kann 2013). For TN, reports indicate that on a seasonal basis, TN increases from May through November, with peak concentrations (<0.5 mg/L) typically observed during September and October (Asarian et al. 2010). Relative to the higher concentrations measured near Iron Gate Dam, these lower nutrient concentrations may be limiting periphyton growth in this portion of the river.

Nutrient levels in the Klamath River estuary experience inter-annual and seasonal variability. Measured levels of TP in the estuary are typically below 0.1 mg/L during summer and fall (June to September), and TN levels are consistently below 0.6 mg/L (June to September) (YTEP 2012; YTEP 2013b; YTEP 2014a; YTEP 2016).

2.4.1.1.5 Suspended Sediment Concentrations

Rivers transport numerous materials in suspension including sediments (i.e., clay, silts, and sands) and fine organic matter (e.g., leaves, needles, algae, plankton, and microbes). High levels of sediment transport can reduce habitat and water quality for salmonids, and are also of concern because high densities of *M. speciosa* (freshwater annelid worms) have been observed in these habitats (Hillemeier et al. 2017; Som and Hetrick 2017). Suspended sediment refers to the settleable fine sediments (i.e., clays, silts, and sand) transported in suspension by a river or stream. These fine sediments tend to settle out due to their density but during flow events are repeatedly re-suspended into the flow by turbulent fluid forces until the streamflow recedes or sediments are transported into zones with weak fluid forces (e.g., backwater areas). Suspended sediment refers to these settleable suspended material in the water column. Bed materials, such as sand, gravel, and larger substrates, are considered bedload, and are discussed in Section 2.4.1.1.6 (Sediment Supply and Conditions) below. Two types of suspended material are important to water quality in the Klamath Basin and are discussed below: algal-derived (organic) suspended material and mineral (inorganic) suspended material. Sources of each type of suspended material differ, as do spatial and temporal trends for each, in the Upper, Middle, and Lower Klamath basins (DOI and CDFG 2012; FERC 2021a).

Between Link River at Klamath Falls and the upstream end of J.C. Boyle Reservoir, algal-derived (organic) suspended material is the predominant form of suspended material affecting water quality. Summer and fall algal-derived (organic) suspended materials decrease with distance downstream, as algae are exported from Upper Klamath Lake and into Lake Ewauna and Keno Reservoir, where they largely settle out of the water column (Sullivan et al. 2011). In the winter and spring, suspended material in the Hydroelectric Reach is dominated by mineral sediment loads transported during high flow events, which can also settle out in the hydroelectric reach as water carries relatively heavy sediment loads during high flow events (DOI and CDFG 2012). The four Lower Klamath Project facilities prevent most sediment from reaching downstream of Iron Gate Dam, and the sediment supply from the Hydroelectric Reach (i.e., between Keno and Iron Gate dams) is relatively small (i.e., 3.4 percent) when compared to the total sediment supplied to the Klamath River (CSWRCB 2020b). Just downstream of Iron Gate Dam, summer and fall SSC become relatively low. Between Iron Gate Dam and Seiad Valley, suspended materials can increase due to the transport of in-reservoir algal blooms during summer as well as riverbed scour and resuspension of previously settled materials during high flows in winter and spring (Armstrong and Ward 2008; Watercourse Engineering 2019). Mineral suspended sediments begin to have prominence again in the Klamath River downstream of Iron

Gate Dam, as major tributaries to the mainstem contribute large amounts of mineral suspended sediments to the river during winter and spring (Armstrong and Ward 2008). During large winter storms or following landslides in the Klamath Basin, extremely high SSCs have been observed in the Klamath River mainstem and tributaries. 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 1,000 mg/L during winter high flows (FERC 2021a). SSCs generally increase in a downstream direction from the contribution of tributaries. SSCs within the Klamath River estuary are relatively high (YTEP 2010; YTEP 2013a; YTEP 2014b; YTEP 2017).

2.4.1.1.6 Sediment Supply and Conditions

Sediment erosion (e.g., landslides), delivery to the streams and rivers, and transport rates (i.e., suspended sediment and bedload) in the Klamath River system vary significantly and are a function of tectonic forces, topography (i.e., hillslope steepness or river slope), geology, geomorphology, precipitation and streamflow runoff patterns, and land use. The Klamath River is different than most large watersheds which typically have high relief areas with steeper hillslopes in the headwater areas and gentler slopes with lower relief in the lower watershed. Instead, the Upper Klamath River watershed (i.e., headwaters to Iron Gate Dam), contains several large tributaries with relatively mild slopes, low relief (except immediately along Crater Lake), low drainage density, extensive floodplains and terraces, several lakes, and extensive lacustrine deposits in volcanic terrain that create complex groundwater systems. In contrast, the lower watershed (i.e., downstream of Iron Gate Dam) contains numerous steep, high relief tributaries, and the majority of the Lower Klamath River flows through a nearly continuous series of gorges with few floodplains (CSWRCB 2020b).

2.4.1.1.6.1 Sediment Quantity

<u>Hydroelectric Reach</u>

The Klamath River is supply-limited for fine material (sands and small gravels), but capacity-limited for large material (cobbles and boulders) (Reclamation 2011b). Minor amounts of sediment are supplied to the Klamath River from the watershed above Keno Dam because UKL traps nearly all sediment delivered from upstream tributaries. Some finer material may be transported through the UKL during high runoff events. Sources between Keno and Iron Gate dams supply 24,160 tons/year of coarse sediment (≥0.063mm; 1.3 percent of the cumulative average annual basin-wide coarse sediment delivery) to the Klamath River (CSWRCB 2020b).

In 2009 and 2010, Reclamation conducted a sediment sampling study in the project reservoirs to describe sediment composition and determine sediment thickness throughout all major sections of the reservoirs (Reclamation 2011f). The study found that fine-grained sediment in all of the reservoirs except Copco No. 2 Reservoir consisted primarily of elastic silt and clay, with lesser amounts of elastic silt with fine sand. Reclamation determined that the sediment was mostly an accumulation of silt-sized particles of organic material such as algae and diatoms, and silt-sized particles of rock. The average grain size decreases nearer to the dams because smaller particles settle more slowly than larger particles. Accordingly, the upper reaches of each reservoir contained a higher percentage of silt, sand, and gravel than the lower reaches, which contain more clay, sandy elastic silt, and elastic silt with trace sand. The elastic silt in all of the reservoirs had the consistency of pudding and had very high water content (more than double the mass). Reclamation also found that the fine-grained sediment had a low cohesion and was erodible; where water flowed faster than 2.9 to 5.8 feet per second (fps), accumulations of sediment were less than a few inches (Reclamation 2011c).

Between Keno Dam and Iron Gate Dam, coarse sediment inputs from tributary streams and other streamside sources are currently trapped within the Hydroelectric Reach reservoirs. Sources in this reach supply 24,160 tons/year of coarse sediment (1.3 percent of the cumulative average annual basin-wide coarse sediment delivery)(CSWRCB 2020b). Reclamation (2011b) estimated that there were approximately 13,150,000 cy of sediment stored in the Hydroelectric Reach. The CSWRCB (2020b) estimated that the total sediment stored in the Hydroelectric Reach in 2020 would be 15,130,000 cubic yards. The sediment stored in the reservoirs has a high water content, and 85 percent of the particles are silts and clays (less than 0.063 millimeter [mm]), while 15 percent are sand or coarser (larger than 0.063 mm) (GEC 2006; Reclamation 2011b; CSWRCB 2020b).

Downstream of Iron Gate Dam

The four dams in the Lower Klamath Project 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. Most (~98 percent) of the sediment supplied to the mainstem Klamath River is delivered from tributaries downstream of Cottonwood Creek, limiting the effects of interrupting upstream sediment supply downstream around Scott River. The sediment delivered to the Klamath River increases rapidly once the contributions from the Scott River (10 percent), Salmon River (5.5 percent), Trinity River (57 percent), and the numerous other smaller tributaries such as Indian, Clear, Elk, and Dillon Creeks enter the mainstem (CSWRCB 2020b).

Curtis et al. (2021) examined sediment mobility in a 140-kilometer segment of the mainstem Klamath River downstream of Iron Gate Dam. Field and remote sensing methods were used to assess fundamental indicators of active sediment transport and river response to a combination of natural runoff events and reservoir releases during the study period from 2005 to 2019. These datasets validate channel-maintenance flows defined by USFWS (2016d). Flood disturbance within the study reach was produced by the combined effect of natural flows and reservoir releases, which resulted in mobile bed conditions during the study period.

2.4.1.1.6.2 Sediment Quality

Reclamation collected sediment samples from the J.C. Boyle, Copco No. 1, and Iron Gate reservoirs in 2009 and analyzed them for chemical constituents (Reclamation 2011a). A screening-level human health and ecological risk evaluation of the sediment data concluded that chemicals detected in reservoir sediments are at concentrations unlikely to cause adverse effects in exposed human and wildlife receptors (Reclamation 2011a). Additional sediment samples were collected from the J.C. Boyle Reservoir in December 2017, January 2018, and February 2018, and analyzed for arsenic. Arsenic concentrations found in the 2017 samples were consistent with those found in 2009 and consistent with regional background ranges for arsenic (FERC 2021a). To evaluate the risk to biota from the release of reservoir sediments, arsenic sediment concentrations were compared to sediment and soil ecological screening levels. The range of arsenic sediment concentrations (4.3 to 15 milligrams per kilogram [mg/kg]) found in the J.C. Boyle Reservoir in both 2009 and 2017 are lower than most soil and sediment screening levels. It should be noted that regional background studies suggest that the arsenic background concentration is around 12 mg/kg. Natural geologic sources of arsenic may contribute to the relatively high background arsenic levels in southern Oregon soils (Sturdevant 2011).

2.4.1.1.7 Hydrology

2.4.1.1.7.1 Natural Flow Regime

In this Opinion, NMFS uses the concepts of a natural flow regime (Poff et al. 1997) to help us assess baseline conditions for species and critical habitat and also analyze the effects of the proposed action. The natural flow regime of a river is the characteristic pattern of flow quantity, timing, rate of change of hydrologic conditions, and variability across time scales (hours to multiple years), all without the influence of human activities (Poff et al. 1997). A universal feature of the natural hydrograph of the Klamath River and its tributaries is a spring pulse in flow followed by recession to a base flow condition by late summer (NRC 2004). This main feature of the hydrograph has undoubtedly influenced the adaptations of native organisms in the Klamath basin, as reflected in the timing of their key life-history features (NRC 2004). Understanding the link between the adaptation of aquatic and riparian species to the flow regime of a river is crucial for the effective management and restoration of running water ecosystems (Beechie et al. 2006), because humans have now altered the flow regimes of most rivers (Poff et al. 1997; Bunn and Arthington 2002). The altered hydrology of the Klamath Basin is significant. The four dams in the Lower Klamath Project have effectively blocked fish passage to the upper basin, blocked sediment transport downstream of Iron Gate Dam, caused a dramatic reduction in flow variability resulting in constant, stable flows downstream of Iron Gate Dam, and decreased water quality downstream of Iron Gate Dam from algae blooms in the reservoirs. The flow volume and timing of the natural hydrograph has also been altered dramatically by operation of Reclamation's Klamath Project, which is discussed in the next section.

2.4.1.1.7.2 Reclamation's Klamath Project

The Reclamation Act of 1902 (43 U.S.C. 391 et seq.) authorized the Secretary of the Interior to locate, construct, operate, and maintain works for the storage, diversion, and development of water for the reclamation of arid and semiarid lands in the western States. The Oregon and California legislatures passed legislation for certain aspects of the Klamath Project, and the Secretary of the Interior authorized construction May 15, 1905, in accordance with the Reclamation Act of 1902 (Act of February 9, 1905, Ch. 567, 33 Stat. 714). The Project was authorized to drain and reclaim lakebed lands in Lower Klamath and Tule Lakes, to store water of the Middle Klamath and Lost rivers, including water in the Lower Klamath and Tule lakes, to divert and deliver supplies for Project purposes, and to control flooding of the reclaimed lands. Additional history of Reclamation's Klamath Project is described in additional detail in the Background Section (Section 1.1.2 Reclamation's Klamath Project) above. Klamath River Basin hydrology associated with Reclamation's Klamath Project is described and analyzed in NMFS (2019a) biological opinion. In addition, as described in section 1.1.2, later in 2019, Reclamation reinitiated consultation with the Services on Reclamation's Klamath Project operations. That reinitiated consultation is ongoing. More recent information regarding the IOP and temporary operating procedures is described in additional detail in the Background Section (Section 1.1.2 Reclamation's Klamath Project) above.

The portion of the Project served by UKL and the Klamath River consists of approximately 200,000 acres of irrigable land, including areas around UKL, along the Klamath River (from Lake Ewauna to Keno), Lower Klamath Lake, and from Klamath Falls to Tulelake. Most irrigation deliveries occur between April and October, although water is diverted year-round for irrigation use within the Project. Current operation of the Klamath Project intends to mimic the natural river flow regime; however, the flow volume, spring peak magnitude and duration, deep flushing flows, and flow variability are all greatly reduced relative to the natural hydrograph due to Project water deliveries and PacifiCorp's hydroelectric operations. Under current Klamath Project operations, the median annual Klamath Project delivery from all surface water sources is approximately 408,00 acre-ft (379,000 acre-ft in spring/summer, 29,000 acre-ft in fall/winter), with a minimum of 26,000 acre-ft and a maximum of 490,000 acre-ft for the 1981 to 2016 period of record (Reclamation 2018). The majority of this Project water comes from UKL; median annual Project Supply from UKL is approximately 306,000 acre-ft, with a minimum of 12,000 acre-ft and a maximum of at or near 350,000 acre-ft in nearly half of the years in the period of record.

Primarily due to the annual Project deliveries over the last century there has been a shift in both the magnitude and timing of average peak flows in the Klamath River at Keno, Oregon, in part as a result of Reclamation's Klamath Project (Figure 16). The average peak flow has declined from approximately 3,400 cfs (96.3 m^3/sec) in the 1905 to 1913 period to approximately 2,700 cfs (76.5 m^3/sec) in the period after 1960. The timing of the average peak for these periods has shifted from late April or early May to mid- to late-March, a significant shift of more than one month. Additionally, there is far less flow during the spring and summer in the period since 1960 than during the early 1900s.

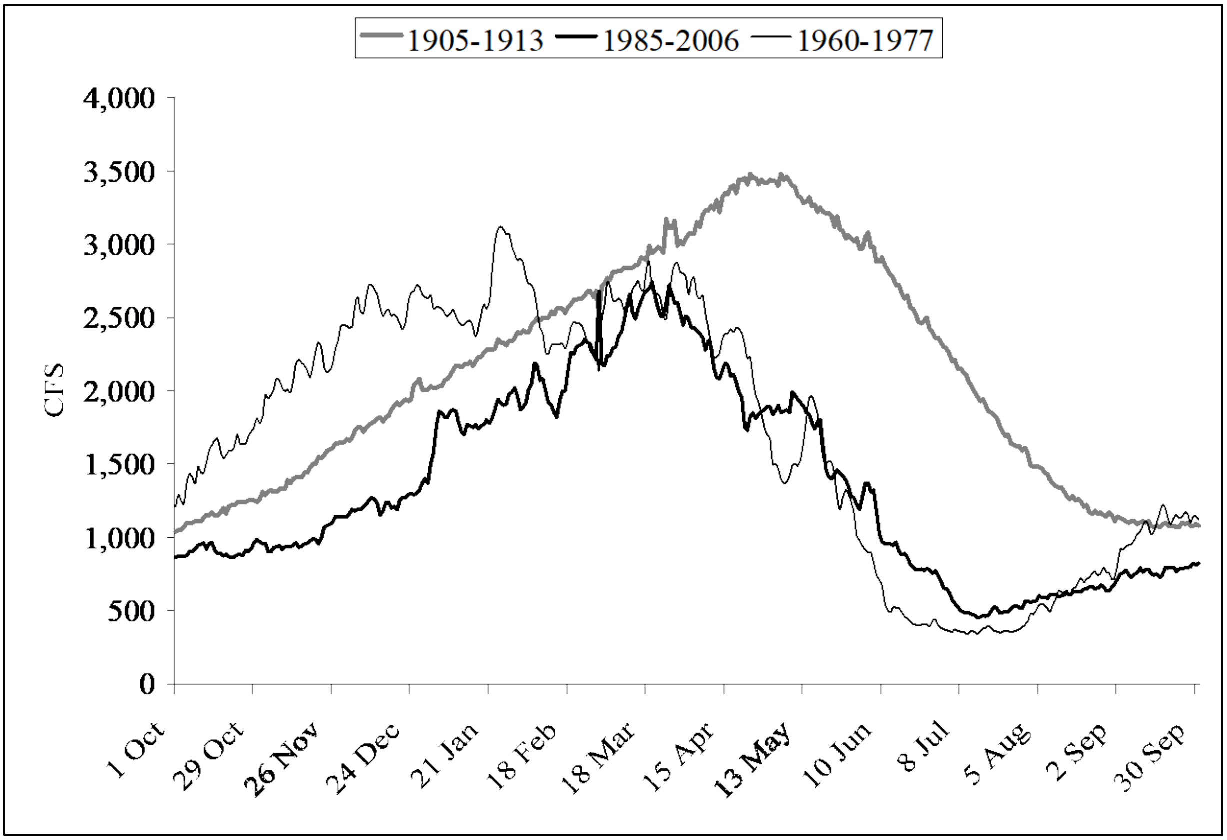

Figure 16. Average daily Klamath River discharge at Keno, Oregon, during three different time periods. The 1905 to 1913 dataset represents historical, relatively unimpaired river flow, while two more modern time periods represent discharge after implementation of Reclamation's Klamath Project.

2.4.1.1.8 Disease

Since the late 1990s, fish disease research and monitoring has been conducted extensively in the Klamath River Basin. Disease effects are likely to negatively impact all of the VSP parameters of the Klamath and Trinity coho salmon populations because both adults and juveniles can be affected. In terms of critical habitat, disease impacts adult and juvenile migration corridors, and juvenile spring and summer rearing areas. Several documents provide extensive overviews of aquatic diseases that affect salmonids in the Klamath River, including:

- USFWS and NMFS (2013) biological opinion,
- NMFS (2019a) biological opinion,
- the Synthesis of the Effects to Fish Species of Two Management Scenarios for the Secretarial Determination on Removal of the Lower Four Dams on the Klamath River (Hamilton et al. 2011),

- the Klamath Facilities Removal Environmental Impact Statement/Environmental Impact Report (DOI and CDFG 2012),
- the Final Environmental Impact Report for the Lower Klamath Project License Surrender (CSWRCB 2020b),
- a series of USFWS Technical Memoranda (USFWS 2016a; USFWS 2016b; USFWS 2016c; USFWS 2016d).

Existing data and observations in the Klamath River indicate that the most common pathogens of concern can be grouped into four categories: (1) viral pathogens such as infectious haematopoietic necrosis; (2) the bacterial pathogens *R. salmoniranrum* (bacterial kidney disease), *Flavobacterium columnare* (columnaris), and *Aeromonas hydrophila*; (3) external protozoan parasites *Ichthyophthirius* (Ich), *Ichthyobodo,* and *Trichodina*; and (4) the myxozoan parasites *Ceratonova shasta* (causes ceratomyxosis) and *Parvicapsula minibicornis*. Other pathogens are likely present in the Klamath River, but are rarely detected. Ich and columnaris have occasionally had a substantial impact on adult salmon downstream of Iron Gate Dam, particularly when habitat conditions include exceptionally low flows, high water temperatures, and high densities of fish (such as adult salmon migrating upstream in the fall and holding at high densities in pools). In 2002, these habitat factors were present, and a disease outbreak occurred, with more than 33,000 adult salmon and non-listed steelhead losses, including an estimated 334 coho salmon (Guillen 2003). Most of the fish affected by the 2002 fish die-off were non-listed fall-run Chinook salmon in the lower 36 miles of the Klamath River (Belchik et al. 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 worm intermediate host.

The life cycles of both *P. minibicornis* and *C. shasta* involve an invertebrate host and a fish host, where these parasites complete different parts of their life cycle. In the Klamath River, *P. minibicornis* and C. shasta share the same invertebrate host: an annelid worm, *Manayunkia occidentalis sp,* identified previously as *Manayunkia speciosa* Leidy, 1859. (Atkinson et al. 2020). Once the annelids are infected, they release *C. shasta* actinospores into the water column. Temperature and actinospore longevity are inversely related. In one study, actinospores remained intact the longest at 4°C, but were short-lived at 20°C. Actinospores are generally released when temperatures are above 10°C, and remain viable (able to infect salmon) from 3 to 7 days at temperatures ranging from 11 to 18ºC (Foott et al. 2006). When temperatures are outside of 11 to 18ºC, actinospores are viable for a shorter time. USFWS (2016c) states that myxospores released from adult salmon carcasses contribute the bulk of myxospores to the system; mostly from carcasses upstream of the confluence with the Shasta River.

The annelid host for *C. shasta* is present in a variety of habitat types, including runs, pools, riffles, and edge-water; as well as sand, gravel, boulders, bedrock, and aquatic vegetation; and is frequently present with *Cladophora* (a type of algae) (Bartholomew and Foott 2010). The altered river channel downstream of Iron Gate Dam has resulted in an atypically stable river bed, which provides favorable habitat for the annelid worm. Slow-flowing habitats may have higher densities of annelids, and areas that are more resistant to disturbance, such as eddies and pools with sand and Cladophora, may support increased densities of annelid populations (Bartholomew and Foott 2010), especially if flow disturbance events are reduced or attenuated. High annelid densities increase parasite loads, which leads to higher rates of infection and mortality for coho salmon. Alexander et al. (2016) concluded that the summer distribution of M. occidentalis is related to observed hydraulic and substrate conditions during base discharge (summer) and modeled hydraulic and substrate conditions during peak discharge (late winter to early spring). In the Klamath River, the annelid 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 upstream of 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, especially from April through August (Beeman et al. 2008), although within and between years the size of the infectious zone and the magnitude of parasite densities may vary geographically (True et al. 2016b; Voss et al. 2018; Voss et al. 2019; Voss et al. 2020). The highest rates of infection occur in the Klamath River within approximately 50 miles downstream of Iron Gate Dam (Stocking and Bartholomew 2007; Bartholomew and Foott 2010).

Periodic scour and substrate disturbance are considered to be integral for managing disease induced mortality of juvenile and adult salmonids (Alexander et al. 2014; Curtis et al. 2021). In addition, Turecek et al. (2021) investigated the efficacy of reducing streamflow to desiccate annelid hosts to reduce disease risk. Stocking and Bartholomew (2007) noted that the ability of some annelid 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.

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 (Ray et al. 2012). High infection rates can result in high mortality of juvenile salmonids. Coho salmon migrating downstream have been found to have infection rates as high as 50 percent (Bartholomew and Foott 2010). Sentinel studies, which have been conducted annually since 2006, indicated that in 2014, mortality from *C. shasta* observed in coho salmon was as high as 93 percent mortality in May at one site; this high loss of coho salmon was similar to that observed in 2007 and 2008 (Bartholomew et al. 2016). 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 suggest that higher spring discharge increased smolt survival (Beeman et al. 2008; Beeman et al. 2012).

Annual prevalence of the myxozoan parasite *C. shasta* has been documented in emigrating juvenile salmon populations during spring and early summer in the Klamath River. *C. shasta* in out-migrating juvenile salmonids has been well studied (True et al. 2016a; True et al. 2016b; 2017; Voss et al. 2018; Som et al. 2019; Voss et al. 2019; Robinson et al. 2020; Voss et al. 2020), and the processes that influence *C. shasta* impacts on Klamath River salmon are increasingly understood (Robinson et al. 2020). Robinson et al. (2020)'s results suggested that hatchery origin smolts may exacerbate the impacts of the disease as evidenced by an associative relationship between the prevalence of infection in outmigrating hatchery fish with the densities of water-borne *C. shasta* spores in subsequent seasons.

Since 2009, the USFWS's California/Nevada Fish Heath Center (CNFHC) has been collecting data that can be used as an index of severity of *C. shasta* infection (Voss et al. 2020). *C. Shasta* was detected by QPCR in 64% of naturally produced Chinook salmon in 2020, which ranks as third highest detection rate since 2009 (Voss et al. 2020). Prevalence of infection (POI) was highest in the Scott River to Salmon River reach. The mean *C. shasta* POI for natural Chinook salmon from 2009 to 2020 was 34%, ranging from a low of 4% in 2012 to a high of 75-76% during the drought years of 2014-2015 (Voss et al. 2020). Preliminary data for 2021 indicated the *C. shasta* POI for Chinook salmon was 57% of 911 fish tested (USFWS 2021c). The occurrence of infection severity that can lead to significant mortality varies within and between years. For example, in 2015 the percent of Chinook salmon infected with *C. shasta* was up to 100 percent and the severity of infections was high, whereas in 2016 infection rates were up to 90 percent and infection severity was low.

Prevalence of infection and prevalence of mortality are variable based on year, species, and population (USGS 2019). Som et al. (2019) found that *C. shasta* related mortality rate estimates in coho ranged from 0% to 68% for the Shasta and Scott river coho salmon populations between 2005 and 2016, and that the Shasta River population experienced higher mortality rates than the Scott River population due to their prolonged exposure history in the mainstem Klamath River. USFWS estimated a *C. shasta* related mortality rate of 11.8% for juvenile coho salmon from the Shasta River (FERC 2021a). USGS simulated an overall prevalence of mortality of 34.8 percent of naturally produced juvenile Chinook salmon and 87.0 percent of hatchery-origin juvenile Chinook salmon caused by *C. shasta* during the 2020 outmigration at the Kinsman trap on the Klamath River downstream of Iron Gate Dam (FERC 2021a).

2.4.1.1.9 Hatcheries

Two hatchery programs release anadromous salmonids in the Klamath Basin: IGH on the Klamath River, and Trinity River Hatchery (TRH) on the Trinity River. The coho salmon propagated at IGH and TRH are part of the ESA listed SONCC coho salmon ESU (50 CFR 223.102(e)). Although not in the action area, TRH produces coho salmon, Chinook salmon, and steelhead that will pass through the action area, specifically the lower Klamath River reach, and these fish could be impacted by the proposed action, as discussed in Sections 2.4.1.1.15.1.1 (Juvenile Migratory Habitat Conditions) and 2.4.1.1.15.2 (Adult Migratory Habitat Conditions) above. In addition, the fish that are produced at TRH could adversely affect coho salmon in the action area through competition in the lower Klamath River. Therefore, production at TRH is included in this section (Table 12). However, additional detail is provided for IGH, which is the only hatchery that produces anadromous fish in the action area.

Table 12. Iron Gate and Trinity River hatcheries production goals.

Hatchery	Species	Number released	Life Stage	Released Target Date	Adult Run timing
IGH	Chinook Salmon	5,100,000	smolts	May-June	Mid-September to early November
IGH	Chinook Salmon	900,000	yearlings	mid-October through November	Mid-September to early November
IGH	coho salmon	75,000	yearlings	March-May	October to January
IGH	Steelhead*	200,000	smolts		November to March
TRH	Chinook Salmon	3,000,000	smolts	May-June	Mid-September to early November
TRH	Chinook Salmon	1,300,000	yearlings	November	Mid-September to early November
TRH	Steelhead	448,000	smolts	April	November to March
TRH	coho salmon	300,000	Yearlings	March	October to January

*No steelhead have been produced at IGH since 2012 due to low adult returns.

Based on mitigation goals established when IGH was constructed in 1962, the IGH historically released approximately six million Chinook salmon, 75,000 coho salmon and 200,000 steelhead annually (Table 12). Of the six million Chinook salmon that is the goal for production at IGH, about 5.1 million are smolts that are typically release from mid-May through early June and about 900,000 are yearlings that are typically released from mid-October through November. Production of Chinook salmon and coho salmon has been maintained but production targets are not always reached, especially for Chinook salmon in recent years. Due to insufficient returns of Chinook Salmon, egg take was 7,044,080 eggs (69%) short of the target of 10,200,000 eggs in 2019 (Giudice and Knechtle 2020), and 7,164,606 eggs (70%) short of the same target in 2020 (Giudice and Knechtle 2021a). Adult returns of coho salmon to IGH were sufficient to reach egg production goals in 2017 through 2020, but produced less than half of the egg production target in 2015 and 2016 (Giudice and Knechtle 2021a). The production of steelhead at IGH tapered off and then ceased in 2012, due to low adult returns.

Similar to production targets and associated release numbers, release timing is also variable each year. The timing of release for Chinook salmon at IGH is dependent on fish growth and environmental conditions. In 2021, due to inhospitable in-river conditions in the Klamath River, no IGH Chinook salmon were released during the typical smolt release timing, and instead were held at TRH during the summer before being returned to IGH to be released during the typical yearling timing in the fall (CDFW 2021d).

The target 75,000 coho salmon are typically released from IGH as yearlings after March 15th each spring. Prior to 2001, all of the Chinook salmon smolts were released after June 1 of each year. However, beginning in 2001, the CDFW began implementing an early release strategy in response to recommendations provided by the Joint Hatchery Review Committee (CDFG and NMFS 2001). The Joint Hatchery Review Committee stated that the current smolt release times (June 1 to June 15) often coincide with a reduction in the flow of water released by Reclamation into the Klamath River, and that this reduction in flows also coincides with a deterioration of water quality and reduces the rearing and migration habitat available for both natural and hatchery reared fish. In response to these concerns the CDFW proposed an Early Release Strategy and Cooperative Monitoring Program in April of 2001 (CDFG 2001). The goals of implementing the early release strategy are to:

1. Improve the survival of hatchery released fall Chinook salmon smolts from IGH to the commercial, tribal, and sport fisheries.

2. Reduce the potential for competition between hatchery and natural salmonid populations for habitats in the Klamath River, particularly for limited cold water refugia habitat downstream of Iron Gate Dam.

A HGMP for coho salmon was developed for IGH as part of the CDFW's application for an ESA section 10(a)(1)(A) permit for the IGH coho salmon program (CDFW and PacifiCorp 2014). The IGH HGMP is intended to guide hatchery practices toward the conservation and recovery of SONCC coho salmon; specifically, through protecting and conserving the genetic resources of the upper Klamath River coho salmon population. In addition, the HGMP is also intended to reduce the immediate threat of extirpation for both the upper Klamath River and Shasta River populations by encouraging release of adult coho salmon from the hatchery that are not required or suitable for use in the hatchery genetic spawning matrix. Starting in 2010 all returning adult coho salmon to IGH that were not used as broodstock were returned back to the Klamath River where they would have the opportunity to spawn naturally in the upper Klamath River or nearby tributary streams. Under the HGMP the IGH program will operate in support of the basin's coho salmon recovery efforts by conserving a full range of the existing genetic, phenotypic, behavioral, life history, and ecological diversity of the run. The program includes conservation measures, genetic analysis, and rearing and release techniques that will improve fitness and reduce adverse impacts that may result from straying of hatchery fish and limit effects of hatchery releases on wild fish. Although these management strategies are intended to reduce impacts to wild salmonids, some negative interactions between hatchery and wild populations likely still persist through competition between hatchery and natural fish for food and resources, especially limited space and resources in thermal refugia important during summer months (McMichael et al. 1997; Kostow et al. 2003; Kostow and Zhou 2006).

The exact effects on wild juvenile coho salmon in the Klamath River from the annual release of up to 6,000,000 hatchery-reared Chinook salmon smolts and 75,000 yearling coho salmon from IGH are not known precisely. The release of a relatively large number of hatchery origin juvenile Chinook salmon has the potential to affect wild coho salmon juveniles via competitive interactions, increased predation, and exposure to disease, but habitat partitioning between the two species likely limits these effects. However, while both hatchery and wild origin coho salmon in the system are listed under the ESA, the hatchery releases of yearling coho salmon (75,000 fish) may still compete with wild coho salmon juveniles for rearing habitat, migratory habitat, prey items, and thermal refugia. Hatchery juveniles are often larger and can displace wild juveniles in pools and other high-quality habitats. In addition, when hatchery coho salmon adults return, a small percentage can stray and spawn with wild adults. Modeling conducted for CDFW's IGH HGMP indicates that the release of 75,000 coho salmon juveniles has the potential to reduce wild coho salmon juvenile abundance by up to 6 percent through increased predation, competition and disease, assuming the wild juvenile coho salmon abundance is 75,000 (CDFW and PacifiCorp 2014).

2.4.1.1.10 Harvest

Coho salmon have been harvested in the past in both coho- and Chinook-directed ocean fisheries off the coasts of California and Oregon. However, stringent management measures, which began to be introduced in the late 1980s, reduced coho salmon harvest substantially. The prohibition of coho salmon retention in commercial and sport fisheries in all California waters began in 1994 (NMFS 2014a). With the exception of some tribal harvest by the Yurok and Hoopa Valley for subsistence and ceremonial purposes, the retention of coho salmon is prohibited in all California river fisheries. Tribal fishing for coho salmon within the Yurok tribe's reservation on the lower Klamath River has been monitored since 1992. The median Yurok harvest from the entire area from 1994 to 2012 was 345 coho salmon, which approximates an average annual maximum harvest of 3.1 percent of the total run (NMFS 2014a). The annual Yurok Tribe Fall Harvest Management Plan (e.g., Yurok Tribe 2021) continues to implement weekly coho protection fishing closures intended to protect coho salmon from harvest. The majority of coho salmon captured by Hoopa Valley tribal fisheries are TRH origin fish (Orcutt 2015). With regards to ocean fisheries, in 1995, ocean recreational fishing for coho salmon was closed from Cape Falcon in Oregon to the United States/Mexico border, and remains closed. In order to comply with the SONCC coho salmon ESU conservation objective, projected incidental mortality rates on Rogue/Klamath River hatchery coho salmon stocks are calculated during the preseason planning process using the coho salmon Fishery Regulation Assessment Model (Kope 2005). Specifically, the Pacific Fishery Management Council applies a SONCC coho salmon ESU consultation standard requirement of no greater than a 13.0 percent marine exploitation rate on Rogue/Klamath hatchery coho salmon, which applies to incidental mortality in the Chinook salmon ocean fisheries from Cape Falcon in Canada to the United States/Mexico border, and the observed exploitation rate is typically substantially less than 13.0 percent each year (PFMC 2018; PFMC 2021a). For example, the preliminary postseason estimate for marine exploitation of California origin coho salmon in 2020 was 2.1% (PFMC 2021a). In summary, major steps have been taken to limit effects of harvest on SONCC coho salmon, but there is still some small impact of incidental mortality associated with various Chinook salmon fisheries, and by subsistence and ceremonial tribal fisheries.

2.4.1.1.11 Predation

Predation of adult and juvenile coho salmon is likely to occur from a number of sources including piscivorous fish, avian predators, pinnipeds, and other mammals. However, the effect of predation on coho salmon in the Klamath Basin is not well understood. Pinniped predation on adult salmon can significantly affect escapement numbers within the Klamath River Basin. Hillemeier (1999) assessed pinniped predation rates within the Klamath River estuary during August, September, and October 1997, and estimated that a total of 223 adult coho salmon were consumed by seals and sea-lions during the entire study period. Increased rates of predation of juvenile coho salmon from piscivorous fish (e.g., steelhead) may result from the concentrated hatchery releases from IGH (Nickelson 2003). While the extent of predation is not well understood, some level of predation is known to be occurring, and the associated mortality and lost production is likely having some adverse effect on coho salmon in the Klamath Basin (NMFS 2014a), including in the action area.

2.4.1.1.12 Restoration Activities

There are various restoration and recovery actions underway in the Klamath Basin aimed at removing barriers to salmonid habitat and improving habitat and water quality conditions for anadromous salmonids. While habitat generally remains degraded across the ESU, restorative actions have effectively improved the conservation value of critical habitat throughout the range of the SONCC coho salmon, including portions of the Klamath Basin. Recent projects have included techniques to create important slow water and off channel habitat that is limited across the range of the ESU, and studies have shown positive effects of these restorative techniques to coho salmon growth and survival (Cooperman et al. 2006; Ebersole et al. 2006; Witmore 2014; Yokel et al. 2018). The magnitude of restoration efforts that have occurred in the Klamath Basin is difficult to summarize in terms of metrics like stream miles restored or pieces of Large Woody Debris (LWD) installed because restoration projects and practitioners have variable restoration approaches and goals. The complexity of the restoration and associated monitoring landscape in the Klamath Basin is summarized in the ESSA (2017) Klamath Basin Integrated Fisheries Restoration and Monitoring Synthesis Report, and further described in the ESSA (2019) Klamath Basin Integrated Fisheries Restoration and Monitoring Plan (IFRMP). In 2002, NMFS began ESA recovery planning for the SONCC and Oregon Coast coho salmon ESU through a scientific technical team created and chaired by the Northwest and Southwest Regional Fishery Science Centers, referred to as the Oregon and Northern California Coast coho salmon technical recovery team. In 2014, NMFS issued a final recovery plan for the SONCC coho salmon ESU (NMFS 2014a). Planned and implemented actions intended to help recover SONCC coho salmon, as guided by the recovery plan, include:

- Reclamation has provided $500,000 per year since 2013 for the Klamath Coho Habitat Restoration Program administered by National Fish and Wildlife Foundation (NFWF). The grant program funds restoration activities to improve habitat, water quality, water quantity, and fish passage, as well as research projects for coho salmon recovery. Restoration activities can occur on the mainstem Klamath River and its tributaries, with most restoration being conducted in the Shasta, Scott, and Mid Klamath tributaries. Restoration projects are typically implemented by state, tribal, local, or private non-governmental organizations. Since 2016, the Reclamation Klamath Basin Coho Habitat Restoration Program has awarded approximately $2.5 million to 21 projects. These projects have leveraged over $2.8 million in matching funds and in-kind contributions. The grant program is for projects that address limiting factors to be part of Reclamation's Program, projects for SONCC coho salmon in the Klamath Basin (NMFS 2019a). Additionally, Reclamation will be providing a total of $1.7 million for FY2022 and anticipates awarding an additional $500k in FY2023 and $500k in FY2024 for Program purposes.

- Covered activities under the PacifiCorp Klamath Hydroelectric Project Interim Operations HCP for Coho Salmon (PacifiCorp 2012) and associated incidental take permit under ESA section 10(a)(1)(B) include activities that are necessary to operate and maintain the Klamath hydroelectric facilities prior to the potential removal of four mainstem hydroelectric facilities. NMFS issued the incidental take permit in 2012 for a term of ten years. In 2020, PacifiCorp requested a one year extension to the Klamath HCP and associated Incidental Take Permit (PacifiCorp 2012; 2020b), which NMFS (2021b) found to be consistent with applicable laws and regulations. As part of PacifiCorp's HCP (PacifiCorp 2012), PacifiCorp provides $500,000 per year to a "Coho Enhancement Fund", which is also administered by the NFWF, to pay for coho recovery actions in the Klamath River during the interim period prior to potential dam removal. Detailed information on habitat conservation plan's covered activities can be found in Chapter 2 of the PacifiCorp HCP (PacifiCorp 2012). As of December 31, 2020, the PacifiCorp Coho Enhancement Fund has awarded approximately $5.7 million to 57 projects (PacifiCorp 2021b).

  The PacifiCorp HCP has seven goals and objectives, which were developed with technical assistance from NMFS technical staff, based on the conservation needs of the SONCC coho salmon, as follows (PacifiCorp 2012):

  - Offset biological effects of blocked habitat upstream of Iron Gate Dam by enhancing the viability of the Upper Klamath coho salmon population;
  - Enhance coho salmon spawning habitat downstream of Iron Gate Dam;
  - Improve instream flow conditions for coho salmon downstream of Iron Gate Dam;
  - Improve water quality for coho salmon downstream of Iron Gate Dam;
  - Reduce disease incidence and mortality in juvenile coho salmon downstream of Iron Gate Dam;
  - Enhance migratory and rearing habitat for coho salmon in the Klamath River mainstem corridor;
  - Enhance and expand rearing habitat for coho salmon in key tributaries.

- Congress authorized $1 million annually from 1986 through 2006 to implement the Klamath River Basin Conservation Area Restoration Program. The Klamath River Basin Fisheries Task Force was established by the Klamath River Basin Fishery Resources Restoration Act of 1986 (Klamath Act) to provide recommendations to the Secretary of the Interior on the formulation, establishment, and implementation of a 20-year program to restore anadromous fish populations in the Klamath River Basin to optimal levels.

- Multiple local watershed groups exist in the action area, including: TNC and Caltrout (who are active in the Shasta River sub-basin and other locations in the Klamath Basin), Scott River Watershed Council (Scott sub-basin), Siskiyou Resource Conservation

District (Scott sub-basin), Scott Valley Water Trust (Scott sub-basin), Salmon River Restoration Council (Salmon sub-basin), Karuk Tribe and Mid-Klamath Watershed Council (mid-Klamath sub-basin), and the Yurok Tribe (lower-Klamath sub-basin). These groups have all received funds from the Reclamation and PacifiCorp funded grant programs described in previous bullets. Some key restoration actions that have been implemented in these sub-basins include (PacifiCorp 2020a; 2021a):

    - Construction of off-channel ponds and side channels to provide winter velocity refugia for juvenile salmonids. These projects typically include connection to ground water so the habitat can also function as cold water refugia throughout the summer as well.
    - Construction of beaver dam analogue structures (BDAs) to improve floodplain connectivity and instream complexity. The BDAs increase ground water storage, sort sediment, and provide both winter and summer refugia for juvenile salmonids.
    - Placement of large wood jams in tributaries to improve floodplain connectivity, provide winter, and summer refugia for juvenile salmonids.
    - Remediation of mine tailings and reconstruction of stream reaches to improve sinuosity and floodplain connection.
    - Implementation of off-channel stock watering systems to improve water quality and quantity as well as riparian vegetation condition.

- NMFS administers several grant programs to further restoration efforts in the Klamath River Basin. Since 2000, NMFS has issued grants to the States of California and Oregon, and Klamath River Basin tribes (Yurok, Karuk, Hoopa Valley and Klamath) through the Pacific Coast Salmon Restoration Fund (PCSRF) for the purposes of restoring coastal salmonid habitat. California integrates the PCSRF funds with their salmon restoration funds and issues grants for habitat restoration, watershed planning, salmon enhancement, research and monitoring, and outreach and education. In addition, the NOAA Restoration Center has provided more than $4.1 million from 2001 through 2018 on fish passage, LWD, water conservation and floodplain reconnection projects in the Klamath Basin (Pagliuco 2020).
- The Fish and Wildlife Service has three ecological services offices in the Basin. The Service's Partners for Fish and Wildlife Program delivers conservation on private lands and tribes. Fish and Wildlife Service programs also invest in habitat restoration, science, and monitoring activities throughout the Basin. The Service is also in the process of constructing a conservation hatchery to support the federally listed Lost River and shortnose suckers. In FY 21, the Service invested over $11M to advance the restoration of Klamath Basin native fish species in the Upper Basin and anadromous salmon, steelhead, and lamprey in the Lower Basin. The Service used these funds to invest in improving conditions for salmon and suckers, and water quality. The Service was also able to provide tribal grants totaling approximately $2M to assist them in developing more internal capacity to undertake tribal fisheries priorities. The Service, along with

Tribes and other Stakeholders also provide funding and resources to study and restore the Trinity River through the Trinity River Restoration Program for native aquatic species (Matt Baun, USFWS, personal communication[16]).

- The Klamath National Forest (KNF) continues to implement floodplain and instream habitat restoration projects along the Mid Klamath River corridor to benefit salmonids, including SONCC coho salmon. Most notable of these is a side channel and floodplain restoration project at the confluence of Fish Gulch and mainstem Horse Creek, a tributary to the Klamath River. Completed in fall 2018, this effort has reactivated more than 900 linear feet of salmonid spawning and rearing habitat. The KNF has also undertaken large woody debris placement projects along this reach of lower Horse Creek, as well as in SONCC coho salmon critical habitat in several other tributaries to the Klamath River (NMFS 2017c).
- One component of the KBRA was an IFRMP for the Klamath Basin, which included coho salmon, among other species. The IFRMP is a multi-agency and stakeholder collaboration and is intended to help agencies and tribes with fisheries management jurisdiction wisely allocate funds to support restoration work in the Klamath Basin. The IFRMP process stalled in 2015 when the KBRA expired, but the PSMFC since continued the effort. The PSMFC completed a Synthesis Report in 2017 (ESSA 2017) and a draft IFRMP in 2019 (ESSA 2019). The PSMFC continues to be engaged in this process and is working towards an updated version of the IFRMP that will include restoration project and monitoring prioritizations for the entire Klamath Basin.

2.4.1.1.13 Land Use/Management Activities

2.4.1.1.13.1 Wildfire

Two linked factors that have affected coho salmon in the action area are the occurrence and subsequent suppression of wildfires. A number of significant fires were seen in the Klamath Basin during and after the recent drought. The Klamathon fire in 2018 impacted 38,000 acres around Iron Gate Reservoir, including the Camp Creek area and the river reach downstream of the dam. Since 2008, many large wildfires (i.e., wildfires greater than 10,000 acres) occurred downstream of the hydroelectric dams, including the Siskiyou Complex in 2008, Fort Complex in 2012, Beaver and Happy Camp Complex in 2014, Bear in 2015, Gap in 2016, Prescott and Abney in 2017, Klamathon and Natchez in 2018, Slater/Devil in 2020, and the McCash and Lava fires in 2021 (CalFire 2021; FERC 2021a). Negative impacts to anadromous fish from wildfires can result from altered hydrologic function, increased sediment loading and turbidity, decreased habitat resulting from water drafting (i.e., water being removed from streams for firefighting and dust abatement), water quality impacts from the misapplication of fire retardants, and other factors. NMFS has consulted with the United States Forest Service (USFS) on projects to reduce impacts of wildfires in key coho salmon tributaries (NMFS 2016b). Wildfire effects to coho

[16] Email from Matt Baun (USFWS) to Bob Pagliuco (NOAA Restoration Center), October 29, 2021.

salmon habitat have been minimized through application of federal protective guidance including NMFS' (2001c) Water Drafting Specifications to avoid dewatering, fish impingement and entrainment impacts, and USFS' Interagency Wildland Fire Chemicals Policy and Guidance described in USFS' Implementation Guide for Aerial Application of Fire Retardant (USFS 2019). Despite application of this guidance, wildfires have and will continue to impact coho salmon in the action area. The magnitude and extent of future wildfire impacts may increase due to a recent period of protracted drought in the Klamath Basin.

2.4.1.1.13.2 Timber

Timber harvesting in the action area has resulted in long-lasting effects to fish habitat conditions. As described in NMFS' SONCC coho salmon recovery plan (NMFS 2014a), harvest of streamside trees during the early and middle 1900s has left a legacy of reduced large woody debris recruitment. Lack of large wood recruitment has contributed to elevated stream temperatures due to decreased incidence of pool habitats and altered hydrodynamics, particularly along the Klamath mainstem and along the lower reaches of the Scott River. Sedimentation from modern-day harvest units, harvest-related landslides and an extensive road network continues to impact habitat, although at much reduced levels in comparison to early logging. Ground disturbance, compaction, and vegetation removal during timber harvest have modified drainage patterns and surface runoff, resulting in increased peak storm flows that have, in turn, increased stream channel simplification and channel aggradation. Simplification of stream channels and sediment aggradation result in loss or destruction of salmonid holding and rearing habitat, as pool complexes and side channel habitats become degraded to the point of no longer providing refugia for juveniles.

In order to combat the severe alteration of salmon habitat caused by historical forest practices, several forest practices and management plans are being implemented in the Klamath Basin. The Northwest Forest Plan (NFP) is an integrated, comprehensive design for ecosystem management, intergovernmental and public collaboration, and rural community economic assistance for federal forests in western Oregon, Washington, and northern California. Since adoption of the NFP in 1994, timber harvest and road building on USFS lands in the Klamath Basin have decreased dramatically and road decommissioning has increased. It is expected that implementation of the NFP in its revised form will help to recover aquatic habitat conditions adversely affected by legacy timber practices. The Klamath National Forest is also committed to treat legacy sediment sources, through a conditional waiver issued by the North Coast Regional Water Quality Control Board, under Section 404 of the Clean Water Act. These sediment sources include road-stream crossings, the largest, chronic producers of sediment capable of mobilization downstream to SONCC ESU coho salmon critical habitat.

Along the lower Klamath River, Green Diamond Resource Company owns and manages approximately 265 square miles of commercial timber lands downstream of the Klamath-Trinity River confluence. The company has completed an HCP for aquatic species, including SONCC ESU coho salmon (GDRC 2006), and NMFS issued an ESA section 10(a)(1)(B) incidental take permit on June 12, 2007 (NMFS 2007b). The 50-year HCP commits Green Diamond to reducing sediment mobilization from approximately half of its high- and moderate-priority road segments for treatment. These sediment-reduction treatments are to be property-wide, and are to occur during the first 15 years of implementation. The HCP also places restrictions on timber harvest on unstable slopes and in fish-bearing watercourses. The HCP is, therefore, expected to reduce impacts of Green Diamond's timber operations on aquatic species habitat over time.

2.4.1.1.13.3 Agriculture

Crop cultivation and livestock grazing in the upper Klamath Basin began in the mid-1850s. Since then, valleys have been cleared of brush and trees to provide more farm land. Besides irrigation associated with Reclamation's Klamath Project, other non-Project irrigators operate within the Klamath River Basin. Irrigated agriculture both above (e.g., Williamson, Sprague, and Wood rivers) and surrounding UKL consists of approximately 180,000 acres. Excluding Reclamation's Project, estimated average consumptive use in the upper Klamath Basin is approximately 350,000 acre feet per year (NRC 2004).

Two diversion systems transfer water from the Klamath River Basin to the Rogue River Basin: Fourmile Creek and Jenny Creek. Water operators annually divert an average of 24,000 acre-feet of water from the Klamath River basin at Jenny Creek into the Rogue River Basin (Reclamation 2013). An additional 6,600 acre feet is diverted annually from Fourmile Creek into the Rogue River Basin; however, 2,200 acre feet of the Fourmile diversion is lost through canal leakage and assumed to stay in the Klamath Basin (RRVID 2018). Thus, roughly 28,400 acre feet of water is diverted annually from the Klamath River Basin to the Rogue River Basin via those diversion systems (NMFS 2012b).

The consumptive use of water described above is expected to negatively impact one or more of the VSP criteria for the interior Klamath populations because it reduces summer and fall discharge of tributaries that the populations use (Van Kirk and Naman 2008); and low flows in the summer have been cited as limiting coho salmon survival in the Klamath Basin (CDFG 2002a; NRC 2004). Specifically, the spatial structure, population abundance, and productivity can be impacted by agricultural activities. Altered flows likely interfere with environmental cues that initiate distribution of juvenile coho salmon in the river, alter seaward migration timing, and potentially impact other important ecological functions, leaving juveniles exposed to a range of poor-quality habitat, and prolonged exposure to stressful over wintering and summer rearing conditions.

2.4.1.1.13.4 Mining

Mining activities within the Klamath River Basin began prior to 1900. The negative impacts of stream sedimentation on fish abundance were observed as early as the 1930s. Mining operations adversely affected spawning gravels, decreased survival of fish eggs and juveniles, decreased benthic invertebrate abundance, increased adverse effects to water quality, and impacted stream banks and channels. Gravel mining also has removed coarse sediment which can significantly alter physical habitat characteristics and fluvial mechanisms, such as causing increased river depth, bank erosion, and head-cutting (Freedman et al. 2013). Since the 1970s, however, large-scale commercial mining operations have been eliminated in the basin due to stricter environmental regulations, and in 2009 California suspended all instream mining using suction dredges (NMFS and USFWS 2013). The use of vacuum or suction dredge equipment, otherwise known as suction dredging, remains prohibited and unlawful throughout California (https://wildlife.ca.gov/Licensing/Suction-Dredge-Permits, visited on December 1, 2021; see generally California Fish and Game Code 5653, 5653.1, 12000, subdivision (a)).

2.4.1.1.14 Habitat Conditions in the Upper Klamath River Reach (Iron Gate Dam to Spencer Creek)

Although the current upstream terminus of anadromous habitat in the Klamath Basin is Iron Gate Dam, because coho salmon are expected to re-populate their historic habitat above Iron Gate Dam, which is believed to be at least as far upstream as Spencer Creek (Hamilton et al. 2005), the current habitat conditions in this reach are discussed here. Critical habitat for SONCC coho salmon is not designated upstream of Iron Gate Dam. While coho salmon are not currently present in this reach, habitat characteristics in this reach have been evaluated and compared to coho salmon habitat needs (Ramos 2020). In addition, the habitat in this reach does support a population of potadromous rainbow/redband trout (*Oncorhynchus mykiss*), and evaluation of the rainbow trout habitat usage in this reach may inform potential usage by anadromous species when anadromous species again have access to this reach (Hamilton et al. 2011). The majority of spawning habitat for rainbow/redband trout in this reach is in Spencer and Shovel creeks; however, various life stages of rainbow/redband trout utilize other tributaries and sections of the reach, including cold water refugia at Big Springs and Fall Creek (Hamilton et al. 2011).

Ramos (2020) conducted habitat surveys and specifically analyzed the recolonization potential for coho salmon in the largest tributaries to the Klamath River between Iron Gate Dam and Spencer Creek. Ramos (2020) used temperature and other physical features of six tributaries (i.e., Scotch, Camp, Jenny, Fall, Shovel, and Spencer creeks) to assess their capacity to support juvenile coho salmon following dam removal, and found that the six newly accessible tributary streams will provide greater than 33 km of newly accessible habitat, and maintained significant juvenile coho salmon summer rearing capacity, redd capacity, and intrinsic potential for adult coho salmon spawner escapement (Table 13). Ramos (2020) concluded that there was prolific cold-water temperatures throughout Scotch, Camp, Fall, Shovel, and portions of Spencer creeks, and that newly accessible habitat in the study tributaries will provide substantial rearing and spawning habitat for coho salmon after dam removal. Building on the work done by Ramos (2020), Bob Pagliuco of the NOAA Fisheries Restoration Center initiated habitat surveys in additional smaller tributaries in this reach, including areas of the Ramos (2020) tributaries that were previously inaccessible. These habitat surveys identified additional habitat features, including spawning gravel in Spencer Creek and Camp Creek, a complex of unnamed coldwater springs flowing into Copco Lake, and cold water refugial rearing areas (e.g., several springs on Shovel Creek, East Branch and West Branch Long Prairie Creek, and Frain Creek) that could be utilized by coho salmon (Pagliuco 2021).

Table 13. Overall summary of results of habitat surveys in tributaries upstream of Iron Gate Dam to Spencer Creek. Adapted from Table 8 in Ramos (2020).

Stream	Scotch Creek	Camp Creek	Jenny Creek	Fall Creek	Shovel Creek	Spencer Creek
MWMT* (°C)	16.6 – 17.1	17.1	20.8 – 22.2	15.6 – 16.2	13.2 – 15.4	16.7 – 23.7
MWAT* (°C)	15.1 – 16.6	14.6	19.8 – 20.7	13.8 – 14.0	12.1 – 13.7	15.2 – 19.2
Accessible Habitat (km)	1.0	2.2	3.3	1.6	4.7	20.5
HLFM* Juvenile Coho Salmon Summer Rearing Capacity	2,600	--	18,100	4,700	13,300	66,300
HLFM* Redd Capacity	205	--	51	92	23	17,993
HLFM* Egg Capacity	512,500	--	127,500	230,00	57,500	44,982,500
IP* (km)	1.7	1.6	1.3	0.9	2.8	13.1
IP* Coho Salmon Spawner Escapement Target	67	65	52	37	111	526

*MWMT = maximum weekly maximum temperature. MWAT = maximum weekly average temperature. HLFM = habitat limiting factors model. IP = Intrinsic Potential.

2.4.1.1.15 Habitat Conditions downstream of Iron Gate Dam

As described above, critical habitat for SONCC coho salmon in the Klamath River Basin that overlaps with the action area consists of the water, substrate, and adjacent riparian zone from the Iron Gate Dam (RM 193.1) to the Klamath River mouth at the Pacific Ocean, excluding the Yurok Reservation, Karuk Reservation, and Resighini Rancheria, which includes the Klamath River downstream of the confluence with the Trinity River. In addition, the tributaries to the Klamath River downstream of Iron Gate Dam, including the Shasta, Scott, Salmon, and Trinity (excluding the Hoopa Valley Reservation) rivers are also designated critical habitat, although they are not in the action area. The following sub-sections describe habitat conditions in reaches downstream of Iron Gate Dam, including juvenile migratory, adult migratory, juvenile rearing, and spawning habitat conditions. In some cases, conditions outside of the action area are described where they have effects on the abundance and distribution of SONCC coho salmon in the action area.

2.4.1.1.15.1 Juvenile Migratory Habitat Conditions

Juvenile migratory habitat must support both smolt emigration to the ocean and the seasonal redistribution of juvenile fish. This habitat must have adequate water quality, water temperature, water velocity, and passage conditions to support migration. It's important that migratory habitat is available year round since juvenile coho salmon spend at least one year rearing in freshwater and have been shown to move upstream, downstream, in the mainstem, and into non natal tributaries when redistributing to find suitable habitat (Adams 2013; Witmore 2014). Emigrating smolts are usually present within the mainstem Klamath River between February and the beginning of July, with April and May representing the peak migration months (Figure 17). Emigration rate tends to increase as fish move downstream (Stutzer et al. 2006).

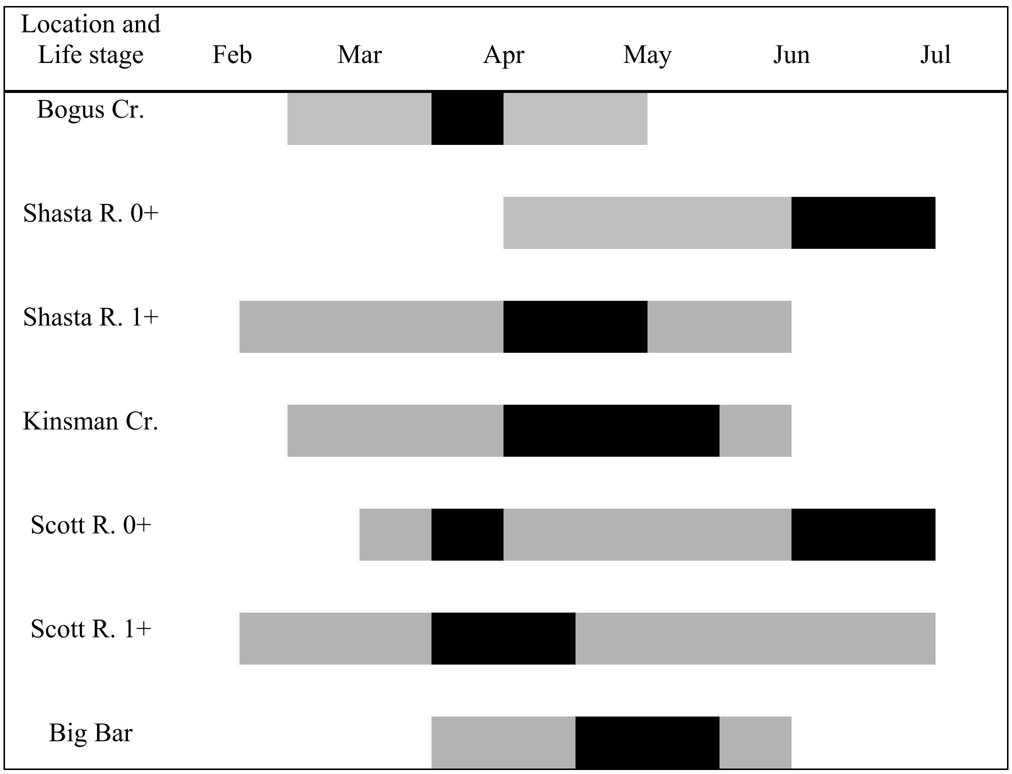

Figure 17. General emigration timing for coho salmon smolt within the Klamath River and tributaries. Black areas represent peak migration periods, those shaded gray indicate non-peak periods. 0+ refers to young-of-year while 1+ refers to smolts (Pinnix et al. 2007; Daniels et al. 2011).

Juvenile migratory habitat conditions by sub-reach are described as follows:

2.4.1.1.15.1.1 Middle Klamath River Reach (Trinity River Confluence to Iron Gate Dam)

Downstream of Iron Gate Dam, some juvenile migration corridors are degraded because of diversion dams, low flow conditions, poorly functioning road/stream crossings in tributaries, disease effects, and high water temperatures and low water velocities that slow and hinder emigration or upstream and downstream redistribution in both tributaries and the mainstem portion of this reach. The unnatural and steep decline of the hydrograph in the spring, due to anthropogenic factors including water diversions and timing of water releases, observed in both the mainstem and tributaries, likely slows the emigration of coho salmon smolts, speeds the proliferation of fish diseases in the mainstem, and increases water temperatures more quickly than would occur otherwise. Disease effects, particularly in areas of the mainstem such as the Trees of Heaven site (RM ~174), have been found to have had a substantial impact on the survival of migrating juvenile coho salmon in this stretch of river (NMFS 2014a). Low flows in the mainstem during the spring can slow the emigration of smolt coho salmon, which can in turn lead to longer exposure times for disease, and greater risks due to predation.

<u>Shasta River population</u>

Smolt emigration in the Shasta River coincides with the drop in flows from irrigation water withdrawal, typically in mid-April. Because there are significant water diversions and impoundments in the Shasta River, the unnatural and steep decline of the hydrograph following the start of the irrigation season in April decreases the quantity of rearing habitat and causes water temperatures to increase more quickly than would occur otherwise. These changes can displace young-of-year coho salmon, forcing them to redistribute in search of suitable rearing habitat and thereby increasing their risk of mortality (Gorman 2016). Similarly, the reduction in water quality and quantity likely has a negative impact to emigrating coho salmon smolts, increasing their risk of mortality. Recent drought conditions in the Shasta River basin are an additional factor that can negatively impact emigrating coho salmon smolts. As a response to these drought conditions, the SWRCB has instituted diversion curtailments in the Shasta River Basin (https://www.waterboards.ca.gov/drought/scott_shasta_rivers/, visited on December 3, 2021).

<u>Scott River</u>

Some anthropogenic features in the Scott River can impact the timing of juvenile migration. A number of physical fish barriers exist in the Scott River watershed. For instance, Big Mill Creek, a tributary to the East Fork Scott River, has a complete fish passage barrier caused by down cutting at a road culvert outfall. Additionally, historical mining has left miles of tailings piles along the mainstem and some tributaries of the Scott River. A seven-mile reach of Scott River goes subsurface every summer due to this channel modification in combination with low flows, limiting juvenile redistribution. For many years, the City of Etna’s municipal water diversion dam on Etna Creek effectively blocked fish passage into upper Etna Creek; however, this dam was retrofitted with a volitional fishway in 2010. In addition, valley-wide agricultural surface water withdrawals and diversions, and groundwater extraction have all combined to cause premature surface flow disconnection in the summer and delayed re-connection in the fall along the mainstem Scott River. These conditions can consistently result in restrictions or exclusions to suitable rearing habitat, contribute to elevated water temperatures, and contribute to conditions that force juvenile fish to move, become stranded, and increase mortality risks (NMFS 2014a). Recent drought conditions in the Scott River basin are an additional factor that can negatively impact emigrating coho salmon smolts. As a response to these drought conditions, the SWRCB has instituted diversion curtailments in the Scott River Basin (https://www.waterboards.ca.gov/drought/scott_shasta_rivers/, visited on December 3, 2021).

Salmon River

Juvenile migration corridors exhibit high water temperatures that may hinder juvenile redistribution during the summer. Seasonal low flow barriers were previously a concern for juvenile migration, but those barriers were largely addressed and barriers are now a low level stressor for the Salmon River (NMFS 2014a).

Trinity River

The Trinity River Division of the Central Valley Project has caused loss of hydraulic function, habitat loss, and habitat simplification in the mainstem Trinity River. The juvenile stage of the Upper Trinity River population unit of SONCC coho salmon is the most limited life stage and suitable quality summer and winter rearing habitat is lacking for the population. Water withdrawals from important tributaries like Weaver and Rush creeks reduce baseflows in the summer and fall months, contributing to low flows and high water temperatures that can impact juvenile migration. In the summer, flow regimes and the lack of LWD and off-channel habitat leads to poor hydrologic function, disconnection and diminishment of thermal refugia, and poor water quality in tributaries and the mainstem during dry years. These issues are being addressed through restoration efforts but will continue to persist as limiting factors for the population (NMFS 2014a).

2.4.1.1.15.1.2 Lower Klamath River Reach (Klamath River mouth to Trinity River Confluence)

The mainstem lower Klamath River provides migratory and rearing habitat for juvenile coho salmon for all Klamath River coho salmon populations (NMFS 2014a). Water temperatures are typically suitable for juvenile salmonids in the Klamath River downstream of the Trinity River (see Section 2.4.1.1.2, Water Temperature, above), and flow is also generally suitable to preclude the formation of barriers and support juvenile migration year-round.

2.4.1.1.15.2 Adult Migratory Habitat Conditions

Adult migration corridors should provide satisfactory water quality, water quantity, water temperature, water velocity, cover/shelter, and safe passage conditions for adults to reach spawning areas. Adult coho salmon typically begin entering the lower Klamath River in late September (but as early as late August in some years), with peak migration occurring in mid-October (Ackerman et al. 2006). Adults may remain in the rivers until spawning is completed as late as February.

Adult migratory habitat conditions by sub-basin are described as follows:

2.4.1.1.15.2.1 Middle Klamath River Reach (Trinity River Confluence to Iron Gate Dam)

The current physical and hydrologic conditions of the adult migration corridor in the mainstem Middle Klamath River reach are likely functioning in a suitable manner. Water quality is sufficient for upstream adult migration, and with implementation of flows analyzed in the NMFS (2019a) biological opinion and subsequent IOP, flow volume is above the threshold at which physical barriers to migration are likely to form.

Shasta River

Migration timing of adult coho salmon entering the Shasta River typically begins in about the middle of October. The run typically begins to decrease quickly after the second week of December. Flow levels throughout the Shasta River typically increase after October 1st when most of the irrigation diversions upstream are turned off at the end of the season. Therefore, in most years, physical and hydrologic conditions in the lower Shasta River have improved by mid-October providing suitable conditions for adult coho salmon migratory access to spawning habitats in the upper Shasta River near Big Springs Creek.

Scott River

In the Scott River, upstream migration of adult coho salmon may begin in the last two weeks of October and may last into the first week of February. However, the majority of coho salmon migrate upstream during November with numbers decreasing in December and January. The irrigation season ends on October 15 under the Scott River Decree; however, stock water is still diverted through the winter. In addition to the surface water diversions, there are a substantial number of larger alfalfa farms in the lower portions of the Scott Valley and along Moffett Creek that rely on groundwater pumping to meet their irrigation demands. These withdrawals lower the groundwater table below the elevation of the existing river channel, adversely affecting the abundance of interconnected groundwater to stream and river channels along the valley floor (Harter and Hines 2008; Hathaway 2012; S.S. Papadopulos & Associates Inc. 2012). As a result, surface flow connectivity in the fall is delayed until fall precipitation events and tributary flow contributions restore groundwater elevations up to a level equal to or greater than the elevations of the river channel. The delay in the establishment of adequate surfaces flows results in a corresponding delay in creating suitable flow conditions for adult salmon to migrate upstream through the lower Scott River canyon where several naturally occurring migration obstacles are present. This altered flow regime can result in substantial delay for migrating adult Chinook salmon and early migrations of coho salmon.

Salmon River

The current physical and hydrologic conditions of the adult migration corridor in the Salmon River reach are likely properly functioning in a manner that supports its conservation role of the adult migration corridor. Water quality is suitable for upstream adult migration, and flow volume is above the threshold at which physical barriers are likely to form (NMFS 2014a).

Trinity River

The Trinity River supports three populations of SONCC coho salmon that must migrate through the Lower Klamath River: the Upper Trinity River, Lower Trinity River, and Lower Klamath River Population Units (NMFS 2014a). The Upper-Trinity Population unit is unique within the Trinity River system as these coho salmon are currently the longest migrating adult coho salmon in the diversity stratum. While coho salmon likely used to migrate as far as Hayfork Creek on the South Fork Trinity River, habitat degradation and water utilization on that river has restricted the spatial structure of the population unit. The run timing of the Upper Trinity River population unit is earlier (September and October) than those fish in the Lower Trinity Population unit (November through January).

2.4.1.1.15.2.2 Lower Klamath River Reach (Klamath River mouth to Trinity River Confluence)

Implementation of the flows analyzed in the NMFS (NMFS 2019a) biological opinion and subsequent IOP has likely alleviated many of the adult migration issues observed in the past and improved critical habitat in the Lower Klamath reach. The implemented flows include fall and winter flow variability, which has alleviated instream conditions brought about by low flows that likely resulted in impairments to upstream adult migration in the past.

2.4.1.1.15.3 Juvenile Rearing Habitat Conditions

Juvenile coho salmon rear in freshwater for a full year and can be found in the mainstem and tributaries. Although their rearing needs and locations may change on a seasonal basis, an interconnected system is critical so that they can access different resources provided in different water bodies. For example, Witmore (2014) and Brewitt and Danner (2014) documented juvenile salmonids rearing in tributaries of the Klamath River while simultaneously relying on mainstem food sources. These individuals displayed a diurnal movement pattern that highlights the importance of tributary/mainstem connection even during times when the mainstem appears to be inhospitable.

Juvenile rearing habitat conditions by sub-basin are described as follows:

2.4.1.1.15.3.1 Middle Klamath River Reach (Trinity River Confluence to Iron Gate Dam)

Juvenile summer rearing areas have been compromised by low flow conditions, high water temperatures, insufficient dissolved oxygen levels, excessive nutrient loads, habitat loss, disease effects, pH fluctuations, non-recruitment of large woody debris, and loss of geomorphological processes that create habitat complexity. Water released from Iron Gate Dam during summer months is already at a temperature stressful to juvenile coho salmon, and solar warming can increase temperatures even higher (up to 26 ºC) as flows travel downstream (NRC 2004). The period of time when fry and juvenile rearing, as well as smolt migration, is possible along the mainstem has been shortened by these conditions and is, therefore, a temporal limitation. In the summer, the diversion and impoundment of water continues to lead to poor hydrologic function, disconnection and diminishment of thermal refugia, and poor water quality in tributaries and the mainstem. Most tributaries with summer rearing potential are highly impacted by agriculture and past timber harvest. Very few remaining areas exist downstream of Iron Gate Dam with the potential and opportunity for summer rearing. Overwinter rearing habitat may be a limiting factor for juvenile coho salmon in the Middle Klamath River. Human activities such as mining and agriculture have significantly altered the mainstem and tributaries into a more simplified channel with limited access to the floodplain. Additionally, much of the Middle Klamath River reach parallels Highway 96, leaving little room for floodplain complexity. As a result, slow velocity water, such as side channels, off channel ponds, and alcoves, have been eliminated, decreasing the ability for juvenile coho salmon to persist during high velocity flows in the winter (NMFS 2014a). As mentioned above, many of the tributaries in this reach are small and may go subsurface near their confluence with the mainstem Klamath River. Yet these intermittent tributaries sometimes remain important rearing habitat for coho salmon, when and where sufficient instream flows, water temperature, and habitat conditions are suitable to sustain them. Coho salmon have adapted life history strategies (spatial and temporal) to use intermittent streams. For example, adult coho salmon will often stage within the mainstem Klamath River at the mouth of natal streams until hydrologic conditions allow them to migrate into tributaries, where they are able to find more suitable spawning conditions, and juveniles can find adequate rearing conditions and cover. In summer when the downstream sections of these tributaries may go dry, the shaded, forested sections upstream provide cold water and high quality summer rearing habitat for juvenile coho salmon.

Unlike many of the other tributary streams within the Middle Klamath River reach, Bogus Creek and its largest tributary Cold Creek, contain several cold water springs that provide favorable conditions for rearing coho salmon during the summer (Hampton 2010). These springs are located upstream of a waterfall (RM 3.48) that prevented anadromous fish access to these locations historically. In 1965, a fish ladder was constructed over this migration barrier and adult salmon and steelhead have had access to another six miles of habitat upstream of the barrier since that time. There are several habitat and water conservation projects that have been completed recently or are currently underway to further improve rearing habitat conditions for juvenile coho salmon in the reach upstream of the ladder. These projects include installation of cattle exclusion fencing, riparian plantings, piping of irrigation ditches, construction of tailwater capture systems, and direct infusion of cold spring water to the channel. The mouth of Bogus

Creek is located adjacent to IGH and hatchery origin coho salmon are known to stray and spawn in Bogus Creek. The CDFW has been monitoring emigration of smolt from Bogus Creek since 2015. Results of this effort indicate that age 1+ coho salmon emigrate from late February through May, and fry coho salmon have been observed from April through mid-June (Knechtle and Giudice 2018; Knechtle and Giudice 2021b).

Over approximately the last 10 years, there has been a large effort to improve over winter habitat for juvenile coho salmon in the Middle Klamath River reach. In particular, the Mid Klamath Watershed Council and Karuk Tribe have been constructing off channel pond features in key locations to provide slow velocity water. Over a dozen ponds have been constructed in locations such as Seiad Creek, Horse Creek, Tom Martin Creek, West Grider Creek, and O'Neil Creek. Monitoring efforts have shown that both natal and non-natal juvenile coho salmon are using these sites in large numbers (Witmore 2014).

There are approximately 79 miles of potentially suitable juvenile rearing habitat spread throughout the mainstem Klamath River and tributaries in the Middle Klamath region (NMFS 2014a). However, juvenile summer rearing areas in this stretch of river are degraded relative to the historic state. High water temperatures, exacerbated by water diversions and seasonal low flows, restrict juvenile rearing in the mainstem Klamath River and lessen the quality of tributary rearing habitat (NMFS 2014a). Nevertheless, a few tributaries within the Middle Klamath River Population (e.g., Boise, Red Cap and Indian Creeks) support populations of coho salmon, and offer critical cool water refugia within their lower reaches when mainstem temperatures and water quality approach uninhabitable levels. Other important tributaries for juvenile rearing include Sandy Bar, Stanshaw, China, Little Horse, Pearch, and Boise creeks (NMFS 2014a). However, these cool water tributary reaches can become inaccessible to juveniles when low flows and sediment accretion create passage barriers; therefore, summer rearing habitat can be limited.

Shasta River

Historically, instream river conditions, fostered by unique cold spring complexes, created abundant summer rearing and off channel overwintering habitat that were favorable for production of coho salmon in the Shasta River basin. However, a reduction in the frequency of large flood flows along with the elimination of sediment transport processes downstream of Dwinnell Dam have resulted in coarsening of the bed and reduction in habitat diversity immediately downstream of the dam. The loss of woody debris, pools, side channels, springs, and accessible wetlands from land use conversions have also contributed to reduced summer and winter rearing capacity for juvenile coho salmon (NMFS 2014a).

Juvenile rearing is currently confined to the mainstem Shasta River from RM 17 to RM 23, Big Springs Creek, Lower Parks Creek, Shasta River Canyon, Yreka Creek, and the upper Little Shasta River. Stream temperatures for summer rearing are poor throughout much of the mainstem Shasta River from its mouth upstream to near the confluence of Big Springs Creek. The onset of the irrigation season in the Shasta River watershed has a dramatic impact on discharge when large numbers of irrigators begin taking water simultaneously. This results in a rapid decrease in flows below the diversions, stranding coho salmon as channel margin and side channel habitat disappears and in some extreme cases channels can become entirely de-watered, Low stream flows can decrease rearing habitat availability for juvenile coho salmon. Further alterations to stream channel function from agricultural practices includes a reduction in the number of beaver ponds, which provide important habitat attractive to rearing coho salmon (NMFS 2014a).

Historically, the most vital habitat in the Shasta River basin were its cold springs, which created cold water refugia for juvenile coho salmon, decreased overall water temperatures, and allowed for successful summer rearing of individuals in natal and non-natal creeks and mainstem areas. These areas have been significantly adversely affected by water withdrawals, agricultural activities, and riparian vegetation removal. These land use changes have compromised juvenile rearing areas by creating low flow conditions, high water temperatures, insufficient dissolved oxygen levels, and excessive nutrient loads. However, habitat restoration in the Big Springs complex and on The Nature Conservancy's Nelson Ranch have improved juvenile rearing conditions in those areas.

Streamflow in the Upper Shasta River is primarily controlled through releases from Dwinnell Reservoir, which is owned and operated by the Montague Water Conservation District (MWCD). There are several ways in which MWCD can release water to the Upper Shasta River downstream of Dwinnell Dam. These include releases of irrigation water to meet rights of prior water right holders downstream, short term voluntary release of water and participation in water lease agreements to improve instream conditions for salmonids, and release of environmental water as agreed to under their Conservation and Habitat Enhancement and Restoration Program (CHERP) which was developed coincident with a Settlement Agreement with the Klamath River Keeper and Karuk Tribe. Under the CHERP, once water conservation projects have been completed to their main canal, MWCD will increase instream environmental releases by an average of 4,400 acre-feet below Dwinnell Dam as a conservation measure to improve conditions for coho salmon.

In addition to CHERP, a substantial Safe Harbor Agreement (SHA) was recently completed in the Shasta River (NMFS 2020d). Under the SHA, 11 landowners on 14 properties associated with water and land use in the upper Shasta River basin agree to complete a suite of beneficial management activities such as LWD installations, or water conservation and forbearance agreements, that are intended to improve habitat in the Shasta basin. LWD is depleted in the Shasta River due to anthropogenic land use changes, including grazing and agricultural practices. Additionally, water diversions have likely lowered the water table throughout the basin, thereby limiting growth of riparian vegetation and channel forming wood. The lack of large wood in the Shasta River creates a deficit of shade and shelter, and decreases habitat complexity and pool volumes, all necessary components for over-summering juvenile survival. The Shasta SHA is expected to provide a net conservation benefit in the upper Shasta River basin, including improving juvenile rearing conditions for coho salmon.

Scott River

Numerous water diversions, dams and interconnected groundwater extraction for agricultural purposes, and the diking and leveeing of the mainstem Scott River have reduced summer and winter rearing habitat in the Scott River basin, limiting juvenile survival. Although rearing habitat still exists in some tributaries, access to some of these areas is hindered by dams and diversions, the existence of alluvial sills, and the formation of thermal barriers at the confluence of tributaries. Where passage is possible, there are thermal refugial pools and tributaries where the water temperature is several degrees cooler than the surrounding temperature, providing a limited amount of rearing habitat in the basin.

Currently, valley-wide agricultural water withdrawals and diversions, groundwater extraction, and drought have all combined to cause premature surface flow disconnection along the mainstem Scott River. In addition, summer discharge has continued to decrease significantly over time, further exacerbating detrimental effects on coho salmon in the basin. These conditions restrict or exclude available rearing habitat, elevate water temperature, decrease fitness and survival of over-summering juveniles, and sometimes result in juvenile fish strandings and death.

Woody debris is scarce throughout the mainstem Scott River and its tributaries. Mainstem habitat has been straightened, leveed, and armored. Anthropogenic impacts have resulted in a lack of channel complexity from channel straightening and reduced amounts of woody material (Cramer Fish Sciences 2010). The present-day mainstem Scott River bears minor resemblance to its more complex historic form although meandering channel planforms are still present (Cramer Fish Sciences 2010). Over the last several years the Scott River Watershed Council has been working collaboratively with NMFS and CDFW to improve habitat conditions for rearing coho salmon, improve wetland habitat, improve floodplain connectivity, and help maintain surface water and groundwater connectivity through development of BDAs at strategic locations in major tributary streams and in the mainstem Scott River. Fry and juvenile coho salmon have been documented using these restoration sites throughout the year. The Scott River Watershed Council in collaboration with NMFS has shown through their long term monitoring efforts that the fish in these BDA sites have displayed high rates of growth and high rates of over-winter survival (Yokel et al. 2018). Development of more of these types of projects, if combined with improved water conservation and management practices, is anticipated to improve conditions for rearing coho salmon in the future.

Salmon River

According to available juvenile fish survey information beginning in 2002, juvenile coho salmon have been found rearing in most of the available suitable tributary habitat. These streams are tributaries to the South Fork Salmon (Knownothing and Methodist Creek), at least nine tributaries to the North Fork Salmon, and in mainstem Salmon River tributaries, including Nordheimer and Butler Creeks (Hotaling and Brucker 2010). The lower reaches of these tributaries provide substantially cooler summer habitat than mainstem river habitat. During juvenile coho salmon presence/absence surveys conducted from 2015-2017 a total of 89 juvenile coho salmon were observed (0 in 2015, 53 in 2016, 36 in 2017), primarily within the South Fork or its tributaries. In 2018, 54 juvenile coho salmon were observed at the mouth of and within Methodist Creek, a tributary to the South Fork (Amy Fingerle 2019, unpublished data). There is some indication that juvenile coho salmon move up from the mainstem Klamath River into the cooler Salmon River tributaries during summer months when stressed by mainstem water temperatures. Some juveniles found in surveys are thought to reflect non-natal as well as natal rearing (NMFS 2014a).

Trinity River

Tributaries known to support coho salmon rearing in the Lower Trinity include Mill Creek, Horse Linto Creek, Tish Tang Creek, and Sharber-Peckham Creek. The presence of juvenile coho salmon has also been confirmed in Manzanita Creek, Big French Creek, East Fork New River, Cedar, Supply, Campbell, and Hostler creeks, as well as in Willow Creek as far upstream as the Boise Creek confluence. Lack of floodplain and channel structure impacts have a major impact on the productivity of the Lower Trinity River population. Rearing opportunities and capacity are low due to disconnection of the floodplain, a lack of LWD inputs, poor riparian conditions, and sediment accretion. Low-lying areas of streams such as Supply, Mill, and Willow creeks have been channelized, diked, and disconnected from the floodplain. Many tributaries in low-gradient areas of the Lower Trinity experience similar habitat characteristics due to development of the floodplain, sedimentation and changes in flow. Loss of flow variability and reduced rearing habitat during the fall and winter months as a result of truncated flow release is expected to reduce the ability of the habitat in the Upper Trinity River to support winter rearing of juvenile coho salmon. The mainstem also lacks side channel, backwater, and wetland habitat where juvenile coho salmon could find habitat in the winter. A lack of floodplain and channel structure impacts winter rearing because high flow events can displace juveniles from streams and there exists very little low-velocity rearing habitat. Lack of complex habitat also impacts summer rearing due to the loss of predatory refugia, low-flow refugia, and foraging habitat. In some portions of this population unit cannabis farming impacts summer rearing areas for juveniles, due to runoff and pollution, as well as contributing to poor water quality and quantity.

2.4.1.1.15.3.2 Lower Klamath River Reach (Klamath River mouth to Trinity River Confluence)

In addition to providing connectivity to tributary watersheds for spawning and rearing, the mainstem Lower Klamath River provides rearing habitat for juvenile coho salmon for all Klamath River coho salmon populations. Juvenile coho salmon have been found in many tributary streams in this reach, including Salt, High Prairie, Hunter, Hoppaw, Saugep, Waukell, Terwer, McGarvey, Tarup, Omagaar, Blue, Ah Pah, Bear, Surpur, Little Surpur, Pularvasar, One Mile, Tectah, Johnsons, Pecwan, Mettah, Roaches, Cappell, Richardson, and Tully creeks. In general, coho salmon were only observed in the lower reaches of most tributaries, and in some cases the Yurok Tribe noted that their presence appeared to be non-natal rearing. Faukner et al. (2019) studied the role of the Klamath River mainstem corridor in the life history and performance of juvenile coho salmon in this reach between 2011 and 2017. Their report focuses on sampling conducted in four Lower Klamath River tributaries (Waukell, McGarvey, Panther, and Salt Creeks). Annual spring outmigration estimates for age-1+ coho salmon in Waukell Creek were generally higher than those observed at the other tributaries. Constructed off-channel features in Terwer and McGarvey Creeks were utilized by both natal and non-natal juvenile coho salmon. Non-natal use was higher in the lower portion of McGarvey Creek where most recent stream restoration has occurred. Although the majority of non-natal juvenile coho salmon utilized the lower portion of McGarvey Creek individuals consistently traveled at least 1.4 miles upstream. Fall emigrants from upstream locations that overwinter in Lower Klamath River tributaries contribute substantially to total coho salmon smolt production for the Klamath

River population (Faukner et al. 2019). A detailed analysis of survival and emigration rates of both natal fish in two reaches of McGarvey Creek and non-natal fish from Mid Klamath tributaries suggest that a high proportion of the 2017 spring outmigration estimate were most likely non-natal (Antonetti et al. 2017).

2.4.1.1.15.4 Spawning Habitat Conditions

Coho salmon are typically tributary spawners, but low numbers of adult coho salmon annually spawn in the Middle Klamath River mainstem. However, upstream dams block the transport of sediment into this reach of river, and the lack of clean and loose gravel diminishes the quality of salmonid spawning habitat downstream of the dams. This condition is especially critical directly downstream of Iron Gate Dam (FERC 2007). However, water temperatures and water velocities are generally sufficient in this reach for successful adult coho salmon spawning. Downstream of Iron Gate Dam, channel conditions reflect the interruption of sediment flux from upstream by reservoir capture and the eventual re-supply of sediment from tributaries entering the mainstem Klamath River (PacifiCorp 2004a).

Spawning habitat conditions by sub-basin are described as follows:

2.4.1.1.15.4.1 Middle Klamath River Reach (Trinity River Confluence to Iron Gate Dam)

The quality and amount of spawning habitat in the Middle Klamath River reach is naturally limited due to the geomorphology and the prevalence of bedrock in this stretch of river. Coho salmon are typically tributary and headwater stream spawners, so it's unclear if there was historically very much mainstem spawning in this reach. In addition to the tributaries discussed below, key Middle Klamath River reach spawning tributaries to which adult coho salmon return annually to spawn include Red Cap Creek, Camp Creek, Seiad Creek and Horse Creek in the lower portion of the reach, Beaver Creek in the middle portion of the reach, and Bogus Creek located in the upper portion of the reach.

<u>Shasta River</u>

The Shasta River in particular, with its cold flows and high productivity was once especially productive for anadromous fishes. The current distribution of spawners is limited to the mainstem Shasta River from RM 17 to RM 23, Big Springs Creek, lower Parks Creek, and the Shasta River Canyon. The reduction of LWD recruitment, channel margin degradation, and excessive sediment has limited the development of complex stream habitat necessary to sustain spawning habitat in the Shasta Valley. Persistent low flow conditions through the end of the irrigation season (October 1) can also constrain the timing and distribution of spawning adult coho salmon. Unlike the majority of the Shasta Valley, the irrigation season in Parks Creek doesn't end until November 1, and there are also several stock water diversions that continue to divert throughout the fall and winter season. Therefore, persistent low flow conditions, particularly in dry years can limit the extent of spawning, and may in some years prevent coho salmon from spawning in Parks Creek.

Coho salmon spawning has been observed in the Shasta River Canyon, lower Yreka Creek, throughout the Big Springs Complex area, and in Lower Parks Creek. In some reaches, particularly in the lower canyon and the reach below the Dwinnell Dam, limited recruitment of coarse gravels is likely contributing to a decline in abundance of spawning gravels (Ricker 1997). The causes of the decline in gravels include gravel trapping by Dwinnell Dam and other diversions, bank-stabilization efforts, and historical gravel mining in the channel. In a 1994 study of Shasta River gravel quality, Jong (1997) found that small sediment particles and fines (<4.75mm) were present in quantities associated with excessive salmon and steelhead egg mortality. Jong (1997) also concluded that gravel quality had deteriorated since 1980 when the California Department of Water Resources performed similar work in the Shasta basin. Greenhorn Dam blocks the movement of gravel down Yreka Creek, and alters the Yreka Creek hydrograph.

Scott River

Gravel transport in the Scott River basin is relatively unimpeded; however, significant water diversions can reduce the volume and power of the mainstem and tributaries such that bedload mobilization is reduced. Pebble count data and survey data indicate that suitable gravels sizes are found in conjunction with slopes also suitable for spawning (Cramer Fish Sciences 2010). These observations suggest that the amount of coarse sediment and its rate of delivery are not limiting spawning habitat availability in the Scott River Watershed.

Although gravel mobilization is unimpeded, historic land uses create a legacy of effects that are continuing to impact available spawning habitat. Data shows that spawning substrate is largely suitable throughout the basin, but the spatial extent of these areas is limited due to mine tailing piles and other legacy mining effects. Current conditions in the Scott River mimic hydraulic conditions similar to bedrock canyons where sediment used by salmonids has a lower likelihood of persistence due to increased (or more efficient) sediment transport compared to unconfined reaches (Cramer Fish Sciences 2010). The over extraction of streambed alluvium likely also has stripped the alluvial cover from some river reaches exposing underlying bedrock, the net result of which is enhanced sediment transport, less persistent alluvium, and an overall loss of physical complexity (Cramer Fish Sciences 2010). Channel confinement by historic mining tailings indirectly affects the diversity of stream habitat that might otherwise be available. Many of these tailing piles are too large for the adjacent watercourse to reshape.

Salmon River

Known coho salmon spawning has been observed in the Nordheimer Creek, Logan Gulch, Brazil Flat, and Forks of Salmon areas along the mainstem Salmon River, in the Knownothing and Methodist Creek reaches of the South Fork Salmon River, and in the lower North Fork Salmon River (NMFS 2014a). Twelve percent of the 1,414 miles of stream within the Salmon River watershed are able to support anadromous salmonids, due to the mountainous topography and associated hydrology of the landscape (Elder et al. 2002). For this reason, coho salmon in the Salmon River population are naturally restricted in their distribution (NMFS 2014a).

Trinity River

The Trinity River supports three populations of coho salmon: The Lower Trinity River, Upper Trinity River, and South Fork Trinity River populations. Good spawning habitat exists in a few tributaries in the Lower Trinity River. The Burnt Ranch and New River subareas have some of the best known spawning habitat in the population area. Tributaries known to support coho salmon spawning and/or rearing include Mill Creek, Horse Linto Creek, Tish Tang Creek, and Sharber-Peckham Creek. Spawning also occurs in each of the other two Trinity River coho populations (NMFS 2014a).

2.4.1.1.15.4.2 Lower Klamath River Reach (Klamath River mouth to Trinity River Confluence)

Because of the high incidence of non-natal rearing, juvenile survey data cannot be used to determine the distribution of spawning in this reach. Spawner distribution data provide more accurate information regarding natal population distribution. Spawning coho salmon have been found in Blue, Hunter, Waukell, McGarvey, Terwer, Ah Pah, Tectah, and Pine creeks. Blue Creek is the largest and most resilient watershed and correspondingly supports the largest anadromous fish populations in the sub-basin (Antonetti and Partee 2013). Habitat surveys in other creeks have shown only marginal habitat suitability for coho salmon spawning, primarily due to the high embeddedness of spawning gravels, and lack of channel structure (e.g., fluvial stored wood) required to facilitate necessary gravel sorting and retention dynamics (NMFS 2014a).

2.4.1.2 Factors Affecting Habitat in the Klamath Basin, Including the Action Area

2.4.1.2.1 Climate Change

Climate change has some general long-term implications for the Klamath Basin, including warming of air and water temperatures, changes in precipitation (i.e., amount of rain versus snow, and frequency of rain-on- snow events), the amount of snowpack, water quantity (e.g., more frequent, high-intensity storms, and lower summer flows), and overall seasonal streamflow patterns (NRC 2004; Halofsky et al. 2018). In the Klamath Basin, climate change effects will vary widely on the SONCC coho salmon populations. The hydrologic characteristics of the Klamath River mainstem and its major tributaries are dominated by seasonal snowmelt runoff (NRC 2004). Van Kirk and Naman (2008) found statistically significant declines in April 1 snow water equivalent since the 1950s at several snow measurement stations throughout the Klamath Basin, particularly those at lower elevations (<6000 ft.). The overall warming trend that has been ubiquitous throughout the western United States (Groisman et al. 2004), particularly in winter temperatures over the last 50 years (Feng and Hu 2007; Barnett et al. 2008), has caused a decrease in the proportion of precipitation falling as snow (Feng and Hu

2007). Basins below approximately 5900-8200 feet in elevation appear to be the most impacted by reductions in snowpack (Knowles and Cayan 2004; Regonda et al. 2005; Mote 2006). Over the last 50 years, some of the largest declines in snowpack over the Western U.S. have been in the Cascade Mountains and Northern California (Mote et al. 2005; Mote 2006). Regonda et al. (2005) analyzed western states data from 1950 through 1999, including data from the Cascade Mountains of southern Oregon, and found a decline in snow water equivalent of greater than 6 inches during March, April, and May in the southern Oregon Cascades for the 50-year period evaluated. A decline of 6 inches equals an approximate 20 percent reduction in snow water equivalent. Declines in snowpack are expected to continue in the Klamath Basin. Mote et al. (2018) found that there have been declines in the snow water equivalent in the mountains of northern California of 40 to 80 percent from 1955-2016.

Recent winter temperatures are as warm or warmer than at any time during the last 80 to 100 years (Mayer 2008). Air temperatures over the region have increased by about 1.8º to 3.6º F (1° to 2º C) over the past 50 years and water temperatures in the Klamath River and some tributaries have also been increasing (Bartholow 2005; Flint and Flint 2012). Reclamation (2011d) reports that the mean annual temperature in Jackson and Klamath Counties, Oregon, and Siskiyou County, California, increased by slightly less than 1 °C between 1970 and 2010. During the same period, total precipitation for the same counties decreased by approximately 2 inches.

Projections of the effects of climate change in the Klamath Basin suggest temperature will increase in comparison to the 1961 through 2000 time period (Barr et al. 2010; Reclamation 2011d). Projections are based on ensemble forecasts from several global climate models and carbon emissions scenarios. Anticipated temperature increases during the 2020s compared to the 1990s range from 0.9 to 1.4° F (0.5 to 0.8° C)(Reclamation 2011d). During the 2035 and 2045 period, temperature increases are expected to range from 2.0 to 3.6° F (1.1 to 2.0° C), with greater increases in the summer months and lesser increases in winter (Barr et al. 2010).

Effects of climate change on precipitation are more difficult to project and models used for the Klamath Basin suggest decreases and increases. During the 2020s, Reclamation (Reclamation 2011d) projects an annual increase in precipitation of approximately 3 percent compared to the 1990s. Reclamation (2011d) also suggests that an increase in evapotranspiration will likely offset the increase in precipitation. In the winter months, December through February precipitation is expected to increase by up to 10 percent while June through August precipitation is expected to decrease between 15 and 23 percent (Barr et al. 2010).

Reclamation (2011d) projects that snow water equivalent during the 2020s will decrease throughout most of the Klamath Basin, often dramatically, from values in the 1990s. Projections suggest that snow water equivalent will decrease 20 to 50 percent in the high plateau areas of the upper basin, including the Williamson River drainage. Snow water equivalent is expected to decrease by 50 to 100 percent in the Sprague River basin and in the vicinity of Klamath Falls. In the lower Klamath Basin, Reclamation projects decreases in snow water equivalent between 20 and 100 percent. The exception to the declines is the southern Oregon Cascade Mountains, where snow water equivalent is projected to be stable or increase up to 10 percent (Reclamation 2011d).

Bartholow (2005) found that the Klamath River is increasing in water temperature by 0.5°C per decade, which may be related to warming trends in the region and/or alterations of the hydrologic regime resulting from the dams, logging, and water use in Klamath River tributary basins. Particularly, changes in the timing of peak spring discharge, and decreases in water quantity in the spring and summer may affect salmonids of the Klamath River. Most life history traits (e.g., adult run timing, juvenile migration timing) in Pacific salmon have a genetic basis (Quinn et al. 2000) that has evolved in response to watershed characteristics (e.g., hydrograph) as reflected in the timing of their key life-history features (Taylor 1991). In their natural state, anadromous salmonids become adapted to the specific conditions of their natal river like water temperature and hydrologic regime (NRC 2004). Therefore, the ability of individuals and populations to adapt to the extent and speed of changes in water temperatures and hydrologic regimes of the Klamath River Basin will determine whether or not coho salmon of the Klamath River are capable of adapting to changing river conditions.

Reclamation (2011d) and Woodson et al. (2011) suggest that projected climate change will have the following potential effects for the basin:

- Warmer conditions might result in increased fishery stress, reduced salmon habitat, increased water demands for instream ecosystems and increased likelihood of invasive species infestations (Reclamation 2011d).
- Water demands for endangered species and other fish and wildlife could increase due to increased air and water temperatures and runoff timing changes (Reclamation 2011d).
- Shorter wet seasons projected by most models will likely alter fish migration and timing and possibly decrease the availability of side channel and floodplain habitats (Woodson et al. 2011).
- Groundwater fed springs will decrease and may not flow year around (Woodson et al. 2011).
- Disease incidence on fishes will increase (Woodson et al. 2011).
- Dissolved oxygen levels will fluctuate more widely, and algae blooms will be earlier, longer, and more intense (Woodson et al. 2011).

In addition to having multiple hydrologic effects, climate change may affect biological resources in the Klamath Basin. Climate change could exacerbate existing poor habitat conditions for fish by further degrading water quality. Climate change may at best complicate recovery of coho salmon, or at worst hinder their persistence (Beechie et al. 2006; Van Kirk and Naman 2008). By negatively affecting freshwater habitat for Pacific salmonids (Mote 2003; Battin et al. 2007), climate change is expected to negatively impact one or more of the VSP criteria for the interior Klamath populations. Climate change can reduce coho salmon spatial structure by reducing the amount of available freshwater habitat. Diversity could also be impacted if one specific life history strategy is disproportionately affected by climate change. Population abundance may also be reduced if fewer juveniles survive to adulthood. Climate change affects critical habitat by decreasing water quantity and quality, and reducing the amount of space available for summer juvenile rearing.

In terms of future climate change effects on coho salmon in the Klamath Basin, NMFS believes that within the period of effects of the proposed action (short and long term as described above in the Analytical Framework 2.1.5.4), climate changes will have noticeable additional effects on coho salmon or its critical habitats beyond what has been occurring. Specific projections during the period of effects of the proposed action that are expected to affect coho salmon and their habitat include changes in seasonality of runoff, decreased snow water equivalent, decreased snowpack, and warmer air and water temperatures (Reclamation 2011d). These predicted changes are part of our analysis in Section **2.7** *Integration and Synthesis.*

2.4.1.3 Status of Coho Salmon Populations in the Klamath Basin that utilize the Action Area

As described in the Analytical Approach (Section 2.1), in addition to coho salmon populations that occur (in their freshwater life history stages) wholly within the action area, coho salmon that originate in locations that are adjacent to the action area (see Section 2.3) may be impacted by the proposed action while utilizing habitat in the action area. Therefore, the status and life history characteristics of those populations are relevant to our analysis of the effects of the proposed action. The condition of coho salmon populations that utilize the action area during all or some portion of their freshwater life history stages is summarized in this section.

2.4.1.3.1 Periodicity

The biological requirements of SONCC ESU coho salmon in the Klamath Basin, including in the action area, vary depending on the life history stage present at any given time (Spence et al. 1996; Moyle 2002). Generally, during salmonid spawning migrations, adult salmon prefer clean water with cool temperatures and access to thermal refugia, dissolved oxygen near 100 percent saturation, low turbidity, adequate flows and depths to allow passage over barriers to reach spawning sites, and sufficient holding and resting sites. Anadromous fish select spawning areas based on species-specific requirements of flow, water quality, substrate size, and groundwater upwelling (Sandercock 1991). Embryo survival and fry emergence depend on substrate conditions (e.g., gravel size, porosity, permeability, and dissolved oxygen concentrations), substrate stability during high flows, and, for most species, water temperatures of 14 ºC or less (Quinn 2005). Figure 18 depicts the seasonal periodicities of coho salmon that utilize the action area.

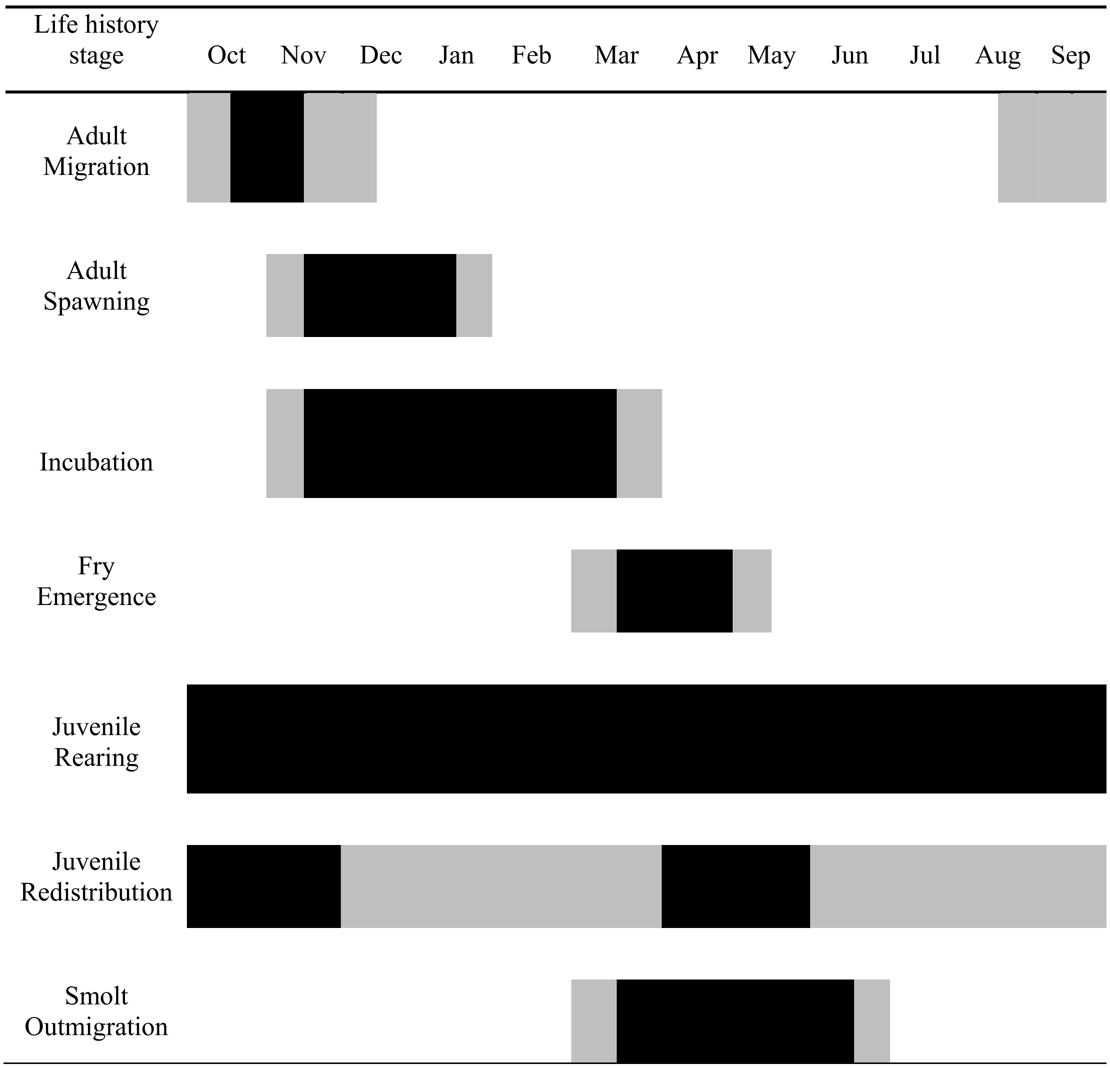

Figure 18. Life stage periodicities for coho salmon within the Klamath River Basin. Black areas represent peak use periods. Shaded gray indicate non-peak periods (Leidy and Leidy 1984; NRC 2004; Justice 2007; Carter and Kirk 2008).

2.4.1.3.2 Abundance and Distribution

Robust abundance estimates are not available for all populations of coho salmon that utilize the action area. However, population estimates of adult coho salmon in the basin that are available are all reduced from historic numbers and are all estimated to be below the viability threshold each year since 2009 (Table 14; NMFS (2014a), updated through 2020). The most robust abundance estimates of natural populations in the Klamath Basin come from the Shasta River, Scott River, and Bogus Creek, at which CDFW maintains video weirs (Table 14)(Kier et al. 2020; Giudice and Knechtle 2021b; Knechtle and Giudice 2021b; 2021a). Abundance estimates in most other locations are derived from spawner surveys. The Trinity River has had the largest runs of SONCC coho salmon in the Klamath Basin in most recent years, but the Scott River also maintains a strong run, which has occasionally been larger than the Trinity River in recent years

(Table 14). Abundance and seasonal distribution characteristics are summarized for each sub-basin population in the following sections (Section 2.4.1.3.2.1 to Section 2.4.1.3.2.7).

Table 14: Estimated spawning coho salmon escapement for populations potentially affected by the action.

Population	Origin	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Iron Gate Hatchery [a]	Hatchery	70	485	586	644	1,268	384	72	86	122	200	116	242
Upper Klamath Population [b]	Natural	< 200	<350	<300	<300	<300	<300	<300	<300	<300	<300	<300	<300
Bogus Creek [c]	Natural	7	154	142	185	446	97	14	85	48	47	67	187
Middle Klamath Population [d]	Natural	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500
Shasta River [e]	Natural	9	44	62	114	163	46	45	48	41	39	50	37
Scott River [f]	Natural	81	927	355	201	2,752	485	212	226	382	739	346	1,766
Salmon River [g]	Natural	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Trinity River [h]	Natural	3,045	3,522	10,186	10,422	15,275	9,629	1,282	798	235	744	424	425*
Trinity River Hatchery [h]	Hatchery	3,351	4,425	4,810	8,236	6,631	3,908	3,337	527	420	742	649	962*
Lower Klamath River [i]	Natural	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500

a (Giudice and Knechtle 2021a)
b Estimates based on Bogus Creek counts, which are shown in the row below (Knechtle and Giudice 2021b) plus an estimated small numbers of mainstem and tributary spawners (Corum 2011).
c (Knechtle and Giudice 2021b)
d Projected using the highest estimates (i.e., 2004) from Ackerman et al. (2006)(see discussion below).
e (Giudice and Knechtle 2021b)
f (Knechtle and Giudice 2021a)
g Continues from Ackerman et al. (2006) estimates for the Salmon River.
h (Kier et al. 2020)
i Regular monitoring of coho salmon escapement does not occur annually for this population. Projected using the estimates from Ackerman et al. (2006). The majority of spawning occurs in Blue Creek (Gale et al. 1998; Gale 2009; Antonetti and Partee 2012; 2013).
* Preliminary data provided by CDFW.

After emergence from spawning gravels within the mainstem Klamath River, or as they move from their natal streams into the river, coho salmon fry distribute themselves upstream and downstream while seeking favorable rearing habitat (Sandercock 1991). Further redistribution occurs following the first fall rain freshets as fish seek stream areas conducive to surviving high winter flows (Ackerman et al. 2006). The Yurok Tribal Fisheries Program and the Karuk Tribal Fisheries Program have been monitoring juvenile coho salmon movement in the Klamath River using passive integrated transponder (PIT) tags. Some coho salmon parr, tagged by the Karuk Tribal Fisheries Program, have been recaptured in ponds and sloughs over 90 river miles away in the lower 6-7 miles of Klamath River (Soto et al. 2016). Juvenile coho salmon (parr and smolts) have been observed residing within the mainstem Klamath River between Iron Gate Dam and Seiad Valley throughout the summer and early fall in thermal refugia during periods of high ambient water temperatures (>22 ºC). Mainstem refugia areas are often located near tributary confluences, where water temperatures are 2 to 6°C lower than the surrounding river environment (NRC 2004; Sutton 2007; Antonetti et al. 2017; Faukner et al. 2019).

In summary, abundance and seasonal distribution of coho salmon by sub-basin is as follows:

2.4.1.3.2.1 Upper Klamath River Population

The Upper Klamath River Population currently occupies approximately 64 miles of mainstem habitat and numerous tributaries to the Klamath River, extending upstream of Portuguese Creek to Iron Gate Dam. Juvenile coho salmon may migrate through the action area during summer and fall redistribution periods when seeking non natal refugial habitats. Smolts outmigrate during the spring and adult coho salmon immigrate during the fall and winter, utilizing the mainstem reaches within the action area. Tributaries that flow into the action area (*i.e.*, Horse Creek and Seiad Creek) provide sources of cold water where juvenile coho salmon can be found over summering and low velocity reaches and off channel habitat features that provide low velocity refugia during the winter rearing period.

Coho salmon within the Upper Klamath River population spawn and rear primarily within several of the larger tributaries between Portuguese Creek and Iron Gate Dam, including Horse and Seiad creeks. Coho salmon presence was confirmed in six surveyed tributary streams including Horse, Seiad, Grider, West Grider, Walker, and O'Neil creeks (Garwood 2012). In surveys from 2014 to 2017, KNF fisheries staff routinely observed 100s of young-of-year juvenile coho salmon in lower Horse and Seiad creeks (NMFS 2014a).

Escapement of adult coho salmon entering Bogus Creek has been monitored by the CDFW annually since about 2004. Over that period the number of adult coho salmon estimated to have entered Bogus Creek has ranged between 7 fish (2009) and 446 fish (2013) and the proportion of hatchery coho salmon present in the run has ranged between 0.09 (2019) and 0.88 (2012). Between 2014 and 2019 the total number of adult coho salmon observed has been less than 100 fish, down substantially from the average run size between 2004 and 2013, but the 2020 return was 187 fish (Knechtle and Giudice 2018). Due to the low numbers of the Upper Klamath River population, IGH coho salmon strays are currently an important component of the adult returns for these populations because of their role in increasing the likelihood that wild/natural coho salmon find a mate and successfully reproduce (NMFS 2014a).

2.4.1.3.2.2 Middle Klamath River Population

Little data on adult coho salmon are available for this stretch of river. Adult spawning surveys and snorkel surveys have been conducted by the USFS and Karuk Tribe, but data from those efforts are insufficient to draw definitive conclusions on run sizes (Ackerman et al. 2006). Ackerman et al. (2006) relied on professional judgment of local biologists to determine what run sizes would be in high, moderate, and low return years to these tributaries; therefore, the run size approximations are professional judgment based estimates. NMFS (2014a) does identify that the Middle Klamath River population is at moderate risk of extinction. Most of the juveniles observed in the Middle Klamath have been in the lower parts of the tributaries, which suggests many of these fish are non-natal rearing in these refugial areas. Adults and juveniles appear to be well distributed throughout the Middle Klamath; however, use of some spawning and rearing areas are restricted by water quality, flow, and sediment issues. Although the Middle Klamath River population's spatial distribution appears to be good, many of the Middle Klamath tributaries are used for non-natal rearing, and too little is known to infer its extinction risk based on spatial structure.

2.4.1.3.2.3 Shasta River

Adult coho salmon returns to the Shasta River have generally been in decline over the last decade. Since 2007 the number of adult coho salmon observed entering the Shasta River has ranged from a high of 249 fish in 2007 to a low of only 9 fish in 2009 (Giudice and Knechtle 2021b). From 2014 through 2020 the number of adult coho salmon have been 50 or less fish annually (Giudice and Knechtle 2021b). To reduce the risk of local extirpation, all IGH surplus adult coho salmon have been released back to the Klamath River since 2010. Some of these surplus adults have been observed entering the Shasta River which is about 14 river miles downstream from IGH. Since that time the percentage of hatchery origin coho salmon observed in the Shasta River spawning population has ranged from about 25 percent to 80 percent. Due to the low numbers of the Shasta River population, IGH origin fish play an important role in increasing the likelihood that wild/natural coho salmon find a mate and successfully reproduce. The proportion of hatchery origin adults in the spawning population for most recent years (2015 to 2019) was unknown because sampling efforts were unable to recover any adult carcasses during this time, but the proportion of hatchery spawners in the Shasta River in 2020 was 43 percent.

The current distribution of coho salmon spawners is concentrated in the mainstem Shasta River from RM 32 to about RM 36, Big Springs Creek, lower Parks Creek, and in the Shasta River Canyon (RM 0 to RM 7). Juvenile rearing is also occurring in these same areas (NMFS 2014a).

2.4.1.3.2.4 Scott River

Abundance estimates on the Scott River are relatively robust due to the presence of a video fish counting weir, which has been utilized since 2007. In 2018, 2019, and 2020, adult coho salmon returns to the Scott River were estimated to be 727, 365, and 1,671 fish, respectively (Knechtle and Giudice 2021a). Spawning activity and redds have been observed in the East Fork Scott

River, South Fork Scott River, Sugar, French, Miners, Etna, Kidder, Patterson, Shackleford, Mill, Canyon, Kelsey, Tompkins, and Scott Bar Mill creeks. Fish surveys of the Scott River and its tributaries have been occurring since 2001. These surveys have documented that many of the tributaries do not consistently sustain juvenile coho salmon, indicating that the spatial structure of this population is restricted by available rearing habitat. Many of these tributaries likely have intermittent fish occupation due to low flow barriers for juvenile and adult migration periods as described in the sections above. Juvenile fish have been found rearing in the mainstem Scott River, East Fork Scott River, South Fork Scott River, Shackleford Creek and its tributary Mill Creek, Etna Creek, French Creek and its tributary Miners Creek, Sugar Creek, Patterson Creek, Kidder Creek, Canyon Creek, Kelsey Creek, Tompkins Creek, and Mill Creek (NMFS 2014a).

2.4.1.3.2.5 Salmon River

Since 2002, the Salmon River Restoration Council along with CDFW, the Karuk Tribe, the USFS and the USFWS have conducted spawning and juvenile surveys throughout the watershed. Juvenile coho salmon have been found rearing in most of the available tributary habitat with moderate or high intrinsic potential values (NMFS 2014a). Juvenile presence/absence and abundance data from a variety of surveys indicate that many of the tributaries throughout the watershed are used for spawning, including tributaries to the lower Salmon River, Wooley Creek, and the North and South Fork Salmon (NMFS 2014a). Annual adult coho salmon abundance observed in the Salmon River has varied between 0 and 14 spawning adults since 2002 (Hotaling and Brucker 2010). Between 2002 and 2007 only 18 adults and 12 redds (average of 4 spawners per year) were found in the roughly 15 miles of surveyed habitat. Known coho salmon spawning has been observed in the Nordheimer Creek, Logan Gulch, Brazil Flat, and Forks of Salmon areas along the mainstem Salmon River, in the Knownothing and Methodist Creek reaches of the South Fork Salmon River, and in the lower North Fork Salmon River (Hotaling and Brucker 2010), with the most recent recorded observation being two individuals building a redd in 2017 (Meneks 2018), and a single individual in 2018 (Amy Fingerle 2019, unpublished data). Without any new information to show coho salmon spawner abundance increased, NMFS continues to estimate the total Salmon River spawner abundance as less than 50 individuals. An adult population of 50 or less would represent a population with limited spatial structure.

2.4.1.3.2.6 Trinity River

Information regarding population size of individual SONCC coho salmon population units in the Trinity Basin is limited because systematic monitoring on the coho salmon populations in the area is limited. Because adult coho salmon from all three population units of the Interior-Trinity Diversity Stratum pass through the Willow Creek weir on the lower Trinity, it is not known which population of coho salmon is captured at the weir. As such, the weir provides an aggregate population estimate for all unmarked coho salmon upstream of the weir. The mean natural area spawners for the four year period of 2016 to 2019 was 550 fish, which was substantially lower than the average for the four year period of 2012 to 2015, which was 9,152 fish (Kier et al. 2020). The natural area coho salmon spawner estimate for the 2020 spawning season was 425 fish (Kier et al. 2021). Coho salmon continue to be present in many of the tributary streams in this population unit, but low adult returns in recent years have left some habitat unoccupied. Although there may be robust numbers of spawners occasionally in some years, the overall number of naturally produced coho salmon in the Upper Trinity River watershed is low compared to historic conditions, and hatchery fish dominate the run. The Upper Trinity River Population unit has the greatest degree of temporal and spatial exposure to hatchery fish of any of the population units in the action area. SONCC coho salmon in this population unit are exposed to both genetic interactions through breeding with TRH coho salmon, as well as ecological interactions (predation, competition and disease transfer) with hatchery coho salmon, Chinook salmon, and steelhead. Limited data exists for the Lower Trinity population and the South Fork Trinity population as few surveys have been completed.

2.4.1.3.2.7 Lower Klamath River

Coho salmon have a wide distribution throughout the Lower Klamath, but almost always low abundances, based on the results of juvenile surveys, spawner surveys, and outmigrant trapping. Moderate densities of coho salmon are found in Blue, McGarvey and Ah Pah creeks. The majority of spawner observations have been made in Blue Creek (Gale 2009; Antonetti and Partee 2012; 2013). Adult coho salmon population abundance, estimated by Ackerman et al. (2006) ranged from 14 to approximately 1,500 spawners between 2002 and 2006 (NMFS 2014a).

2.4.1.4 Relevant Federal Actions in the Klamath Basin that Have Undergone ESA Section 7 Consultation

NMFS has performed a number of other ESA Section 7 consultations on Federal actions in the action area. NMFS has performed numerous informal consultations in the action area for activities such as: bridge replacement and widening, road rehabilitation, fire management, and approval of Total Maximum Daily Loads (TMDLs) under the Clean Water Act. For all of these, NMFS concurred with the federal action agency that their proposed action was not likely to adversely affect listed species under NMFS' jurisdiction. Some key formal consultations, where adverse effects to listed species were likely, that NMFS has performed for Federal actions in the Klamath Basin include:

- NMFS has completed multiple consultations over the past approximately 20 years with Reclamation on their Klamath Project operations, which are summarized in more detail in Background Section 1.1.2, Reclamation's Klamath Project. Early consultations (NMFS 2001a; NMFS 2002) concluded that the Reclamation action, as proposed, was likely to jeopardize the continued existence of SONCC coho salmon and destroy or adversely modify critical habitat for the SONCC coho salmon, which was avoided by implementation of reasonable and prudent alternatives. Subsequent biological opinions described in Section 1.1.2 concluded that the proposed action would not jeopardize listed species or adversely modify their critical habitat.
- Consultation with NMFS relating to issuance of ESA Section 10(a)(1)(A) Permit 15755 to CDFW for enhancement and scientific purposes for implementation of an HGMP for the coho salmon program at the Iron Gate Hatchery as described in Sections 1.3.5.6, Fish Hatcheries, and 2.4.1.1.9, Hatcheries, above, resulting in a non-jeopardy biological

opinion. The proposed action was expected to result in adverse effects to SONCC coho salmon critical habitat and individuals, including direct take associated with hatchery activities (NMFS 2014b).

- Consultation with NMFS on the issuance of an ESA Section 10(a)(1)(B) Permit associated with an HCP for SONCC coho salmon (PacifiCorp 2012), which is previously described in Section 1.1.4 Additional Relevant ESA Consultations and Permits, resulting in a non-jeopardy biological opinion. Under the HCP, PacifiCorp is responsible for implementing several extensive conservation measures, as described in the HCP. The proposed action was expected to result in adverse effects to SONCC coho salmon critical habitat and individuals, including incidental take effect mostly in the form of harm, because effects from continued PacifiCorp operations and maintenance activities, despite minimization and mitigation measures implemented via the HCP, would impair habitat and normal behavior patterns of SONCC coho salmon (NMFS 2012c).

- Consultation with Klamath National Forest in 2018 on fire related activities (see *Wildfire* section 2.4.1.1.13.1) resulting in a non-jeopardy biological opinion. The proposed action was expected to result in adverse effects to SONCC coho salmon critical habitat and individuals, including incidental take in the form of reduced survival rates of in-gravel coho salmon in West Fork Horse, Middle Horse, and Middle Seiad creeks (NMFS 2018a).

- Consultation with NMFS on our issuance of an ESA Section 10(a)(1)(A) permit for enhancement and scientific purposes to CDFW in 2014 (see the *Hatcheries* section (Section 2.4.1.1.9) above) resulting in a non-jeopardy biological opinion. The proposed action was expected to result in adverse effects to SONCC coho salmon critical habitat and individuals, including take of SONCC coho salmon fry, juveniles, and smolts as a result of outmigrant trapping, predation, competition, and disease (NMFS 2014b).

- Consultation with the California Department of Transportation in 2016 on the proposed construction of a bridge over the Klamath River at RM 176.8, near the confluence with the Shasta River, resulting in a non-jeopardy biological opinion. The proposed action was expected to result in adverse effects to SONCC coho salmon critical habitat and individuals, including take of sub yearling juveniles related to pile driving activities (NMFS 2016d).

For most of these consultations, and for other formal consultations in the action area, NMFS concluded that the proposed federal action would not be likely to jeopardize the continued existence of listed species or destroy or adversely modify their critical habitat. However, NMFS did conclude the proposed action for Reclamation’s Klamath Project operations would be likely to jeopardize the continued existence of listed species and destroy or adversely modify their critical habitat in 2001 and 2002, and Reclamation implemented reasonable and prudent alternatives to avoid the likelihood of jeopardizing the continued existence of listed species or resulting in the destruction or adverse modification of critical habitat.

2.4.2 Southern Resident Killer Whales (SRKWs)

2.4.2.1 Factors Affecting the Prey of SRKWs in the Action Area

In the *Rangewide Status of the Species and Critical Habitat* and *Environmental Baseline* sections for SONCC coho salmon, we discussed the impacts of various activities and factors affecting coho salmon populations in the freshwater environment and, specifically, the action area for SONCC coho salmon in the Klamath River Basin, including major influences such as water operations in the Klamath River and climate change. In general, the factors affecting Chinook salmon in the freshwater environment are identical or very similar to what is discussed for coho salmon in the Klamath River. All of these important influences on Chinook salmon in the freshwater environment contribute to the health, productivity, and abundance of Chinook salmon that ultimately survive to reach the ocean environment and influence the prey base and health of SRKWs. Given that the factors that affect salmon in the freshwater environment of the Klamath River Basin have already been discussed, and the action area for SRKWs does not include the Klamath River Basin, this section focuses on important factors for Chinook salmon and for SRKWs in the marine environment.

2.4.2.1.1 Significance of Prey and Prey reductions

As described in the SRKWs subsection of the *Rangewide Status of the Species* and *Critical Habitat* section (2.2.2), Chinook salmon are the primary prey of SRKW and relationships between various Chinook salmon abundance indices and the vital rates (fecundity and survival) of SRKWs have been outlined in several papers. In addition to examining the linkages between vital rates and prey abundance, many analyses have been aimed at distinguishing which Chinook salmon stocks (or grouping of Chinook salmon stocks) may be the most closely related to these vital rates for SRKWs. Largely, attempts to compare the relative importance of any specific Chinook salmon stocks or stock groups using statistical relationships have not produced clear distinctions for which stocks are most influential. One complicating factor is that most Chinook salmon stock indices are highly correlated with each other. It is also possible that different populations may be more important in different years. Large aggregations of Chinook salmon stocks that reflect abundance on a coastwide scale appear to be as equally or better correlated with SRKW vital rates than any specific or smaller aggregations of Chinook salmon stocks. This includes those that originate from the Fraser River that have been positively identified as key sources of prey for SRKWs during certain times of the year in specific areas (see Hilborn et al. 2012; Ward et al. 2013) and related to the body condition of J pod (Stewart et al. 2021). However, there are still questions about the diet preferences of SRKWs throughout the entire year, as well as the relative exposure of SRKWs to various Chinook salmon or other salmon stocks outside of inland waters during the summer and fall.

As referenced above, an Independent Science Panel found good evidence that Chinook salmon are a very important part of the SRKW diet and that some SRKWs have been in poor condition recently, which is associated with higher mortality rates. They further found that the data and correlations developed to date provide some support for a cause and effect relationship between salmon abundance and SRKW survival and reproduction. They identified "reasonably strong" evidence that vital rates of SRKWs are, to some degree, ultimately affected by broad-scale changes in their primary Chinook salmon prey. They suggested that the effect is likely not linear, however, and that predicted improvements in SRKW survival may not be realistic or may diminish at Chinook salmon abundance levels beyond the historical average (Hilborn et al. 2012).

In 2019, the PFMC convened an ad-hoc workgroup (Workgroup) to reassess the effects of PFMC ocean salmon fisheries on SRKWs. As part of their risk assessment, the Workgroup included conducting updated correlative analyses in the relationships between Chinook salmon abundance and SRKW demography similar to those included in the Panel Report (Hilborn et al. 2012) and described by Ward et al. (2013). These new analyses include more recent data and include a broader range of SRKW demographic indices. Similar to past efforts, the Workgroup found predicting the relationship between SRKWs and Chinook salmon abundance to be challenging. The relationships between modeled Chinook salmon abundance and SRKW demographics examined by the Workgroup in this most recent analysis appear weaker than those from prior analyses. For example, although the average coastwide Chinook salmon abundance in this last decade is higher than the average over the entire time series (1992 – 2016), the SRKW population has experienced a decline in their population. Ultimately, the only significant statistical correlation that was identified was between the winter abundance of Chinook salmon in the North of Falcon (NOF) coastal area (i.e., off the coast of Washington) and SRKW survival (PFMC 2020b). Overall, while not statistically significant, the majority of analyses found the general patterns in the relationship that were expected; namely that the survival and fecundity increased with increasing Chinook salmon abundance while occurrence of peanut-head decreased with increasing Chinook salmon abundance (PFMC 2020b). Although the Workgroup emphasized that caution is warranted when interpreting the results given the limitations of the data, they concluded that these results, coupled with the potential occurrence of SRKWs in the NOF area in all seasons, suggest that Chinook salmon abundance in the NOF area may be more consistently important than Chinook salmon abundance in the South of Falcon (SOF) coastal area (i.e., off the coasts of Oregon and California; PFMC 2020b).

However, further interpretation of these results by NMFS have concluded that the SRKW demographic data alone would not be expected to help provide anything more than weak evidence for or against a significant change related to prey abundance or any other perturbation (NMFS 2021a). Analysis suggests that increases in fecundity would need to be extremely large – perhaps approaching what is possible for the species -- to be likely to detect a significant effect from the change in prey abundance. From this we can conclude that analyses that are attempting to detect a significant change in SRKW demographic rates given a change in prey abundance (from management change or other source) may be unlikely to detect a significant effect even if a biologically significant effect is present (NMFS 2021a). Given all the available information, and considering the uncertainty that has been highlighted, we assume that the overall abundance of Chinook salmon as experienced by foraging SRKWs throughout their range may be influential on their health and vital rates, even if Chinook abundance in some areas could be more influential than others.

2.4.2.1.2 Link between SRKWs and Klamath River Chinook Salmon as Prey

As described in the SRKWs subsection of the *Rangewide Status of the Species and Critical Habitat* section (Section 2.2.2), SRKWs (particularly K and L pod) are known to reside in coastal waters along the west coast of U.S. and Canada during the winter and spring, including at least occasional visits to California. The BA describes in general some of what is known about the distribution of Klamath River Chinook salmon in the Pacific Ocean in comparison to the distribution of SRKWs. Largely, our knowledge of the distribution of these Chinook salmon in the ocean comes from the data obtained from coded wire tags (CWT) and genetic stock information (GSI) obtained from fish harvested in ocean fisheries that generally occur sometime between April and October.

Unfortunately, the timing of ocean salmon fisheries does not overlap well with the occurrence of SRKWs in coastal waters during the winter and spring, especially in the last few decades. Ocean distribution of Chinook salmon populations based on summer time fishery interactions generally indicates northern movements of Chinook salmon from their spawning origins (Weitkamp 2010). However, we note the range of these movements is quite variable between populations and run timings, and the distribution of Chinook salmon populations in the winter and spring when SRKWs are likely to encounter Klamath River Chinook salmon stocks is not as well known. Recently, Shelton et al. (2018) did estimate the seasonal ocean distribution, survivorship, and aggregate abundance of fall run Chinook salmon stocks from California to British Columbia. While their analysis did not appear to reveal significant seasonal variance in the relative distribution of Chinook salmon stocks from California, they generally concluded that fall run stocks tended to be more northerly distributed in summer than in winter-spring, and ocean distributions also tend to be spatially less concentrated in the winter-spring (Figure 3 in Shelton et al. 2018). Without any additional information available that would suggest the distribution of Klamath River Chinook salmon shifts substantially seasonally, we assume the distribution of Klamath Chinook salmon during the winter and spring is similar to what has been documented during the summer and fall. We also assume that data collected from hatchery fish (usually where CWTs are applied) are representative of the distribution of both wild and hatchery populations consistent with the approach used by federal and state agencies to manage salmon fisheries and populations using CWT data for many decades. The limited amount of available information suggests their distributions are similar (Weitkamp 2010).

The available data from CWT and GSI confirm that Chinook salmon from the Klamath River (particularly fall-run) occur in small numbers as far north as the Columbia River, but are primarily encountered by ocean salmon fisheries in a relatively concentrated area ranging from Northern California through Central Oregon (Weitkamp 2010; Bellinger et al. 2015; Shelton et al. 2018). The coastal area off the Klamath River is reportedly where the greatest concentration of Klamath origin Chinook salmon occurs. Klamath River Chinook salmon was estimated to make up to 37 percent of the adult Chinook salmon off of Fort Bragg during the spring and up to about 45 percent off of the southern Oregon coast in July depending on: (1) the inter-annual variability in strength of salmon runs; (2) the month; and (3) the location (Reclamation 2011e). Recent GSI studies by Bellinger et al. (2015) indicated that Klamath Chinook salmon (primarily fall-run) constituted sizeable proportions of Chinook salmon sampled off the coast of Oregon and northern California at times during the 2010 fishing season where comprehensive GSI data were collected.[17] Shelton et al. (2018) also found that Chinook from Northern California origins (primarily Klamath River) constitutes at least 20% of the Chinook salmon found in coastal areas ranging from San Francisco up through Central Oregon.

In total, the available data suggest that Klamath River Chinook salmon can constitute a sizeable percentage of Chinook salmon that would be expected to be encountered by SRKWs in coastal waters off Northern California and South/Central Oregon, and at least a small portion of Chinook salmon in the ocean as far north as the Columbia River.

The final biological report supporting the 2021 coastal critical habitat designation found relatively high SRKW use occurred within the Klamath Management Zone (NMFS 2021h), and the Northern California Area (Area 4) was identified as an important feeding habitat for SRKWs and for the prey resources. Chinook salmon originating from rivers adjacent to Area 4 include two of the top ten priority Chinook salmon populations identified as being important to the recovery of SRKWs (NOAA and WDFW 2018), including Klamath fall and spring run Chinook salmon. In addition, ratios of contaminants in blubber biopsies found that the blubber of K and L pod match with similar ratios of contaminants in Chinook salmon from California, which was indicated by the relatively high concentrations of dichlorodiphenyltrichloroethane (DDT). These DDT fingerprints suggest fish from California[18] form a significant component of their diets (Krahn et al. 2007; Krahn et al. 2009; O'Neill et al. 2012). As a result, we conclude that Klamath River Chinook salmon are an important part of the diet for most SRKWs during portions of the year when SRKWs occur in coastal waters off the North American coast. This is especially true south of the Columbia River, which includes the times of potential reduced body condition and increased diet diversity that received additional weight during the prey prioritization process described above.

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[17] 2010 was a slightly below average year for estimates of ocean abundance of Klamath Chinook salmon, although it was a very poor year for Central Valley Chinook salmon which typically make up a large percentage of Chinook salmon off the California and Oregon coast. Salmon stocks originating from the northern Oregon coast and other systems northward were not detected at all off the California coast that year. A wide variety of Chinook salmon stocks can be found off the coast of Oregon, although the influences of major systems such as the Columbia River become more prominent off the coast of northern Oregon.

[18] The research does not specify if or how much fish from the Klamath River specifically contribute to the diet: only that SRKWs must feed in areas where Chinook salmon with California origins occur. Consistent with the information reviewed, Klamath-origin Chinook salmon overlap in space and time with Chinook salmon from other California origins like the Central Valley (Shelton et al. 2018).

2.4.2.1.3 Relationship of Klamath River Chinook Salmon to Overall Ocean Abundance

Given that the best information available has linked the health and vital rate of SRKWs with the abundance of Chinook salmon to some degree at various scales over time and that impacts from the proposed action are expected to occur only to salmon from the Klamath River, it is important to understand how significant Klamath River Chinook salmon are to the abundance of Chinook salmon within various scales across the range of SRKWs.

In general, ocean abundance estimates for Chinook salmon that originate from U.S. systems are provided by the Pacific Fishery Management Council (PFMC 2021c). The estimated 2021 ocean abundance of Klamath River Fall-run Chinook salmon, which constitutes most of the Chinook salmon that return to the Klamath River in terms of abundance, is 181,500 fish. This is generally consistent with some of the recent ocean abundances of Klamath Chinook over the last decade, although significantly lower than ocean abundances approaching/exceeding 1 million fish that have occurred at times in the past (PFMC 2021c). Another significant stock that overlaps with the range of Klamath Chinook salmon off the coast of California and Oregon is Sacramento Fall Chinook salmon. In 2021, the Sacramento Index[19] (SI) is estimated to have an ocean abundance of 271,000 fish (PFMC 2021c). Since the early 1980s, SI values commonly range from 500,000 to 1 million fish, although recent abundances have been much smaller than historical averages, and SI values have exceeded 500,000 only 4 times in the last 4 years (PFMC 2021c). Since the 2021 SI is estimated to be low compared to the historical ranges, 2021 is expected to be a relatively low abundance year compared to historical perspectives for Sacramento River Fall-run Chinook salmon, which historically would be more significant to the overall abundance especially in the action area.

Previously, there had been limited capabilities to generate specific estimates of the number of Chinook salmon that may be found in the ocean within any defined boundary that would include likely or possible coastal migrations of SRKWs during the winter and spring. There are many different management and monitoring schemes that are employed for Chinook salmon along the western North American coast that make it difficult to directly relate and compare metrics of Chinook salmon abundance. In 2019, the PFMC Workgroup generated coastwide adult abundance estimates for most Chinook salmon stocks that were used to construct area and season-specific estimates of Chinook salmon abundance for the purposes of exploring the impact of ocean harvest on SRKWs (PFMC 2021c). From these efforts, we can characterize the coastwide abundance of Chinook throughout most of their range as well as more localized estimates off the coast of California and Oregon where Klamath Chinook salmon can be found in the range of SRKWs.

The PFMC Workgroup estimated that the ocean abundance of Chinook salmon coastwide within the U.S. Exclusive Economic Zone (EEZ) has ranged from about 2.1 to 6.0 million Chinook from 1992-2016; averaging 3.7 million Chinook salmon over that time period (PFMC 2020b).

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[19] The Sacramento Index (SI) is limited to a measure of catch and escapement abundance, and not absolute abundance in the ocean. The SI index is the sum of (1) adult Sacramento River Fall Chinook (SRFC) salmon ocean fishery harvest south of Cape Falcon, OR (2) adult SRFC impacts from non-retention ocean fisheries when they occur, (3) the recreational harvest of adult SRFC in the Sacramento River Basin, and (4) the SRFC adult spawner escapement. The SI forecasting approach uses jack escapement estimates to predict the SI (PFMC 2021a).

During the most recent 10 years of this time series (2007-2016), the range and average number of Chinook salmon in the U.S. EEZ has been essentially the same (PFMC 2020b). In addition, the PFMC Workgroup estimated 1.4 million Chinook salmon were in ocean waters in the range of SRKWs outside the EEZ on average each year during the most recent 10 years (PFMC 2020b). While we acknowledge there are additional Chinook salmon available within the full range of SRKWs that are not accounted for the PFMC Workgroup models, we conclude that the relative magnitude of Chinook salmon in the coastal ocean range of SRKWs is likely at least several million fish each year. The PFMC Workgroup also looked at Chinook salmon abundance at different regional levels, including estimates of Chinook salmon off the coast of California and Oregon. During the most recent 10 years analyzed (2007-2016), the average Chinook salmon abundance off the coasts of Oregon and California collectively (i.e., SOF) where Klamath Chinook salmon are expected to occur was 2.1 million Chinook salmon (1.5 million and 0.6 million off Oregon and California, respectively; PFMC 2020b).

Based on the recent ocean abundances of Klamath Chinook salmon and the work done by the PFMC Workgroup, we can characterize the relative contribution of Klamath River Chinook salmon (as represented by the Klamath Fall-run) to the total abundance of Chinook salmon in the coastal ocean range of SRKWs in the United States. Using post season estimates from 2007-2016 that match with time periods analyzed by the PFMC Workgroup, the average ocean abundance of Klamath Chinook salmon from 2007-2016 was about 356,000 (PFMC 2021c). This equates to nearly 10% (9.6%) of the average ocean abundance of Chinook salmon that may be encountered by SRKWs within the U.S. EEZ, and about 7% (7.0%) of average abundance of Chinook salmon encountered by SRKW in ocean waters throughout their range. Within the range of Klamath Chinook salmon off the coasts of Oregon and California (SOF), Klamath Chinook salmon constituted about 17% (17.0) of the average ocean abundance of Chinook salmon during this time period. Importantly, we recognize this proportion likely varies each year depending on varying strengths in run size (Kope and Parken 2011).

Looking at forecasts for 2021, the PFMC models estimate that the ocean abundance of Klamath Chinook salmon (182,000) would make up about 6% (6.1%) of the 3.0 million Chinook salmon available within the U.S. EEZ, and about 4% (4.2%) of total ocean abundance of 4.3 million Chinook salmon within the range of SRKWs in 2021 (PFMC 2021b). These estimates are generally consistent with previous analyses by NMFS that suggested Klamath River Chinook salmon contributes 1-9% of the total SRKW Chinook salmon prey base when they inhabit outer coastal areas (NMFS 2019a). Within the range of Klamath Chinook salmon (SOF), Klamath Chinook salmon constitute about 11% (11.3%) of the Chinook salmon available off the coast of California and Oregon on average.

As a result, we conclude that Klamath River Chinook salmon can make up a sizeable portion of the total abundance of Chinook salmon available to SRKWs within the U.S. EEZ and coastal ocean areas throughout their range in some years. Their ocean abundance is likely at least several hundred thousand individual fish other than during years of exceptionally low abundance for Klamath River Chinook salmon. The known distributions of Chinook salmon along the coast suggest that Klamath River Chinook salmon are an increasingly significant prey source (as SRKWs move south along the U.S. West Coast) during any southerly movements of SRKWs along the coast of Oregon and California that may occur during the winter and spring (Weitkamp 2010; Bellinger et al. 2015; Shelton et al. 2018).

2.4.2.1.4 Climate Change and Environmental Factors in the Ocean

A number of environmental factors and climate change affect the availability of Chinook salmon to SRKWs. Predation in the ocean contributes to natural mortality of salmon in addition to predation in freshwater and estuarine habitats, and salmonids are prey for pelagic fishes, birds, and a wide variety of marine mammals (including SRKWs). Recent work by Chasco et al. (2017) estimated that marine mammal predation of Chinook salmon off the West Coast of North America has more than doubled over the last 40 years. They found that resident salmon-eating killer whales consume the most Chinook salmon by biomass, but harbor seals consume the most individual Chinook salmon (typically smolts). In particular, they noted that southern Chinook salmon stocks ranging south from the Columbia River have been subject to the largest increases in predation, and that SRKWs may be the most disadvantaged compared to other more northern resident killer whale populations given the northern migrations of Chinook salmon stocks in the ocean. Ultimately, Chasco et al. (2017) concluded that these increases in marine mammal predation of Chinook salmon could be masking recovery efforts for salmon stocks, and that competition with other marine mammals may be limiting the growth of the SRKW population.

Recent studies have provided evidence that growth and survival rates of salmon in the California Current off the Pacific Northwest can be linked to fluctuations in ocean conditions related to Pacific Decadal Oscillation and the El Nino-Southern Oscillation conditions and events (Peterson et al. 2006; Wells et al. 2008), as well as the recent northeast Pacific marine warming phenomenon (aka “the blob”) (Bond et al. 2015; Cavole et al. 2016). The frequency of extreme climate conditions associated with El Niño events or “blobs” are predicted to increase in the future with climate change (greenhouse forcing) (Di Lorenzo and Mantua 2016) and, therefore, it is likely that long-term anthropogenic climate change would interact with inter-annual climate variability.

Evidence suggests that early marine survival for juvenile salmon is a critical phase in their survival and development into adults. In the marine ecosystem, salmon may be affected by warmer water temperatures, increased stratification of the water column, intensity and timing changes of coastal upwelling, loss of coastal habitat due to sea level rise, ocean acidification, and changes in water quality and freshwater inputs (ISAB 2007; Mauger et al. 2015). The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on broad and local scales, provides an indication of the role they play in salmon survival in the ocean. When discussing the potential extinctions of salmon populations, Francis and Mantua (2003) point out that climate patterns would not likely be the sole cause, but could certainly increase the risk of extinction when combined with other factors, especially in ecosystems under stress from humans.

Salmon marine migration patterns could be affected by climate-induced contraction of thermally suitable habitat. Abdul-Aziz et al. (2011) modeled changes in summer thermal ranges in the open ocean for Pacific salmon under multiple Intergovernmental Panel on Climate Change (IPCC) warming scenarios. For chum, pink, coho, and sockeye salmon and steelhead, they predicted contractions in suitable marine habitat of 30-50% by the 2080s, with an even larger contraction (86-88%) for Chinook salmon under the medium and high emissions scenarios. Northward range shifts are a climate response expected in many marine species, including salmon (Cheung et al. 2015). However, salmon populations are strongly differentiated in the northward extent of their ocean migration, and hence would likely respond individualistically to widespread changes in sea surface temperature. Shelton et al. (2021) used a Bayesian state-space model to model ocean distribution of fall-run Chinook salmon stocks in the Northeast Pacific, paired with data on sea surface temperature associated with each stock and future ocean climate predictions to predict future distribution of Chinook salmon related to changing sea surface temperature in 2030-2090. In warm years (compared to cool), modeled Klamath River, Columbia River (upriver bright run, lower, middle), and Snake River stocks shifted further North, while California Central Valley stock shifted south. Predicted future shifts in distributions due to warming led to future increases in ocean salmon abundance off northern British Columbia and central California, minimal changes off Oregon, Southern British Columbia, and Alaska, and declines in abundance off Washington and northern California (Shelton et al. 2021). Such changes in salmon abundance and distributions would impact SRKW access to their prey species throughout their range.

2.4.2.1.5 Salmon Harvest Actions

NMFS has consulted on the effects of numerous salmon fishery harvest actions that may affect Chinook salmon availability in coastal waters for SRKWs. These include the Pacific Coast Salmon Plan (NMFS 2021a), other fisheries managed under the Pacific Salmon Treaty including fisheries in Alaska and Puget Sound (NMFS 2019c; NMFS 2021f) and the *United States v. Oregon* 2008 Management Agreement (term of biological opinion from 2018-2027; NMFS 2018c). In these harvest opinions, NMFS has considered the short-term effects to SRKWs resulting from reductions in Chinook salmon abundance that occur during a specified time period and the long-term effects to whales that could result if harvest affected viability of the salmon stock over time by decreasing the number of fishes that escape to spawn. These analyses suggested that short-term prey reductions were small relative to remaining prey available to the whales. In the long term, harvest actions have been designed or modified via Reasonable and Prudent Alternatives to meet the conservation objectives of harvested stocks in a manner determined not likely to appreciably reduce the survival and recovery of listed Chinook salmon and, therefore, ultimately not likely to jeopardize the continued existence of listed Chinook salmon. The harvest biological opinions referenced above that considered potential effects to SRKWs have all concluded that the harvest actions cause prey reductions, but were not likely to jeopardize the continued existence of ESA-listed Chinook salmon or SRKWs. These biological opinions have also evaluated potential effects to designated (or proposed) critical habitat for SRKWs (including prey reductions and other features as appropriate), and have concluded these harvest actions were not likely to adversely modify its designated (or proposed) critical habitat.

The most recent consultation on the Pacific Coast Salmon Plan fisheries included consideration of implementation of Amendment 21, which includes measures intended to limit the effects that the fisheries have on SRKWs by way of reduced prey availability and accessibility in years when Chinook abundance in the NOF area is particularly low (NMFS 2021a). Specifically, the proposed Amendment would establish a threshold representing a low pre-fishing Chinook salmon abundance in the NOF area (including abundance in the EEZ and state ocean waters), below which the PFMC and states would implement specific management measures. Although the abundance threshold is based on estimates of NOF abundance, actions to reduce the impact of ocean harvest on SRKWs will occur off the coast of Oregon and California where Klamath Chinook salmon are a significant source of Chinook salmon abundance.

Due to weak stock management in PFMC salmon fisheries, a relatively large portion of the overall abundance goes unharvested. The proportion that goes unharvested has been increasing over the time period 1992 – 2016 (NMFS 2021a)(Figure 19). For example, during the most recent decade available for analysis by the PFMC Workgroup (2007 to 2016),[20] average Chinook salmon reductions coastwide from the PFMC salmon fisheries (280,006 fish or a 7.0% reduction in prey) were less than the average over the entire time period (552,888 fish or 14.9%) even though average coastwide Chinook salmon abundances in these two time periods were similar (3.7 million fish on average).

[20] Models used to complete retrospective analyses of salmon fisheries such as the Fisheries Regulation Assessment Model (FRAM) require that data for each cohort (lasts up to 5 years) be complete before finalizing estimates of their abundance at previous time steps. As a result, Chinook salmon cohorts from 2016 were the most recent cohort for which the available data could be used to estimate their abundance in the ocean at each time step.

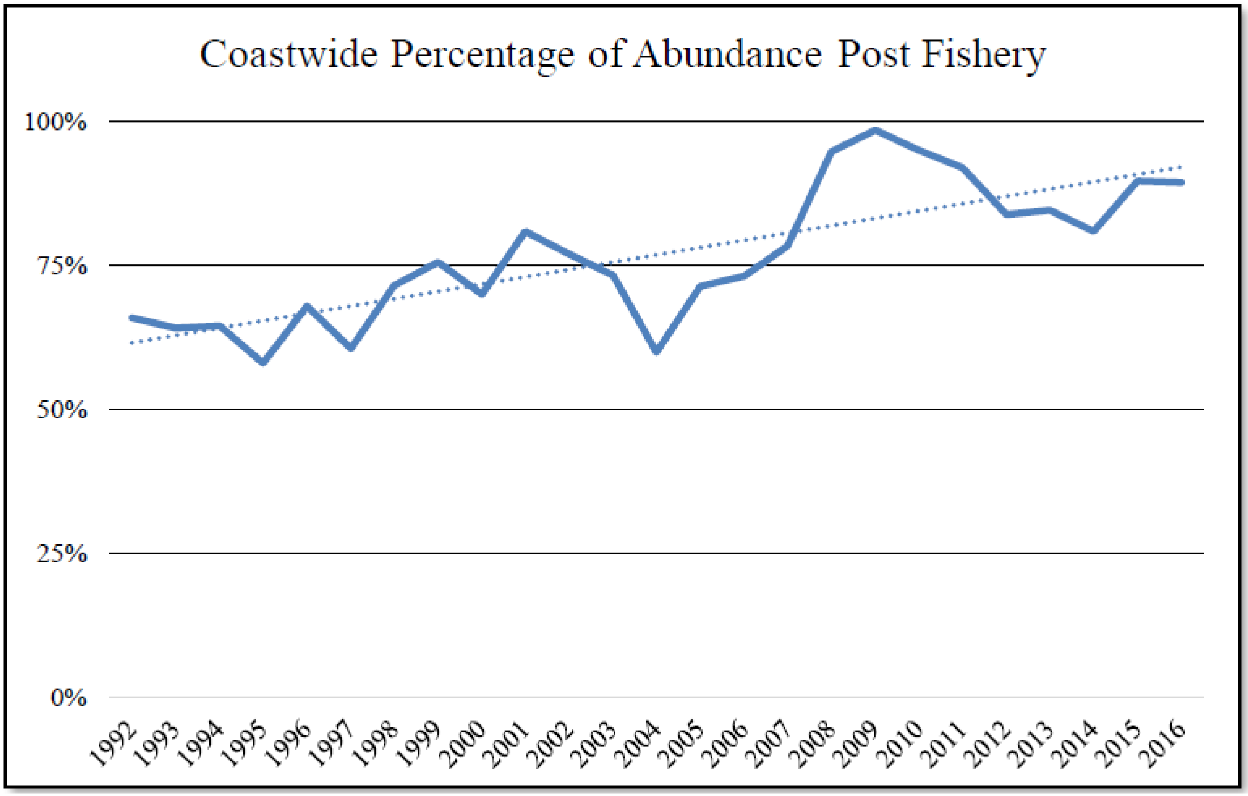

Figure 19. From NMFS (2021a) Coastwide (EEZ) 1992-2016 trend in percent of Chinook adult salmon abundance remaining after PMFC ocean salmon fisheries (from October through the following September).

Fisheries off Alaska, Canada, Washington, and Oregon are managed under the Pacific Salmon Treaty (PST). The Treaty has annex agreements that provide detailed implementation provisions that are renegotiated periodically for multi-year periods ("PST Agreement"). The 2019 – 2028 PST Agreement currently in effect includes provisions limiting harvest impacts in all Chinook salmon fisheries and refining the management of coho, sockeye, chum, and pink salmon within its scope. NMFS' (2019c) biological opinion on domestic actions related to the 2019-2028 PST Agreement assumed that the State of Alaska would manage its Southeast Alaska (SEAK) salmon fisheries consistent with the provisions of the Agreement. Percent reductions of Chinook salmon in coastal waters of WA and OR from the SEAK fisheries were expected to range from 0.2% to 12.9% (NMFS 2019c). In addition, NMFS considered the effects of new funding to increase prey availability for SRKW through hatchery production associated with implementation of the new PST Agreement, expected to result in the release of over 18 million additional hatchery-origin Chinook salmon in 2021. In the programmatic assessment of the PST funding initiative (NMFS 2019c), we described our expectations for increased prey abundance for SRKWs through increases in the abundance of age 3-5 Chinook salmon in the times and areas most important to SRKWs, included increased abundance in outside areas (coast) during the winter (Dygert et al. 2018) resulting in a minimum increase of adult fish abundance by 4-5 percent in coastal areas in the winter. More recent consultations on the coastal and Puget Sound Chinook salmon fisheries

(NMFS 2021a; NMFS 2021f) included details on how the first years of the programmatic conservation initiatives were funded and implemented.

2.4.2.1.6 Other ESA Consultations on Salmon Bycatch

PFMC Groundfish Fisheries

The groundfish fisheries in the EEZ off the U.S. West Coast are managed by NMFS and the PFMC pursuant to the Pacific Coast Groundfish FMP. PFMC groundfish fisheries catch Chinook salmon as bycatch while conducting these fisheries. Chinook salmon bycatch in the groundfish fishery ranged from 3,068 to 15,319 from 2008 to 2015 and averaged 6,806 (NMFS 2017a). Bycatch consists of primarily subadult Chinook salmon taken annually in the groundfish fisheries, which are typically age 2 and 3 year old Chinook salmon (NMFS 2017b) that are typically smaller than the preferred prey size of SRKW, which limits the risk of direct competition between the groundfish fishery and SRKWs during their foraging. In addition, the anticipated natural mortality of young salmon in the ocean reduces the impacts from bycatch of young fish in terms of how many would have ultimately survived to be available as prey for SRKWs. Previous analysis indicated that latitude was an important factor in determining expected Chinook salmon bycatch and associated stock composition (NMFS 2017a). Chinook salmon bycatch was higher when fishing at more southerly latitudes (NMFS 2016a).

NMFS SWFSC Surveys

The SWFSC is a research arm of NMFS in the southern part of the West Coast that plans, develops, and manages a multidisciplinary program of basic and applied research to inform management of the region's marine and anadromous fish and invertebrate populations to ensure they remain at sustainable and healthy levels. As part of SWFSC's comprehensive environmental compliance efforts, NMFS completed a biological opinion in 2020 that evaluated the bycatch of juvenile and sub-adult salmon in their research surveys; specifically trawl and purse seine surveys in the California Current Ecosystem (CCE) for coastal pelagic and rockfish species. In total, analysis indicated that up to 838 juvenile and 184 sub-adult Chinook salmon will be incidentally captured and killed in SWFSC survey trawls, and up to 79 juvenile Chinook will be incidentally captured and killed in SWFSC purse seine surveys, in the CCE each year (NMFS 2020b).

2.4.2.1.7 Scientific Research

Research activities on SRKWs are typically conducted between May and October in inland waters of Washington, and some permits include authorization to conduct research in coastal waters as well. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. Recent permits issued by NMFS include research to characterize the population size, structure, feeding, ecology, behavior, movement patterns and habitat use of the SRKWs, especially during the winter and spring when SRKWs are using coastal waters extensively. Impacts from permitted research include temporary disturbance and potential short term disruptions or changes in behavior such as feeding or social interactions with researchers in close proximity, and any minor injuries that may be associated with biopsy samplings or attachment of tags for tracking movements and behavior. We note that in 2016, a SRKW (L95) was found to have died of a fungal infection that may have been related to a satellite tag deployment approximately 5 weeks prior to its death (Carretta et al. 2021) and the satellite-tagging program is currently no longer operating.

2.4.2.1.8 Other Factors Affecting SRKWs in the Action Area

As described above in the SRKWs subsection of the *Rangewide Status of the Species* and *Critical Habitat* section (Section 2.2.2), SRKWs are affected by a number of activities and stresses in the marine environment, including vessel activity, anthropogenic sounds resulting from various sources, and potential exposure to oil spills. All of these potential impacts are occurring or remain constant stresses or threats to SRKWs throughout their range, including when they occur in coastal waters within the action area.

2.4.2.2 Summary of Environmental Baseline for SRKW

SRKWs and their designated critical habitat are exposed to a wide variety of human activities and environmental factors in the action area. All the activities discussed above in the SRKWs subsection of the *Rangewide Status of the Species and Critical Habitat* section (Section 2.2.2) are likely to have some level of impact on SRKWs and their designated critical habitat when they are in the action area. No single threat has been directly linked to or identified as the cause of the relative lack of growth of the SRKWs population over time, although three primary threats that have been identified are: prey availability, environmental contaminants, and vessel effects and sound (Krahn et al. 2002; NMFS 2016e). There is limited information on how these factors or additional unknown factors may be affecting SRKWs and their designated critical habitat when in coastal waters; however, the small size of the population and projected decline of the population in coming years increases the level of concern about all of these risks (NMFS 2008; NMFS 2016e). The abundance of their preferred prey (Chinook salmon) throughout the action area is reduced through activities that include ocean harvest, fisheries bycatch, and research. Environmental pressures that include freshwater habitat issues, variable ocean conditions, and predation by other species also contribute to reduced Chinook salmon availability for SRKWs. Overall, the availability of Chinook salmon as prey for SRKWs is constrained and/or affected by numerous factors that make it increasingly challenging for SRKWs to find abundant prey resources.

2.4.3 <u>Southern DPS Eulachon</u>

While the Status of Southern DPS eulachon section (Section 2.2.3.2) discussed the viability of the eulachon DPS as a whole, this section will focus on the condition of the Southern DPS

Pacific eulachon and their critical habitat in the action area, and factors affecting their condition within the action area.

2.4.3.1 Status of Eulachon in the Action Area

Historically, large aggregations of eulachon were reported to have consistently spawned in the Klamath River. Allen et al. (2006) indicated that eulachon usually spawn no further south than the lower Klamath River and Humboldt Bay tributaries. The California Academy of Sciences ichthyology collection database lists eulachon specimens collected from the Klamath River in February 1916 and March of 1947 and 1963, and in Redwood Creek in February 1955 (see http://research.calacademy.org/research/Ichthyology/collection/index.asp). During spawning, fish were regularly caught from the mouth of the river upstream to Brooks Riffle, near the confluence with Omogar Creek (Larson and Belchik 1998) indicating that this area contains the spawning and incubation, and migration corridor PBFs.

Historically, the Klamath River was described as the southern limit of the range of eulachon (Hubbs 1925; Schultz and Delacy 1935). Other accounts have described large spawning aggregations of eulachon occurring regularly in the Klamath River (Fry 1979; Moyle et al. 1995; Larson and Belchik 1998; Moyle 2002; Hamilton et al. 2005) occasionally in the Mad River (Moyle et al. 1995; Moyle 2002), and Redwood Creek (Ridenhour and Hofstra 1994; Moyle et al. 1995). In addition, small numbers of eulachon have been reported from the Smith River (Moyle 2002). The only reported commercial catch of eulachon in Northern California occurred in 1963 when a combined total of 25 metric tons (56,000 lbs.) was landed from the Klamath River, the Mad River, and Redwood Creek (Odemar 1964). Since 1963, the run size has declined to the point that only a few individual fish have been caught in recent years. Despite records of large runs in the past for eulachon, recent sporadic surveys have shown a decline in population. Without an active fishery or consistent broad-range population surveys, it is unknown what the true number of fish are that spawn in the Klamath River currently. Moyle (2002) indicates that eulachon have been scarce in the Klamath River since the 1970s, with the exception of three years: they were plentiful in 1988 and moderately abundant again in 1989 and 1998. After 1998, they were thought to be extinct in the Klamath Basin, until a small run was observed in the estuary in 2004. According to accounts of Yurok Tribal elders, the last noticeable runs of eulachon were observed in the Klamath River in 1988 and 1989 by Tribal fishers (Larson and Belchik 1998). However, in January 2007, six eulachon were reportedly caught by tribal fishers on the Klamath River. Larson and Belchik (1998) report that eulachon have not been commercially important in the Klamath River. With funding from NMFS, the Yurok Tribal fisheries biologists surveyed for eulachon in the lower Klamath River and found only two eulachon (tribal fishermen caught another five) in early 2011 and 40 in 2012 (YTFP 2011; YTFP 2012). Reports from Yurok tribal fisheries biologists also report capturing adult eulachon in presence/absence surveys (seine/dip nets) in the Klamath River in 2013 (112 eulachon), and 2014 (1,000 eulachon) (Robert Anderson, NMFS, personal communication[21]). Surveys for presence/absence using eDNA were conducted in 2020 and have yet to be analyzed, but according to tribal fishers, few fish have been observed recently (Barry McCovey Jr., Yurok

[21] Email from Robert Anderson (NMFS) to Heather Wiedenhoft (NMFS), September 9, 2021

Senior Fisheries Biologist, personal communication[22]). Based on the available information, NMFS concludes that the current run size in the Klamath River is very small relative to the number of eulachons in the DPS.

2.4.3.2 Eulachon Critical Habitat in the Action Area

In the Klamath River, critical habitat is designated from the mouth of the Klamath River upstream to the confluence with Omogar Creek at approximately RM 10.5; however, critical habitat does not include any tribal lands of the Yurok Tribe or the Resighini Rancheria (76 FR 65324, October 20, 2011, codified at 50 CFR 226.222). Lands of the Resighini Rancheria overlap with approximately 0.5 km (0.3 mi), or 3 percent, of the areas occupied by eulachon in the Klamath River. The boundaries of the Yurok Indian Reservation encompass the entire 17.5 km (10.9 mi) of the areas occupied by eulachon in the Klamath River. However, land ownership within the reservation boundary includes a mixture of Federal, state, Tribal, and private ownerships. Exclusion from critical habitat designation only applies to Native- owned lands (76 FR 65324, 65344-45, October 20, 2011).

The action area includes all three PBFs of eulachon critical habitat: (1) freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, (2) freshwater and estuarine migration corridors free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted, and (3) nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival.

All three PBFs do not appear to be limited in the lower Klamath River and nearshore marine area. The lands surrounding the lower Klamath River have remained mostly undeveloped over the years, and the relatively intact estuary is unique among rivers in the U.S., and a main reason it is considered to be restorable. Eulachon rely on the estuary for both migration and feeding. Lower river temperatures have remained relatively stable, and a safe and unobstructed migration corridor exists for adults to pass from estuarine to riverine habitats in order to spawn, and for larval eulachon to migrate downstream from freshwater spawning habitats.

2.4.3.3 Factors Affecting Eulachon and Their Critical Habitat in the Action Area

In the absence of any consistent targeted surveys or fisheries for the Klamath River, very little is known about the presence or populations of Pacific eulachon within the action area. The presence of suitable spawning habitat in the Lower Klamath River does not seem to be limited; therefore, the strength of their runs may be strongly dependent on the influence of climate change and/or harvest.

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[22] Email from Barry McCovey Jr., (Yurok Senior Fisheries Biologist) to Heather Wiedenhoft (NMFS) September 16, 2021.

Fisheries

There are currently no harvest regulations for eulachon in the Klamath River. However, eulachon abundance has declined so dramatically that there is little fishing effort for eulachon in the Klamath River. Limited eulachon fishing is conducted mostly by the Yurok Tribe in the lower Klamath River.

Climate Change

Bartholow (2005) found that the Klamath River is increasing in water temperature by 0.5°C/decade, which may be related to warming trends in the region. Because eulachon spawning normally occurs when water temperature is between 39º and 50º F, water temperature increases in the Klamath River during the late winter/early spring due to future effects of global warming could reduce eulachon spawning habitat in the lower Klamath River. However, because spawning occurs over a wide range of temperatures and the lower river generally maintains cool ambient temperatures offered by the marine layer of the coastal zone, especially during the time of year when eulachon are likely to be in the Klamath River, eulachon are not anticipated to be affected by any associated decrease in habitat in the action area.

ESA Section 7 Consultations on Eulachon in the Action Area

Since the Southern DPS of eulachon was listed in 2010, only one formal ESA section 7 consultation has been completed in the action area on the effects of a proposed action on eulachon, which was a biological opinion on the Yurok Tribe's eulachon survey. Information on the 2011 survey effort resulted in a total of two adult eulachon captured by the Tribe, while an additional five adult eulachon were donated to the Tribe by tribal fishermen. In 2012, the Tribe caught 40 adults, all in the month of February (YTFP 2012).

2.5 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action (see 50 CFR 402.02). A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.17). In our analysis, which describes the effects of the proposed action, we considered the factors set forth in 50 CFR 402.17(a) and (b).

As described in the Analytical Approach section, NMFS first organizes the effects analyses using a stressor identification - exposure – response – risk assessment framework. In addition, NMFS also analyzes the anticipated beneficial effects to listed resources. In the Integration and Synthesis section, we integrate information presented in the Status of the Species and Environmental Baseline sections with the results of our effects analyses to estimate the probable risks the proposed action poses to listed species and designated critical habitat. We note that our effects analysis is based on the best available scientific and commercial information.

The proposed action will have impacts on aquatic organisms and their habitat. In this section we describe both short term and long term impacts as well as the anticipated beneficial effects. For the purposes of our analysis, we define short term effects as those persisting for less than two years. Long-impacts are those persisting for two years or more. In the SRKW analysis below, we also differentiate long term impacts into mid-term and long term impacts. See that analysis for details on mid-term impacts

2.5.1 SONCC coho salmon

In this analysis we first describe all the actions that may impact listed coho salmon as a result of implementing the proposed action. Although these identified potential stressors could impact coho salmon, coho salmon may not be exposed to the potential stressors. When coho salmon are likely to be exposed, we move forward with the analysis to determine the risk to individuals. Below, is a list of potential stressors and benefits associated with the proposed action that may impact individual coho salmon:

Potential stressors include:

- Toxicity from chemical spills;
- Toxicity from sediment contaminants;
- Toxicity from herbicide and adjuvant use to control weeds in the reservoir areas;
- Sound pressure waves from blasting and associated demolition activities;
- Reduction in spawning habitat;
- Reduction in rearing habitat (e.g., substrate and space, food resources, water temperature; and dissolved oxygen);
- Reduction in migration habitat;
- Increase in suspended sediment concentrations from reservoir drawdown and in-water construction activities;
- Sediment deposition in the mainstem;
- Injury or mortality from demolition activities;
- Injury or mortality from juvenile fish trapping and relocation activities.

Potential beneficial effects include:

- Increased flow variability,
- Decreased disease rates,
- Restoration of the water temperature regime,

- Increased dissolved oxygen concentration,
- Reduced toxic blue-green algal blooms,
- Increased large wood recruitment,
- Increased sediment transport,
- Restored access to historic migratory, rearing and spawning habitat.

2.5.1.1 Effects to Coho Salmon

In our Effects of the Action section, we define short term effects as those persisting for less than two years. Long term impacts are those persisting for two years or more. Reservoir drawdown and construction-related activities associated with dam removal are expected to result in mortality of coho salmon in the short term. Restoration actions will begin in the year dam removal occurs and minimization measures will be implemented by the Renewal Corporation as described in the BA (FERC 2021a) and appended management plans. The restoration actions and minimization measures are expected to limit the level of mortality. Effects associated with reservoir drawdown (i.e., SSC and dissolved oxygen impacts) will affect all populations of SONCC coho salmon that utilize the Klamath River during some portion of their life history cycle, while the other short-term effects associated with dam removal, construction, and restoration will primarily be limited to individuals from the Upper Klamath population. Therefore, the proposed action is likely to adversely affect coho salmon from the Upper Klamath River, Shasta River, Scott River, Middle Klamath River, Salmon River, Lower Klamath River, Upper Trinity River, Lower Trinity River, and South Fork Trinity River population units in the short term. In addition, capture and relocation of coho salmon from the Upper Klamath River, Shasta River, Scott River, and Middle Klamath River populations is expected to have adverse effects in the short term prior to and during drawdown. In the long term, monitoring and restoration actions in the hydroelectric reach is expected to require some capture and relocation of individuals from the Upper Klamath River population, resulting in adverse impacts. Specific effects are described below. For the purposes of the effect's analysis, the three SONCC coho salmon populations that are present in the Trinity River basin will be grouped together as "Trinity Populations", since each population will have the same exposure to the effects of the proposed action. The Trinity River populations will be exposed only in the mainstem Klamath River during migration.

2.5.1.1.1 Blasting and Associated Demolition

The Renewal Corporation will begin out-of-water demolition at Iron Gate to remove the powerhouse, penstock, and remaining fish facilities in April of the drawdown year, and these activities will be completed by the end of August of the drawdown year. Blasting might be required to remove the fish-holding ponds at the base of the dam. If blasting is required at this location, it will likely occur in August, and take approximately 2 weeks to complete. This work is expected to take place in the dry, and, therefore, no coho salmon will be present in the blasting areas. However, noise and vibration from demolition and blasting activities have the potential to affect life stages of coho salmon present in or near the vicinity of Iron Gate Dam. During the in-water construction window at Iron Gate Dam and during blasting activities, coho salmon are not expected to be present in aquatic habitat near the dam due to high water temperatures, low dissolved oxygen, and elevated SSCs that are expected to occur immediately downstream of the dam. Additionally, the Renewal Corporation will place block nets to ensure fish are excluded from aquatic habitat near the work site. NMFS expects all life stages of coho salmon to avoid or otherwise be excluded from the immediate areas surrounding construction and any impacts of blasting. Therefore, coho salmon will not be exposed to impacts of blasting activities.

2.5.1.1.2 Effects of Chemical Spills

Use of heavy equipment in and around the waterway and removal of concrete and other materials from the existing dams increase the potential for contaminants to enter fish habitat. Accidental releases of fuels, lubricants and other construction-related chemicals from equipment or hazardous materials in the dam structure could negatively affect water quality, fish health, and fish habitat. Contaminants reduce salmon reproductive capacity, growth rates, and resistance to disease, and may lead to lower survival for salmon (Arkoosh et al. 1998a; Arkoosh et al. 1998b).

The proposed BMPs (described in FERC (2021a), Appendix C: Best Management Practices) include maintaining all fuel storage and refueling sites in an upland location well away from the stream channel; ensuring vehicles and construction equipment are in good working condition, and show no signs of fuel or oil leaks; and servicing equipment in an upland location. Furthermore, equipment entering the stream will be checked for leaks prior to moving to the instream landing pad. NMFS anticipates that proposed minimization measures and human responses to any accidental spill of toxic materials should be sufficient to restrict the effects to the immediate area and not enter the waterway. Because of these minimization measures, the likelihood of listed species being exposed to chemical spills is improbable.

2.5.1.1.3 Effects of Contaminants in Sediment

The proposed action may cause short-term (<2 years following dam removal) and long-term (2 to 50 years following dam removal) degradation of the water quality as a result of mobilizing organic and inorganic contaminants in the sediment behind the four dam facilities. Sediment chemistry data on 26 cores in J.C. Boyle, Copco 1, and Iron Gate reservoirs collected in 2004 and 2005 indicate generally low levels of metals, pesticides, chlorinated acid herbicides, polycholorinated bi-phenols, volatile organic compounds, semi-volatile organic compounds, cyanide, and dioxins (Shannon & Wilson Inc. 2006; DOI and CDFG 2012). Collection of additional sediment cores in 2009 to 2010 indicated no positive exceedances of applicable screening levels for those contaminants, which suggests a low risk of toxicity to freshwater sediment-dwelling organisms in the lower Klamath River.

Except for a small number of sediment samples from J.C. Boyle Reservoir, there were no positive exceedances of the applicable and available maximum marine screening levels (CDM 2011). Sediment samples from J.C. Boyle Reservoir exceeded the applicable marine screening level for dieldrin, a banned insecticide, and 2,3,4,7,8,-PECDF, an environmental contaminant (CDM 2011). The marine screening levels are designed to be protective of direct toxicity to benthic and epibenthic organisms. Therefore, the majority of 2009 to 2010 samples indicate a low risk of toxicity to sediment-dwelling organisms. The small area of sediment that exceeded the marine screening level for dieldrin and 2,3,4,7,8,-PECDF are expected to be dispersed over a wide area during sediment release and transit through the Klamath River estuarine and/or marine nearshore environment, exposing downstream coho salmon and their prey to an average water column concentration rather than a reservoir- or site-specific concentration.

Regarding bioaccumulation potential, there were no exceedances of applicable marine bioaccumulation screening levels (CDM 2011). Further, with the exception of four samples in J.C. Boyle Reservoir (CDM 2011) levels of other known bioaccumulative compounds did not exceed ODEQ bioaccumulation screening levels for marine fish. While ODEQ bioaccumulatory screening levels are not necessarily applicable in the California marine offshore environment, they are indicative of potentially bioaccumulative compounds. As with the dieldrin and 2,3,4,7,8,-PECDF, the relatively small samples that exceeded the bioaccumulation screening levels would be dispersed and diluted upon release towards the Klamath River estuary and are expected to be negligible.

The proposed action's potential effects of contaminants in sediments released during dam removal activities are anticipated to be negligible due to the very low levels of contaminants in the reservoir sediments, low bioaccumulation potential, and the dilution effects of the river and ocean.

2.5.1.1.4 Reduced Food Resources

Food resources for coho salmon are expected to be impacted during drawdown due to elevated SSCs as described in Section 2.5.1.2.3. Food resources may be impacted downstream as far as Orleans (about 134 miles downstream of Iron Gate) (FERC 2021a), affecting juvenile coho salmon from the Upper Klamath, Shasta, Scott, and Mid-Klamath populations. Only juveniles that rear in the mainstem during the winter or utilize the mainstem during outmigration in the spring may be exposed to conditions with fewer prey sources. However, elevated SSCs are expected to impact only benthic macroinvertebrates (BMI) during their feeding and reproductive period in the spring and summer. During the winter, when SSCs are the most elevated, BMI will be in a dormant phase. Juvenile coho salmon feed primarily on drifting terrestrial insects, many of which are produced in the riparian canopy, and on aquatic invertebrates growing in the interstices of the channel bed and in the leaf litter in pools (Hetrick et al. 1998). BMI are expected to recolonize quickly (weeks to months) due to their short life cycles and rapid dispersal through drift or dispersal of adult life stages (FERC 2021a). Therefore, NMFS expects any impacts to juvenile coho salmon in the mainstem due to reduced food resources would be negligible.

2.5.1.1.5 Construction of Fall Creek Hatchery (FCH):

The Renewal Corporation will complete construction of the FCH prior to dam removal when no coho salmon are present in the construction zone or affected area. However, the presence of

Dam A, Dam B, and a seasonal weir could impact coho salmon in the years post dam removal when they presumably will repopulate Fall Creek. Dam A is located on an artificial waterway (the tailrace channel) and prevents fish from becoming entrained in the City of Yreka's water intake. Dam B is located just downstream of the impassable Fall Creek waterfall and only excludes fish from a short length of habitat that is high gradient and consists of large boulder substrate. The picket weir will only be in place during the adult migration period to guide adult fish into the hatchery. The spacing of the pickets is such to allow juvenile fish to pass upstream or downstream. Because these barriers will not exclude fish from suitable spawning, rearing, or migratory habitat, NMFS believes any impacts to individual coho salmon from the barriers will be negligible.

In addition, the City of Yreka water supply pipeline will be replaced under the Klamath River near Fall Creek, which will occur prior to drawdown. The pipeline will be buried deep enough that we do not anticipate future high flows in the river to scour down to it and expose it. Coho salmon will not experience any effects of the pipeline installation or future presence. Any sediment from installation that is suspended downstream will settle out in the reservoir prior to reaching Iron Gate Dam and will not increase sediment related effects to coho salmon during and after reservoir drawdown by more than a negligible amount.

2.5.1.1.6 Effects of In-water Construction Activities that Support Dam Removal

In-water construction activities that have the potential to affect coho salmon include pre-drawdown construction on the downstream side of Iron Gate Dam and at Lakeview Road Bridge. Following drawdown, dam removal construction activities that have the potential to affect coho salmon include demolition activities associated with removal of Iron Gate Dam facilities; embankment removal, disposal, final cofferdam breach, and final channel grading. Dam removal activities will conclude with the creation of a volitional fish passage channel at each dam site, allowing fish to access and use the historical habitat upstream of each dam. In-water construction activities that may impact coho salmon are described below:

Pre-Dam Removal

- Construction of an access road from the right bank across to the fish collection facilities could kill or injure coho salmon and cause short-term increased SSCs downstream of Iron Gate Dam.

- Construction of a temporary bridge adjacent to Lakeview Road could kill or injure coho salmon and cause short- term increased SSCs downstream of Iron Gate Dam.

- Construction of a fire access ramp near Lakeview Road Bridge could kill or injure coho salmon and cause short-term increased SSCs downstream of Lakeview Road Bridge.

- Installation of tunnel outlet erosion protection measures (e.g., armoring the existing left bank access road) could kill or injure coho salmon and cause short-term increased SSCs downstream of Iron Gate Dam.

- Removal of temporary access roads could kill or injure coho salmon and cause short-term increased SSCs downstream of Iron Gate Dam.

Dam Removal

- The filling of Iron Gate Dam tailrace with concrete rubble and rock could kill or injure coho salmon and cause short-term increased SSCs downstream of Iron Gate Dam.

- Embankment removal, disposal, and cofferdam breach could kill or injure coho salmon and cause short-term increased SSCs downstream of Iron Gate Dam.

- Volitional fish passage channel grading could kill or injure coho salmon and cause short-term increased SSCs downstream of Iron Gate Dam.

2.5.1.1.6.1 Exposure

The pre-drawdown construction, including the placement of the temporary road, work pads, fire access ramp, and Lakeview Road bridge will occur during the months of July and August. During this time water temperatures frequently exceed 22ºC and dissolved oxygen levels are close to zero immediately downstream of Iron Gate Dam. Additionally, The Renewal Corporation will remove any fish in the work zone and maintain exclusion barriers to prevent direct harm. During the winter when the access road and work pads are decommissioned, dissolved oxygen levels remain low, water velocities do not support juvenile rearing, and adult fish are expected to be in tributaries such as Bogus Creek or further downstream where spawning gravels are not so armored. Therefore, NMFS does not expect coho salmon to be exposed to impacts associated with pre-drawdown construction.

Following the completion of drawdown, activities necessary to remove Iron Gate Dam and associated infrastructure will take place primarily between March 15 and October 15 of the drawdown year. During a ten day period between August and September, the tailrace is scheduled to be filled with rock. During this period, coho salmon are not expected to be exposed to impacts as water quality in the work area and immediately downstream remains unsuitable (> 22ºC). The final cofferdam breach and channel grading is expected to occur around Oct 1st and take about two weeks to complete. During this period NMFS expects juvenile and adult coho salmon from the Upper Klamath River population to be exposed to elevated SSCs as a result of the instream construction. NMFS does not expect redds to have been constructed prior to the final breach. USFWS has only detected redds in late November through late December in the mainstem Klamath River (USFWS 2021, unpublished data). Furthermore, adult coho salmon are expected to avoid redd construction in the disturbed mainstem reach immediately downstream of the Iron Gate Dam site and enter nearby tributaries or migrate upstream of the dam site. Therefore, eggs will not be exposed to impacts of the final breach.

2.5.1.1.6.2 Response

Excessive suspended sediment can have lethal, sublethal (i.e., physiologic), and behavioral effects to salmonids (Newcombe and MacDonald 1991; Bash et al. 2001; Kemp et al. 2011). Sublethal effects may include gill trauma, osmotic imbalance, and increased stress (i.e., increased plasma cortisol concentrations). According to Newcombe and Jensen (1996), adverse effects will result from exposure duration to high suspended sediment concentration to fish that could not leave the area (i.e., based on fish in lab studies). If fish could leave the area, the actual effect of suspended sediment on salmonids is difficult to predict, but is likely to be less than modeled results because fish tend to avoid high suspended sediment concentrations (Newcombe and Jensen 1996). Salmonid tolerance to suspended sediment varies with environmental factors, such as sediment particle characteristics (Lake and Hinch 1999), water temperature (Servizi and Martens 1991) and other stressors that might have synergistic effects (Bash et al. 2001).

In a summary of literature reporting effects of suspended sediment on salmonids, Lloyd (1987) reports several studies that document stress at 300 mg/L (McLeay et al. 1984) and 50 mg/L (McLeay et al. 1987). Redding et al. (1987) found that juvenile coho salmon showed signs of stress at high levels of suspended sediment (2000-3000 mg/L), but not at low levels (400 to 600 mg/L). Servizi and Martens (1991) found that at 18°C, 8100 mg/L was the concentration where 50 percent of the exposed coho salmon juveniles died.

Behavioral effects resulting from elevated suspended sediment include alarm reactions, avoidance, and reduced feeding. Cederholm and Reid (1987) found that juvenile coho salmon prefer low to medium concentrations of suspended sediment, and that juvenile coho salmon prey capture success significantly declined at concentrations of 100 to 400 mg/l. Salmonids have been observed to prefer clear over turbid water (Bisson and Bilby 1982), and move vertically near the water surface (Servizi and Martens 1992) and/or downstream to avoid turbid areas (McLeay et al. 1984; McLeay et al. 1987). More than six weeks of exposure to concentrations of 100 mg/L reduces feeding success, reduces growth, causes avoidance, and displaces individuals (Spence et al. 1996).

2.5.1.1.6.3 Risk to Individuals

The cofferdam breach and final channel grading is timed near the end of the migration period for adult coho salmon in the Upper Klamath River population. While likely to be in low numbers, any adults present will experience periods of elevated SSCs. Similarly, a small number a mainstem-rearing juvenile salmon are likely to experience impacts of elevated SSCs from the final cofferdam breach and channel grading. Although NMFS expects SSCs will be significantly elevated compared to seasonal background levels, NMFS does not expect lethal impacts to juvenile or adult coho salmon. The number of individuals likely to be exposed will be few, and exposure duration will be short (<14 days) for both juvenile and adult coho salmon. Additionally, we expect that both juvenile and adult coho salmon will be able to avoid the most severe impacts by seeking refuge in clear water tributaries. Therefore, effects of in-water construction are expected to be small, resulting in avoidance behavior of adult and juvenile coho salmon if they are exposed to elevated SSCs.

2.5.1.1.7 Effects of Increased Suspended Sediment

The proposed action is anticipated to release 1.2 to 2.9 million metric tons of fine sediment stored in the reservoirs into the Klamath River downstream of Iron Gate Dam (Reclamation 2011b), resulting in higher SSCs than normally occur under background conditions (Figure 20). From the beginning of drawdown on January 1 through October 1 of Year 2, SSCs will 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. The drawdown of Copco Lake will begin on November 1 of the year before drawdown, in advance of the drawdown of the J.C. Boyle and Iron Gate reservoirs, which are expected to commence on January 1 of the drawdown year (Year 1). Drawdown of Copco Lake is not expected to increase SSCs in the mainstem Klamath River downstream of Iron Gate Dam due to settling of those suspended sediments in Iron Gate Reservoir. Based on the suspended sediment modeling conducted to analyze background conditions and the proposed action (Appendix I of FERC 2021a) SSCs are expected to exceed 1,000 mg/L for approximately 8 weeks in early Year 1, with the potential for peak concentrations exceeding 5,000 mg/L for several days to up to 2 weeks, depending on the water year. The transport of the suspended sediment load is expected to have lethal and sublethal effects on coho salmon and other native fish species inhabiting the Klamath River in the Hydroelectric Reach and downstream of Iron Gate Dam as described in greater detail below.

Impacts to coho salmon related to suspended sediment are highly dependent on the water year type. Elevated SSCs will occur with higher flow events. Therefore, we look at exposure to individuals based on when each life stage is present in the action area and when a flow event may result in elevated SSCs that may impact exposed fish. We describe in the Approach to Analysis Section an identified “median impact year” and a “severe impact year”. In this effects section, we will present both scenarios side by side. Figure 20 illustrates elevated SSCs for both the median impact and severe impact year.

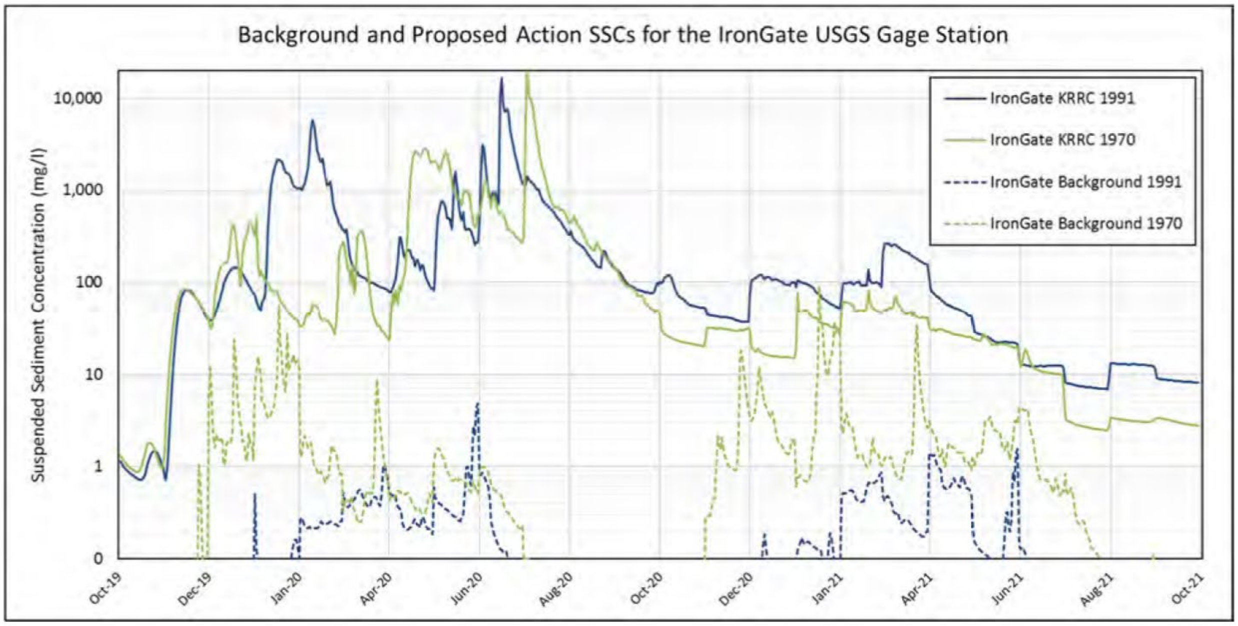

Figure 20. Comparison of modeled daily SSCs at the Iron Gate Station for coho salmon median impact year (1991) and severe impact year (1970) scenarios under background conditions and the proposed action (Appendix I of FERC 2021a).

2.5.1.1.7.1 Exposure

All populations of coho salmon in the Klamath Basin have the potential to be exposed to elevated SSC during project implementation. All populations use the mainstem Klamath River as a migratory corridor during both the adult life stage and outmigrating smolt life stage. Additionally, some juvenile (i.e., young-of-year, subyearling, yearling) individuals from each population will use the mainstem for over-summer and over-winter rearing, although the proportion of populations using the mainstem for rearing varies (further described in the Environmental Baseline, Juvenile Rearing Habitat Section 2.4.1.1.15.3). Because elevated SSC levels are expected throughout the mainstem Klamath River in both year 1 (drawdown) and year 2 (dam removal), all individuals utilizing the mainstem will be exposed to sediment impacts. Populations closest to the Iron Gate dam site will be exposed to the longest duration and highest concentration, while populations furthest away such as the Lower Klamath River will be only minimally exposed. NMFS does not expect coho salmon to be adversely impacted by elevated SSCs once they enter the ocean. Suspended sediment that does reach the estuary will primarily settle at the mouth of the Klamath River with any remaining plume dissipating rapidly in the ocean (DOI and CDFG 2012; Appendix K of FERC 2021a). Table 15 summarizes the potential exposure of each population and year class to SSCs related to the proposed action. Additionally, to understand the response to elevated SSC, duration of the exposure to elevated SSCs must be estimated. Estimates for exposure duration for each life stage of coho salmon (Table 16) have been provided by the Renewal Corporation based on their modeling results and after a thorough literature review (FERC 2021a).

Adult coho salmon are expected to enter the action area and be exposed to elevated SSCs as a result of the proposed action. Upstream migration in the mainstem Klamath River occurs between September and January. On average, only around four percent of adult coho salmon remain in the mainstem after January 1st when drawdown is scheduled to begin (DOI and CDFG 2012). In most years all adult coho salmon have entered tributaries prior to December 15.

A small number of coho salmon (e.g., fewer than 10) from the Upper Klamath River population, spawn in the mainstem Klamath River (USFWS 2021, unpublished data), and thus a relatively small number of embryos and fry are expected to be present in the mainstem during year one (drawdown year). After removal of the dams, coho salmon may still spawn downstream of the Iron Gate Dam site; however, adults are likely to migrate upstream of the dam site or into nearby tributaries because the habitat immediately downstream of Iron Gate Dam will likely be unsuitable for spawning for one to two years after removing Iron Gate Dam due to the predicted level of aggradation described below in Section 2.5.1.1.9.

Juveniles may rear in the mainstem throughout the year, and consist of sub-yearlings (0+) and yearlings (1+). Juvenile coho salmon have been observed residing within the mainstem Klamath River downstream of Iron Gate Dam throughout the summer and early fall in thermal refugia during periods of high ambient water temperatures (>22 °C). Sub-yearling juveniles may be present in the mainstem from the time they leave the tributaries to the following winter. However, most juveniles from the tributaries are assumed to rear in the tributaries. A small number of sub-yearling juveniles that successfully emerged from mainstem redds will be present in the mainstem until they redistribute in the fall. The Renewal Corporation modeled suspended sediment concentrations associated with reservoir drawdown using trap data, run timing, and location information to estimate exposure and potential risk to rearing 0+, rearing 1+, and outmigrating 1+ smolt coho salmon (Appendix H of FERC 2021a). Because coho salmon have complex life history strategies, we cannot predict with certainty the timing of exposure. Spring and seasonal redistribution of 0+ juveniles and outmigration is timed based on a variety of environmental cues. For example, the outmigration period may start in February and last into June. However, no individual fish spends that entire period of time in the mainstem. The Renewal Corporation evaluated effects to fish based on a standard exposure period for each life history period that was defined based on a thorough literature review including data from local PIT tag studies in the Klamath River (FERC 2021a)(Table 16).

Coho salmon smolts (1+ yearlings) are expected to migrate to the ocean beginning in late February, although most natural origin smolts outmigrate to the mainstem Klamath during April and May (Wallace 2003). Courter et al. (2008), using USFWS and CDFG migrant trapping data from 1997 to 2006 in tributaries upstream of and including Seiad Creek (e.g., Horse Creek, Seiad Creek, Shasta River, and Scott River), reported that 44 percent of coho salmon smolts were trapped from February 15 to March 31, and 56 percent from April 1 through the end of June.

Table 15. Summary of potential exposure of each coho salmon life stage, and populations to suspended sediments related to the proposed action

Life Stage	Populations Exposed	General Period of Exposure
Year One		
Adults	All Populations	Sept 1 – Jan 1
Embryos to pre-emergent fry	Upper Klamath	Nov 1 – Mar 14
Sub yearling (0+) summer mainstem rearing juveniles	All Populations	Mar 15 – Nov 14
Yearling (1+) winter mainstem rearing juveniles	All Populations	Nov 15 – Feb 14
Outmigrant smolts (1+)	All Populations	Feb 15 – Jun 30
Year Two		
Adults	All Populations	Sept 1 – Jan 1
Embryos to pre-emergent fry	Upper Klamath	Nov 1 – Mar 14
Sub yearling (0+) summer mainstem rearing juveniles	All Populations	Mar 15 – Nov 14
Yearling (1+) winter mainstem rearing juveniles	All Populations	Nov 15 – Feb 14
Outmigrant smolts (1+)	All Populations	Feb 15 – Jun 30

Table 16. Coho salmon period of use by life stage, date, and exposure duration in the mainstem Klamath River (FERC 2021a)

Period of Use	Life Stage	Date Window	Duration
Upstream Migration	Adults	9/1 – 1/1	14 days
Spawning and Incubation	Embryos, pre-emergent fry	11/1 – 3/14	60 days
Summer Rearing	Age 0+ juveniles	3/15 – 11/14	20 days
Winter Rearing	Age 1+ juveniles	11/15 – 2/14	20 days
Spring Outmigration	Age 1+ juveniles	2/15 – 6/30	14 days

2.5.1.1.7.2 Response

Excessive suspended sediment can have lethal, sublethal (i.e., physiologic), and behavioral effects to salmonids (Newcombe and MacDonald 1991; Bash et al. 2001; Kemp et al. 2011). Sublethal effects may include gill trauma, osmotic imbalance, and increased stress (i.e., increased plasma cortisol concentrations). According to Newcombe and Jensen (1996), adverse effects will result from exposure duration to high suspended sediment concentration to fish that could not leave the area (i.e., based on fish in lab studies). If fish could leave the area, the actual effect of suspended sediment on salmonids is difficult to predict, but is likely to be less than modeled results because fish tend to avoid high suspended sediment concentrations (Newcombe and Jensen 1996). Salmonid tolerance to suspended sediment varies with environmental factors, such as sediment particle characteristics (Lake and Hinch 1999), water temperature (Servizi and Martens 1991) and other stressors that might have synergistic effects (Bash et al. 2001).

In a summary of literature reporting effects of suspended sediment on salmonids, Lloyd (1987) reports several studies that document stress at 300 mg/L (McLeay et al. 1984) and 50 mg/L (McLeay et al. 1987). Redding et al. (1987) found that juvenile coho salmon showed signs of stress at high levels of suspended sediment (2000-3000 mg/L), but not at low levels (400 to 600 mg/L). Servizi and Martens (1991) found that at 18°C, 8100 mg/L was the concentration where 50 percent of the exposed coho salmon juveniles died.

Behavioral effects resulting from elevated suspended sediment include alarm reactions, avoidance, and reduced feeding. Cederholm and Reid (1987) found that juvenile coho salmon prefer low to medium concentrations of suspended sediment, and that juvenile coho salmon prey capture success significantly declined at concentrations of 100 to 400 mg/l. Salmonids have been observed to prefer clear over turbid water (Bisson and Bilby 1982), and move vertically near the water surface (Servizi and Martens 1992) and/or downstream to avoid turbid areas (McLeay et al. 1984; McLeay et al. 1987). More than six weeks of exposure to concentrations of 100 mg/L reduces feeding success, reduces growth, causes avoidance, and displaces individuals (Spence et al. 1996).

Eggs deposited with a high percentage of fine sediment have lower survival to emergence because of decreased dissolved oxygen and water exchange and buried fry (Spence et al. 1996; Suttle et al. 2004). Large amounts of sediments may clog the preferred spawning substrate interstices and diminish intragravel flows, thereby reducing the delivery of dissolved oxygen and resulting in an increase in ammonia levels (Hetrick et al. 1998). Embryos and alevins need high levels of oxygen to survive (Spence et al. 1996). McHenry et al. (1994) found excessive amounts of fine sediments resulted in intragravel mortality for coho salmon embryos because of oxygen stress. Fine sediments may also act as a physical barrier to fry emergence (Phillips 1965 in Cederholm and Reid 1987). Through a literature review, Kondolf (2000) found that redds with over 30 percent fines (<6.4 mm) reduced salmonid emergence and survival by 50 percent.

Suspended sediment contributes to turbidity, which also can have adverse effects if excessive. Bisson and Bilby (1982) found that juvenile coho salmon avoided water with turbidities of 70 Nephelometric Turbidity Units (NTU). Sigler et al. (1984) found a significant difference in growth rate of coho salmon reared in clear versus turbid water. A minimum of 25 NTU of turbidity was enough to reduce coho salmon growth (Sigler et al. 1984). Berg and Northcote (1985) found that dominance hierarchies broke down, territories were not defended and gill flaring occurred more frequently when coho salmon were exposed to turbidities from 30 to 60 NTU. They also found that reaction distance to brine shrimp, capture success and the percentage of prey ingested decreased at the referenced turbidities. During juvenile migration, highly turbid waters are generally avoided if possible by juveniles as they make their way toward the estuary. Lightly turbid waters may actually aid migration, removing predation as a factor in juvenile survival rates (Spence et al. 1996). Moderate to high turbidity may also delay or divert spawning runs and in some instances can cause avoidance by spawning salmon. Adults may avoid concentrations greater than 350 mg/L, impeding upstream migrations (Whitman et al. 1982).

2.5.1.1.7.3 Risk to Individuals

This section is separated into the different life stages that are expected to be exposed and, therefore, may be affected by the elevated SSCs. We provide a risk analysis for each life under a median impact year and a severe impact year. In the Approach to Analysis section above we describe how the median impact and severe impact years were identified. The timing and magnitude of suspended sediment concentrations differ between water years. In addition, suspended sediment effects vary for each life stage even during the same water year.

Adults

High suspended sediment concentrations at the Iron Gate Dam site can cause avoidance by spawning salmon (Whitman et al. 1982). Quinn and Fresh (1984) found coho salmon strayed away from the sediment-filled Toutle River to nearby streams for two years following the eruption of Mount St. Helens. Therefore, adult coho salmon that normally spawn in the mainstem may seek Klamath River tributaries to spawn to avoid the elevated suspended sediment in the mainstem Klamath River downstream of Iron Gate Dam when SSCs are elevated. Under the median and severe impact scenarios, effects of the proposed action on migrating adults from all populations are expected to be sub-lethal, resulting in major stress and impaired homing (Table 17). Stress to adult coho salmon will likely lead to the fish avoiding high SSCs and holding in refugia areas such as tributary mouths or spawning in non-natal tributaries. These sublethal impacts are not expected to rise to a level that reduces spawning success or survival of adults. It is anticipated that most adult coho salmon will already be in tributaries in January of the drawdown year. The effects of the proposed action on migrating adults in Year 1 from all population units are anticipated to be higher than those experienced under background conditions. In Year 2, NMFS expects that SSCs in the Klamath River will be only slightly higher than background levels as indicated by the SSC modeling results (Appendix H in FERC 2021a). The increased SSCs during Year 2 will likely result in minor stress to migrating adults (Table 17) but not rise to a level that reduces spawning success or survival of adults. In Year 2, NMFS expects adult coho salmon (particularly those in the Upper Klamath River population) will experience beneficial effects of the proposed action that include access to previously inaccessible historical tributary and mainstem spawning habitats, cooler fall water temperatures during migration, and reduced disease impacts.

Table 17. Summary of elevated SSC effects for adult coho salmon migration (adapted from Appendix H of FERC 2021a).

	Median Impact Year		**Severe Impact Year**	
Population	**14-day Median SSC Range (mg/L)** [1]	**Response**[2]	**14-day Median SSC Range (mg/L)**	**Response**
Year One				
Upper Klamath, Shasta	52 - 194	Sublethal effects, including major stress and impaired homing	38 – 123	Sublethal effects, including major stress and impaired homing
Mid Klamath, Scott	30 - 170	Sublethal effects, including major stress and impaired homing	20 -100	Sublethal effects, including major stress and impaired homing
Lower Klamath, Salmon, Trinity	18 - 133	Sublethal effects, including major stress and impaired homing	15 – 76	Sublethal effects, including major stress and impaired homing
Year Two				
Upper Klamath, Shasta	14 - 14	Sublethal effects, including moderate stress	2 – 2	Sublethal effects, including minor stress
Mid Klamath, Scott	8 - 9	Sublethal effects, including moderate stress	2 – 2	Sublethal effects, including minor stress
Lower Klamath, Salmon, Trinity	7 – 7	Sublethal effects, including moderate stress	2 – 2	Sublethal effects, including minor stress

[1] Data for Upper Klamath and Shasta populations relied on USGS Iron Gate Dam station; data for Mid Klamath and Scott populations relied on USGS Seiad Valley station; data for Lower Klamath, Salmon, and Trinity populations relied on USGS Orleans station.

[2] Response was determined using Newcombe and Jensen (1996) Severity Index as described in the Approach to Analysis.

Embryos and Pre-emergent Fry

Coho salmon spawning in the mainstem is uncommon (Magneson and Gough 2006) with most coho salmon spawning in tributaries (Trihey & Associates 1996; NRC 2004; Dunne et al. 2011). Additionally, as stated above, adults are likely to avoid high SSCs and not construct redds in the impacted mainstem Klamath River reaches. However, some mainstem spawning may still occur in the Upper Klamath River population unit just downstream of Iron Gate Dam. Mainstem Upper Klamath River coho salmon redd surveys between 2001 and 2019 observed, on average, six coho redds (USFWS 2021, unpublished data). Redds constructed in the Upper Klamath River population area will be exposed to the greatest level of elevated SSCs (Appendix H in

FERC 2021a) and deposition of fine material that would suffocate eggs (FERC 2021a). Bedload deposition that impacts mainstem Klamath River redds is only expected to occur in the areas downstream of Iron Gate Dam where adult coho salmon from the Upper Klamath River population unit may occasionally spawn. Conservatively, NMFS estimates that coho salmon eggs and pre-emergent fry in up to six redds may be killed as a result of deposition in Year 1 (Table 18).

In Year 2, the suspended sediment concentrations will be substantially reduced from Year 1 (Appendix H in FERC 2021a). Because salmon are able to significantly clean fine sediment from spawning gravels during redd construction (Kondolf et al. 1993) and the degradation of spawning habitat in the mainstem Klamath River downstream of Iron Gate Dam site is expected to be short-term, adult coho salmon are likely to be able to use suitable spawning habitat in the mainstem starting in Year 2, especially where aggradation is minimal (i.e., <0.5 feet of deposition), which will be true for all mainstem Klamath River habitat with the exception of a five mile stretch downstream of the Iron Gate Dam site (Appendix H in FERC 2021a). In addition, the removal of the dams will allow adult coho salmon, which might have constructed redds in the mainstem downstream of Iron Gate Dam, access to tributaries upstream of the Iron Gate Dam site, such as Jenny Creek or Spencer Creek. Based on these factors, NMFS expects fewer redds to be constructed in the mainstem downstream of the Iron Gate Dam site during fall of Year 2, and those redds that are constructed will only experience sublethal impacts (e.g., small reduction in the growth of embryos that we do not expect will affect individual emergence success) due to the reduced SSC and bedload deposition in Year 2.

Table 18. Summary of SSC effects to coho salmon eggs and pre-emergent fry related to the proposed action

Population	**Median Impact Year**	**Severe Impact Year**	**General Location**	**Approximate Time**
Year One				
Upper Klamath	100% mortality in up to 6 redds	100% mortality in up to 6 redds	Iron Gate Dam to Seiad Valley	Jan 1 – Mar 15
Year Two				
Upper Klamath	Sublethal impacts	Sublethal impacts	Iron Gate Dam to Seiad Valley	Jan 1 – Mar 15

Juvenile rearing and outmigration

Juvenile coho salmon rearing in and outmigrating through the mainstem Klamath River during reservoir drawdown are expected to respond to elevated SSCs in a way that allows some of them to avoid many of the most severe impacts. Juveniles may use clear-water tributary junctions, off channel ponds, tributaries, spring seeps, increase their use of the benthic zone (Bash et al. 2001; Kjelland et al. 2015) or use the upper portion of the water column (Servizi and Martens 1992). NMFS expects juvenile fish to actively seek refugial areas; however, not all will be able to avoid elevated SSCs, major physiological stress, and mortality. Two year classes of juvenile coho (0+ and 1+) are expected to be exposed to elevated SSCs with some level of mortality during the reservoir drawdown period. Impacts to younger fish are expected to be more severe. Figure 21 shows an example of the strategy used in the analysis and aides in the understanding of the summary impact tables. Additional details of the analysis including determination of model inputs such as exposure timing, etc. can be found in Section 2.1.2 of the Analytical Approach and FERC's BA (Appendix H in FERC 2021a).

Table 19, Table 20, and Table 21 describe the expected impacts to the juvenile life stage of both year classes. Estimates of impacts are based on juvenile use of the mainstem under baseline conditions (e.g., with no avoidance behavior). The modeled results assume elevated SSCs as a result of proposed action implementation; however, juveniles would likely avoid some level of exposure as described above. Therefore, the estimated number of juveniles exposed is likely an over-estimate since we are unable to describe the extent to which fish may avoid impacts by seeking refuge. In addition, The Renewal Corporation will relocate winter rearing 1+ juvenile coho salmon to further minimize impacts to mainstem rearing individuals. Impacts associated with the relocation effort are described in Section 2.5.1.1.10.

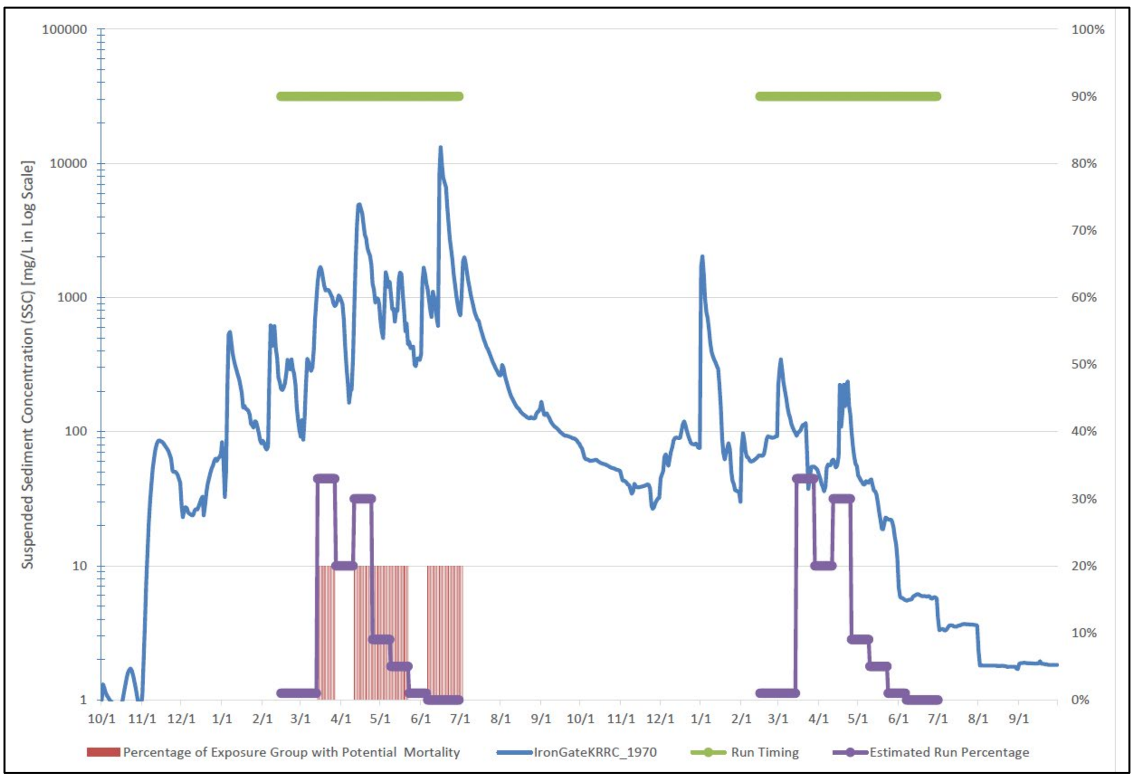

Figure 21. Illustration of impact, exposure, and estimated mortality based on run timing data and modeled SSCs for a "severe impact" water year. The purple lines show the percentage of the run that is exposed to SSCs on any given day of the water year. Of the fish exposed, the red vertical lines indicate the percentage of those fish likely to die. Provided by KRRC (2021f)

Table 19. Summary of elevated SSC effects for age 0+ juvenile coho salmon rearing in the mainstem Klamath River.

	Median Impact Year		**Severe Impact Year**	
Population	**20-day median SSC range (mg/L)**[1]	**Response**[2]	**20-day median SSC range (mg/L)**	**Response**
Year One				
Upper Klamath, Shasta	51 - 1165	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem 15% of the summer rearing period	39 - 2111	Major stress, reduced growth, 0– 20% mortality of fish rearing in the mainstem for 31% of the summer rearing period and 20-40% mortality of fish rearing in the mainstem for 8% of the summer rearing period
Mid Klamath, Scott	32 – 858	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 8% of the summer rearing period	23 - 1510	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 38% of the summer rearing period
Lower Klamath, Salmon, Trinity	19 – 454	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	18 – 679	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 15% of the summer rearing period
Year Two				
Upper Klamath, Shasta	5 - 36	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	2 – 60	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Mid Klamath, Scott	4 – 19	Sublethal effects, including reductions in feeding and moderate stress for fish rearing in the mainstem	2 – 45	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Lower Klamath. Salmon, Trinity	4 - 38	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	2 - 39	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem

[1] Data for Upper Klamath and Shasta populations relied on USGS Iron Gate Dam station; data for Mid Klamath and Scott populations relied on USGS Seiad Valley station; data for Lower Klamath, Salmon, and Trinity populations relied on USGS Orleans station.

[2] Response was determined using Newcombe and Jensen (1996) Severity Index as described in the Approach to Analysis.

Table 20. Summary of elevated SSC effects for age 1+ juvenile coho salmon rearing in the mainstem Klamath River.

	Median Impact Year		**Severe Impact Year**	
Population	**20-day median SSC range (mg/L)[1]**	**Response[2 3]**	**20-day median SSC range (mg/L)**	**Response**
Year One				
Upper Klamath, Shasta	33 - 2319	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 20% of the winter rearing period and 0-40% mortality of fish rearing in the mainstem 20% of the winter rearing period	27 - 264	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 20% of the winter rearing period and 0-40% mortality of fish rearing in the mainstem 20% of the winter rearing period
Mid Klamath, Scott	25 - 1739	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 40% of the winter rearing period	31 - 198	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 40% of the winter rearing period
Lower Klamath, Salmon, Trinity	17 - 992	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 20% of the winter rearing period	25 - 124	Sublethal effects, including reduction in feeding and major stress for fish rearing in the mainstem
Year Two				
Upper Klamath, Shasta	16 -111	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	39 – 354	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Mid Klamath, Scott	13 - 49	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	31 - 102	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Lower Klamath. Salmon, Trinity	12 - 34	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	26 - 74	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem

[1] Data for Upper Klamath and Shasta populations relied on USGS Iron Gate Dam station; data for Mid Klamath and Scott populations relied on USGS Seiad Valley station; data for Lower Klamath, Salmon, and Trinity populations relied on USGS Orleans station.

[2] Response was determined using Newcombe and Jensen (1996) Severity Index as described in the Approach to Analysis.

[3] The impacts for this life stage of coho salmon in the Lower Klamath, Salmon, and Trinity River populations are greater in the median impact year than in the severe impact year. However, when all SEV scores are summed for these water years, the impacts to other life stages outweigh this one, resulting in the determination of median impact year.

Table 21. Summary of elevated SSC effects for age 1+ outmigrating (smolt) coho salmon rearing in the mainstem Klamath River.

	Median Impact Year		**Severe Impact Year**	
Population	**20-day median SSC range (mg/L)**[1]	**Response**[2]	**20-day median SSC range (mg/L)**	**Response**
Year One				
Upper Klamath, Shasta	72 - 2433	Major stress, reduced growth, and up to 20% mortality for approximately 30% of the outmigration period	250 - 2844	Major stress, reduced growth, and up to 20% mortality for approximately 60% of the outmigration period
Mid Klamath, Scott	47 - 1598	Major stress, reduced growth, and 0 - 20% mortality of smolts for 10% of the spring outmigration period	179 - 1899	Major stress, reduced growth, and 0 - 20% mortality of smolts for 30% of the spring outmigration period
Lower Klamath, Salmon, Trinity	27 - 949	Major stress, reduced growth, and 0 - 20% mortality of smolts for 10% of the spring outmigration period	96 - 961	Major stress, reduced growth, and 0 - 20% mortality of smolts for 20% of the spring outmigration period
Year Two				
Upper Klamath, Shasta	13 - 38	Sublethal effects, including reductions in feeding and moderate stress	6 - 165	Sublethal effects, including major stress and reduced growth
Mid Klamath, Scott	8 - 20	Sublethal effects, including short – term reductions in feeding and moderate stress	12 - 59	Sublethal effects, including reductions in feeding and major stress
Lower Klamath, Salmon, Trinity	18 - 43	Sublethal effects, including reductions in feeding and major stress	13 - 49	Sublethal effects, including reductions in feeding and major stress

[1] Data for Upper Klamath and Shasta populations relied on USGS Iron Gate Dam station; data for Mid Klamath and Scott populations relied on USGS Seiad Valley station; data for L. Klamath, Salmon, and Trinity populations relied on USGS Orleans station.

[2] Response was determined using Newcombe and Jensen (1996) Severity Index as described in the Approach to Analysis.

2.5.1.1.7.4 Summary of Suspended Sediment Effect to Coho Salmon

In summary, although no single-year class is expected to be lost, all populations in the action area are expected to encounter concentrations of suspended sediment under the proposed action that are elevated when compared to background conditions. Exposure to the elevated SSCs is likely to cause varying levels of direct mortality, impaired homing, increases in physiological stress, and reduced feeding and growth, all of which would impact the overall fitness and survival of individuals. However, impacts resulting in mortality are expected to occur only in Year One during the reservoir drawdown. Following drawdown, SSC will quickly be reduced and meet background conditions by Year 3 (FERC 2021a).

2.5.1.1.8 Effects of decreased dissolved oxygen

As described in the Approach to Analysis Section 2.1.3, the BOD and IOD are predicted in a spreadsheet model using empirically derived oxygen depletion rates for a particular SSC based on laboratory incubations conducted under the Klamath Dam Removal Secretarial Determination oxygen demand (DO) study (Stillwater Sciences 2011). The DO spreadsheet model was used to assess DO conditions downstream of Iron Gate Dam during reservoir drawdown. Because the model is sensitive to initial DO concentrations, the Renewal Corporation used two initial DO levels to model the range of conditions. For the High Initial DO Scenario, the Renewal Corporation used 80 percent saturation as a conservative estimate and for the Low Initial DO Scenario the Renewal Corporation used 0 percent saturation. The Low Initial DO Scenario is considered to be an extreme condition that, with the High Initial DO Scenario, provides the full range of impacts that may occur due to depleted DO levels as a result of reservoir drawdown. Both DO conditions are modeled with median impact year (1991) and severe impact year (1970) flows to produce a reasonably likely and an extreme DO condition as a result of the proposed action. In all scenarios discussed below, the distance of depleted DO conditions downstream of Iron Gate Dam varies daily depending on SSC concentrations, water temperatures, (actual) DO saturation, and tributary discharge.

The release of the largest volumes of sediments containing elevated levels of BOD and IOD will occur in January and June in year 1 of the proposed action. The January release will include sediments from all four dams while the bulk of the sediments in June (in the more likely median impact flow year) are anticipated to be from the Copco. No. 1 reservoir when the historic cofferdam is breached following the initial drawdown. In 2010, DOI conducted a sediment sampling study in the reservoirs to describe sediment composition. The sediment was determined to be mostly an accumulation of silt size particles of organic material such as algae and diatoms, and silt size particles of rock (Reclamation 2011a), establishing the large oxygen demand associated with the sediments.

Under the median impact year scenario, with flows from Iron Gate Dam outlet tunnel containing 80% DO saturation, impacts during mid-January result in a low DO concentration of 0.2 mg/L approximately 1.2 miles downstream from Iron Gate Dam (which is at RM 193.1). The DO levels will rebound to conditions where salmonids can survive with moderate impairment to oxygen related functions (5 mg/L) (e.g., swimming ability) at RM 148.6 and to conditions safe for adult and juvenile salmonids (7 mg/L) at RM 131.8. This is 44.5 and 61.3 miles downstream from Iron Gate Dam, respectively. Depleted DO conditions to the 5 mg/L level are anticipated to last for 3 consecutive days while it will take 6 days for the DO levels to recover to the 7 mg/L threshold.

In June of the median impact year modeling scenario, assuming initial DO levels at 80% of saturation in Iron Gate Reservoir, the minimum DO level of 0.0 mg/L is expected to occur just 0.6 miles downstream of Iron Gate Dam and the modeling predicts that DO levels will return to the 5 mg/L level by RM 177.8 (just downstream of Shasta River confluence) and to the 7 mg/L level by RM 161.6 (between the Shasta and Scott River confluences). This is 15.3 and 31.5 miles downstream of Iron Gate Dam, respectively. There is more variability in how long these river conditions may last though, due to widely variable ambient air temperatures in the summer months and the loss of the thermal "insulation" the masses of water experienced in the pre-removal environment. KRRC anticipates that the low DO conditions close to Iron Gate Dam may last for 1 to 2 months depending on the water temperatures while DO conditions further downstream may only be below 5 mg/L for 9 days but below 7 mg/L for up to 47 consecutive days.

In January of the severe impact year scenario, initial mobilization of the sediments is expected to be decreased due to reservoir inflows exceeding the outlet tunnel capacity of the dam and the initial DO impacts would not be as severe as the median impact year scenario. The Renewal Corporation did not present data for this scenario, presumably because there would be a high potential level of error due to necessary assumptions to use the model. Conversely, the DO impacts in June are predicted to be greater as more sediment will still be coming out of Iron Gate Reservoir in addition to those released from the removal of the Copco No. 1 historical cofferdam. While the minimal DO level in June is expected to be the same as the previous scenario (0.0 mg/L at 0.6 miles downstream of Iron Gate Dam), the model predicts that the 5 mg/L DO level will not be met until RM 161.0 (between Shasta and Scott River confluences) and the 7 mg/L level will not be achieved until RM 145.5 (just upstream of Scott River confluence). This is 32.1 and 47.6 miles downstream of Iron Gate Dam, respectively. The 5 mg/L level is predicted to be achieved after 8 days but it may take more than 3 months for DO levels to rise above the 7 mg/L level.

Effects to the river are greater at the other end of the boundary conditions where (the Low Initial DO Scenario) the initial DO level in Iron Gate Reservoir is set at 0.0 mg/L due to high BOD and IOD demand from the upstream reservoirs. In this case, for the median impact year scenario, depressed oxygen conditions below 5 mg/L are expected from Iron Gate Reservoir until RM 113.2 (between Scott and Salmon River confluences) and 7 mg/L DO is not achieved until RM 88.3 (upstream of Salmon River confluence) in January. This is 79.9 and 104.8 miles downstream of Iron Gate Dam, respectively. Under these conditions in June of the initial year, depressed oxygen conditions are modeled to be below 5 mg/L until RM 164.7 and below 7 mg/L until RM 154.2 (both between Shasta and Scott River confluences). This is 28.4 and 38.9 miles downstream of Iron Gate Dam, respectively. In the other months of this scenario, depleted DO levels recover to 5 mg/L by RM 164.1 and to 7 mg/L by RM 153.6 (both between Shasta and Scott River confluences). This is 29 and 39.5 miles downstream of Iron Gate Dam, respectively.

2.5.1.1.8.1 Exposure

Exposure to low DO levels will largely correspond with the exposure to high SSC levels during the drawdown year as detailed in the preceding section. In the second year of the proposed action when the earthen dams and associated facilities are being removed, the suspended sediments generated are not expected to contain a high percentage of organic matter. The vast majority of this silt and smaller sized material will have already been evacuated from the formerly inundated reservoir sites during the drawdown period. Therefore, depressed DO levels are not anticipated to be a major issue in the second year. As detailed in the SSC analysis (Section 2.5.1.1.7.3), some coho salmon are expected to be rearing in the mainstem during the key release months of the drawdown year (January and June), but some smolts may delay emigration in June until DO conditions are sufficient. NMFS expects only some individuals from various populations to be rearing in the mainstem during the summer and winter months. Adult coho salmon will be in the tributaries by January when DO impacts reach harmful levels and thus are not expected to be exposed to DO impacts. Therefore, NMFS only describes impacts to mainstem rearing juvenile coho salmon and early season smolts.

In order to estimate impacts to coho salmon under a range of possible conditions, we use a "best case" scenario and a "worst case" scenario. The worst case scenario uses the lowest possible DO saturation in a severe impact year (as described in the Approach to Analysis Section 2.1.2). The worst-case scenario (0.0 mg/L DO in Iron Gate Reservoir in January of the drawdown year with severe impact year flows) subjects coho salmon in the mainstem to DO levels depressed below 7 mg/L from Iron Gate dam to the estuary (193.1 miles) for likely several days and up to two weeks. DO levels are modeled to rebound significantly one month later though with DO levels below 5 mg/L and 7 mg/L for approximately 54.5 miles (downstream of Scott River confluence) and 86.1 miles (between Scott and Salmon River confluences) downstream of Iron Gate Dam, respectively, in February. Nonetheless, the few coho salmon expected in the mainstem at that time would be subjected to conditions that would likely result in injury or mortality unless they find refugial areas as detailed in the SSC section. The second large release in June is not expected to cause this level of DO depression with levels of 5 mg/L being achieved at RM 149.2 and levels of 7 mg/L being achieved at RM 133.7 (both near the Scott River confluence). This is 43.9 and 59.4 miles downstream of Iron Gate, respectively.

The "best case" scenario uses the median impact year as defined in the Approach to Analysis Section 2.1.2 and a higher, but feasible, rate of DO saturation (80% DO saturation in Iron Gate Reservoir in January of the drawdown year with median impact year flows). This "best case scenario" subjects coho salmon in the mainstem to DO levels depressed below 7 mg/L from Iron Gate dam downstream for 61.3 miles (downstream of Scott River confluence) and only for 6 days. DO levels are expected to be depressed below 5 mg/L for only 44.5 miles (just upstream of Scott River confluence) downstream of Iron Gate Dam, and only for 3 days.

2.5.1.1.8.2 Response

The effects of low dissolved oxygen on aquatic organisms can range from acute mortality to impaired function. Low dissolved oxygen concentration can impair growth, swimming performance and avoidance behavior (Bjornn and Reiser 1991). Davis (1975) reported effects of dissolved oxygen levels on salmonids, indicating that at dissolved oxygen concentrations greater than 7.75 mg/L salmonids functioned without impairment, at 6.0 mg/L onset of oxygen-related distress was evident, and at 4.25 mg/L widespread impairment is evident. These values are consistent with those reported by the USEPA (1986). USEPA reported that for life stages other than embryos and larvae, no impairment was observed at dissolved oxygen levels of 8 mg/L, slight impairment was evident at 6 mg/L, moderate impairment at 5 mg/L, severe impairment at 4 mg/L, and acute mortality at 3 mg/L or lower. NMFS has generally interpreted these EPA numbers to mean that harm to some individual salmonids may be occurring at DO levels < 7 mg/L and is likely when DO levels are ≤ 5 mg/L. Low DO can affect fitness and survival by altering embryo incubation periods, decreasing the size of fry, decreasing swimming performance, increasing the likelihood of predation, and decreasing feeding activity (Carter 2005). Under extreme conditions, prolonged exposure to low dissolved oxygen concentrations can be lethal to salmonids.

Organisms can tolerate low dissolved oxygen concentrations for short periods of time, as low as 2 mg/L, but prolonged and repeated exposure to low dissolved oxygen has detrimental effects on activity, feeding, growth, and other normal biological functions. The growth of young fish can be significantly slowed under low dissolved oxygen conditions if dissolved oxygen falls to 3 mg/L for part of the day, even if it rises to 100 percent saturation at other times (Bevelhimer and Coutant 2006). Given the general understanding of dissolved oxygen effects on aquatic organisms, studies examining coho salmon survival under natural conditions have found coho salmon tolerance for low dissolved oxygen in the natural environment may be higher than expected. Winter studies in Alaska on juvenile coho salmon found 100 percent survival of juvenile coho salmon for 24 hours when dissolved oxygen concentrations were 3.1 mg/L and high survival was observed when juveniles were exposed for 4 to 5 days to a dissolved oxygen concentration of 3.2-3.3 mg/L (Ruggerone 2000).

A study examining use of emergent wetlands by juvenile coho in the Chehalis River in Washington found that emigrating coho salmon were surviving in freshwater wetlands at extremely low dissolved oxygen concentrations, although dissolved oxygen concentrations as low as 0.5 mg/L may have resulted in juveniles preferring to utilize better conditions elsewhere (Henning et al. 2006). Another recent study conducted in slough environments in Washington found coho salmon surviving in late spring dissolved oxygen conditions as low as 4.8 mg/L while emigrating through the slough environments (Beamer et al. 2010).

USEPA (1986) summarized twelve studies on the effects of dissolved oxygen on coho salmon growth, and estimated that coho salmon juveniles had 37 percent reduced growth at 3 mg/L dissolved oxygen concentration in an average of 18 °C. However, the USEPA (1986) did not estimate how long coho salmon needed to be exposed to the 3 mg/L for the estimated growth reduction.

2.5.1.1.8.3 Risk to Individuals

The decrease in dissolved oxygen in the drawdown year will occur when the suspended sediment concentrations are elevated. The low dissolved oxygen concentrations pose an additional stressor to juvenile coho salmon when these individuals are in the mainstem downstream of Iron Gate Dam. How far downstream the depressed DO levels extend is dependent on the water year type as detailed previously. It is anticipated that the few coho salmon expected in the mainstem during the months of highest SSC concentrations and corresponding lower DO conditions will likely seek refugial habitats while those in the tributaries will remain there and not enter the mainstem until conditions improve. There are studies in the literature, as mentioned in the proceeding section, that indicate coho salmon can tolerate low DO conditions for short periods of time and this may allow them to seek refugial habitats. Nevertheless, a small percentage of mainstem rearing juvenile coho salmon may remain in this reach and may have reduced feeding, growth, and overall survival. The Renewal Corporation will employ minimization measures to reduce the impact of low DO including the capture and relocation of mainstem rearing juvenile coho salmon prior to drawdown. Additionally, the Renewal Corporation will monitor key tributary mouths and relocate outmigrant smolt if they appear to be trapped in refugia areas and unable to enter the mainstem due to inhospitable conditions (i.e., elevated SSCs and low DO). Impacts of the relocation effort are described in Section 2.5.1.1.10.

2.5.1.1.8.4 Summary of Dissolved Oxygen Effects to Coho Salmon

In summary, depressed DO levels will co-occur with elevated SSCs. NMFS expects that the co-occurring conditions in the proposed action are likely to result in mortality. We believe that the conservative range of mortality estimated as a result of elevated SSCs (Section 2.5.1.1.7) in a severe-impact year captures the predicted mortality of the two stressors occurring simultaneously for those coho juveniles rearing in the mainstem and unable to locate refugial habitat in time. No single-year class is expected to be lost, but all populations in the action area are expected to encounter dissolved oxygen concentrations that are decreased when compared to background conditions under the worst case scenario. Exposure to the decreased DO levels is likely to cause varying levels of direct mortality, increases in physiological stress, reduced feeding and growth, reduced swimming performance and significant habitat modification or degradation that impairs essential behavioral patterns such as dispersal within the mainstem, all of which would impact the overall fitness and survival of individuals. However, conditions resulting in these impacts are expected to occur only in Year One during the reservoir drawdown when the reservoir sediments and associated organic matter is eroding. The impacts of low dissolved oxygen are impossible to separate out from those associated with high SSCs since the two conditions will co-occur. Therefore, NMFS relies on estimates of impacts made in Section 2.5.1.1.7 *Effects of Increased Suspended Sediment* to describe the range of lethal impacts which are expected to be inclusive of the DO impacts.

2.5.1.1.9 Effects of bedload deposition

In addition to the release of suspended sediment, the removal of Iron Gate Dam will result in the deposition of coarse sediment downstream of the dam. As discussed in the Effects to Coho Salmon Habitat section, approximately 2.5 to 5 ft. of reach-averaged deposition of fine and coarse sediment will occur near Iron Gate Dam (RM 193.1) and Bogus Creek (RM192), decreasing to 1.0 to 1.5 ft. of deposition between Bogus Creek and Willow Creek (RM 188). Sediment deposition results in the loss of pool quantity and quality and spawning habitat quality.

2.5.1.1.9.1 Exposure

The deposition of sediments downstream of the Iron Gate dam site will likely fill in some pools completely, and result in others becoming shallower with higher fine sediment loads. Depending on the hydrology (e.g., dry water years will disperse less of this sediment), the loss of pool quantity and quality may last several years as described by the Renewal Corporation's bedload analysis (FERC 2021a). Fry, juveniles, smolts, and adults use pools for rearing and holding; therefore, they are likely to be affected by the loss in pool quantity and quality in the mainstem from the Iron Gate Dam site to the Scott River reach where bedload deposition is predicted to occur (FERC 2021a). While there will be some aggradation in the mainstem from the Iron Gate Dam site to Scott River, the majority of the potential loss of pool quality and quantity, and overall reduction in habitat complexity will occur between the Iron Gate Dam site (RM 193) and Willow Creek (RM 188) (FERC 2021a). Loss in spawning habitat quantity and quality will occur as fine sediment will cover some gravel spawning beds and other spawning areas may be buried under coarse sediment loads too deep for coho to find suitable spawning gravels. The loss in spawning habitat quality may affect adult coho salmon and their progeny because coho salmon spawn near Iron Gate Dam (Magneson and Gough 2006). Few adults are expected to be exposed to the decreased spawning habitat because of their ability to migrate upstream and to other suitable spawning habitat in the mainstem and tributaries.

2.5.1.1.9.2 Response

Pool quantity and quality as well as habitat complexity are important for fry, juveniles and smolt survival. Pools provide a complex of deep, low water velocity areas, backwater eddies, and submerged structural elements that provide cover, winter holding, and flood refuge for fish (Brown and Moyle 1991). During their upstream migration, adult salmonids typically move quickly through rapids and pause for varying duration in deep pools (Gray and Haynes 1979). Pools provide salmonids with safe areas to rest when low flows or fatigue suppress migration. Pools are also preferred by juvenile coho salmon (Fausch and White 1986). Pools with sufficient depth and size can also moderate elevated water temperatures stressful to salmonids (Matthews et al. 1994). Deep, thermally stratified pools with low water velocities, or connection to cool groundwater, provide important cold water refugia for cold water fish such as salmonids (Nielsen et al. 1994; Sutton and Soto 2012). Pool habitat is strongly related to smolt production (Sharma and Hilborn 2001), and thus the loss of pool habitat may reduce numbers of coho salmon juveniles.

Aggradation resulting from sediment release is expected to limit suitability of the mainstem reach below the Iron Gate Dam site for coho salmon spawning. However, coho salmon adults are expected to be able to use the mainstem downstream of Willow Creek (RM 188) because aggradation is expected to be less than 0.5 feet, flows will flush fine sediment downstream, and adults are capable of cleaning fines when building redds (Kondolf and Matthews 1991). Sediment deposited downstream of the dam will initially be unstable, potentially resulting in the loss of eggs if used for spawning. In addition, the higher the proportions of sand content in the spawning gravel, the higher the fry mortality (Phillips et al. 1975).

2.5.1.1.9.3 Risk to Individuals

The loss of pool quantity and quality in the mainstem, particularly between Iron Gate Dam (RM 193) and Willow Creek (RM 188), will reduce coho salmon rearing until new or existing pools are scoured. With the removal of the four dams, the Klamath River downstream of Keno Dam will have a more natural hydrology and sediment regime. Below, in Section 2.5.1.2.5, we describe the expected beneficial effects of dam removal, which include a more natural hydrology and sediment regime. The more natural hydrology and sediment regime are expected to increase peak flows and sediment mobilization, which will scour pools and create channel complexity. Although NMFS expects pool habitat will be recreated, the length of time necessary to scour a pool is unclear and depends upon stream flow and hydraulics. Similarly, spawning habitat downstream of the Iron Gate Dam site will recover as flows flush the fines and larger gravel are exposed, deposited, or both.

Coho salmon experiencing stress from low DO and elevated SSC will also be exposed to a temporary reduction in pool and spawning habitat in the Upper Klamath population area. However, only exposure to SSC and low DO is expected to result in mortality since those extreme environmental conditions will have a more immediate impact on individuals. Because we see coho salmon alter their behavior and relocate in response to environmental stress as detailed in Section 2.5.1.1.7, NMFS expects fish that are able to avoid the expected high SSCs and low DO to relocate to more suitable habitat and mostly avoid harm as a result of the loss of habitat related to sediment deposition. While there will be some temporal loss in pool and spawning habitat quality, especially between the Iron Gate Dam site (RM 193) and Willow Creek (RM 188), coho salmon fry, juveniles, smolts, and adults will be able to use newly accessible habitat upstream of Iron Gate Dam and nearby tributaries such a Willow Creek, Cottonwood Creek, and Bogus Creek. In addition, the increased recruitment of large woody debris (i.e., from behind the four dams that are proposed for removal, and riparian corridor along the mainstem and tributaries upstream of Iron Gate Dam) is expected to scour new pools. At least an estimated 76 miles of additional habitat, including at least 30 miles of tributary habitat (DOI and CDFG 2012), will be available to adults, subyearlings, yearlings, and smolts to use. Below, in Section 2.5.1.2.5, we further detail the benefits of the newly accessible habitat which is expected to be occupied immediately by adults and juvenile coho salmon in the Upper Klamath River population. Therefore, NMFS expects the temporary loss in pool and spawning habitat quantity and quality in a small reach of the mainstem to reduce the fitness of a very small number of coho salmon fry, juveniles, smolts that may be in the reach downstream of Iron Gate Dam.

2.5.1.1.10 Effects of Relocation of Coho Salmon

The Renewal Corporation proposes to capture and relocate juvenile coho salmon that may be directly harmed by effects of the proposed action. A number of Aquatic Resource Management Actions that include capture and relocation of coho salmon are described in the Aquatic Resource Management Plan (Appendix D of FERC 2021a).

Starting in the summer prior to drawdown, the Renewal Corporation will relocate any fish found rearing in the construction zones associated with pre-drawdown work near Iron Gate Dam including access road construction, temporary bridge construction, armoring of left bank access road, construction of fire access ramp, and removal of temporary roads. Then, in December, just prior to reservoir drawdown, the Renewal Corporation will relocate mainstem-rearing juvenile coho salmon as described in Section 1.3.7.2.

During the reservoir drawdown period, the Renewal Corporation will be monitoring key tributary locations in the spring and summer to ensure outmigrating coho salmon (1+ smolt) will be able to enter the mainstem river to complete their downstream migration. If conditions in the mainstem are unsuitable for downstream migration, fish may delay migration and hold in tributary mouths. If fish remain in tributary mouths into the summer months when water temperatures rise, they may become trapped and unable to seek quality refugia or migratory habitat. During this time, if surveys indicate there are large numbers of coho salmon holding while identified water temperature, DO, and SSC thresholds for suitable rearing habitat are exceeded, the Renewal Corporation will pursue a capture and relocation effort that moves the fish to suitable downstream habitat in the mainstem river.

After dams are removed in the Fall of Year 1, coho salmon will have access to the former reservoir sites. The mainstem channel and tributaries that enter the reservoir footprint are expected to be dynamic as a new single thread channel becomes established. During this time, conservation measures described in the Reservoir Area Management Plan (Appendix C of FERC 2021a) are designed to minimize impacts to fish passage by rapidly stabilizing new channels. Restoration actions will include replacement of culverts in tributary streams, regrading of tributary stream channels for volitional fish passage, placement of boulder clusters and willow baffles, and construction of large wood structures with ground-based equipment and helicopters. The Renewal Corporation will conduct these restoration actions starting in Year 2, following reservoir drawdown and dam removal. In Years 2-7, the Renewal Corporation will conduct a monitoring and maintenance period with minimal instream activities. Each of the restoration and maintenance projects that require instream work will result in fish relocation.

In the years following dam removal, a number of boat ramps may be installed in the Hydroelectric Reach and may require fish removal during the construction period. A summary of fish removal activities can be found in Table 22.

2.5.1.1.10.1 Exposure

During pre-drawdown construction activities near Iron Gate Dam, it is unlikely coho salmon will be using the mainstem Klamath River. The construction activities will occur approximately between Iron Gate Dam and Lakeview Road Bridge (about 1700 ft) during the summer months. This reach is extremely disturbed due to the impacts of the dam, offers no slow water or cold water refugia, and will likely have temperatures exceeding 21ºC with low DO. Therefore, it is unlikely that juvenile coho salmon will be encountered. However, the nearby tributary, Bogus Creek, could offer some refugia and allow juvenile coho salmon to enter the work area. Therefore, the Renewal Corporation will capture and exclude any fish that may be encountered during pre-drawdown construction. Only juvenile coho salmon in the Upper Klamath River population would be impacted by this effort.

In December, prior to drawdown, the Renewal Corporation will relocate fish found in known mainstem winter rearing areas such as alcoves and backwater channels that are expected to be impacted by elevated SSCs. The fish relocated may be from the mainstem populations or have redistributed from tributary populations such as the Shasta and Scott River. NMFS expects juvenile coho salmon from Upper Klamath, Shasta, Scott, and Mid Klamath populations to be exposed to relocation efforts that occur prior to drawdown.

Based on the proposed schedule for establishing volitional fish passage at Iron Gate Dam in early October in Year 1, there is potential for coho salmon to be present in the proposed work areas upstream of the Iron Gate Dam site during reservoir restoration. In Year 2, when coho salmon may be exposed to reservoir restoration actions, only age 0+ coho salmon will likely be present since they will have been spawned by the first adult generation to access the new habitat post dam removal. NMFS expects very few fish to be present in Year 2 as these individuals would have been spawned by adults entering the reservoir reach immediately after access is restored. Beyond Year 2 when more life stages of coho salmon may be present, instream work is expected to be minimal and likely occur only when monitoring indicates passage may be impaired by sediment aggradation. Further, in-water work windows (June 15 – Oct 31), BMPs, and exclusion measures described in the BA (FERC 2021a) will minimize exposure to any fish that may be in the area. NMFS expects only a small number of 0+ coho salmon in the Upper Klamath River population to be exposed to instream restoration actions in Year 2 (first year of reservoir restoration). In years 3-7, NMFS expects a small number of 0+ and 1+ juvenile coho from the Upper Klamath River population to be exposed to instream maintenance activities. Adults and eggs will not be exposed as they are only present in the action area outside of the instream work window.

2.5.1.1.10.2 Response

The impacts to juvenile coho salmon as a result of instream restoration work is similar to those impacts already described associated with instream construction activities in Section 2.5.1.1.6. However, because juveniles are likely to be present in at least some of the work area, the Renewal Corporation will remove any fish that is present in the worksite and set block nets to exclude fish from re-entering during construction.

The stress of relocation can cause injury or mortality in juvenile salmonids (Habera et al. 1996; Nielsen 1998; Habera et al. 1999; Nordwall 1999). The amount of unintentional injury or mortality attributable to fish removal varies depending on the method used, ambient conditions, and the expertise and experience of the field crew. Fish collecting gear, whether passive or active poses some risk to individuals, including stress, disease transmission, injury, or death (Murphy and Willis 1996). Studies of fish response to electrofishing have shown that although often not externally obvious or fatal, spinal injuries and associated hemorrhages have been documented in over 50 percent of fish examined internally that were subject to electrofishing (Snyder 2003). Significantly fewer spinal injuries are reported when direct current, low-frequency pulsed direct current (<30 Hz), or specially designed pulse trains are used (Snyder 2003).

2.5.1.1.10.3 Risk to Individuals

Because fish relocation activities will be conducted by qualified fisheries biologists and follow both CDFW and NMFS guidelines, injury or mortality of juvenile coho salmon during capture should be minimal. Data synthesized from seven years of project data in California on fish relocation mortality indicate the average mortality rate is below one percent (Collins 2004; NMFS 2012d). NMFS applies the one percent mortality rate in this section for each relocation type activity.

Prior to drawdown when modifications will be necessary near Iron Gate Dam, the majority of the work will be completed during the summer while water temperatures are inhospitable to coho salmon. However, because juvenile coho salmon may be rearing in refugia nearby (e.g., Bogus Creek), there is a chance the Renewal Corporation will encounter them while completing their pre-drawdown construction activities during the summer. Based on the low likelihood of finding fish in this area and using data from other relocation efforts (NMFS 2012d), NMFS estimates up to only 30 individuals from the Upper Klamath River population may be relocated during pre-drawdown construction activities (Table 22).

During the winter, pre-drawdown relocation efforts are expected to result in the handling of no more than 1,000 juvenile coho salmon and will represent less than 50% of juvenile coho salmon present in the mainstem Klamath River at the onset of drawdown (FERC 2021a). Numerous studies have documented seasonal redistribution of juvenile coho salmon in the Klamath Basin (Witmore 2014; Soto et al. 2016; Manhard et al. 2018), finding fish from multiple populations rearing in the same mainstem refugial sites. Because juvenile coho salmon have complex life history traits and may be rearing in non-natal locations, we assume that it would be unlikely for all fish captured in a mainstem location to be from the same population. Therefore, NMFS assumes that the fish relocated during this effort have an equal potential of being from the Upper Klamath, Middle Klamath, Scott, or Shasta River populations. Applying the expected maximum mortality rate of one percent to the maximum estimated 1,000 coho salmon caught during the winter prior to drawdown, then ten coho salmon juveniles could be killed during relocation or up to three individuals from any one population. The captured fish will be relocated to suitable habitat such as off channel ponds or nearby tributaries that will not be exposed to elevated SSCs. Snorkel surveys at potential sites will guide relocation efforts to prevent over-crowding and competition.

During the drawdown period, NMFS expects most coho salmon smolts will be able to find windows of suitable water quality conditions to outmigrate. However, in the rare circumstance that they become trapped in tributary mouths in late spring or early summer, the Renewal Corporation may capture and relocate fish (based on recommendations by the ARG) to locations of suitable water quality in downstream reaches of the mainstem so they can continue their migration (Appendix D of FERC 2021a). Thirteen tributary mouths will be monitored for water quality conditions. Because redistributing fish typically move in a downstream direction, we assume only fish from the Upper Klamath, Shasta River, and Scott River populations would be present in the confluences of the identified tributaries. NMFS reviewed data from other relocation projects (NMFS 2012d) and considered the number of locations, relative number of expected fish to be present, and potentially low capture efficiency to estimate that the Renewal Corporation may capture and relocate up to 1,200 individuals from the identified tributaries. Because juvenile coho salmon have complex life history traits and may be rearing in non-natal locations, we assume there is an equal likelihood that relocated fish will be from the Upper Klamath, Shasta, or Scott River populations (Table 22). Therefore, about 400 fish from each population are estimated to be captured and about four fish from each population are estimated to die.

Post dam removal, NMFS estimates up to 12 instream habitat restoration projects may be implemented (e.g., culvert replacement, channel grading, and instream habitat feature placement) based on our understanding of prioritized restoration locations and projects. The instream restoration sites will be completed at Camp, Scotch, Jenny, Beaver, Deer, Long Gulch, and Spencer Creeks. The culvert replacements will be on Camp, Scotch, and Fall Creeks and 2 submerged culverts will be removed on Long Gulch Creek. Based on our understanding of potential instream barriers that may arise during high flow and depositional events at key tributary junctions, we estimate an additional 15 instream maintenance projects could be implemented over the 5-year maintenance period following dam removal. In the initial five years following dam removal, repopulation of the newly accessible habitat will likely be low. Taking into consideration the low rate of repopulation in the initial years post dam removal and data from other relocation efforts (NMFS 2012d), NMFS expects no more than 100 0+ coho young of the year from the Upper Klamath River population to be relocated per instream project (Table 22).

Up to four boat ramps may be installed after dams are removed and fish are present in the Hydroelectric Reach. These sites are located within the J.C. Boyle, Copco, and Iron Gate reservoir footprints. The boat ramp locations are along the mainstem Klamath where likely low quality summer rearing habitat exists. However, juvenile fish from the Upper Klamath River population may be using the mainstem as a migratory corridor and could be encountered. Based on data reviewed from other relocation efforts (NMFS 2012d) and the possibility that fish may be encountered during migration (e.g., summer redistribution), NMFS expects no more than 500 fish from the Upper Klamath River population may be relocated across all four projects (Table 22).

The juvenile coho salmon relocated are expected to belong to the Upper Klamath River population, since it would be unusual for juveniles from downstream populations to migrate that far upstream. The newly accessible habitat will not yet be fully seeded and will likely have very low densities of fish present. Considering the number of coho salmon relocated will be low relative to available habitat, NMFS does not expect the relocated individuals to contribute to overcrowding or increased competition to a level that would decrease individual fitness or survival. Reestablishment of vegetation along riparian corridors and uplands will stabilize sediments and shade tributary corridors, habitat complexity features will improve habitat heterogeneity and refugia under varied flow conditions, and fish passage monitoring and corrective actions will minimize the potential for blockages that would impede returning coho salmon from accessing historic habitat. These benefits will occur in the short term, but are also anticipated to persist and accelerate the long-term recovery of the riparian habitat under the former reservoirs and dams.

Table 22. Summary of fish removal activities.

Timing	Location	Effected Populations	Activity	Estimated Number of Fish to be Relocated	Estimated Number of Fish Killed
Pre-drawdown Summer	Iron Gate Dam to Lakeview Rd Bridge	Upper Klamath	Temporary road construction, temporary bridge construction, armoring of left bank access road, construction of fire access ramp	30	1
Pre-drawdown Winter	Mainstem Klamath; Iron Gate Dam to Trinity confluence	Upper Klamath, Shasta, Scott, Mid-Klamath	Relocation of mainstem-rearing juvenile coho salmon to minimize SSC impacts	1000	10
During drawdown	Tributary confluences from Bogus Cr to Seiad Cr	Upper Klamath, Shasta, Scott	Relocation of outmigrating smolt (1+) from tributary mouths	1200	12
Post-dam removal (years 2-7)	Mainstem Klamath and tributaries in Hydroelectric Reach	Upper Klamath	Instream habitat restoration projects	1200	12
Post-dam removal (years 2-7)	Mainstem Klamath and tributaries in Hydroelectric Reach	Upper Klamath	Fish passage maintenance projects	1500	15
Post-dam removal (years 2-7)	J.C. Boyle, Copco, Iron Gate	Upper Klamath	Boat ramp construction	500	5

2.5.1.1.11 Herbicide Application

The proposed action includes use of herbicides and associated adjuvants in the three year restoration program, which may result in exposure of coho salmon in the near shore habitats. Exposures are only expected to occur periodically within the former reservoir footprints and last for short periods of time (hours to days). NMFS has previously analyzed the effects of herbicide use in IEV control and restoration projects on large scale, multi-year actions proposed by the USFS, BLM, and Bonneville Power Administration (BPA) (NMFS 2010a; NMFS 2012a; NMFS 2020a). The types of plant control actions analyzed here are a less aggressive subset of the types of actions considered in those analyses and some of the work environment (i.e., previously inundated areas now devoid of vegetation) is unique. The effects presented here are summarized from the previous analyses, updated using the best available information, and consider the unusual work environment. The BMPs described earlier are designed to limit the potential for exposure from these applications. If they work as intended, no fish should be exposed to herbicide or any adjuvant. Realistically, the BMPs may not be enough to prevent movement of herbicides via drift, erosion of treated sediments, or transport through shallow groundwater connections to the waterbodies. NMFS has determined that the use of herbicides and associated adjuvants in this proposed action over the course of several years may affect fish though a combination of chemical and biological endpoints including chemical toxicity, impacts to forage species and emergent vegetation that provides habitat benefits.

While the Renewal Corporation proposed some no spray buffers for aquatic glyphosate, aquatic imazapyr and dicamba for streams, wetlands, and ditches that have water present, it does not propose a buffer for intermittent streams or wetlands and ditches that do not have water present at the time of spraying. This alone presents a route of exposure to habitats potentially occupied by listed coho salmon if the herbicide and associated adjuvants, or their degradation products, are still present when water once again flows through or occupies these landscape features. This is a reasonable possibility as spraying is proposed from late fall to early spring in response to newly discovered infestations of IEV or when new plant growth is most likely to take up the herbicide.

The reservoir footprint areas that are the priority for treatment are also expected to change rapidly as the developing soils dry, become more compacted and begin to form new landscape features (e.g., ephemeral creek channels) that connect the uplands to the perennial waterbodies. These changes may lead to additional, unpredictable movement of herbicides and adjuvants, and their degradation products, through erosion of treated sediments into the stream margins of the river and associated tributaries.

It is likely that only low numbers of individuals will be exposed because the newly accessible habitat will be at the early stages of being repopulated and it is unknown if the reservoir footprint areas being treated will produce viable rearing habitat during the time period planned for the IEV management actions. Juvenile salmonids, particularly recently emerged fry, are known to use the low velocity areas along stream and river margins until they grow sufficiently to occupy habitats with higher flow velocities. Larger salmonids may also use stream and river margins as velocity refuges, but also for thermal refuge or predator avoidance in addition to foraging opportunities. NMFS has identified three scenarios where the application of herbicides and associated adjuvants may expose salmonids in this habitat and potentially lead to effects: runoff from riparian area applications, accidental application via drift, and runoff from intermittent or ephemeral stream channels and ditches purposefully treated. These exposures may occur as the surface waters are exposed or as a result of movement through shallow groundwater contributions to flowing waterbodies. The BMPs proposed by the KRRC are expected to prevent large scale discharges of herbicides to the river or perennial streams in the treatment areas and as a result any herbicide exposure is expected to be localized and rapidly diluted. Therefore, only coho salmon from the Upper Klamath population are expected to be exposed.

As detailed previously, the Renewal Corporation has proposed numerous BMPs during the initial three years of the spraying program proposed as part of the proposed action (called the Pre-dam Removal and Dam Removal and Restoration phases) that are intended to prevent exposure via these pathways to coho salmon and their habitat. Although these BMPs will minimize the risk of exposure under typical circumstances, they do not eliminate the risk for the proposed action and we assume herbicides and associated adjuvants reaching surface waters may result in impacts.

The NMFS Northwest Fisheries Science Center examined several herbicide formulations used in forestry, including three proposed for use in this project (glyphosate, imazapyr and triclopyr TEA), and found that they were unlikely to pose a threat of mortality to salmonid embryos (Stehr et al. 2009). However, this same study also noted that their findings do not extend to other life stages or physiological processes (e.g., smoltification, respiration, disease resistance, behavioral changes that can result in predation, etc.) or account for effects to aquatic food webs that may reduce feeding success. The caution expressed in Stehr et al. (2009) is warranted due to the findings of other studies. Tierney et al. (2006) found that olfaction performance was compromised by sublethal glyphosate exposure and this can result in disruption of essential behaviors such as migration, feeding, predator avoidance and detection of spawning cues (Meehan 1991; Hecht et al. 2007). Weis et al. (2001) noted that behavioral changes are driven by molecular level physiological stresses such as changes in enzymatic function, ligand-receptor interaction, or oxygen metabolism that is often caused by exposure to contaminants including various pesticide products.

For the most recent consultation on the BPA's Habitat Improvement Program (NMFS 2020a), the BPA examined the aquatic toxicity of all the herbicides proposed for use by the Renewal Corporation. This effort defined adverse effect thresholds as either the lowest acute or chronic "no observable effect concentration" (LOEC or NOEC) or as 1/20th of the Lethal Concentration 50 (the concentration expected to kill 50% of a group) for listed salmonids, whichever was lower. BPA calculated a risk quotient (RQ) by dividing this no adverse effect level by an expected environmental concentration (EEC) or a generic estimated environmental concentration (GEEC). Both EECs and GEECs are developed using EPA modeling software and are generally considered as a worst-case potential for herbicide pollution of a nearby waterbody from typical use patterns. If the resulting RQ is greater than 10, then the risk to an individual fish is considered low. If the result is less than 1, then the risk to an individual fish is considered high. Results between 1 and 10 are considered to carry a moderate amount of risk to an individual fish. The RQs for all the herbicides proposed for use in this proposed action were greater than 10, with the exception of dicamba at 3.3. The herbicide information assembled by BPA and examined by NMFS (2020a) is reliable for use in this proposed action due to its timeliness, the similar use patterns and application methods of the herbicides, and the similar ecotones present in the Columbia River and Klamath River basins.

Information for the proposed herbicides is briefly summarized below:

Aminopyralid. This is a relatively new selective herbicide and is used to control broadleaf weeds. Aminopyralid shows moderate mobility through the soil, but it does not bioconcentrate in the food web. The primary means of exposure for fish and aquatic invertebrates is through direct contact with contaminated surface waters. Acute toxicity tests show aminopyralid to be practically non-toxic, with aquatic invertebrates showing more sensitivity. The calculated RQ is 417.

Chlorsulfuron. This herbicide controls broadleaf weeds and some annual grasses. Chlorsulfuron is likely to be persistent and highly mobile in the environment. It may be transported to nontarget areas by runoff and/or spray drift. Degradation by hydrolysis appears to be the most significant mechanism for degradation of chlorsulfuron, but is only significant in acidic environments (23 day half-life at pH = 5); it is stable to hydrolysis at neutral to high pH. Degradation half-lives in soil environments range from 14 to 320 days. This herbicide does not bioaccumulate in fish and is practically nontoxic to both freshwater and estuarine/marine fish on an acute exposure basis. The calculated RQ is 240.

Dicamba. Dicamba is used to control broadleaf weeds, brush and vines. It is categorized by EPA as slightly toxic to fish and practically non-toxic to aquatic organisms. It is a moderately persistent herbicide, highly mobile in soils, and is a likely groundwater contaminant. Dicamba has been the subject of recent lawsuits because of crop damage caused by drift of dicamba, with recent science showing the dicamba is subject to drift even in stable air applications (Bish et al. 2019). Calculated RQ is 3.3, with an associated moderate level of concern. Due to its potential for toxicity, mobility and drift post application, there is a risk of exposure to coho salmon, particularly juvenile salmonids in shallow habitats adjacent to treatment areas.

Glyphosate (aquatic). Glyphosate is a nonselective herbicide used to control grasses and herbaceous plants. It is moderately persistent in soil, with an estimated average half-life of 47 days but it is not considered mobile. Glyphosate is relatively non-toxic for fish. There is a low potential for the compound to build up in the tissues of aquatic invertebrates. The calculated RQ for aquatic glyphosate is 214.

Imazapyr. Imazapyr is used to control a variety of grasses, broadleaf weeds, vines and brush species. A typical half-life for imazapyr in soils is 10 days. Microbes and sunlight break down imazapyr in the environment. Imazapyr's potential to leach to groundwater is high, surface runoff potential is high, and potential for loss on eroded soil is intermediate. Imazapyr has low volatility and the potential for loss to the atmosphere is low. Bioaccumulation of imazapyr in aquatic organisms is low; therefore, the potential of exposure through ingestion of exposed aquatic invertebrates or other food sources to fish is reduced. Toxicity to fish is considered practically non-toxic. The calculated RQ for imazapyr is 110.

Triclopyr (TEA). Triclopyr is a systemic herbicide with selective control of woody and broadleaf species. Triclopyr triethylamine salt (TEA) is highly soluble in water and dissociates within one minute to the weak acid, triclopyr. Aquatic photolysis and microbial breakdown are significant degradation pathways for triclopyr. Dissipation half lives of triclopyr in water range from 0.5 days to 7.5 days. In sediment, triclopyr dissipation rates ranged from 2.8 to 5.8 days in field studies. Triclopyr is, however, persistent under anaerobic aquatic conditions. It is highly water soluble and is not expected to bind with organic materials. Triclopyr TEA is practically non-toxic to freshwater fish and aquatic invertebrates. The calculated RQ is 75.5.

Adjuvants. The Renewal Corporation states they will only use surfactants and adjuvants permitted for use on aquatic sites, as listed by the Washington State Department of Ecology: http://www.ecy.wa.gov/programs/wq/pesticides/regpesticides.html. However, this link is no longer active. NMFS confirmed with the Renewal Corporation that they will be using the May 15, 2017 revised table from the Washington State Department of Agriculture, Pesticide Management Division (WSDA 2017) that was previously provided to them by NMFS during informal consultation. The complete table contains 51 different products with EPA toxicity classifications ranging from "practically non-toxic" to "moderately toxic" to rainbow trout or daphnids (common salmonid invertebrate prey). Some adjuvants have been shown to be significantly more toxic to fish and invertebrates than the herbicides they are often mixed with in a tank or formulated product. This is the case with the surfactants R-11 and POEA (polyethoxylated tallowamine) and the Renewal Corporation has committed to not using these two chemicals or formulated products that contain them. The Renewal Corporation also limited its choice of solvents to water or specifically labeled vegetable oils.

Adjuvant is a broad term describing any additive to a pesticide spray that enhances pesticide activity and often refers to surfactants and penetrants, but also includes colorants (dyes) that help identify sprayed surfaces and potential off target applications. Surfactants facilitate and accentuate the emulsifying, dispersing, spreading, wetting, or other surface modifying properties of liquids. They are commonly referred to as "spreaders and stickers". Penetrants help the pesticide penetrate a membrane (e.g., plant cuticles or gill tissue). The proposed action as described above use any of the 51 adjuvants on the WSDA (2017) table and could result in exposure of individual coho salmon, likely juveniles or smolts, to an herbicide mixture that contains adjuvants. Given that EPA does not have registration requirements for adjuvants, generation of effects data, alone and/or in combination with compatible herbicides, is either done independently or not at all (Bakke 2007). The states of California and Washington have some data generation requirements for the adjuvants alone (e.g., the data on WSDA (2017)), but determining toxicity in combination with an herbicide is not required and this data gap leaves significant uncertainty in the process. Due to this uncertainty, NMFS has determined that use of these adjuvants could lead to adverse effects to exposed coho salmon individuals and, depending on the toxicity and dose of the herbicide and adjuvant combination, to mortality for those individuals.

2.5.1.2 Effects to Coho Salmon Critical Habitat

As discussed in the Environmental Baseline section, coho salmon critical habitat in the action area consists of the Klamath River mainstem from Iron Gate Dam to just upstream of the mouth of the Trinity River, inclusive of the tributary confluences within the 100 year floodplain. Also described in the Environmental Baseline section, the area upstream of Iron Gate Dam has not been designated as critical habitat as well as the reaches downstream of Trinity River that are within the boundaries of the Yurok Tribe Reservation. Unlike the Effects to Coho Salmon section, this section does not include the proposed action's beneficial effects of increased spawning, rearing, and migration habitat upstream of Iron Gate Dam when discussing effects to critical habitat, because the area upstream of Iron Gate Dam is not designated as critical habitat. Below, we considered the impacts to the PBFs (e.g., water quality and food resources) and their ability to support essential habitat types which are, in summary, 1) spawning, 2) migration, and 3) rearing.

2.5.1.2.1 Spawning Habitat

Short-term impacts to spawning sites are expected to occur during the first two years of the proposed action, as described previously in Section 2.5.1.1.7 where we analyze impacts of elevated SSCs and bedload transport. During the year of reservoir drawdown and in the year following dam removal, a large amount of bedload material will be deposited over an approximate 5-mile reach (Iron Gate to Willow Creek) as indicated by the bedload deposition model (FERC 2021a). This level of deposition in the first two years is expected to have adverse impacts to spawning sites in the mainstem Klamath River, suffocating any redds that may be constructed there. Although the depositional reach immediately downstream of Iron Gate Dam does occasionally support coho spawning, the occurrence of redds in that reach is rare (described in Section 2.5.1.1.7), with most spawning occurring in tributary locations where spawning habitat is of higher quality. The impacted reach supports only poor quality spawning sites due to the reach being starved of sediment (i.e., the dams block sediment transport). The available data indicate that coho salmon only attempt to spawn in the mainstem Klamath River near IGD. These fish are likely from the Upper Klamath River population and are currently blocked by IGD from seeking tributary habitats further upstream. A few of these fish attempt to spawn in the mainstem near IGD. Most are thought to be of hatchery origin (Magneson and Gough 2006). Therefore, NMFS expects bedload transport and deposition of fine material during the first two years of project implementation to result in short term adverse impacts to five miles of coho spawning habitat near IGD that is currently in poor condition. No other coho spawning habitat is present in the mainstem of the Klamath as evidenced by the lack of coho salmon spawning farther downstream from IGD.

In the long term (≥ 2 years) spawning gravel availability downstream of Iron Gate Dam is expected to improve by reducing median substrate size to a more favorable size for spawning (DOI 2011). Below, in Section 2.5.1.2.5.7 we describe the benefits of improved sediment transport post dam removal, which will in turn improve spawning habitat beyond current conditions downstream of the Iron Gate Dam site.

2.5.1.2.2 Adult and Juvenile Migration Habitat

The proposed action will result in high SSCs in the Klamath River in the short term as modeled by the Renewal Corporation (Appendix H of FERC 2021a), and described in Section 2.5.1.1.7. Elevated SSCs due to reservoir drawdown will co-occur with low levels of dissolved oxygen. In Section 2.5.1.1.8, we describe how predicted short-term increases in oxygen demand during reservoir drawdown generally result in dissolved oxygen concentrations above the minimum acceptable level (5 mg/L) for salmonids. Exceptions to this will occur in mid-January and mid-June when dissolved oxygen levels decline to less than 5 mg/L.

SSCs and low dissolved oxygen in the mainstem Klamath River will be high enough to cause major physiological stress and impaired homing for adult coho salmon in the fall of the year of reservoir drawdown, and immediately following removal of the dams in Year 1 (see Section 2.5.1.1.7). In the spring, coho salmon smolts are expected to begin outmigration to the ocean (Wallace 2004) when SSCs and low dissolved oxygen will result in degraded water quality in the mainstem Klamath River. These water quality impacts will be most elevated closest to Iron Gate Dam and become less concentrated moving downstream as indicated by the sediment transport model (FERC 2021a). Although less severe downstream, these impacts will affect the entire mainstem Klamath River downstream of Iron Gate Dam. Therefore, NMFS expects a temporary (< 2 years) reduction in quality of the migratory corridor for adult coho salmon and outmigrating smolt.

Short term sediment wedges may be deposited during reservoir drawdown and immediately after dam removal. If these deposits occur at the mouth of tributaries, adult and juvenile migration could be impeded. However, fish passage maintenance and monitoring actions described in the Proposed Action Section 1.3.5.5 are expected to minimize the development and duration of depositional barriers to migration. Frequent monitoring in key locations identified as potential depositional zones will allow early identification and remediation (sediment removal) of any barriers that may form, minimizing these adverse effects.

2.5.1.2.3 Rearing Habitat

The primary effects to rearing habitat will result from the sediment release downstream of Iron Gate Dam during drawdown (see discussion on bedload deposition in Section 2.5.1.1.9). Coarse sediment deposition is expected to degrade rearing habitat immediately downstream of Iron Gate Dam. While specific changes are not entirely predictable, modeling predicted a reduction in pool quantity and quality., in addition to the high loads of suspended sediment and low DO discussed above These changes in habitat may temporarily reduce the quantity and quality of rearing habitat in the mainstem Klamath River between Iron Gate Dam site and Willow Creek, a distance of approximately five river miles (FERC 2021a). However, because the reach between Iron Gate Dam and Willow Creek has had limited sediment supply, the coarse sediment deposition may increase habitat complexity in this reach (Kondolf et al. 2014).

The degree of habitat modification is expected to be highest immediately downstream of the Iron Gate Dam site and is expected to diminish farther downstream. An average of approximately 2.5 to 5 ft. of deposition of fine and coarse sediment will occur on the mainstem reach between the Iron Gate Dam site and Bogus Creek (0.5 mile long reach), decreasing to 1.0 to 1.5 ft. of deposition between Bogus Creek and Willow Creek (4.5 mile long reach. Reaches downstream of Willow Creek are expected to have less than 0.5 feet of reach-averaged bed elevation change (Reclamation 2011b).

Food resources (a PBF) are also expected to be adversely impacted which would, in turn, reduce the quality of rearing habitat in the mainstem where juveniles may be feeding. Under the proposed action, increased SSCs are expected to affect BMI production in the short term (FERC 2021a). The high concentrations of suspended sediments and low DO that occurs in the winter during drawdown will occur during the dormancy period of macroinvertebrates. However, elevated SSCs and low DO in the spring and summer are expected to cause physiological stress, reduced growth, and mortality to BMIs. Elevated SSCs could impact BMI as far downstream as Orleans, approximately 134 miles downstream of Iron Gate Dam (FERC 2021a). During summer of the drawdown year, high SSCs associated with cofferdam breaching activities and drawdown completion will be expected to impact macroinvertebrates during the peak of their feeding and reproductive period. Recolonization of affected BMI populations will occur relatively quickly (within weeks or months) due to the short life cycle of BMIs and rapid dispersal through drift and/or the flying stages of many BMI adults. In addition, repopulation is expected to occur rapidly through drift or dispersal of adult life stages from established BMI populations in the many tributaries to the Klamath River (FERC 2021a).

Juvenile coho salmon feed primarily on drifting terrestrial insects, many of which are produced in the riparian canopy, and on aquatic invertebrates growing in the interstices of the channel bed and in the leaf litter in pools (Hetrick et al. 1998). Likely, the elevated suspended sediment will increase invertebrate drift rates (Culp et al. 1986; Molinos and Donohue 2009; Larsen and Ormerod 2010) and reduce the density (Wagener and LaPerriere 1985; Larsen and Ormerod 2010) and abundance of benthic macroinvertebrates (Larsen et al. 2011). The anticipated increase in sand composition in the channel (indicated from the bedload transport model in

FERC (2021a) will partially fill in interstitial spaces between gravel, cobble, and boulders, which will adversely affect BMI production and availability as a food source for coho salmon. The extent of this adverse impact is unknown and dependent on how suspended sediment moves through the channel (flow dependent). However, NMFS expects that only some food resources will be impacted (benthic) while drifting food remains available and impacts will only last a short period of time (weeks to months) due to rapid recolonization. In the long term, food resources will be improved through implementation of the proposed action and a restored sediment transport regime as detailed in Section 2.5.1.2.5.7

Although rearing habitat is expected to be temporarily reduced, the loss of some pool quantity and quality in the reach between Iron Gate Dam site and Willow Creek represents a small and short-term reduction in rearing habitat. This reach represents less than 3 percent of the total channel length of the mainstem Klamath River downstream of Iron Gate Dam (190 miles). The reduction in food resources is expected to extend further downstream but should be relatively minor in relation to other available food sources and only a short term impact for the reasons described above.

Herbicide applications in the footprint of the former reservoir areas to control invasive exotic vegetation may also result in minor impacts to coho food resources. Exposure to the full suite of potential chemicals proposed by KRRC could result in impacts such as increased invertebrate drift rates and reduced density. However, the BMPs proposed are expected to control exposure so that any discharge of the chemicals would only be short lived and infrequent, and only into the near shore areas of the river or perennial steams immediately adjacent to the application sites. The short potential exposures (hours to days) will not prevent rapid recolonization of the area by benthic macroinvertebrates.

2.5.1.2.4 Summary of Effects to Coho Salmon Critical Habitat

The initial reservoir drawdown and release of sediment is likely to adversely affect the PBFs for spawning, migration, and rearing essential habitats in the short-term. These impacts are expected to be more severe in the upstream reaches that are immediately downstream of Iron Gate Dam. Impacts such as degraded water quality are reduced in downstream reaches with tributary dilution. Therefore, in the short term, the proposed action will have an adverse effect on SONCC coho salmon critical habitat in the mainstem Klamath River with the most severe impacts concentrated in the upstream most reaches. However, as described below, in Section 2.5.1.2.5, the proposed action will result in more natural sediment transport and hydrologic processes downstream of Iron Gate Dam, which will help create more natural substrate characteristics, increase the number and quality of spawning sites, enhance food resources, improve water quality, and expand the amount of riparian vegetation available for coho salmon. Therefore, in the long term, the proposed action will have a beneficial effect on SONCC coho salmon critical habitat.

2.5.1.2.5 Beneficial Effects on Coho Salmon and their Critical Habitat

As discussed in greater detail below, the proposed action will restore aspects of the natural ecosystem of the mainstem Klamath River downstream of Keno Dam from its current state to a more dynamic river that will be influenced by the hydrology of multiple tributaries within the Hydrologic Reach. Coho salmon will benefit from a host of ecological improvements resulting from dam removal including: (1) access to approximately 76 miles of spawning and rearing habitat upstream of Iron Gate Dam, (2) a more natural river hydrology, (3) improvements to water quality conditions including higher dissolved oxygen and lower risks of algae blooms, (4) decreased risks due to disease, and (5) in-river habitat improvements including increased recruitment of large woody debris and spawning gravel. The ecological improvements on the Klamath River mainstem should enhance viability of coho salmon populations. The degree of restoration of these aspects of the natural ecosystem will vary depending on each aspect and other factors unrelated to the proposed action.

2.5.1.2.5.1 Long-term Increased Flow Variability

The proposed action does not include a water management element. However, as a result of the removal of the four dams in the Lower Klamath Project, flow variability in the mainstem Klamath River will increase. Unlike current conditions, tributary flows between Iron Gate and Keno dams, such as from Fall, Shovel, and Spencer creeks, will be able to flow freely in the mainstem Klamath River. This means that, for example, during rainfall events river flows in the mainstem will increase (and then subside) more readily because water will no longer be impounded by the 4 dams.

Table 23 shows the exceedance table for the monthly volumes of Keno to Iron Gate dam accretions in thousand acre-feet (TAF) for water years 1981-2020 (Reclamation 2021, unpublished data). The percent exceedance defines the probability of a specified monthly accretion volume to be met or exceeded in a given month (e.g., Table 24 indicates that 90% of the time in October, 17.3 TAF of accretions will be met or exceeded). The monthly accretion volumes in Table 23 include the estimated evaporation volumes from the four reservoirs added to the historic accretion volumes, and thus represent estimated accretions post-dam removal. Inclusion of estimated evaporation volumes increased the historic (pre-dam removal) accretions by ranges of 0.2-1.3 TAF per month and 7.4-7.9 TAF per year (Reclamation 2021, unpublished data). The flow volume in the Keno to Iron Gate Dam reach will vary each month, depending on climate, seasons, and hydrologic year type. The increase in flow variability in this reach and downstream vicinity of the Iron Gate Dam site will benefit coho salmon.

Increased flow variability (in response to rainfall events, for example) will increase the effectiveness of environmental cues and better enable juvenile coho salmon to adapt to short-term environmental changes. Juvenile coho salmon in the Klamath Basin have been shown to make localized movements in response to changes in environmental conditions at temporal scales of hours to months (Witmore 2014). Increased flow variability, therefore, is expected to increase the likelihood of juveniles redistributing from marginal overwintering habitat in the mainstem to more suitable habitat downstream or upstream.

As outlined in the *Environmental Baseline* section, seasonal redistribution is an integral life history strategy of juvenile coho salmon. Seasonal redistribution is triggered through environmental cues, including flow variability resulting from precipitation. Juvenile coho salmon are likely to redistribute downstream to overwintering habitat in the Lower Klamath River reach and downstream non-natal tributaries. Enhanced fall flow variability will provide transitory habitat in side-channels and margins preferred by juvenile coho salmon. This habitat is expected to provide suitable cover from predators, and ideal feeding locations.

For the reasons discussed in greater detail in the next subsection, NMFS also anticipates enhanced flow variability in the fall and winter will help disrupt the fine sediment habitat of *M. speciosa polychaete* and increase the redistribution of adult salmon carcasses in the mainstem Klamath River, thereby reducing actinospore concentrations of *C. shasta and P. minibicorni*s the following spring and ultimately reducing disease rates amongst juvenile salmonids in the mainstem Klamath River.

Table 23. Percent exceedance table for monthly volumes of Keno to Iron Gate dam accretions post dam-removal in thousand acre-feet from 1981-2020 (Reclamation 2021, unpublished data).

Exceedance	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
90%	17.3	18.0	19.2	22.7	20.8	24.8	22.9	19.3	16.9	16.8	16.3	16.5
70%	19.0	20.7	22.5	26.5	24.0	31.9	29.7	26.9	20.2	18.8	17.4	17.9
50%	21.8	22.6	25.6	30.7	29.5	42.4	38.0	31.5	22.8	20.6	19.7	20.4
30%	22.9	24.1	32.8	37.7	40.4	58.8	49.4	36.6	26.3	22.0	21.1	21.3
10%	26.2	30.8	58.3	47.4	76.5	70.1	65.2	53.6	34.7	25.3	24.4	23.3

2.5.1.2.5.2 Long-term Decreases in Disease

The current altered hydrology of the Klamath Basin is significant. The four dams in the Lower Klamath Project have blocked sediment transport downstream of Iron Gate Dam, caused a dramatic reduction in flow variability resulting in constant, stable flows downstream of Iron Gate Dam, and decreased water quality downstream of Iron Gate Dam from algae blooms in the reservoirs. Periodic scour and substrate disturbance are considered to be integral for managing disease induced mortality of juvenile and adult salmonids (Alexander et al. 2014; Curtis et al. 2021). In addition, Turecek et al. (2021) investigated the efficacy of reducing streamflow to desiccate annelid hosts to reduce disease risk. Stocking and Bartholomew (2007) noted that the ability of some annelid 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.

The proposed action is likely to reduce the effects of fish disease on coho salmon because the factors needed to develop an infectious zone for coho salmon will be at least partially disrupted. Fish disease from *C. shasta* and *P. minibicornis*, require the following factors to co-occur: polychaete habitat (e.g., pools, eddies, periphyton and sediment); microhabitats with stable flows and low velocities; polychaete host proximity to salmon spawning areas; and water temperatures greater than 15°C (Bartholomew and Foott 2010). Habitat quality for the polychaete host is likely to reduce with the increased flow variability and more natural sediment transport regime as a result of the proposed action. The initial increase in suspended and coarse sediment downstream of Iron Gate Dam will reduce the population density of polychaetes (Bartholomew and Foott 2010). Polychaete populations in sand-silt habitats will be reduced the most, while polychaete populations attached to Cladophora or on vertical surfaces (bedrock) will be fairly protected (Bartholomew and Foott 2010). Therefore, disease transmission rates to coho salmon and polychaete hosts, respectively, are likely to decrease post-dam removal.

Per the FERC (2021a) BA analysis, the proposed action is expected to reduce fish disease impacts to adult and juvenile salmon, especially downstream of Iron Gate Dam. Dam removal is expected to lead to more natural channel processes including channel bed scour and sediment transport. The altered river channel downstream of Iron Gate Dam has resulted in an atypically stable river bed, which provides favorable habitat for the annelid host for *C. shasta* and *P. minibicornis*. Slow-flowing habitats may have higher densities of annelids, and areas that are more resistant to disturbance, such as eddies and pools with sand and *Cladophora*, may support increased densities of annelid populations (Bartholomew and Foott 2010), especially when flow disturbance events are reduced or attenuated. High annelid densities increase parasite loads, which leads to higher rates of infection and mortality for salmon. In the Klamath River, the annelid 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 (RM 179) to Seiad/Indian Creek is known to be a highly infectious zone with high actinospores, especially from May through August (Beeman et al. 2008), although within and between years the size of the infectious zone and the magnitude of parasite densities may vary geographically (True et al. 2016b; Voss et al. 2018; Voss et al. 2019; Voss et al. 2020). The highest rates of infection occur in the Klamath River within approximately 50 miles downstream of Iron Gate Dam (Stocking and Bartholomew 2007; Bartholomew and Foott 2010). Infection prevalence in annelid host populations was an order of magnitude greater in the reach between the Tree of Heaven and Interstate 5 than at any other site throughout the river (Stocking and Bartholomew 2007). Although infection rates are greatest in the upstream reaches of the mainstem Klamath River, infected fish migrate downstream as smolt and further transmit the disease to other populations. Because coho salmon from all populations in the basin utilize the mainstem as a migratory corridor, they are all exposed and impacted by the high rates of disease.

Periodic scour and substrate disturbance are considered to be integral for managing disease induced mortality of juvenile and adult salmonids (Alexander et al. 2014; Curtis et al. 2021), and studies have shown that worm host distribution and abundance decreases when their preferred habitat is substantially disturbed (Malakauskas et al. 2013; Wright et al. 2014; Alexander et al. 2016). Although the exact timing and extent of improved disease conditions in the Klamath River during drawdown and following dam removal is difficult to quantify (Schakau et al. 2019), it is expected that improvements in disease conditions should occur after the dams are removed (CSWRCB 2020b). If fewer fish in the upstream reaches are infected with disease post dam removal, all populations in the basin will benefit from the reduced transmission that would occur during outmigration.

M. speciosa, the speciose, polychaete host, is an endemic species, and some level of recolonization is anticipated to occur; however, future densities are anticipated to decrease in comparison to current levels. Post dam removal, the substrate in the mainstem downstream of the Iron Gate Dam site is expected to consist of finer material than is currently present, and will be mobilized more easily. For instance, lower flows will be required to mobilize sediment in the reaches between Bogus Creek to Willow Creek (e.g., from 3,000 to 7,000 cfs or 1.5 to 2.5 year recurrence interval period) and from Willow Creek to Cottonwood Creek (e.g., from 5,000 to

9,000 cfs or 1.5 to 3.2 year recurrence interval period) than current conditions (DOI and CDFG 2012). Finer substrate, which is habitat for the polychaete host, is expected to be more frequently disrupted at lower flows (Varyu and Greimann 2010 in Bartholomew and Foott 2010). As discussed above, the expected increase in flow variability (Table 23)(Hetrick et al. 2009) will increase sediment mobilization, and destabilize polychaete habitat. Increased mobilization of substrate helps to reduce the availability of habitat for polychaetes (Stocking and Bartholomew 2007). In addition, the abundance of algae and other forms of planktonic species in the Klamath River will be reduced as a result of removing the four reservoirs, which will reduce forage for the polychaete intermediate host. Thus, a more naturally flowing river with increased sediment transport and flow variability is likely to reduce densities of *C. shasta* and *P. minibicornis* in the mainstem, which should reduce coho salmon mortalities and morbidities from these diseases.

The removal of the four dams will also enable adult salmon to migrate upstream past Iron Gate Dam throughout the Hydroelectric Reach to access approximately 76 miles of additional habitat (DOI and CDFG 2012), thus increasing the dispersal of adults. Because spawned salmon carcasses are the major vectors for myxospore transmission (Bartholomew and Foott 2010), increased dispersal of spawned salmon carcasses decreases the densities of the myxospores and reduces their proximity to the dense polychaete populations currently downstream of Iron Gate Dam, which will lead to fewer infected polychaetes and resulting actinospores.

Daily water temperatures are expected to be more variable, with an overall temperature increase in the spring between the Iron Gate Dam site and the Salmon River. Spence et al. (1996) observed that most coho salmon outmigrate before temperatures reach 11 to 12 °C. With earlier temperature increases in the spring, smolts are likely to move downstream earlier (Hoar 1951; Holtby 1988) and faster (Moser et al. 1991), thus reducing juvenile and smolt exposure to actinospore infection.

2.5.1.2.5.3 Long-term Restoration of the Water Temperature Patterns

By removing the dams, diurnal fluctuations will also become broader and more variable (PacifiCorp 2004b). In addition, water temperature in the Klamath River downstream of the Iron Gate Dam site will be warmer in the spring and early summer, while cooler in the fall. In particular, the changes to water temperature are expected to be 2 to 10°C (3.6 to18°F) lower during August through December and 2 to 5°C (3.6 to 9°F) higher during January through March than under the existing conditions (Figure 22). Just downstream of the Iron Gate Dam site, water temperatures will average 2ºC greater in May, while October water temperatures would average 4ºC cooler. At the confluence with the Scott River, the differences will be diminished, but there will still be a slight warming (<1ºC) in the spring and cooling (1–2ºC) in the late summer and fall (Perry et al. 2011).

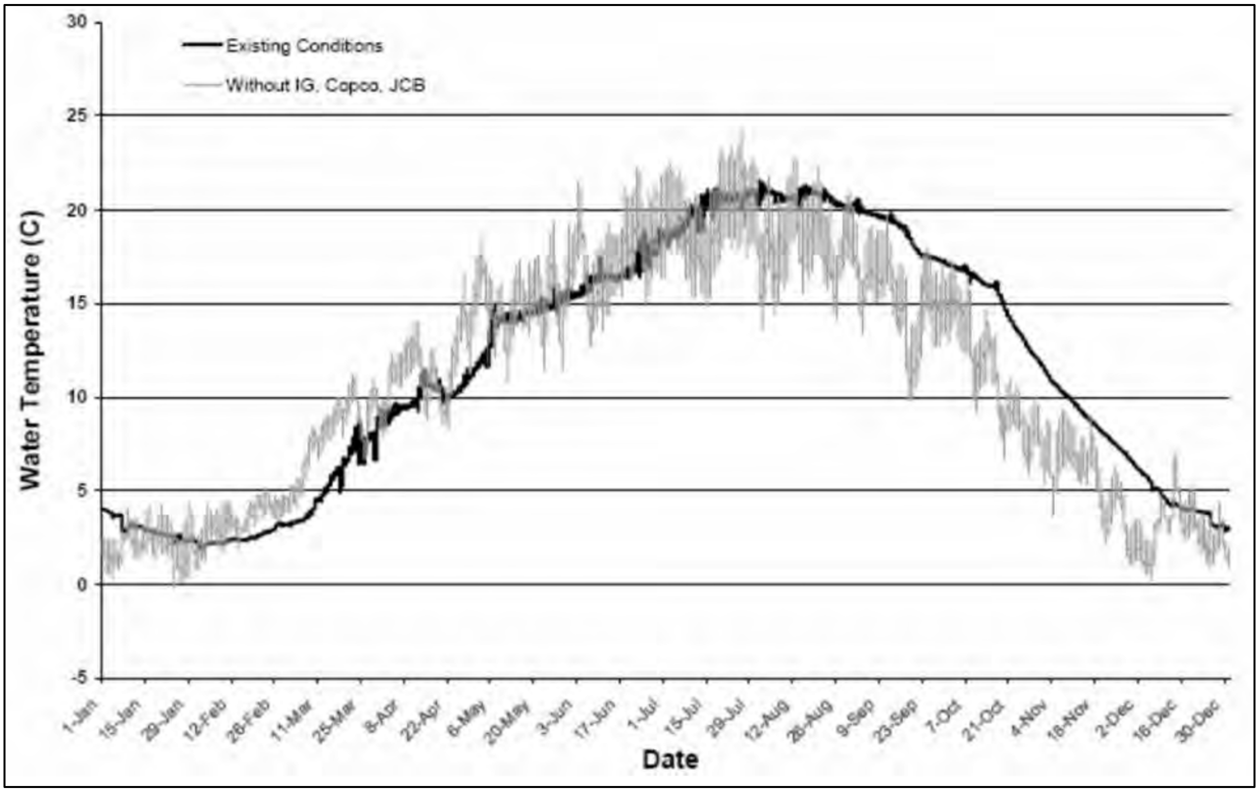

Figure 22. Simulated hourly water temperature downstream of Iron Gate Dam for existing conditions compared to hypothetical conditions post-dam removal (from PacifiCorp 2004c).

The generally warmer spring temperatures and cooler summer and fall temperatures are likely to benefit coho salmon. The more natural diurnal water temperature variation will be more synchronous with historical migration and spawning periods for coho salmon, warming earlier in the spring, and cooling earlier in the late summer (Stillwater Sciences 2009; Hamilton et al. 2011). Increased spring and early summer water temperatures may temporarily reduce the size of thermal refugia in the mainstem (Ring and Watson 1999; Ficke et al. 2007; Hamilton et al. 2011) between the Iron Gate Dam site and the mouth of the Scott River, which will increase inter and intra-specific competition. Although there may be some temporary stress associated with increased summer day-time water temperatures (e.g., when daily maximum temperatures are at least 16° C), there would also be beneficial effects from the decreased minimum water temperatures in the spring and summer (i.e., at night). The National Research Council (NRC) (2004) emphasized the importance of low minimum water temperatures for coho salmon in the summer to provide nocturnal relief from the high water temperature. Increased fluctuations in diurnal water temperatures will also enable juveniles to move between refugial areas, as well as forage in the mainstem at night when temperatures are cool (Dunne et al. 2011).

Additional benefits associated with increased spring water temperatures include likely increased growth for juveniles (Dunne et al. 2011). Increased growth confers higher over-wintering survival (Quinn and Peterson 1996) and increases the size of smolts, which has been shown to increase ocean survival (Bilton et al. 1982; Henderson and Cass 1991; Lum 2003; Jokikokko et al. 2006; Muir et al. 2006). In addition, larger smolts produce larger adults (Henderson and Cass 1991; Lum 2003), which have higher fecundity than smaller adults (Weitkamp et al. 1995;

Fleming 1996; Heinimaa and Heinimaa 2004). Furthermore, smolts are likely to move out earlier (Hoar 1951; Holtby 1988) and faster (Moser et al. 1991) during spring with warmer water temperatures, which will reduce their exposure to parasites and disease.

Cooler fall water temperature will benefit upstream migrant adults and juvenile redistribution to overwintering habitats by providing a broader window of suitable water quality during migration. Water temperatures in the fall will be less stressful and more favorable for adult and juvenile coho salmon in the mainstem. Adult coho salmon may be able to migrate upstream earlier (Dunne et al. 2011) although water temperatures in the late fall and winter are typically not limiting adult migration.

The results from the water temperature model show that dam removal appears to delay the effects of climate change to some extent near Iron Gate Dam (Perry et al. 2011). With dam removal, annual-mean water temperatures exceeded the 49-year historical mean temperature beginning in 2045; whereas with dams, annual-mean temperatures exceeded the historical mean beginning in 2025 (Perry et al. 2011).

2.5.1.2.5.4 Long-term Increase in Dissolved Oxygen

Long-term (≥ 2 years after dams are removed) increases in dissolved oxygen, as well as increased daily variability in dissolved oxygen, are expected in the mainstem, particularly for the reach immediately downstream of the Iron Gate Dam site, with possible increases of 3 to 4 mg/L during summer and late fall (PacifiCorp 2005). The increases in dissolved oxygen concentration will diminish with distance downstream of Iron Gate Dam, such that there will be no measurable effects on dissolved oxygen by the confluence with the Trinity River.

Increases in summer and fall dissolved oxygen in the mainstem immediately downstream of Iron Gate Dam will reduce stress to juvenile coho salmon rearing in the mainstem. As discussed in the Environmental Baseline section, juvenile coho salmon face a myriad of stressors, many of which may have synergistic effects that reduce survival probabilities. NMFS expects that over-summer survival of juvenile coho salmon should increase with improved dissolved oxygen conditions. Higher dissolved oxygen concentrations should afford juvenile coho salmon greater foraging opportunities outside the confines of the existing thermal refugia areas, ultimately resulting in higher survival rates for juvenile coho salmon that rear in the mainstem downstream of Iron Gate Dam during the summer and early fall.

2.5.1.2.5.5 Reduced Toxic Blue-green Algal Blooms

The removal of the four dams will significantly reduce the reservoir habitat for the toxic blue-green algae, such as *M. aeruginosa* (Dunne et al. 2011; Hamilton et al. 2011). Because *M. aeruginosa* is intolerant of turbulent water, *M. aeruginosa* blooms will likely be eliminated downstream of Keno Reservoir (Dunne et al. 2011). A reduction in algal blooms will improve water quality (pH and DO) and reduce potential exposure to the toxin it produces (microcystin) in the mainstem Klamath River. As described in the *Environmental Baseline*, Microcyctins are hepatotoxins and have been shown to cause problems with hatching, developmental defects (e.g., yolk sac effects, curved body and tail, heart rate perturbations), osmoregulatory imbalance, liver damage (enlargement, lesions), kidney lesions, and/or increased mortality in several species of fish including rainbow trout and particularly in embryo and fry lifestages (Kotak et al. 1996; Best et al. 2003; Malbrouck and Kestemont 2006; 2009; Pavagadhi and Balasubramanian 2013). Although we do not have specific information that the microcystin toxin is impacting coho salmon downstream of Iron Gate Dam, based on information about effects in similar species, it is likely to be having a small, but negative impact on individuals.

2.5.1.2.5.6 Increased Large Wood Recruitment

The removal of the four dams will increase future large wood recruitment into the mainstem Klamath River downstream of the Iron Gate Dam site. In addition to existing trees along tributaries and the mainstem upstream of Iron Gate Reservoir, the proposed revegetation of the reservoir areas will contribute to future large wood recruitment into the Klamath River. Greater amounts of large wood often equate to more frequent and larger pools, which in turn, results in a greater number of juvenile coho salmon per channel length (Roni and Quinn 2001). Large wood provides juvenile coho salmon important refuge sites to avoid higher water velocities and cover from predators (Peters 1996; Lestelle 2007). Large wood has also been shown to increase salmonid abundance, survival, and production (Keeley et al. 1996; Solazzi et al. 2000; Roni and Quinn 2001; Whiteway et al. 2010; White et al. 2011).

2.5.1.2.5.7 Increased Sediment Transport

The removal of the four dams will increase sediment transport in the mainstem Klamath River between Iron Gate Dam and the Shasta River (Figure 23)(Reclamation 2011b). The proposed action will reduce the estimated median mobilization flow from about 10,000 cfs to 6,000 cfs in the Bogus Creek to Willow Creek reach. In the Willow Creek to Cottonwood Creek reach, the median estimate of the mobilization flow will reduce from about 11,000 cfs to 6,000 cfs. The return period of mobilization flow in this reach will decrease from 4 years to approximately 2 years (Reclamation 2011b).

Post dam removal, spawning gravel availability downstream of Iron Gate Dam is expected to improve by reducing median substrate size to a more favorable size for spawning (Reclamation 2011c). The release of sediment from behind the dams will help create more natural substrate characteristics in the Hydroelectric Reach and increase the number of spawning sites available for coho salmon relative to current conditions. These same dynamics will also support habitat complexity and increased quality of rearing habitat.

Food resources are expected to improve as a result of increased sediment transport with long term improvement to BMI production. After the four dams are removed, the reformation of river channels in the Hydroelectric Reach reservoirs following the proposed action is expected to benefit BMIs by providing more suitable substrates than currently exist (FERC 2021a). As a result, suitable habitats formed in the Hydroelectric Reach will be opened to additional colonization by BMIs through rapid dispersal by drift from upstream populations in current riverine reaches and/or dispersion of adult life stages. Increased habitat availability for BMI populations is anticipated to increase food availability for juvenile coho salmon downstream of Iron Gate Dam as BMI freely drift or migrate downstream of the Hydroelectric Reach. Increased habitat availability will result in a substantial increase in the amount of food resources available for coho salmon in the long term.

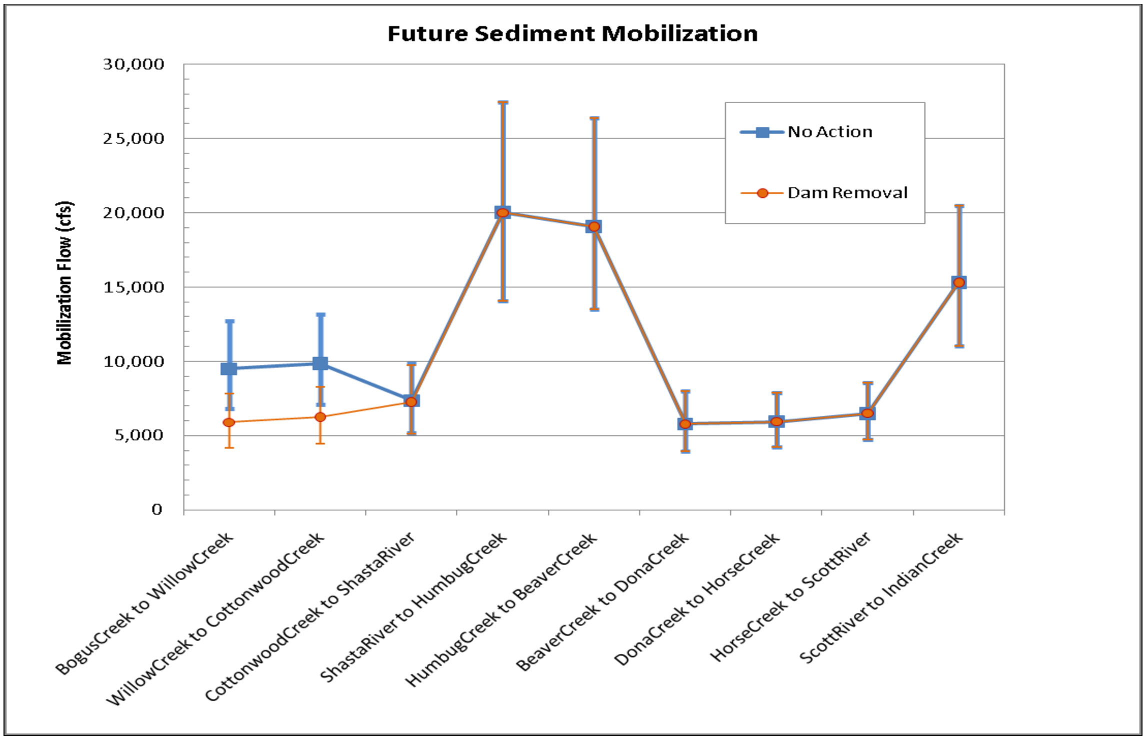

Figure 23. Future estimate of initiation of sediment mobilization flows under Dam Removal and No Action Alternative (Figure from Reclamation 2011b).

2.5.1.2.5.8 Restored Access to Previously Blocked Habitat

With the removal of the four dams under the proposed action and additional culvert replacements in key tributaries (e.g., Daggett Road at Fall Creek), coho salmon will be able to access approximately 76 miles of habitat (DOI and CDFG 2012), including at least 30 miles in tributaries such as Fall, Jenny, Shovel, and Spencer creeks. Approximately 40 percent of the historic habitat of the Upper Klamath River Population of coho salmon will become available again (Williams et al. 2006b). Historical records show that coho salmon occupied areas up to Spencer Creek (Hamilton et al. 2005).

Jenny, Fall, Shovel, and Spencer Creeks presently support spawning populations of resident salmonids, which suggests that these tributaries may also be suitable for use by coho salmon. The expected habitat conditions for coho salmon in tributaries will vary in quality; however, there is significant suitable habitat, including tributary habitat, upstream of Iron Gate Dam for the needs of the life history of coho salmon (Administrative Law Judge 2006). Access to these habitats will provide increased spawning and rearing habitats, including cold water for thermal refugia, large woody cover, and increased food resources. Juvenile coho salmon will have access to significant thermal refugia in the J.C. Boyle bypass reach. An estimated 200 to 250 cfs of cold spring accretion flows in the J.C. Boyle bypass reach (FERC 2007; USDOI 2007).

NMFS and the Renewal Corporation expect salmonids to quickly repopulate habitat upstream of Iron Gate Dam following dam removal. This response has been observed after barrier removal on the Elwha River (Liermann et al. 2017; Duda et al. 2021), White Salmon River (Allen et al. 2016; Hatten et al. 2016), Cedar River (Burton et al. 2013; Anderson et al. 2015), Rogue River

(McDermott 2016), and the Penobscot River (Izzo et al. 2016). Salmon have evolved with mechanisms for populating new habitat when that habitat is suitable and accessible (Bett et al. 2017; Pearsons and O'Connor 2020). Each dam removal project is different; however, as described above, the total habitat that is expected to be accessible and repopulated by coho salmon as a result of the proposed action is substantial. Although some movement past the Iron Gate Dam site by juvenile and adult coho salmon is expected in the first year when habitat conditions are suitable, full utilization of this habitat and associated juvenile production is expected to develop over time.

2.5.1.2.5.9 Increased Coho Salmon Fitness

In general, as a species' habitat availability and diversity increases, the fitness of the individuals increases. The improved mainstem habitat conditions discussed above and access to approximately 76 miles of additional habitat discussed above are expected to improve survival for all life stages of coho salmon, which is expected to increase the abundance of all life stages. Access to approximately 76 miles of additional habitat upstream of Iron Gate Dam will increase the spatial distribution of coho salmon, especially for the Upper Klamath River population. Coho salmon spawners will be able to seek higher quality habitat for spawning, which should increase their reproductive success and enhance productivity of this population. Juveniles that outmigrate from the tributaries will have more favorable rearing conditions in the mainstem, especially during the summer and early fall. Improved mainstem habitat conditions should increase the number of smolts produced from the Klamath River basin, especially the Upper Klamath River population. Although many of the anticipated habitat benefits will have the greatest impact on populations nearest the Iron Gate Dam site (Upper Klamath, Shasta River, and Scott River), all populations that use the action area will benefit from the reduced prevalence of disease as described in Section 2.5.1.2.5.2. As described in the Environmental Baseline section, disease negatively effects all Klamath and Trinity River populations. These impacts are significant as rearing juveniles, outmigrating smolt, and adults are all impacted. Therefore, the reduced rates of disease throughout the Klamath River are expected to improve survival of juveniles, smolt, and adult coho salmon in all populations.

With increased spatial distribution and the ability to use habitat upstream of Iron Gate Dam, coho salmon will be able to express greater life history diversity, and increase behavioral and genetic diversity in the long term. Both increased diversity and spatial structure enables individuals to be resilient towards localized stressors and catastrophic events as well as long term environmental changes as a result of climate change.

2.5.2 Southern Resident Killer Whales (SRKWs)

The primary potential effect of the proposed action on SRKWs that was identified in the BA (FERC 2021a) and in this Opinion is through potential reductions in the abundance and availability of preferred prey, Chinook salmon, in the coastal marine waters where Chinook salmon from the Klamath River may be encountered by SRKWs. As described further below, the effects of the proposed action on SRKW prey are variable across the timeline of the proposed action, including:

- an initial period of time during which Chinook salmon are affected by release of the sediment and other factors immediately following dam removal;
- an intermediate (or mid term) period of time following dam removal during which changes in hatchery production as a result of the proposed action are expected to occur while recovery and restoration of the Klamath River system begins; and
- a long term period during which hatchery production is not part of the proposed action as the benefits of the proposed action are being fully realized, including increased productivity of Chinook salmon associated with accessibility to a large amount of habitat upstream of the former dams and significant improvements in overall habitat conditions in the mainstem Klamath River.

In addition, we consider potential effects to SRKWs from the release of sediment and contaminants following dam removal into the Klamath River and the coastal ocean near the mouth of the Klamath River. We consider the potential for the release of contaminants in sediments that are stored behind the dams to affect SRKWs through uptake in the food web through Chinook salmon prey that may be exposed to and accumulate those contaminants.

Given the significant depth of analysis associated with the abundance and availability of prey resources over the various time periods, we first consider other potential effects to SRKWs that could be associated with release of sediments that occurs immediately following dam removal.

2.5.2.1 Effects from Release of Sediments

2.5.2.1.1 Plume in ocean

The removal of the dams is anticipated to result in a large release of sediment into the Klamath River system and the ocean. A river plume currently occurs at the Klamath River mouth with a variable extent and shape throughout the year. The drawdown activities are anticipated to take place from January to October during Year 1 with the removal of the dam facilities largely taking place from March through October during Year 1. The final embankment removal would then follow in October and November during Year 1 (FERC 2021a). Throughout this time, some "pulses" of sediment release, associated with different stages of the proposed action, are expected, and it is likely that at least some of these pulses, and the resulting plumes, will occur during the winter and spring when SRKWs may be present near the Klamath River. A large portion of the fine sediment released by the dam removals is anticipated to initially settle near the river mouth and extend out to the 60-meter isobath along the coast (DOI and CDFG 2012). The sediment plume is anticipated to rapidly dilute once it reaches and expands through the ocean (FERC 2021a). The variable timing of sediment releases should minimize the impacts on SRKWs due to their limited use of the action area throughout the construction period.

The presence of increased SSCs may have a short term impact on SRKW and their behavior, including foraging activities and success if they are present during the relatively short time period an increase in SSC near the mouth of the Klamath River associated with the proposed action is anticipated. There are no existing studies of how SRKW may respond to a SSC plume created by dam removal consistent with the scale of the proposed action, but we acknowledge that many species of dolphins are found in areas with naturally high levels of suspended sediment (Au and Hastings 2008). Information suggests that SRKW may rely more on echolocation than vision in highly turbid waters for navigation and foraging (Au et al. 2000), Todd et al. 2015). This is the case for other dolphin species such as belugas (Castellote et al. 2013) Ganges River dolphins (Jensen et al. 2013). Observations of resident killer whales in the Pacific Northwest (Northern and Southern Residents) found clicking rates do not necessarily rise in response to increased turbidity, suggesting that echolocation is used in all conditions and likely a low-cost energetic action for the whales (Barrett-Lennard 1992).

Changes in Chinook salmon behavior in response to elevated SSC could have effects on SRKWs. For example, elevated turbidity could disturb fish and/or disrupt their normal feeding and movement patterns which could change their availability as prey for SRKWs. Studies generally focus on the impacts of increased SSC on salmon in freshwater systems (i.e., spawning and reproduction), instead of in the ocean. Generally, piscivorous fish such as salmon that feed on larger prey detected visually over longer distances are thought to be affected to a greater extent by turbidity than planktivorous fish that detect prey visually over short distances (Todd et al. 2015). However, one study found that densities of yearling Chinook salmon increased with higher turbidity associated with Columbia River plume (Emmett et al. 2004). While yearling salmon may continue to reside within the nearshore marine environment for a period of time to develop and mature, sub-adult and adult Chinook salmon are well known to engage in vast migrations throughout the ocean during the marine phase of their life-cycle (see Weitkamp 2010; Shelton et al. 2018 for reviews of Chinook salmon distribution in marine waters).

Any effects to SRKW due to their contact with the sediment plumes or effects through Chinook salmon prey associated with increased SSC would only exist over the short-term period when the dams are being removed and large amounts of sediment are released back into the system. SSC is expected to greatly decrease during Year 2 of the proposed action as the reservoir drawdowns and larger dam removal construction activities are completed and high flow events further flush the Klamath mainstem (FERC 2021a). SRKW are expected to spend limited time off the mouth of the Klamath River, as are adult Chinook salmon that migrate over vast areas during their life. If any SRKWs did occur within the boundary of a short-term plume near the mouth of the Klamath River, the effects are expected to be negligible given that SRKWs are likely to be able to forage successfully in a turbid environment and Chinook salmon are unlikely to be negatively impacted by the plume in the ocean. As a result, we conclude that the short-lived elevated sediment plumes from the sediment pulses are unlikely to have more than negligible effects on SRKWs.

2.5.2.1.2 Release of Contaminants

The release of sediments that have previously been trapped behind the dams that are being removed presents a risk of release of contaminants into the food web for Chinook salmon, and ultimately to SRKWs. Because high contamination levels in SRKWs have been identified as a risk to their recovery (NMFS 2008; NMFS 2016e), we analyzed the potential effects of the release of these contaminates.

As part of the evaluation of dam removal, analysis of sediments and their potential impact on the freshwater and marine environment has been conducted (CDM 2011; DOI and NMFS 2013) . A total of 77 sediment cores were collected at various reservoir and estuary locations; 501 analytes were quantified across the samples, including metals, poly-aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides/herbicides including dichlorodiphenyltrichloroethane (DDT), phthalates, volatile and semi-volatile organic compounds (VOCs, SVOCs), dioxins, furans, and polybrominated diphenyl ether flame retardants (PBDEs). Some of these constituents, especially the persistent organic pollutants (POPs) PCBs, DDT, and PBDEs, have been found in high concentrations in SRKWs (and their prey) that may present significant health risks for SRKWs (Mongillo et al. 2016).

Analysis of the risk of contaminant release from removal of the Klamath dams found that contaminant levels in sediments trapped behind the dams are below critical threshold levels identified for their disposal, and thus do not preclude their downstream release if dams were removed. A screening level evaluation that considered five pathways of potential exposure concluded that some compounds were identified at levels with "potential to cause minor or limited adverse effects" for aquatic receptors in the short term (1-2 years) following dam removal. This evaluation also concluded that long-term adverse effects for biota would be unlikely from the chemicals present in sediments deposited in the river channel, deposited along riverbanks, or left behind on exposed reservoir terraces (CDM 2011; DOI and NMFS 2013).

Generally, the exposure time for surviving juvenile Chinook salmon heading to the ocean to uptake these contaminants is expected to be relatively short, given the short duration that released sediments are expected to remain in the system before being ultimately flushed out to sink to the bottom of the ocean. Research has indicated that salmon accumulate the majority (>96%) of their POP loads while feeding pelagically in the marine environment, rather than in their freshwater and estuarine habitats (Cullon et al. 2009; O'Neill and West 2009), as over 98% of their growth occurs while fish are feeding in salt water (Quinn 2005). Given their vast migrations in the marine environment that are widely attributed to Chinook salmon, the risk associated with Klamath Chinook salmon increasing their POP loads resulting from the short pulse of exposure from the proposed action to ultimately pass on to SRKWs for bioaccumulation is very low. These risks are further diminished by the fact that SRKWs may not necessarily encounter the juvenile Klamath Chinook salmon that may have a small increase in POP load, depending on their ultimate survival to adulthood in the ocean following dam release and the periodic occurrence of SRKWs in marine areas where Klamath Chinook salmon occur. As a result of short exposure to the salmon and limited overlap between mobile SRKW predators and their mobile Chinook salmon prey, we conclude that any adverse effects associated with accumulation of contaminants in SRKW following release of sediments during dam removal are improbable.

2.5.2.2 Effects of Proposed Action on Chinook Salmon

Chinook salmon in the Klamath River are not listed under the ESA; however, we analyze the effects of the proposed action to Chinook salmon because they are a primary food source for SRKWs, and Klamath River Chinook salmon are potential (and important) prey for SRKWs in marine waters along the coast of the United States. As noted above, effects of the proposed action that reduce Chinook salmon production and abundance could lead to adverse effects to

SRKWs. Much like ESA-listed coho salmon, Chinook salmon utilize the Klamath River during all of their life stages and the life history requirements of both Chinook and coho salmon overlap. Therefore, we largely (as described above) rely on our coho salmon analysis of effects of the proposed action to inform us on the effects of the proposed action on Chinook salmon. However, there are life history strategies and habitat preferences of Chinook salmon that do differ from coho salmon.

2.5.2.2.1 Background on Klamath River Chinook Salmon

Klamath River Chinook Salmon Life History

The general life history of Chinook salmon involves incubation, hatching, and emergence in freshwater, migration to the ocean, and subsequent initiation of maturation and return to freshwater for completion of maturation and spawning. Chinook salmon are anadromous and semelparous (i.e., individuals die after spawning). Within this general life history strategy, however, Chinook salmon display considerable variation in the age at which juveniles migrate to the ocean, ocean distribution and migratory patterns, length of residence in the ocean, season of spawning migration, and time of year in which they spawn. Juvenile rearing in freshwater can be minimal or extended.

Chinook salmon display two types of life history strategies in the Klamath River, spring-run and fall-run, which are named for the season of adult freshwater entry and migration upstream. Unlike coho salmon, Chinook salmon typically spawn in larger waterways such as the mainstem Klamath River and large tributaries including the Trinity, Salmon, Scott, and Shasta rivers. Fry emerge from redds between December and February. Juvenile Chinook salmon can display either a “stream type” or “ocean type” life history strategy where the “stream type” rears for a greater length of time in freshwater than the “ocean type.” However, Williams et al. (2013) determined that juvenile Chinook salmon in the Klamath Basin typically do not display the “stream type” strategy. Therefore, juveniles in the Klamath and Trinity rivers will usually outmigrate shortly after emergence between March and June. Chinook salmon from the Klamath River typically mature and return to freshwater between two and six years of age (Snyder 1931). In recent years, the large majority of Chinook salmon from the Klamath Basin have matured and returned to the Klamath river between two and four years of age each year (Gough et al. 2018).

Klamath River Chinook Salmon Spatial Structure/Distribution

Dam construction has greatly reduced the distribution of Chinook salmon in the Klamath River Basin. Fish passage to the Oregon portion of the Klamath River Basin is believed to have been first blocked by an early phase of the construction of Copco 1 Dam at approximately RM 202 in 1912 (Hamilton et al. 2016). Construction of Copco 1 Dam was completed in 1918, followed by Copco 2 in 1925 and Iron Gate Dam in 1962. Iron Gate Dam at RM 193 represents the upstream limit of access of anadromous fish in the Klamath River. The Lewiston water diversion dam on the Trinity River, completed in 1963, has prevented access of spring-run Chinook salmon to their historical spawning grounds on the East Fork, Stuart Fork, and Upper Trinity River and Coffee Creek (Campbell and Moyle 1991). Dwinnell Dam on the Shasta River was completed in 1928 and blocks access to the upper Shasta River basin. In addition, spring-run Chinook salmon populations have likely been extirpated from still accessible areas of the basin, such as the Scott and Shasta rivers, in which fall-run Chinook salmon populations still persist (Snyder 1931; Heizer 1972; CDFG 1990; Myers et al. 1998; Thompson et al. 2019).

Chinook Salmon Abundance and Productivity

Natural-spawned Chinook salmon abundance has declined dramatically since dams were constructed in the Klamath Basin. CDFG (1965) estimated spawning escapement of Chinook salmon at approximately 168,000 adults with the number split about evenly between Klamath and Trinity rivers. The most recent five-year average (2016 to 2020) for wild spawning escapement is 33,578 adults combined for the Klamath and Trinity (CDFW 2021c)(Figure 24). Hatchery production supplements the overall production of Chinook salmon in the Klamath Basin. The IGH target for annual releases is six million fall-run Chinook salmon juveniles each year, while TRH aims to release 4.3 million juvenile spring-run and fall-run Chinook salmon combined. However, when adult returns are not sufficient to reach egg production goals the hatcheries are not able to produce their entire target each year. In the most recent five years of data, IGH released an average of 3.8 million Chinook salmon (63% of target) while TRH produced an average of 3.7 million Chinook salmon (86% of target)(CDFW 2021a). In addition, while both wild and hatchery origin fish experienced high mortality due to disease in some recent years, because the release of IGH juvenile Chinook salmon overlaps with the period of high infection potential, a high proportion of the IGH Chinook salmon stock can often become infected with *C. shasta* (USFWS 2016a). For example, the S3 model simulated an overall prevalence of mortality of 34.8 percent of naturally produced juvenile Chinook salmon and 87.0 percent of hatchery-origin juvenile Chinook salmon caused by *C. shasta* during the 2020 outmigration at the Kinsman trap (FERC 2021a). Figure 24 shows the natural spawner abundance of fall-run Chinook salmon in the Klamath Basin from 1978 to 2020, and Figure 25 shows the entire in-river run of fall-run Chinook salmon during the same period, which includes river harvest and hatchery spawners (CDFW 2021c). Spring-run Chinook salmon have, on average, about an order of magnitude lower abundance in the Klamath River Basin relative to fall-run Chinook salmon. The majority of the spring-run Chinook salmon in the Klamath return to the Trinity River each year, including the TRH, although the Salmon River does maintain a small wild population of spring-run Chinook salmon. Figure 26 summarizes the escapement of hatchery and wild spawning adult spring-run Chinook salmon.

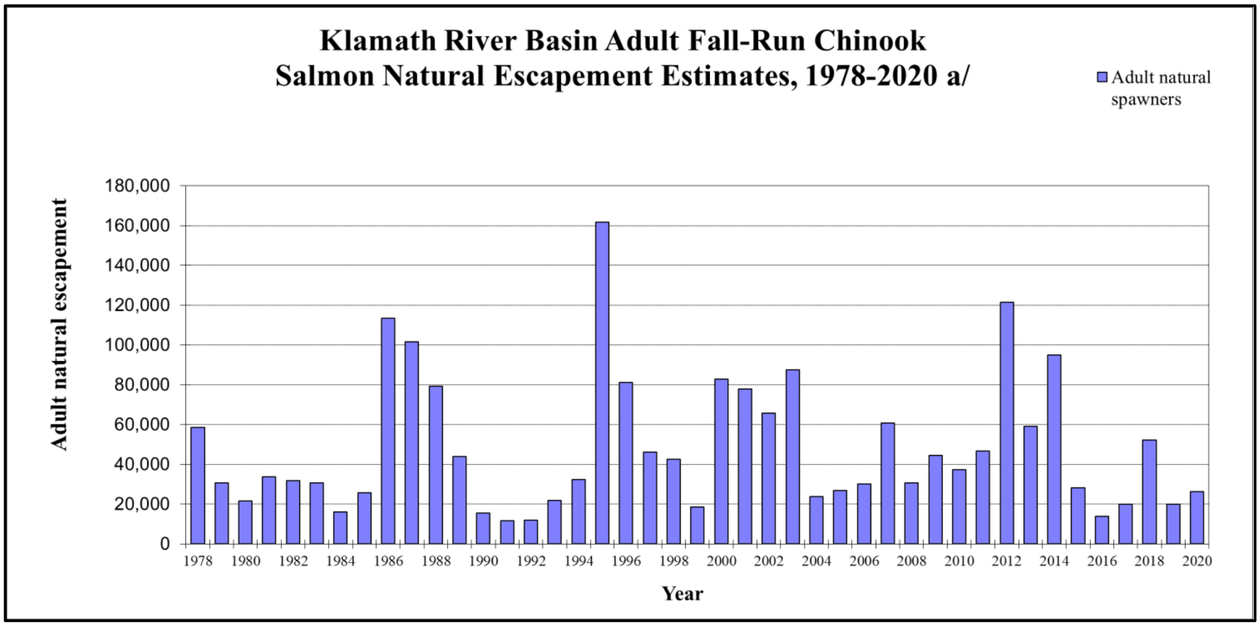

Figure 24. Adult natural escapement of fall-run Chinook salmon in the Klamath Basin, including Trinity River fish (CDFW 2021c). “a/” indicates that 2020 data are preliminary and subject to revision.

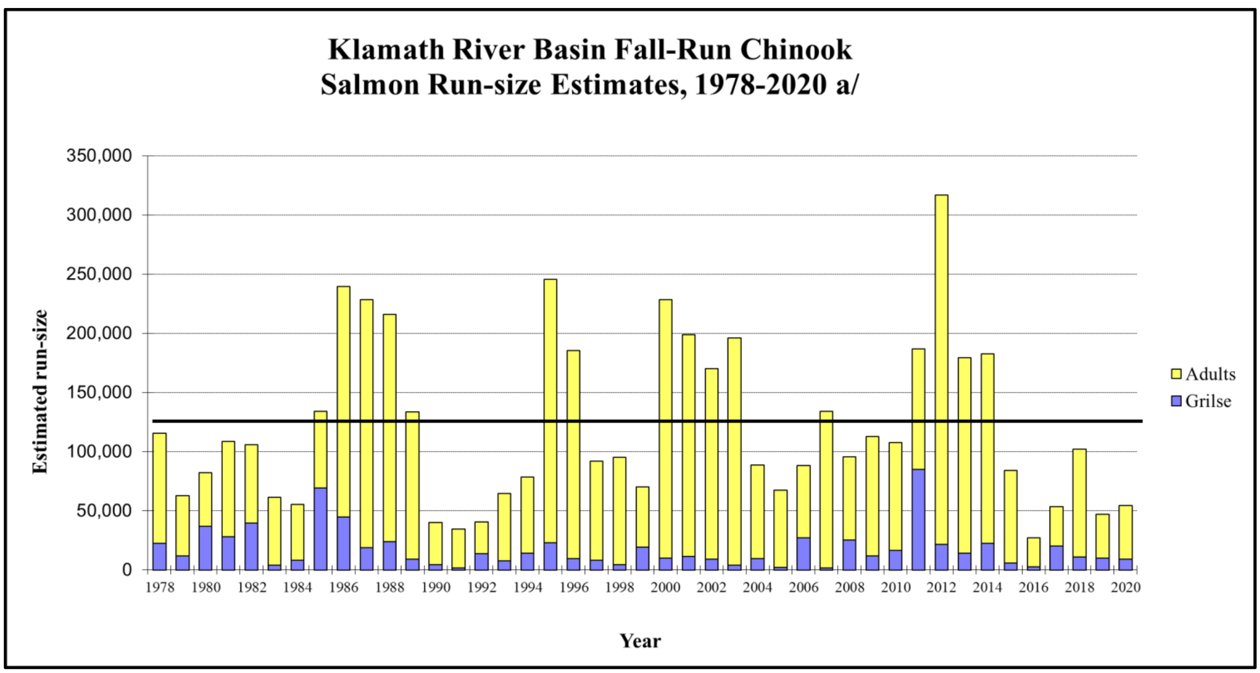

Figure 25. Adult total in-river run of fall-run Chinook in the Klamath Basin, including in-river harvest and hatchery spawning, in the Trinity and Klamath Rivers (CDFW 2021c). “a/” indicates that 2020 data are preliminary and subject to revision.

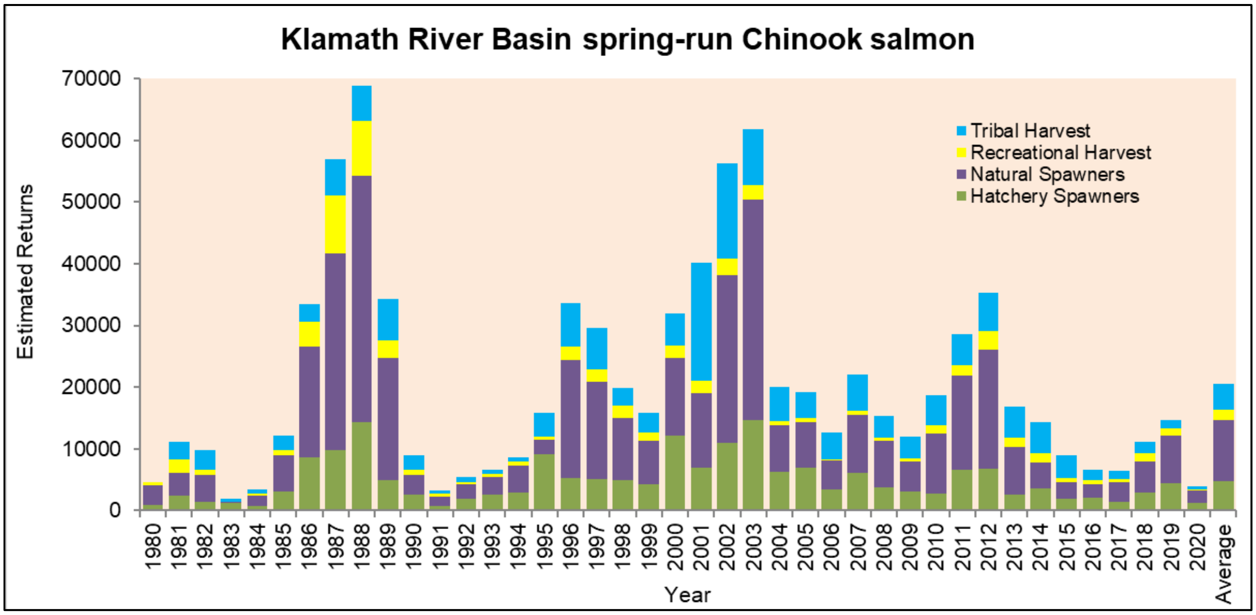

Figure 26. Klamath Basin adult spring-run Chinook salmon abundance estimates (CDFW 2021b). 2020 data is preliminary and subject to revision.

Chinook Salmon Diversity

Diversity within the Chinook salmon population is represented by the differing life history strategies. These include spring and fall-run adult migration timing, different timing for freshwater rearing and smolt emigration, and different periods for adult maturation.

Hatcheries can play a role in shifting genetic diversity within populations. Releasing hatchery-origin fish can result in lower productivity of natural-origin salmonids (Davison and Satterthwaite 2017). Between 1998 and 2019, IGH and TRH released on average roughly 14.4 million hatchery Chinook salmon annually that are part of the UKTR Chinook salmon ESU (CDFW 2021a). Again, IGH releases only fall-run Chinook salmon, while TRH releases both fall-run and spring-run Chinook salmon. In total, these releases were comprised of approximately 85% fall-run Chinook salmon and 15% spring-run Chinook salmon. Hatchery programs contribute to ocean fisheries and affect natural-area spawning at varying rates (Davison and Satterthwaite 2017; Shelton et al. 2018). However, the TRH spring Chinook salmon broodstock was founded from endemic stock, and the California Hatchery Scientific Review Group (2012) noted that "No out-of-basin eggs or fish have been used to supplement this program in at least the last 10 years". Both the IGH and TRH fall run Chinook salmon populations maintain genetic characteristics that align with the geographic locations of the hatcheries in Klamath Basin (Kinziger et al. 2013; Williams et al. 2013). Survey data indicate that straying of hatchery Chinook salmon adults into tributaries is higher for those streams or areas located closest to the two hatcheries in the Klamath Basin (Williams et al. 2013).

2.5.2.2.2 Effects to Chinook salmon

The effects analysis for SRKWs is focused on the potential effects of the proposed action on the abundance of Chinook salmon, their primary food source (Ford and Ellis 2006; Ohlberger et al. 2019; Hanson et al. 2021). Because SRKWs prefer larger prey, Chinook salmon are typically not considered SRKW prey until they are three years of age or older. Chinook salmon in the Klamath Basin typically return from the ocean at age 2 to age 5, with the majority of the river run returning at age 3 or age 4 each year (Gough et al. 2018; PFMC 2021c). Therefore, Chinook salmon that are affected by the proposed action at age 1 or younger (e.g., eggs, emergent fry, migrating or rearing juveniles) will not impact SRKW prey availability until at least two years later. So, while most Chinook salmon in the Klamath Basin outmigrate within their first year, effects to SRKW prey availability will not occur for two years or more. However, for the purposes of discussion in this section, impacts are discussed within the timeframe that they will impact the Chinook salmon populations directly.

Over the course of the eight-year period in which the proposed action will be implemented, most construction or drawdown related impacts are not expected to result in adverse effects to Chinook salmon that last longer than two years. However, the long-term beneficial effects of the proposed action are expected to last far beyond this time frame. In addition, the reduction of Chinook salmon hatchery production at IGH, which is expected to have a positive effect on natural production and reduce disease effects to wild and hatchery fish, may also negatively impact overall production for the basin beginning in the drawdown year. Hatchery production with decreased production targets for smolt and yearling Chinook salmon is expected to continue for 8 years following the drawdown year, and additional changes in hatchery production are possible beyond 8 years, as discussed in Section 2.6.2, Cumulative Effects (for SRKW). Therefore, in this discussion, we consider short term (within the first 2 years after dam removal begins) adverse impacts of the proposed action on Chinook salmon, mid-term (2 to 8 years after dam removal) adverse and positive impacts to Chinook salmon, and long term (> 8 years after dam removal) beneficial effects to Chinook salmon as the Klamath Basin continues to recover from dam and hatchery impacts.

Short term effects (within two years)

Like coho salmon, in the short term, Chinook salmon are likely to be affected by pre-drawdown activities, high sediment and low dissolved oxygen levels during drawdown and dam removal, and bedload deposition during and following dam removal. The proposed action also includes a change in production targets for Chinook salmon produced at IGH.

<u>Suspended Sediment</u>

The KRRC provides a sediment effects analysis to estimate percent mortality of outmigrating Chinook salmon smolts (FERC 2021a). The analysis includes a detailed discussion of various juvenile life-history types. In general, both fall-run and spring-run Chinook salmon found in the Klamath River Basin exhibit a predominantly sub-yearling smolt migration, migrating to seawater within one year of hatching (Myers et al. 1998; Williams et al. 2013). The FERC (2021a) BA approach of the analysis for effects to Chinook salmon is similar to the approach for coho salmon, although the parameterization of the models the KRRC used (e.g., timing of outmigration for various populations) is different. The suspended sediment effects analysis for coho salmon is described in both Section 5.1.1.1 and Appendix H (Suspended Sediment Effects on Coho Salmon Populations) of the FERC (2021a) BA. The suspended sediment effects analysis for Chinook salmon is descried in Section 5.4.1.1 and Appendix J (Suspended Sediment Effects on Coho Salmon Populations) of the FERC (2021a) BA. The KRRC sediment effects analysis includes analyses for both a median and severe impact year, as described in the Analytical Approach (Section 2.1) above.

The Renewal Corporation evaluated effects to fish based on a standard exposure period of 20 days for juveniles and 14 days for adults. Figure 27 shows an example of the strategy used in the analysis and aides in the understanding of the summary effects tables included in the FERC (2021a) BA. The summary of predicted Chinook salmon mortality related to spring outmigration for each affected population is shown in Table 24. For the most likely scenario, the median impact year, the range of Suspended Sediment Concentration (SSC)-related mortality to outmigrants was 0-5%, depending on the population. Even in the worst-case scenario, the severe impact year, the range of SSC-related mortality to outmigrants was estimated to be 2% to 17% for various populations (Table 24).

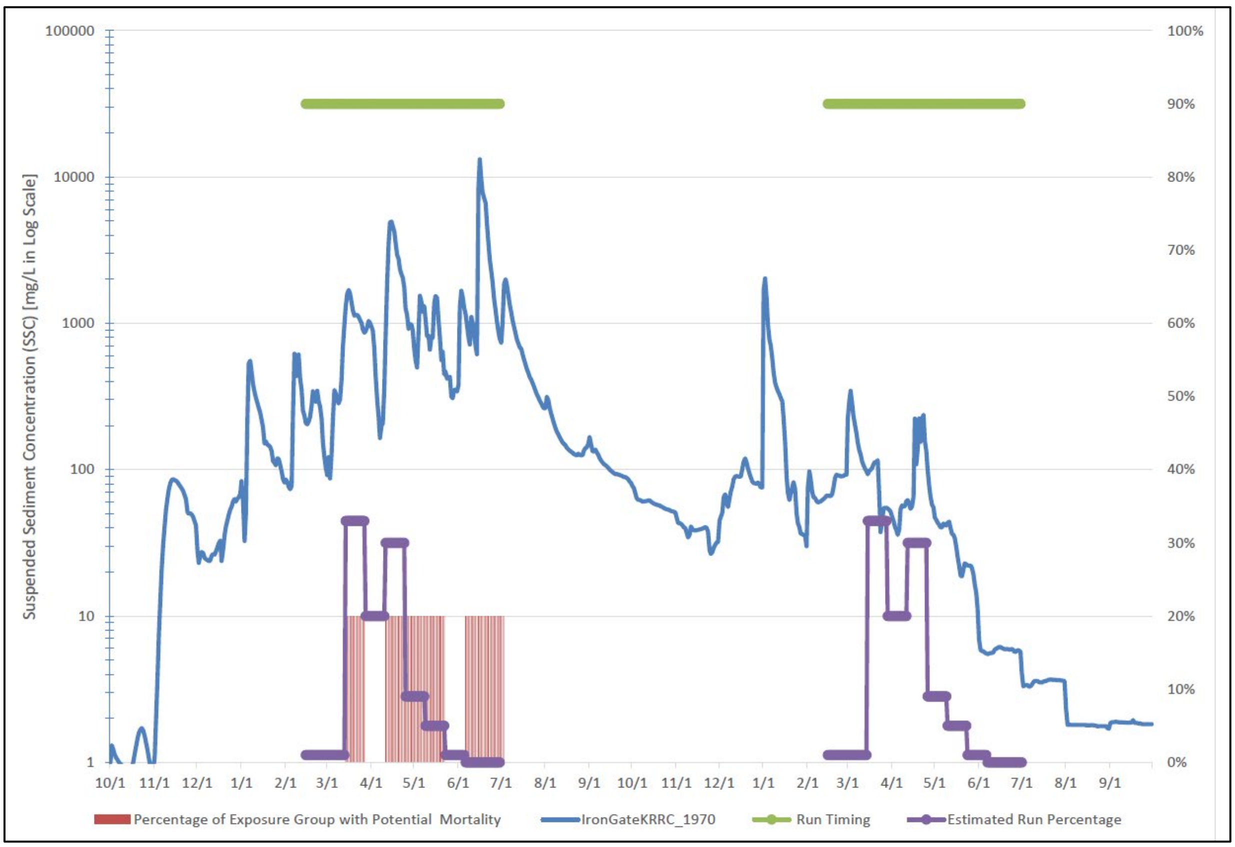

Figure 27. Illustration of impact, exposure, and estimated mortality based on run timing data and modeled SSCs for a "severe impact" water year. The purple lines show the percentage of the run that is exposed to SSCs on any given day of the water year. Of the fish exposed, the red vertical lines indicate the percentage of those fish likely to die. Figure provided by KRRC (2021f).

Table 24: Summary of Predicted Age-0+ Chinook Salmon Mortality Related to Suspended Sediment Impacts to Outmigration in Year 1. Adapted from Table J-9 of FERC (2021a).

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

Impacts to Migrating Adults

Although the proposed action is not anticipated to impact Chinook salmon once they are in the ocean, and once Chinook salmon have returned from the ocean they are no longer potential food for SRKW, if the proposed action causes mortality of adult Chinook salmon this could result in reduced prey for SRKW in the future resulting from lost production. The FERC (2021a) BA analyzes effects primarily to adult fall-run Chinook salmon. Per Table J-1 in Appendix J of FERC's BA, adult Chinook salmon will experience sublethal conditions in Year 1 and Year 2. The severe impact year conditions during drawdown will result in the highest severity of impacts values. Values are most severe at the Iron Gate station, and slightly decline at the Seiad Valley and Orleans stations. Median and severe impact year conditions for the proposed action are similar in Year 2, and greater than the background condition severity of effects values for the same period. However, in all cases the analysis provided in the FERC (2021a) BA only anticipates sub-lethal effects to adults during their migration and spawning period.

The FERC (2021a) BA does not specifically address impacts to adult spring-run Chinook salmon, but impacts to spring-run Chinook salmon are unlikely to result in substantial impacts to SRKWs. One reason for this is that adult spring-run Chinook salmon will only be exposed to elevated SSCs during their migration period in the mainstem. While migrating to the Trinity and Salmon rivers, spring-run Chinook will be exposed only in the downstream-most reaches of the mainstem where impacts of elevated SSCs are expected to be significantly attenuated. Additionally, exposure duration is expected to be relatively short during the migration period and we expect adults to avoid the most severe impacts of SSC by utilizing clear water tributaries or delaying river entry until conditions are suitable. Therefore, we expect elevated SSCs related to the proposed action to result in only sub-lethal impacts to adult spring-run Chinook salmon.

Juveniles

The FERC (2021a) BA analyzes effects to Chinook salmon outmigrants from various populations for the Year 1 exposure period in Tables J-2 through J-8. In Table J-9, the FERC (2021a) BA Summary of Predicted Age-0+ Chinook Salmon Mortality Related to Spring

Outmigration in Year 1, the estimated mortality as a percentage of the sub-population ranges from 2% (Blue Creek population) to 17% (Upper Klamath River migrants at I5). Juvenile Chinook salmon that outmigrate in Year 1 will experience the most severe effects, while subsequent brood years will experience lesser effects as mainstem habitat conditions improve over time. SSCs will remain elevated relative to background conditions through Year 2 at the Iron Gate water quality station, but proposed action and background SSC levels begin to converge between winter of Year 1 and spring of Year 2 at the Seiad Valley and Orleans stations. In Table 5-14, the FERC (2021a) BA indicates sublethal effects to outmigrants in Year 2, with severity of impacts that are similar to background conditions.

Dissolved Oxygen

Section J.4.2 of Appendix J, and the "Dissolved Oxygen Effects" section of the FERC (2021a) BA (beginning on Page 202) discuss the potential for low dissolved oxygen (DO) to affect juvenile Chinook salmon in the year following drawdown. Table J-12 shows that up to 13.0% of Chinook salmon outmigrants could be impacted by the low DO zone in a Severe Impact Year. Because of the conservative nature of the analysis (the threshold for inclusion in the low DO zone is substantially higher than the DO threshold associated with Chinook salmon mortality), it is expected that the majority of fish would experience sub-lethal effects associated with low DO. However, depleted dissolved oxygen levels and hypoxia will be an additive stressor to the high SSCs age-0+ Chinook salmon will encounter during outmigration, potentially increasing age-0+ Chinook salmon mortality during the drawdown year.

Herbicide Application

As discussed in Section 2.5.1.1.11, Herbicide Application, NMFS has previously analyzed the effects of herbicide use in IEV control and restoration projects on large scale, multi-year actions proposed by the Forest Service, Bureau of Land Management and Bonneville Power Administration (BPA) (NMFS 2010a; NMFS 2012a; NMFS 2020a). The types of plant control actions analyzed here are a less aggressive subset of the types of actions considered in those analyses and some of the work environment (i.e., previously inundated areas now devoid of vegetation) is unique.

The Renewal Corporation has proposed numerous BMPs during the initial three years of the spraying program proposed as part of the project (called the Pre-dam Removal and Dam Removal and Restoration phases) that are intended to prevent exposure via these pathways to chinook salmon and their habitat. Although these BMPs will minimize the risk of exposure under typical circumstances, they do not eliminate the risk for the proposed action and we assume herbicides and associated adjuvants reaching surface waters would result in impacts to a small number of Chinook salmon. These small amounts of exposure are unlikely to result in more than negligible bioaccumulation in Chinook salmon, similar to our analysis in Section 2.5.2.1.2.

Bedload Deposition

Redds

Sediment will mobilize during reservoir drawdown and deposit downstream of the Iron Gate Dam site. Bedload deposition has the potential to affect a minimum of two years of Chinook salmon spawning downstream of Iron Gate Dam. The Renewal Corporation expects Chinook salmon redds[23] between Iron Gate Dam and Willow Creek will experience 100% mortality due to sediment burial during Year 1 (FERC 2021a Appendix J). Salmon are able to significantly clean fine sediment from spawning gravels during redd construction (Kondolf et al. 1993) and the degradation of spawning habitat below the Iron Gate Dam site is expected to be short-term. Therefore, Chinook salmon are likely to be able to use suitable spawning habitat in the mainstem starting in Year 2, especially where aggradation is minimal (i.e., <0.5 feet of deposition), which will be true for all mainstem Klamath River habitat with the exception of a five mile stretch downstream of the Iron Gate Dam site (Appendix H in FERC 2021a). In addition, the removal of the dams will allow adult Chinook salmon, which might have constructed redds in the mainstem Klamath River downstream of Iron Gate Dam, access to mainstem habitat upstream of the Iron Gate Dam site. Based on these factors, NMFS expects fewer Chinook salmon redds to be constructed in the mainstem Klamath River downstream of the Iron Gate Dam site during fall of Year 2, and those redds that are constructed will only experience sublethal impacts (e.g., small reduction in the growth of embryos that we do not expect will affect individual emergence success) due to the reduced SSC and bedload deposition in Year 2.

Estimates of the contribution of these lost redds to annual Klamath Chinook salmon spawning escapement range from 8% (CSWRCB 2020b) to 13% (Appendix J-29; FERC 2021a). Further, the Renewal Corporation examined the potential loss of these Chinook salmon redds downstream from Iron Gate Dam, which they estimated to be 8% of total Klamath Basin redds, and determined that access to additional spawning habitat in the mainstem of the Klamath River would offset the potential loss as a Mainstem Target (KRRC 2021a). If this Mainstem Target is not met, the Renewal Corporation will implement spawning habitat enhancement activities to mitigate for lost spawning habitat, as described in the Spawning Habitat Availability Report and Plan (KRRC 2021a). Spawning habitat enhancement activities that are determined to be necessary will be implemented during the reservoir drawdown year (Year 1) and the following year (Year 2)(KRRC 2021a). NMFS conservatively will assume 13% of the Chinook salmon redds in the mainstem Klamath River will be buried by bedload deposition, which equates to those located in the reach between Iron Gate Dam and Willow Creek.

Hatchery Impacts

Under the amended 2016 KHSA, hatchery operation at IGH, or other facility, will be funded by PacifiCorp for a period of eight years following dam removal, but hatchery production targets may be changed from previous mitigation levels by the various fisheries managers (KHSA 2016). Because IGH will no longer have a suitable water supply once Iron Gate Reservoir is

[23] Unlike coho salmon, Chinook salmon preferentially spawn in the mainstems of rivers and large tributaries. Thus, more impacts on Chinook redds in the Klamath are anticipated from sediment mobilized during reservoir drawdown.

drawn down, as part of the proposed action, hatchery production currently at IGH would be moved to a revitalized facility at Fall Creek. The FCH will have a reduced overall production capacity. As a result, annual production levels will be 41% lower for sub-yearling Chinook salmon (IGH production goal of 5.1 million sub-yearlings versus FCH goal of 3.0 million sub-yearlings), and there will be a 72% reduction in yearling Chinook salmon production (IGH production goal of 900,000 yearlings versus FCH goal of 250,000 yearlings) (Appendix J-30).

As discussed in the FERC (2021a) BA, NMFS (2021g) analyzed the impact of this loss in hatchery production specifically related to SRKW prey availability. Assuming no additional positive or negative effects of dam removal or changes in hatchery production, NMFS concluded that the reduction in hatchery production would be expected to reduce mean ocean adult (ages 3-5) abundance by 36,545 fish and mean annual ocean harvest (ages 3-5, commercial and recreational combined) by 2,620 fish. For the period of years analyzed (ocean abundance of broods from 1996-2014), which was variable by brood year and release type, the mean total annual abundance in the ocean of IGH fish was 67,582 fish. A reduction of 36,545 fish would constitute a 54% reduction of IGH fish contribution to total ocean abundance of Klamath Chinook salmon.

Looking at the average ocean abundance of Klamath Chinook salmon from a generally commensurate time period with the data that this hatchery analysis was drawn from (2007-2016), a reduction of 36,545 Chinook from an estimated average of 356,000 Klamath Chinook salmon in the ocean would represent about a 10% (10.3%) reduction of the average abundance of Klamath Chinook salmon in the ocean. Looking at the PFMC Workgroup models from the same time period (2007-2016), this would represent about a 1% (1.0%) reduction in the average abundance of Chinook salmon within the U.S. EEZ and a less than 1% (0.7%) reduction in the average abundance of Chinook salmon in the ocean throughout the range of SRKWs. Off the coast of Oregon and California (SOF), this would represent a reduction of less than 2% (1.6%) in the average abundance of Chinook salmon.

This analysis, which shows a modest reduction in the production of Klamath Basin Chinook salmon resulting from decreased hatchery production, does not account for any improvements in wild production, or improvements to wild or hatchery survival, that could result from decreasing hatchery releases over time. Many studies have shown that hatchery releases interacting with wild fish can lead to decreased productivity of natural-origin salmonids (Araki et al. 2007; Araki et al. 2008; Araki et al. 2009; Kostow 2009; Christie et al. 2014; Davison and Satterthwaite 2017). For example, in a review of 51 estimates from six studies on four salmon species, Christie et al. (2014) found that early-generation hatchery fish averaged only half the reproductive success of their wild-origin counterparts when spawning in the wild, and that all species showed reduced fitness due to hatchery rearing. In the Upper Klamath River, the proportion of the natural spawning population that is made up of hatchery-origin fish averaged 25% with a range of 1% to 48% (2001-2020). It would be expected that these high levels of hatchery fish spawning in the same natural areas as natural origin spawners would have negative impacts on natural spawning.

In addition, the analysis only accounted for changes in hatchery production and did not incorporate other short-term or long-term effects of the proposed action, many of which are also expected to improve survival in the short and long term (see Disease discussion below). Ultimately, during the short term, NMFS anticipates the decrease in Chinook salmon hatchery production as a result of the proposed action will lead to a modest decrease in the amount of Klamath River Chinook salmon available to SRKWs in the ocean.

Water quality changes related to disease

The temporal water temperature pattern of the Hydroelectric Reach is repeated in the Klamath River immediately downstream from Iron Gate Dam, where water released from the Iron Gate Reservoir, when compared with modeled conditions without the dams, is 1 to 2.5 °C cooler in the spring, potentially just below optimal temperatures for juvenile salmonids in some years, and 2 to 10 °C warmer in the summer and fall, well above optimal temperatures for juvenile salmonids in most years (PacifiCorp 2004a; Dunsmoor and Huntington 2006; NCRWQCB2010; Risley et al. 2012). Immediately downstream of Iron Gate Dam, daily water temperatures are also less variable than those documented farther downstream in the Klamath River (Karuk Tribe of California 2009; 2010; 2011; 2013). There is an interaction effect between temperature and disease impacts that is related to both infection rate and severity of infection (Ray et al. 2012). Ray et al. (2012) compared disease progression at four temperatures representative of spring/summer migration conditions and demonstrated that elevated water temperatures consistently resulted in higher mortality and faster mean days to death. A more natural temperature regime is expected to help alleviate disease impacts. This effect is expected to occur quickly after dam removal, and continue to occur into the future.

Disease

Disease can have a substantial impact on the survival of both wild and hatchery juvenile Chinook salmon in the Klamath River. The current altered hydrology of the Klamath Basin is substantial. The four dams in the Lower Klamath Project have blocked sediment transport downstream of Iron Gate Dam, caused a dramatic reduction in flow variability resulting in constant, stable flows downstream of Iron Gate Dam, and decreased water quality downstream of Iron Gate Dam from algae blooms in the reservoirs. Periodic scour and substrate disturbance are considered to be integral for managing disease induced mortality of juvenile and adult salmonids (Alexander et al. 2014; Curtis et al. 2021). In addition, Turecek et al. (2021) investigated the efficacy of reducing streamflow to desiccate annelid hosts to reduce disease risk. Stocking and Bartholomew (2007) noted that the ability of some annelid 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.

Per the FERC (2021a) BA analysis, the proposed action is expected to reduce fish disease impacts to adult and juvenile salmon, especially downstream of Iron Gate Dam. Dam removal is expected to lead to more natural channel processes including channel bed scour and sediment transport. The altered river channel downstream of Iron Gate Dam has resulted in an atypically stable river bed, which provides favorable habitat for the annelid host for *C. shasta* and *P. minibicornis*. Slow-flowing habitats may have higher densities of annelids, and areas that are more resistant to disturbance, such as eddies and pools with sand and *Cladophora*, may support increased densities of annelid populations (Bartholomew and Foott 2010), especially when flow disturbance events are reduced or attenuated. High annelid densities increase parasite loads, which leads to higher rates of infection and mortality for salmon. In the Klamath River, the annelid 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 (RM 179) to Seiad/Indian Creek is known to be a highly infectious zone with high actinospores, especially from May through August (Beeman et al. 2008), although within and between years the size of the infectious zone and the magnitude of parasite densities may vary geographically (True et al. 2016b; Voss et al. 2018; Voss et al. 2019; Voss et al. 2020). The highest rates of infection occur in the Klamath River within approximately 50 miles downstream of Iron Gate Dam (Stocking and Bartholomew 2007; Bartholomew and Foott 2010). Infection prevalence in annelid host populations was an order of magnitude greater in the reach between the Tree of Heaven and Interstate 5 than at any other site throughout the river (Stocking and Bartholomew 2007). Periodic scour and substrate disturbance are considered to be integral for managing disease induced mortality of juvenile and adult salmonids (Alexander et al. 2014; Curtis et al. 2021), and studies have shown that worm host distribution and abundance decreases when their preferred habitat is substantially disturbed (Malakauskas et al. 2013; Wright et al. 2014; Alexander et al. 2016). Although the exact timing and extent of improved disease conditions in the Klamath River during drawdown and following dam removal is difficult to quantify (Schakau et al. 2019), it is expected that improvements in disease conditions should occur after the dams are removed (CSWRCB 2020b), and reduced incidence of disease would be expected to improve Chinook salmon survival in the Klamath River (USGS 2021).

A recent study has also linked the prevalence of infection of juvenile Chinook salmon released from IGH in the spring, and peak spore densities measured in the fall and the spring following hatchery release (Robinson et al. 2020). The study supports the possibility that the release of hatchery Chinook salmon into the infection zone not only results in low survival of those hatchery fish, but may be exacerbating the disease impacts for other populations. In which case, reducing hatchery production could also increase survival of both wild and remaining hatchery fish. This increase in survival would be separate from the other ecological and genetic effects associated with decreased releases of hatchery fish that is discussed in the hatchery section above.

<u>Summary of short-term effects to Chinook Salmon</u>

The exact impact of the various sources of potential lost Chinook salmon production on SRKW prey availability is very difficult to calculate. Chinook salmon in the Klamath basin typically return at age 2 to age 5, and the proportion that return at various ages changes year to year depending on life-stage specific fish condition and environmental cues (PFMC 2021c). SRKWs may or may not overlap with Klamath Chinook salmon in the ocean in the two to five years following drawdown and dam removal. However, it is possible to perform an approximate, worst-case-scenario analysis for what the short-term reductions in Klamath River Chinook salmon could mean for SRKW prey availability in terms of ocean abundance of Klamath River Fall Chinook salmon.

- Bedload Deposition: 13% of the Chinook salmon redds in the mainstem Klamath River will be buried by bedload deposition in Year 1, which equates to those located in the reach between Iron Gate Dam and Willow Creek. This is a conservative estimate, as it assumes complete loss of all mainstem Klamath River redds in that reach in Year 1.

- Suspended sediment: up to 17% of wild juvenile migrants from the Upper Klamath River may be lost in year one in the most severe impact year. Actual mortality of the overall population will certainly be lower as this assumes a severe impact year and other populations experience a smaller percent mortality, even in a severe impact year. In addition, many of the outmigrants that would have been produced by the Upper Klamath River spawners would have already been lost due to sediment deposition on mainstem redds between Iron Gate Dam and the Shasta River. Even though the interaction effect of low DO is expected to result in mortality at the upper end of the range, given that the Upper and Middle Klamath populations will have already been impacted by bedload deposition, it may safely be assumed that the additional mortality associated with suspended sediment will not exceed 10% of the total naturally produced population, and is likely to be much smaller than that.
- Dissolved Oxygen: up to 13% of wild juvenile migrants may be impacted in year one. Again, mortality will be lower as this assumes a severe impact year and the threshold for inclusion in the low DO zone is substantially higher than the DO threshold associated with Chinook salmon mortality. As with suspended sediment effects, the populations most affected by low dissolved oxygen impacts are the same populations that are expected to be most impacted by redd loss due to bedload deposition. In addition, effects related to dissolved oxygen are expected to be sub-lethal, except when in the presence of high SSCs. Therefore, we do not expect additional mortality as a result of low DO, but instead assume that estimated morality associated with SSC exposure is likely to result in mortality that is at the upper extent of the estimated range.
- Changes in hatchery production: we estimate the changed hatchery production at IGH would equate to roughly a 10.3% percent reduction in Klamath River Fall Chinook being available in the ocean, if hatchery performance relative to goals is similar to what has occurred in the past.
- Total: assuming a worst-case-scenario for all of these sources of mortality it is conceivable that up to 23% (=13% due to redd loss + 10% due to mortality from high SSCs and low DO during outmigration) of wild production and 10.3% of IGH ocean contribution could be lost in the worst year. This scenario could only occur in the first year following dam removal, as most conditions are expected to improve in subsequent years. To be clear, NMFS does not expect this level of Chinook salmon mortality to occur even in the first year because we have used a severe impact year scenario with no avoidance behavior of individual fish. However, for the purpose of contextualizing potential effects to SRKW prey base, it is useful to consider this worst-case-scenario.

Over the last 10 years (2011 to 2020) the average spawner escapement in the Klamath and Trinity basins has been comprised of 72% natural spawner and 28% hatchery spawners (CDFW 2021c). Using PFMC estimates of the average ocean abundance of age 3+ (fish age 3 or older) Klamath River fall Chinook salmon from 2007-2016, which was 356,000 fish (PFMC 2021a), we estimate the contribution of wild fish was (356,000 * .72) = 256,320 fish. The potential reduction in the number of wild fishes in this hypothetical worst-case-scenario would be a loss of 58,593 fish (256,320 wild fish * 0.23 impact = 58,594 fish). This represent a 16.5% reduction in the average total number of Klamath Chinook in the ocean (58,594/356,000 fish).

In total, combining the percent reduction of Klamath Chinook salmon in the ocean associated with hatchery impacts (10.3%) with percent reductions associated with impacts to wild fish (16.5%), we estimate that the total reduction in the abundance of Klamath Chinook salmon in the ocean associated with the short term impacts of this proposed action would be about 27% (95,262/356,000). This 95,262 fish reduction in age 3+ Chinook salmon ocean abundance would constitute 2.6% (=95,400/3,700,000) of the prey availability for SRKWs in the U.S. EEZ, and 1.9% of the total abundance of Chinook salmon in the ocean within the range of SRKWs. If the associated reduction in Klamath origin age 3+ Chinook salmon in the ocean is only applied to the SOF area where Klamath fish are expected to occur, the percentage decrease of the lost ocean abundance would be 4.5% (95,400/2,100,000).

In order to illustrate the potential annual variability in the impact of changes in hatchery production in the future, and to characterize this potential impact relative to the most recent conditions, we provide a similar analysis for 2021 estimates of Klamath River Chinook salmon. The 2021 preseason estimate for ocean abundance of age 3+ Klamath River fall Chinook salmon was 181,500 fish (PFMC 2021c). For 2021, the total estimated SRKW prey abundance was 4,312,800 age 3+ Chinook salmon, which was comprised of 1,364,900 fish from North of Falcon, 1,140,100 fish from the Oregon Coast, 464,500 from the California Coast, 738,200 fish from the West Coast Vancouver Island region, and 605,100 fish from the Salish Sea region (PFMC 2021b). Assuming similar contributions of wild/hatchery fish, and similar percent reductions in Klamath River Chinook salmon resulting from the proposed action, there would be 48,751 (181,500*0.72*0.23 + 181,500*0.103) less fish in the ocean. This 48,751 fish reduction in age 3+ Chinook salmon ocean abundance would constitute 1.1% (=48,751/4,312,800) of the prey available for SRKWs in 2021. If the associated reduction in Klamath origin age 3+ Chinook salmon in the ocean is only applied to the SOF area, the percentage decrease of the lost production would be 3.0% for 2021 (48,751/1,604,600).

The worst-case-scenario estimates of 2.6% loss from the average of recent years, and 1.1% loss for 2021 abundances are for total SRKW prey base across their range. The relative percent loss as components of smaller regions (e.g., SOF, 4.5% and 3.0%, respectively) would be higher. However, again, these estimates are conservative for all of the reasons described above, and actual losses are expected to be much lower, even without accounting for the improved juvenile Chinook salmon disease survival and reduced hatchery effects on wild fish described above. If instead we accept the lower range estimate of the percentage of redds that could be lost to sediment deposition, 8% (CSWRCB 2020b) assume that all of the impacts to the Klamath mainstem populations are accounted for by redd loss, and account for the expected mortality of outmigrants associated with a median impact year, which could be less than 2%, then the expected percent loss of wild fish would be less than half of the worst-case-scenario.

Sources of negative effects (i.e., SSC sediment, low DO, and bedload deposition) are expected to be attenuated in Year 2, such that effects will be sub-lethal to all life stages of salmonids.

These approximate analyses, which again require application of a number of assumptions, ignore the age/cohort reconstruction aspect (i.e., not all fish that are affected in a given year will be age 3+ at one time, but instead will be age 3 one year, then age 4 the next year, etc.). However, since the majority of the habitat effects are likely to be worst in the first year and then improved in subsequent years, this again makes these analyses conservative for effects to Chinook salmon as SRKW prey, because it assumes a worst-case-scenario for impacts for age 3, age 4, and age 5 fish in a single year.

Mid term (two to eight years)

Some of the improved conditions associated with the proposed action will be realized immediately while other improved conditions will take time to develop. For example, improved hydrologic, water quality (temperature and dissolved oxygen), and disease conditions may occur as soon as the dams are removed and suspended sediment pulses attenuate, while the expected improvement in spawning gravel quality downstream from Iron Gate Dam will require some time for gravel to recruit. In addition, depending on the channel bed material, hyporheic (intragravel) flow, and cover habitat, adult Chinook salmon could spawn in the recently deposited material downstream of Iron Gate Dam, but subsequent stored sediment mobilization during winter could also bury redds in some years.

Similarly, increased natural-origin production of juvenile Chinook salmon related to repopulation of re-accessible spawning and rearing habitat, improved habitat conditions downstream of Iron Gate Dam, and decreased ecological and genetic impacts of hatchery supplementation, will take some time to develop. NMFS and the Renewal Corporation expect salmonids to quickly repopulate habitat upstream of Iron Gate Dam following dam removal. This response has been observed after barrier removal on the Elwha River (Liermann et al. 2017; Duda et al. 2021), White Salmon River (Allen et al. 2016; Hatten et al. 2016), Cedar River (Burton et al. 2013; Anderson et al. 2015), Rogue River (McDermott 2016), and the Penobscot River (Izzo et al. 2016). Salmon have evolved with mechanisms for populating new habitat when that habitat is suitable and accessible (Bett et al. 2017; Pearsons and O'Connor 2020). However, each dam removal project is different, and the total habitat that is expected to be repopulated by Chinook salmon, which is estimated to be over 303 miles (Huntington 2004; Dunsmoor and Huntington 2006), and potentially over 420 miles (Hamilton et al. 2011), is substantial. Although some movement past Iron Gate by juvenile and adult Chinook salmon is expected in the first year when habitat conditions are suitable, full utilization of this habitat by Chinook salmon, and associated juvenile production, will certainly develop over time.

The effect of the reduction in IGH production that is discussed in the short-term-effects Hatchery Impacts section above (i.e., annual production levels will be 41% lower for sub-yearling and 72% lower for yearling Chinook salmon) is expected to continue into this mid term (two to eight years) effects period. However, following dam removal, survival of the remaining hatchery fish is expected to increase and remain higher than in the pre-dam removal period. This is in part due to the markedly improved disease conditions that are described in the disease section above, which are expected to improve upon dam removal due to sediment and flow impacts to annelid worm disease hosts, and remain improved due to more natural temperature, hydrologic, and sediment transport regimes.

Because of the expected improvements to the river and associated survival, Stream Salmonid Simulator (S3) modeling results suggest that even in the short- to mid- term (1-8 years), and with the reduced production of hatchery fish, the Klamath River should have more juvenile Chinook salmon survive to the ocean in most modeled years with the dams removed relative to a no-action scenario. This difference is evident in most scenarios for dams out relative to dams in (no action), but it is most drastically different when comparing scenarios with dams out, low Prevalence of Infection (POI = 0.15) against scenarios with dams in, high POI (POI = 0.75; Figure 28). Given that POI is expected to remain relatively high as long as dams are in, and POI is expected to drop considerably immediately when the dams are removed and remain lower than would occur if the dams remained in, the comparison of the dams out, low POI scenario against a dams out, high POI scenario is likely the most appropriate in the mid-term (USGS 2021). In this scenario, dams-out, low POI production is expected to be roughly 200,000 to 3,000,000 fish greater than dams-in, high POI production (Figure 28).

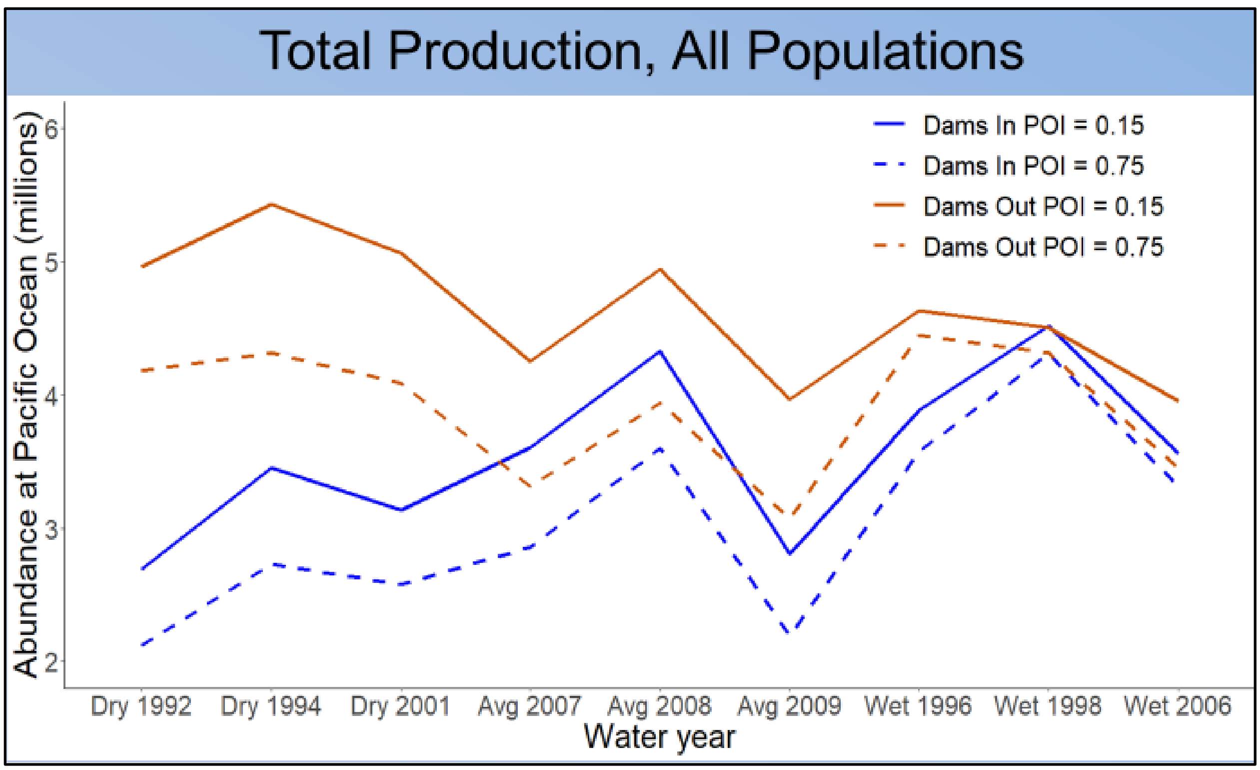

Figure 28. Abundance of total Chinook salmon in the Klamath River (natural and hatchery production) in various scenarios with dams in and dams out, under high (0.75) and low (0.15) levels of Prevalence of Infection (POI) of *C. shasta* (USGS 2021).

The improved expected survival can be seen in the results of the S3 modeling when examining the low POI spore concentration scenarios (USGS 2021). In addition, CDFW's prior experience rearing Chinook salmon at the Fall Creek location demonstrates that rearing conditions are favorable for the production of high-quality juvenile salmon. Improved incubation water temperature at Fall Creek (vs. poorer Iron Gate water quality) and reduced tray loading densities are also expected to increase survival of hatchery fish raised at Fall Creek Hatchery FERC (Appendix F of 2021a). Therefore, while the timing of improved conditions will vary depending on the process being restored, it is certain that at no time will any negative impacts resulting from the proposed action be greater than what is analyzed as conceivable in the first year of dam removal, which was determined to have a very small impact on prey availability for SRKWs.

Long term (>eight years)

Restored access to spawning and rearing habitat above Iron Gate Dam

Many studies, reports, and publications have analyzed or discussed the quality and extent of Chinook salmon habitat above the dams. Many of those are included in the FERC (2021a) BA, although some are not. A brief annotation of some of the more important citations follows:

- Snyder (1931): large numbers of Chinook salmon historically passed the location of Copco Dam on an annual basis. Over 7,500 fish were seen spawning in the mainstem river between the current location of Iron Gate Dam and Copco reservoir.
- Fortune et al. (1966): Chinook salmon were present in the upper Klamath during the months of September to November in the early 1900s. There is some evidence there once was a strong run of spring Chinook salmon, but it had declined due to the construction of log dams in the late 1800s. Locations that maintain good spawning gravel include the mainstem in California and Oregon (capacity of 1,350 spawning pairs), Shovel Creek (limited capacity), Spencer Creek (110 spawning pairs), Wood River (520 spawning pairs), Williamson River (240 spawning pairs), and the Sprague River (2,370 spawning pairs). The estimate for the existing suitable rearing habitat above Copco Reservoir was 167 miles.
- Chapman (1981): estimated total Chinook salmon production capacity in areas blocked by Iron Gate Dam to be 21,508 returning adult Chinook salmon that could produce 597,437 Chinook salmon smolts.
- Huntington (2004): Huntington used six methods to estimate a potential run capacity of adult Chinook salmon returning to areas above Iron Gate Dam that ranged from 9,180 to 32,040, with a mean or "best estimate" value of 21,245 fish. Huntington estimated that historic runs of Chinook salmon to the Wood, Williamson, and Sprague rivers was over 149,000 fish. Huntington (2006) revised this estimate of historic Chinook salmon potential above Upper Klamath Lake to be 111,230 adult Chinook salmon.
- Hamilton et al. (2005): the purpose of this publication was to report the upstream limit of anadromy prior to dam construction, but the authors do report that significant un-utilized anadromous fish habitat exists upstream of Iron Gate Dam.

- Oosterhout (2005): modelling of various management scenarios (e.g., dam removal, volitional passage, trap and haul) showed that abundance was maximized with removal of the four dams. Their estimate for total average spawner capacity was 40,341, with 45% of those being found above Link River dam.

- Huntington and Dunsmoor (2006): estimated over 303 miles and 370 miles of spawning or rearing habitat for fall-run Chinook salmon and spring-run Chinook salmon, respectively.

- Dunsmoor and Huntington (2006): the removal of most or all of the mainstem Klamath Project dams would significantly improve conditions for migration and spawning of adult fall Chinook salmon. Dam removal would provide clear and at times dramatic thermal benefits to migratory salmonids now in, or reintroduced to, the Upper Klamath Basin.

- Hetrick et al. (2009): estimated distances of historical anadromous fish habitat within the Klamath River mainstem, historical side channels, and tributaries that are currently inundated by the Klamath reservoirs. Described additional benefits to dam removal for fish above and downstream of Iron Gate Dam, including that potential increases in food availability, in combination with changes in water temperatures that more closely resemble the historical pre-development thermal regime, are likely to increase the size of smolts at ocean entry, which has been shown to increase estuary/ocean survival.

- Goodman et al. (2011): concluded that a substantial increase in Chinook salmon is possible in the reach between Iron Gate Dam and Keno Dam. The term "substantial" should be understood here to mean a number of fish that contributes more than a trivial amount to the population (on the order of 10,000 spawners).

- Hamilton et al. (2011): dam removal would make habitat accessible to both spring-run and fall-run Chinook salmon above Iron Gate Dam and likely reestablish Chinook salmon above Iron Gate Dam in a short period of time, as observed after barrier removal at Landsburg Dam in Washington (Kiffney et al. 2009). Hamilton et al. (2011) described specific Chinook salmon habitat conditions in reaches above Iron Gate Dam (e.g., Fall Creek, Shovel Creek).

- Hendrix (2011): Median escapements and harvest were higher in the Dam Removal Alternative (DRA) relative to the No Action Alternative (NAA) with a high degree of overlap in 95% confidence intervals due to uncertainty in stock-recruitment dynamics. Still, there was a 0.75 probability of higher annual escapement and a 0.7 probability of higher annual harvest by performing DRA relative to NAA, despite uncertainty in the abundance forecasts. The median increase in escapement in the absence of fishing was 81.4% (95% symmetric probability interval [95%CrI]: -59.9%, 881.4%), the median increase in ocean harvest was 46.5% (95%CrI: -68.7, 1495.2%), and the median increase in tribal harvest was 54.8% (95%CrI: -71.0%, 1841.0%) by performing DRA relative to NAA (estimates provided for model runs after 2033 when portion of the population in the tributaries to UKL are assumed to be established and IGH production has ceased).

- Lindley and Davis (2011): predicted expected escapement of Chinook salmon to watersheds above Iron Gate Dam. Models based on spring-run Chinook salmon data only predict escapement of about 3090 spawners per year (90% confidence interval 1420–25,300) to the upper basin, while models based on the complete dataset predict 3,660 (2420–5510) spawners per year.
- DOI and CDFG (2012): using multiple lines of evidence refers to a process when conclusions are not drawn from a single study but from two or more studies that have different approaches. For example, the conclusion that dam removal and KBRA implementation could increase Chinook salmon production in the Klamath Basin was based on a recent synthesis of previous study findings (Hamilton et al. 2011), two new independent modeling studies (Hendrix 2011; Lindley and Davis 2011), a Chinook salmon expert panel report (Goodman et al. 2011), among others. Although the authors of each of these four peer-reviewed reports used different approaches and assumptions, as well as presented different levels of confidence in quantifying their conclusions and scientific uncertainty, they all concluded that Chinook salmon would increase in number relative to the "no action alternative" of leaving dams in place.
- DOI and NMFS (2013): "There is a high degree of certainty, based on available science (and the lack of contrary studies), that in the long term dam removal would expand usable habitat for Chinook salmon and would significantly increase their abundance as compared to leaving dams in place".
- Hamilton et al. (2016): provides significant new information related to the historical abundance and seasonal distribution of salmonids in the Upper Klamath Basin.
- Ramos (2020): Although this study focuses on coho habitat, the study is also useful for identifying and quantifying current Chinook salmon habitat in some of the reaches (Camp Scotch, Jenny, Fall, Shovel, and Spencer creeks) just above Iron Gate Dam.

The previous annotations are extremely brief summaries focusing on reported capacity or expected productivity. However, in preparing these estimates, most of the previous citations include detailed, in some cases reach specific, descriptions of existing and expected habitat conditions above Iron Gate Dam. The purpose of highlighting the relevant findings of these publications is to show that while there is variation in the extent and timing of the expected increased productivity of Chinook salmon associated with having access to habitat above the dams, there has been substantial investigation into this question, and there is a high degree of certainty that within a reasonable time period, increased production of Chinook salmon occurring as a result of dam removal will replace any reduced production due to changes in hatchery production targets, and that Chinook salmon productivity and abundance in the Klamath Basin will be greater eight years following dam removal than they would have been if the dams had remained. Even the lowest range of the expected increase in production estimates in the long term are higher than what would be expected to be lost due to decreased production at IGH. These evaluations do take into account the status of habitat above Iron Gate Dam, which includes some degraded habitat and seasonal passage concerns associated with Keno Reservoir and Upper Klamath Lake (DOI and NMFS 2013; CSWRCB 2020b).

In order to evaluate what this increased spawning due to restored access to areas above Iron Gate Dam might mean quantitatively in terms of increased prey available to SRKWs, it is meaningful to examine recent escapement against ocean abundance. During the period that NMFS (2021g) estimated that IGH fish contributed 67,582 fish to ocean abundance annually (roughly, 1996 to 2018), the mean escapement of spawners to IGH was roughly 19,500 fish (CDFW 2021c). In comparison, estimates of escapement into the Upper Klamath Basin are also in the tens of thousands, including upwards of 40,000 (Oosterhout 2005; Lindley and Davis 2011). Juvenile outmigrants in the upper basin will need to migrate farther distances than conspecifics that emerge from gravel farther downstream, but improved hydrologic and disease conditions with dam removal are expected to improve survival for all populations. Therefore, it is reasonable to assume that resumed spawning in areas above Iron Gate Dam will more than compensate for cessation of hatchery operations at IGH in the long term, even without accounting for improved productivity of wild spawning fish downstream of Iron Gate Dam or improved survival of the associated juveniles.

Sediment, water quality, bedload transfer

Habitat improvements that are expected to occur in the long-term downstream of Iron Gate Dam as a result of the proposed action are described in the FERC (2021a) BA, and in assorted other documents that have been cited above (e.g. CSWRCB 2020b). For example, in the long-term, the river would eventually exhibit enhanced habitat complexity due to increased sediment supply, a more natural flow regime, greater sediment transport rates, and more frequent bed mobilization that would increase spawning habitat availability and quality and improve early rearing habitat downstream from Iron Gate Dam. Bedload sediment movement and transport are vital to create and maintain functional aquatic habitat. An increased supply of gravel from upstream sources is predicted to improve spawning gravel quality and increase the amount of fall-run Chinook salmon spawning habitat downstream from Iron Gate Dam by decreasing the median substrate size to within the observed range for Chinook salmon spawning (CSWRCB 2020b). Water quality improvements related to flow, temperature, dissolved oxygen, and indirectly disease, are also expected to improve conditions for Chinook salmon in the long term (FERC 2021a).

Biocomplexity

Beyond increased productivity of wild spawners and improved survival of remaining hatchery origin juveniles, there is another long-term potential benefit of the proposed action to SRKW prey availability that is not easily illustrated by only calculating the number of outmigrants a system can produce. This benefit is related to ecosystem/population resiliency and biocomplexity. SRKWs prefer larger (older) Chinook salmon and their migration patterns are variable such that it is difficult to determine exactly when they will overlap with Klamath origin Chinook salmon in the ocean. Natural runs of Chinook salmon exhibit a large variability in life history, described as biocomplexity, including variable run timing, while hatchery origin fish, which generally have relatively truncated release timing windows, tend to be less variable (Hilborn et al. 2003; Satterthwaite et al. 2015; Sullaway et al. 2021). There has been a well-documented shift in Chinook salmon age and size towards younger, smaller fish that has affected both hatchery and wild fish (Ohlberger et al. 2018; Ohlberger et al. 2019; Oke et al. 2020).

While hatchery fish tend to be larger at ocean entry, that gain in size is typically no longer evident by the time the fish are old enough to be SRKW prey (Ohlberger et al. 2018). Large size-at-early-age is known to be associated with earlier maturation (i.e., precocity and earlier age at return migration) and could thereby actually decrease the average size of prey available to SRKWs. Researchers have not identified a direct link relating this decrease in Chinook salmon size to hatchery production, but the link between biocomplexity and maintaining a portfolio of genetic and ecological variability and having a resilient, sustainable population is well understood. Hamilton et al. (2011) discuss the notion of ecosystem resilience, and salmon population resilience, in the context of Klamath dam removal. To strengthen resiliency in salmon populations, habitat opportunities need to be expanded to allow maximum expression of life-history variation. Dam removal would contribute to the resiliency of the Klamath Chinook salmon population by reconnecting important seasonal fish habitat, normalizing temperature regimes and sediment transportation, and improving biological diversity. That is, in addition to improving conditions below the dam, and providing access to substantial "new" habitat above the dams, the proposed action has the potential to provide the Klamath Basin, and its salmonid populations, with additional genetic and ecological diversity. This additional diversity will make Chinook salmon in the Klamath Basin more resilient to changing environmental conditions in the future (Crozier et al. 2008; Crozier and Siegel 2018).

Climate Change

In the long term, air and water temperatures in the Klamath Basin are expected to increase with climate change (Barr et al. 2010; Reclamation 2011d). However, the modeling suggests that dam removal can help buffer the Klamath River against the impact of climate change (Perry et al. 2011). Perry et al. (2011) modeling, which assumed dam removal would occur in 2020, suggested that dam removal appeared to delay the effects of climate change to some extent near Iron Gate Dam. With dams removed, annual-mean water temperatures exceeded the 49-year historical mean temperature beginning in 2045; whereas with dams, annual-mean temperatures exceeded the historical mean beginning in 2025. This buffering, in the long run, is expected to have positive effects on Chinook salmon populations in the Klamath Basin.

Summary of Effects to Chinook salmon

Our worst-case-scenario analysis of the short-term negative effects of the proposed action on SRKW prey availability showed that the proposed action could result in a non-trivial reduction in overall prey availability, ranging from 2.6% for an average year scenario, and 1.1% for a 2021 scenario, which is the most current year with estimated data available. Further, if the associated reduction in Klamath origin age 3+ Chinook salmon in the ocean is only applied to the SOF area, where most Klamath Chinook salmon are typically found, the percentage decrease of the lost production would be 4.5% for the average year scenario and 3.0% for 2021. However, the percentage decrease in SRKW prey availability from the proposed action is almost certainly an over-estimate for all of the reasons described above. In addition, because the effects of the action are to the SRKW prey base, and not to SRKWs directly, some of the beneficial effects of the restoration action that are anticipated to occur relatively quickly after dam removal (e.g., lower disease-related mortality of outmigrants) are likely to help to buffer the negative impacts to prey availability as those impacts extend out over a range of three to five years post dam removal, while the worst-case-scenario negative effects to redds and outmigrating juvenile Chinook salmon are only expected to occur in the first year. After the first year following dam removal the negative impacts of the proposed action, which are expected to have only modest impacts to SRKW prey availability even in the worst-case-scenario, decrease. Conversely, the positive impacts of the proposed action are expected to increase over time as Chinook salmon repopulate the upper basin, and restored hydrologic and sediment transport processes improve conditions in the mainstem Klamath River downstream of Iron Gate Dam. In addition, by opening up a wider range of habitat than currently exists, and also improving conditions downstream of Iron Gate Dam, the proposed action is expected to increase the biocomplexity of the Klamath Basin, thereby increasing the likelihood that Chinook salmon produced by the Klamath Basin may be available to SRKW.

2.5.2.3 Effects on SRKW from changes in Chinook Salmon Abundance

Section 2.5.2.2, Effects of Proposed Action on Chinook Salmon (Chinook salmon analysis), provides the complete analysis of potential impacts of the proposed action on Chinook salmon. Here we summarize the key results from the Chinook salmon analysis from Section 2.5.2.2. above to provide the basis for the analysis of the effects of the proposed action on SRKWs.

2.5.2.3.1 Short Term Effects Summary after Dam Removal

Like coho salmon, Chinook salmon may be impacted for a short term (up to two years) by pre-drawdown activities, high sediment and low dissolved oxygen levels during drawdown and dam removal, and bedload deposition during and following dam removal. The proposed action also includes a change in production targets for Chinook salmon produced at IGH. In total, based on the proposed reductions in hatchery production associated with the proposed action we estimate that the percent reduction of Klamath Chinook salmon in the ocean associated with hatchery impacts could be about 10% (10.3%; Chinook salmon analysis). We also estimate that the percent reduction of Klamath Chinook salmon in the ocean associated with impacts to wild fish could be nearly 17% (16.5%; Chinook salmon analysis). In total, we estimate that the combined reduction in the abundance of Klamath Chinook salmon in the ocean associated with the short-term impacts of this proposed action on Chinook salmon could be about 27% of the ocean abundance of Klamath Chinook salmon that is typically on the order of several hundred thousand each year (26.8%; Chinook salmon analysis). Generally, this analysis represents a worst-case scenario of what could happen with a number of assumptions. There are a number of potentially mitigating factors that could minimize these short-term impacts, including the potential for fairly immediate improvements in conditions and overall survival of juvenile Chinook salmon that could start happening in the second year after dam removal.

During the short term, effects to juvenile Chinook salmon resulting from dam removal and changes in hatchery production for a period of two years are likely to be realized by SRKWs over a 2-3 year period of time following these impacts to juvenile Chinook salmon. The 2-year time lag reflects the time for juveniles to mature and become adult Chinook salmon (age 3+) that are available as prey in the ocean.

2.5.2.3.2 Mid Term Effects Summary after Dam Removal and System Restoration Begins

Some of the improved conditions associated with the proposed action will be realized fairly immediately while other improved conditions will take time to fully develop. In particular: increased natural-origin production of juvenile Chinook salmon related to repopulation of re-accessible spawning and rearing habitat; improved habitat conditions downstream of Iron Gate Dam; and decreased ecological and genetic impacts of hatchery supplementation from IGH, will take some time to fully develop. In the interim, we define a Mid Term effect period (two to eight years) during which modified hatchery production at IGH continues to occur while conditions in the Klamath River are improving, before all the benefits of increased accessibility of available spawning habitat have been realized. As juveniles mature and become prey for SRKW over approximately two years, this will result in effects to the prey base of SRKWs that will be realized four to ten years after dam removal.

As described in the Chinook salmon analysis, the effect of the reduction in IGH production that is discussed in the short-term effects section above is expected to continue into this mid-term effects period. As a worst-case scenario, we could assume that a roughly 10% reduction in the ocean abundance of Klamath Chinook salmon associated with changes in hatchery production would continue during this mid-term period. However, following dam removal, survival of the remaining hatchery fish as well as natural production from existing Chinook salmon spawning habitat is expected to increase and remain higher than in the pre-dam removal period. Results from the Stream Salmonid Simulator (S3) modeling results suggest that even with the reduced production of hatchery fish, the Klamath River should have more juvenile Chinook salmon survive to the ocean in most modeled years with the dams removed relative to a no-action scenario, especially assuming that some of the issues such as prevalence of disease will improve significantly (USGS 2021). As a result, we assume that under most years during the mid-term effects period, there will not be any reduced Chinook salmon abundance in the ocean associated with the proposed action. However, there are scenarios of variable in-river conditions and juvenile survival for a given year where a small reduction in Klamath Chinook salmon consistent with ~10% reduction (or less) of Klamath Chinook as prey for SRKWs in the ocean (in subsequent years) could occur over a given year or two-year period. However, we do not expect these scenarios would persist throughout the entire midterm effects period.

2.5.2.3.3 Long Term Effects as Restoration is Realized

The long-term effects period is generally defined as the period of time after hatchery supplementation is scheduled to end and includes the period when the beneficial effects of the proposed action are being fully realized, especially with respect to improved quality and increased extent of Chinook salmon habitat above the dams. Specifically, this period is expected to represent conditions occurring from eight+ years after dam removal, as hatchery supplementation under the proposed action is proposed to end after eight years (potential hatchery supplementation after eight years is described in the Cumulative Effects section 2.6.2). As described in Chinook salmon analysis above, many studies, reports, and publications have analyzed or discussed the potential benefits and productivity capacity of the upper Klamath

River system once these dams have been removed. While there is variation in the extent and timing of the expected increased productivity of Chinook salmon associated with having access to habitat above the dams, there has been substantial investigation into this question. Together, these studies offer a high degree of certainty that there will be increased production of Chinook salmon occurring as a result of dam removal that will replace any reduced production changes associated with lost hatchery production in the long term effects period. Consequently, along with beneficial effects expected downstream of Iron Gate, we anticipate that Chinook salmon productivity and abundance in the Klamath Basin will be greater eight years following dam removal than they would have been if the dams had remained. This is expected to lead to increased abundances of Klamath Chinook salmon in the ocean as available prey for SRKWs over the long term starting about 10 years after dam removal, heading into the foreseeable future.

As described in the Chinook salmon analysis above, additional long term benefits beyond increased productivity of wild spawning Chinook (and hence more Klamath Chinook salmon in the ocean available to SRKW) and improved survival of remaining hatchery origin juveniles include additional genetic and ecological diversity that will make Chinook salmon in the Klamath Basin more resilient to changing environmental conditions in the future. This will make Klamath Basin Chinook salmon population a better, more reliable source of Chinook salmon in the ocean. Specific examples include the prospect for larger adult Chinook salmon associated with improved diversity in age structure, as well as diversity in run timing increasing availability throughout the year. The potential expansion of spring-run Chinook populations in the upper Klamath River would also be a significant addition to the diversity of Chinook salmon resources in the ocean attributable to the proposed action.

2.5.2.4 General Effects of Reduced Prey Base for SRKWs

Here we review the overall magnitude of prey reduction from the proposed action and generally describe the potential effects of prey reduction on SRKWs. We then describe specific effects expected during the short, mid and long-term periods. The effects from the proposed action, including all of the periods, are then considered together. Our analysis draws extensively from the information described in the Rangewide Status of SRKWs section (2.2.2.1), and the Factors Affecting the Prey of SRKWs in the Action Area section (2.4.2.1).

Previously, we have described the state of the science relating the abundance of Chinook salmon to the population dynamics of SRKWs, including research from the NWFSC (Ward et al. 2013), the Independent Science Panel (Hilborn et al. 2012), and the recent findings by the PFMC Workgroup (PFMC 2020b). There are uncertainties and challenges associated with interpretation of statistical correlations between different Chinook salmon stocks and stock aggregations and SRKW dynamics that are changing over time, and our ability to precisely predict how changes in Chinook salmon abundance will impact these SRKW dynamics is limited. However, there are no data or alternative explanations that contradict the fundamental principles of ecology that wildlife populations respond to prey availability in a manner generally consistent with analyses that link Chinook salmon abundance to the health of individual SRKWs and the status of the population as a whole. As a result of evidence previously described, we conclude that the best available science suggests that reductions in the availability of Chinook salmon could affect the health, survival, and reproductive success of SRKWs.

As previously described, SRKWs (particularly members of K and L pod) are likely to periodically spend some time in coastal waters during the winter and spring where they would be affected by reductions in Klamath River Chinook salmon abundance due to the proposed action. As previously described, SRKWs (particularly members of K and L pod) are linked to consumption of Chinook salmon from California based on the contaminant signatures discussed above. As previously described, Chinook salmon from the Klamath River (especially fall-run Chinook salmon) can constitute a sizeable proportion of the total abundance of Chinook salmon that is available throughout the coastal range of SRKWs (~7% on average from 2007-2016; but varying substantially between ~1-9% during any given year (Kope and Parken 2011). Within the range of Klamath Chinook salmon off the coasts of Oregon and California (SOF), Klamath Chinook salmon constituted about 17% (17.0) of the average ocean abundance of Chinook salmon during this time period. As previously described in the Environmental Baseline (Section 2.4.2.1.2), Klamath River Chinook salmon become an increasingly significant portion of prey source during any southerly movements of SRKWs along the coast of Oregon and California that may occur during the winter and spring. Klamath River Chinook salmon may constitute as much as 45% of local abundance of Chinook salmon within smaller areas along the Northern California or Southern Oregon coast in these areas when SRKWs are present in this area.

In response to a decrease in the amount of available Chinook salmon due to the proposed action, SRKWs could abandon particular areas in search of more abundant prey or expend substantial effort to find prey resources. These changes in behavior can result in increased energy demands for foraging individuals as well as reductions in overall energy intake, increasing the risks of being unable to acquire adequate energy and nutrients from available prey resources (i.e., nutritional stress). SRKWs are known to consume other species of fish, including other salmon, particularly in their coastal habitat (Hanson et al. 2021), but the relative energetic value of these species is substantially less than that of Chinook salmon (i.e., Chinook salmon are larger and thus have more energy value). Reduced availability of Chinook salmon would likely increase predation activity on other species (and energy expenditures) and/or reduce energy intake.

Numerous studies have demonstrated the effects of energetic stress (caused by incremental increases in energy expenditures or incremental reductions in available energy) leading to reduced body size and condition and lower reproductive and survival rates for adults (e.g., Daan et al. 1996; Gamel et al. 2005) and juveniles (e.g., Trites and Donnelly 2003; Noren et al. 2009). In the absence of sufficient food supply, adult females may not successfully become pregnant or give birth and juveniles may grow more slowly. Any individual may lose vitality, succumb to disease or other factors as a result of decreased fitness, and subsequently die or not contribute effectively to future productivity of offspring necessary to avoid extinction and promote recovery of a population. Ultimately, the effect of reduced prey for SRKWs could lead to behavior changes and nutritional stress that could negatively affect the animal's growth, health, reproductive success, and/or ability to survive.

The current status of SRKWs and overall Chinook salmon abundance also factors into the potential severity of effects from reduced prey. Populations with healthy individuals may be less affected by changes to prey abundance than populations with less healthy individuals (i.e., there may be a spectrum of risk based on the status of the whale population). We recognize that prey removals present more risk at lower Chinook salmon abundance levels (coastwide) when the whales have a poor status and/or are otherwise already facing other causes of nutritional stress.

Because SRKWs are already stressed due to the cumulative effects of multiple stressors, and the stressors can interact additively or synergistically, any additional stress such as reduced Chinook salmon abundance would likely have a greater physiological effect than it would for a healthy population, which may have negative implications for SRKW vital rates and population viability (e.g., NAS 2017). Intuitively, at some low Chinook salmon abundance level, the prey available to the whales may not be sufficient to allow for successful foraging leading to adverse effects (such as reduced body condition and growth and/or poor reproductive success). This could affect SRKW survival and fecundity. For example, food scarcity could cause whales to draw on fat stores, mobilizing the relatively high levels of contaminants stored in their fat and potentially affecting reproduction and immune function (Mongillo et al. 2016). Increasing time spent searching for prey during periods of reduced prey availability may decrease the time spent socializing; potentially reducing reproductive opportunities. Good fitness and body condition coupled with stable group cohesion and reproductive opportunities are important for reproductive success.

2.5.2.5 Impacts of Reduced Prey Base for SRKWs from Dam Removal

2.5.2.5.1 Short term Effects after Dam Removal

During the short term, effects to juvenile Chinook salmon resulting from dam removal and changes in hatchery production over two years are likely to be realized by SRKWs over a 2-3 year period of time following those impacts to Chinook salmon. Based on the Chinook salmon analysis as summarized above, we expect that the abundance of Klamath Chinook salmon in the ocean associated with the short term impacts of this proposed action could be reduced by as much as about 27%. This reduction in adult Klamath Chinook salmon ocean abundance would constitute 2.6% of the prey availability for SRKWs in the U.S. EEZ (based on recent average abundances), and 1.9% of the total abundance of Chinook salmon in the ocean within the range of SRKWs. If the associated reduction in Klamath Chinook salmon in the ocean is applied to the SOF area where Klamath Chinook salmon are expected to occur, the estimated decrease of the lost production would be 4.5%. This modest reduction will be short term, lasting no more than 2-3 years approximately 3-5 years after dam removal.

As previously described in the Link between SRKWs and Klamath River Chinook Salmon as Prey (Section 2.4.2.1.2), Chinook salmon from the Klamath River are expected to constitute a sizeable component of the diet of SRKWs in coastal waters within the action area where they overlap. Based on research and the known distribution of SRKWs previously described in Section 2.4.2.1, we conclude that SRKWs are known to occasionally use the southerly end of their range during some years. However, we also conclude it is also likely that this population may limit or avoid use of this area altogether during some years. Based on analysis/conclusions from a NMFS (2021a) Biological Opinion and NMFS (2021h) Final Biological Report, we expect some usage of California and Oregon waters as this area can be important during some years, especially if abundance of Chinook salmon NOF is relatively low (NMFS 2021h). Results from opportunistic sightings, satellite tagging, and acoustic recorders suggest SRKWs are more likely to be present in coastal waters off the coast of California and Oregon during the winter and spring from January through May than in other months of the year. However, we acknowledge the available data are limited and there can be large inter-annual variability in the time spent and distribution in coastal waters.

On their return to their natal rivers as adults, salmon may congregate in marine areas adjacent to the rivers during the months SRKWs are in the coastal waters of the action area. Therefore, it is possible that the overall reduction in prey resulting from the proposed action would not be evenly distributed across coastal waters, but rather the reductions could cause local depletions of prey and potentially result in the whales leaving areas in search of more abundant prey (NMFS 2021a). As described in section 2.5.2.4 General Effects of Reduced Prey Base for SRKWs, this short term effect could lead to changes in behavior that can result in increased energy demands for foraging individuals as well as reductions in overall energy intake. This increases the risks of being unable to acquire adequate energy and nutrients from available prey resources (i.e., nutritional stress) during this period, which can negatively affect the animal's growth, body condition, and health. The potential prey reductions and effects to SRKW are expected to be the highest during the short term period; however, this period would only last for a few years and the highest level of effects from localized depletions would only occur in times when the whales are foraging off the coast of Oregon and California.

2.5.2.5.2 Mid Term Effects after Dam Removal and System Restoration Begins

During the midterm period, effects to juvenile Chinook salmon may result from changes in hatchery production and changing conditions within the Klamath River that influence survival/productivity for Chinook salmon in the Klamath River for a period of two to eight years after dam removal. These are likely to be realized by SRKWs for a period of approximately six years reflected by the subsequent changes in the number of adult Chinook that are available in the ocean 4-10 years following removal of the dams. Based on the Chinook salmon analysis as summarized above, we expect that the abundance of Klamath Chinook salmon in the ocean as potential prey for SRKWs could be reduced by about 10% based on changes in hatchery production alone. We estimate this represents about a 1% (1.0%) reduction in the average abundance of Chinook salmon within the U.S. EEZ, and a less than 1% (0.7%) reduction in the average abundance of Chinook salmon in the ocean throughout the range of SRKWs. Off the coast of Oregon and California (SOF), this would represent a reduction of less than 2% (1.6%) in the average abundance of Chinook salmon during this period.

However, using the S3 model that looks at how natural production and hatchery fish will respond in the Klamath River system without dams, we assume there will not be any reduced Chinook salmon abundance in the ocean associated with the proposed action during most years within the mid-term effects period. In fact, expectations are that the abundance of Klamath Chinook salmon in the ocean will be higher, especially considering that conditions that have been linked with high levels of disease and other factors associated with some recent low years of Chinook salmon productivity that are expected to improve fairly quickly after dam removal. This difference is evident in all scenarios for dams out relative to dams in (no action), but is most drastically different when comparing low prevalence of infection (POI) scenarios with dams out, against scenarios of high POI with dams in. Given that POI is expected to remain relatively high as long as dams are in and POI is expected to drop quickly when the dams are removed and remain lower than would occur if the dams remained in, the comparison of the dams out/low POI scenario against a dams out/ high POI scenario is likely the most appropriate in the mid-term. However, we acknowledge there could be a scenario where there is a small reduction in juvenile Klamath Chinook salmon surviving to reach the ocean that is likely less than the 10% reduction that could be expected looking at changes in hatchery production alone within any individual year.

Over this mid term effects period, we do not expect SRKWs to be affected every year (if at all) by any reduced abundance of Klamath Chinook salmon in the ocean, as the expected increases in juvenile survival will offset the losses from reduced hatchery production during most years. In addition, the available analysis suggests SRKWs do not necessarily forage off Oregon and California every year. As a result, during the mid term effects period, we expect lower risk of localized prey depletions compared to the short term. We expect behaviors that lead to increased energy expenditures would decrease compared to the short term effects period, as the prey reductions anticipated would be smaller and would potentially only occur during some individual years.

2.5.2.5.3 Long Term Effects as Restoration is Realized

Over the long-term effects period, effects to juvenile Chinook salmon include the proposed cessation in hatchery supplementation and improving conditions within the Klamath River downstream of the former dams. The effects also include restoration and repopulation of upstream areas beyond the former dams. The effects described here will occur once the proposed action is complete (from eight years after dam removal through an indefinite period of time). Given the two year delay in maturity of juvenile Chinook salmon before becoming potential prey for SRKWs, these beneficial effects are likely to be realized by SRKWs starting from 10 years after dam removal as reflected by the subsequent changes in the number of adult Klamath Chinook salmon that are available as potential prey for SRKWs in the ocean. Based on the Chinook salmon analysis as summarized above, we expect the abundance of Klamath Chinook salmon in the ocean as potential prey for SRKWs to increase over the long term, through realization of the beneficial effects of the proposed action. This increase is anticipated despite the cessation of hatchery supplementation. While expectations for the productivity potential of newly available spawning habitat are variable, they generally agree that productivity (and subsequent ocean abundances) of Chinook salmon during the long-term effects period will surpass the current productivity of the Klamath River system under current conditions with the existing hatchery production.

In addition to improvements in abundance alone, there are other expected improvements related to Chinook salmon productivity in the Klamath River system that will provide additional benefits to the prey resources of SRKWs. These include genetic improvements that could increase the size of adult Klamath Chinook salmon and the diversity in run timing that would extend the period when returning Chinook salmon are aggregating in the ocean near the Klamath River in preparation for return. Based on our understanding of when SRKWs are most likely to encounter Klamath Chinook salmon, we expect the addition of new spring-run Chinook populations that are aggregating to return or distributed along the coast during the winter and spring could provide enhanced resources of prey when SRKWs are most likely to be within the action area.

This also coincides with the time of year that prey resources are believed to be most limited (NMFS and WDFW 2018).

Over the long term effects period, the anticipated effect of increased Chinook salmon productivity, including improved diversity of Chinook salmon populations in the Klamath River, which is expected to come along with improved and expanded spawning habitat and decreased reliance on hatchery fish supplementation, should improve the extent of available prey resources for SRKWs when they occur off the coast of Oregon and California. As a result, we anticipate the long-term effects of the proposed action will be entirely beneficial for SRKWs, and we do not anticipate any adverse effects associated with effects to behavior/energy over this time period.

2.5.2.6 Overall Effects of Reduced Prey Base for SRKWs as a Result of the Proposed Action

Impacts on prey availability attributed to the proposed action over the short term and to a lesser degree during the mid-term are expected to reduce prey availability to SRKWs off Oregon and California to a modest degree at most. Based on the analyses of expected effects to Chinook salmon populations in the Klamath River, the abundance of Chinook salmon prey available for SRKWs may be reduced by up to 2.6% in the U.S. EEZ, by up to 1.9% in the ocean within the range of SRKWs, and up to 4.5% in the SOF area for a short time 2-3 years after dam removal. These reductions would decrease the abundance of Chinook salmon populations in the ocean and the availability of these Chinook salmon populations as prey for SRKWs in the southern portions of their coastal range. The reduced abundance of prey could be detected by all members of K and L pod during foraging on a reduced prey field, particularly in years when they forage in the southern part of their range. Even modest reductions in prey could lead to increased expenditures of energy, reduced body condition/growth and reduced reproductive success. All members of K and L pod are expected to be adversely affected, or harmed,[24] through the increased health risks from impaired foraging due to decreased Chinook salmon abundance resulting from effects of the proposed action over the short term, and potentially at some point over the mid-term. The exposure of members of J pod to reduced Chinook salmon abundance in coastal waters is not as clear based on the available data regarding their distributions and contaminant signatures as previously described, but available information suggests their exposure may be much more limited or nonexistent.

The extent and/or duration of these adverse effects, however, is expected to be relatively limited. While Chinook salmon are preferred prey with high nutritional value, SRKWs are capable of taking advantage of other prey sources to supplement their nutritional needs and appear to do so when Chinook salmon resources are limited (Hanson et al. 2021). There are also behaviors that may reduce the impacts of limited prey resources. Ford and Ellis (2006) report that Southern Residents engage in prey sharing about 76 percent of the time during foraging activities. Prey

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[24] As "harm" is defined in ESA implementing regulations (50 CFR 222.102), we associate changes in foraging behavior and increased risk of nutritional stress as causing injury to SRKWs **"***by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering"*; specifically, in this case, feeding**.**

sharing would presumably distribute more evenly any effects of prey limitation across individuals of the population than would otherwise be the case (i.e., if the most successful foragers did not share with other individuals). The risks of short-term impacts associated with local depletion and behavior changes/increased energy demand are possible for a couple years, although we acknowledge that SRKWs do not necessarily visit the action area off the coast of Oregon and California every year. While we cannot predict the time or years that SRKWs spend time foraging off Oregon and California, we can assume it is likely to be influenced to some degree by the relative abundances of available Chinook salmon elsewhere. As a result of the magnitude of prey reduction, along with the whales' behavior and distribution patterns, we do not anticipate severe adverse effects such as immediate or delayed mortality or diminished reproductive rates for individuals as a result of the short-term effects associated with the proposed action. However, some whales may experience reduced fitness for a short period of time due to increased nutritional stress from impaired feeding.

Similarly, the extent of potential adverse effects over the midterm is expected to be relatively limited. Generally, we anticipate that the availability of Chinook salmon prey for SRKWs will improve compared to current circumstances, even with reductions in hatchery production in the Klamath River. However, we acknowledge that there could be scenarios where there is a small reduction in Chinook salmon that become potential prey two years later that could occur during some years of the mid term period. These years, if they did occur, are expected to be less impactful to the abundance of Chinook salmon in the ocean than during the short term effects. However, they could still lead to reduced fitness of individual SRKWs through increased energy expended to find sufficient prey and nutritional stress for a short amount of time if they coincide with times/years when SRKWs are foraging off the coast of Oregon and California.

Importantly, given that most scenarios are likely to lead to equivalent or increased abundances of prey during the mid term period, we conclude that the risk of adverse effects of reduced prey over this time as a result of the proposed action that could exacerbate conditions of nutritional stress for individuals will diminish over time. As a result, we do not anticipate severe adverse effects such as immediate or delayed mortality or diminished reproductive rates for individuals as a result of the mid term effects associated with the proposed action. However, some whales may experience reduced fitness for a short period of time due to increased nutritional stress from impaired feeding during some years.

Over the long term, the positive impacts of the proposed action are expected to increase over time as Chinook salmon repopulate the upper Klamath River basin, and restored hydrologic and sediment transport processes improve conditions in the mainstem Klamath River below where the dams were previously located. NMFS anticipates this will ultimately increase the amount of prey available in the ocean for SRKWs, and improve the portfolio of prey resources that are available across their range. As a result, we conclude that the long term effects of the proposed action on the prey resources of SRKWs will be completely beneficial, and will help contribute toward improving the future status of SRKW along with the health of individual SRKWs that come to Oregon and California to forage on prey resources that include Klamath Chinook salmon.

In conclusion, we expect some level of sub-lethal harm to some members of the SRKW population in response to small prey reductions in the short term and even smaller or nonexistent prey reductions in the mid term. Over the long term we expect benefits to SRKW through increased salmon abundance and resiliency contributing to an improved prey base.

2.5.2.7 Effects on SRKW Designated Critical Habitat

In addition to the effects to SRKWs discussed above, the proposed action affects critical habitat designated for SRKWs off the U.S. West Coast. Based on the natural history of SRKW and their habitat needs, we identified three PBFs in designating critical habitat for SRKWs:

- Water quality to support growth and development;
- Prey species of sufficient quantity, quality and availability to support individual growth, reproduction, and development, as well as overall population growth; and
- Passage conditions to allow for migration, resting, and foraging (50 CFR 226.206).

Any impacts to water quality are expected to be insignificant (plume in ocean) or extremely unlikely to occur (release of contaminants) as described in section 2.5.2.1 Effects from Release of Sediments. Because the proposed action would not create obstructions nor result in changes in acoustic disturbance to SRKWs, we do not anticipate any impact to passage conditions from the proposed action. All six distinct areas designated in marine waters along the U.S. West Coast occur within the boundary of the action area identified based on SRKW distribution overlapping with the distribution of Klamath Chinook salmon off the coast of Oregon and California. Specifically, the Northern California (Area 4) and Monterey Bay (Area 6) areas were identified as important feeding habitats for SRKWs that contain prey resources that rely significantly upon Chinook salmon that originate from the Klamath River (NMFS 2021h). The proposed action has the potential to affect the quantity and availability of prey in designated critical habitat, and our analysis of effects on the designated critical habitat focuses on potential impacts on the prey PBF, which have already been analyzed with respect to the whales themselves. The extent of reductions in Chinook salmon in the action area due to prey reduction is described in detail above in section 2.5.2.2 Effects of Proposed Action to Chinook Salmon.

It is difficult to assess how reductions in prey abundance may vary throughout designated critical habitat across the coast of Oregon and California, and we have less confidence in our understanding of where reductions could result in localized depletions within specific areas throughout designated critical habitat. Reductions in local abundance of prey from the proposed action may result in the whales leaving certain critical habitat areas in search of more abundant prey in other areas that are designated critical habitat (or potentially in marine waters outside the range of designated critical habitat). However, generalized estimates of prey reductions throughout the range of designated critical habitats, and/or throughout the range of Klamath Chinook salmon specifically, may not accurately predict reductions in prey available in their foraging hot spots.

As described in section 2.5.2.5, Impacts of Reduced Prey Base for SRKWs from Dam Removal, we anticipate modest prey reductions for SRKWs to occur off the coast of Oregon and California for a short term (2-3 year) period starting two years after dam removal. As described above, the prey reductions attributed to the proposed action could cause local depletions of prey in designated critical habitat and potentially affect the ability of the whales to meet their bioenergetic needs resulting in the whales leaving areas in search of more abundant prey. This circumstance could occur if SRKWs spend time foraging off the coast of Oregon and California during the winter and spring during these years. As a result, we conclude the proposed action is likely to adversely affect the quantity and availability of prey resources (prey PBF) within designated critical habitat. We acknowledge that this adverse effect would not necessarily occur every year, and that the risk of this effect could be influenced by the relative abundance of other Chinook salmon resources in other coastal marine waters.

As described in section 2.5.2.5, Impacts of Reduced Prey Base for SRKWs from Dam Removal, we anticipate that the availability of Chinook salmon prey for SRKWs will likely improve over the mid term period (6 year period occurring 4-10 years after dam removal) compared to current circumstances, even with reductions in hatchery production in the Klamath River. However, we also assume there could be some years with a reduction in Chinook salmon that enter the ocean and subsequently become potential prey two years later. These years (if they did occur) are expected to be less impactful to the abundance of Chinook salmon in the ocean than during the years of short term effects. However, they could still lead to reduced fitness of individual SRKWs through increased energy expended to find sufficient prey and nutritional stress for a short amount of time if they coincide with times/years when SRKWs are foraging off the coast of Oregon and California. As a result, we conclude that adverse effects to the prey PBF of designated critical habitat where Klamath Chinook salmon are found could occur during an individual year during this time period, although adverse effects to designated critical habitat are not expected throughout this period.

As described in section 2.5.2.5, Impacts of Reduced Prey Base for SRKWs from Dam Removal, the beneficial effects of the proposed action are expected to increase over time as Chinook salmon repopulate the upper Klamath River basin, and restored hydrologic and sediment transport processes improve conditions in the mainstem Klamath River below where the dams were previously located. This should ultimately increase the amount of prey available to SRKWs within designated critical habitat in marine waters where Klamath Chinook salmon occur, and improve the portfolio of prey resources that are available across their range. As a result, we conclude the overall long term effects to the prey PBF of designated critical habitat off the coast of Oregon and California will be completely beneficial, and will help contribute toward improving the future status of SRKW along with the health of individual SRKWs that forage on prey resources that include Klamath Chinook salmon. Consequently, we do not anticipate adverse effects to the prey PBF of designated critical habitat for SRKWs over the long term.

2.5.3 Southern DPS Eulachon

NMFS expects that the only adverse effects to eulachon in response to the proposed action will be in the form of elevated SSCs and low dissolved oxygen due to the distance between where eulachon occur in the Klamath River and Iron Gate Dam (i.e., where impacts are greatest). Under the proposed action, sediment released from Iron Gate Dam will decline in concentration with distance from the dam due to tributary flow accretion. Adult eulachon entering the Klamath River in the late winter and spring following reservoir drawdown are expected to be exposed to SSCs exceeding background levels for a portion of their migration period. As described in section 2.5.1.1.8, under a "worst case" scenario, dissolved oxygen could be depleted to levels below 7 mg/L all the way to the estuary for up to two weeks in January.

Impacts to eulachon related to suspended sediment and the co-occurring low DO are highly dependent on the water year type. Elevated SSCs will occur with higher flow events. Therefore, we look at exposure to individuals based on when each life stage is present in the action area and when a flow event may result in elevated SSCs that may impact exposed fish. In the *Approach to Analysis* Section 2.1.2, we describe an identified "median impact year" and a "severe impact year". In this effects section, we will present both scenarios side by side. Figure 29 illustrates elevated SSCs for both the median impact and severe impact year.

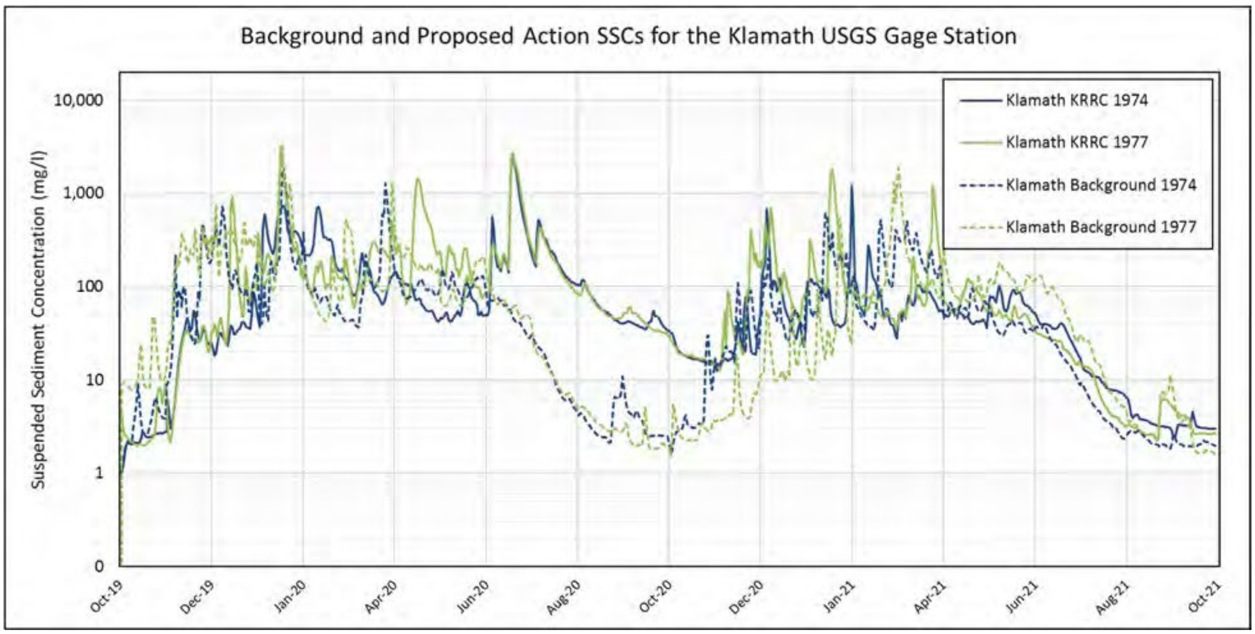

Figure 29. Comparison of modeled daily SSCs at the Klamath Station (RM 5) for sDPS eulachon median impact year (1974) and severe impact year (1977) scenarios under background conditions and the proposed action. Figure from (FERC 2021a). Years noted on horizontal axis are relative and correspond to the first and second year of the proposed action.

2.5.3.1 Exposure

As described in the Environmental Baseline, Section 2.4.3, Eulachon adults rarely migrate more than eight miles inland in the Klamath River (NRC 2004). Spawning and migration usually begins in December and January, continues until May, and peaks between March and April (Larson and Belchik 1998). Therefore, we expect adults, eggs, and larvae to be exposed to elevated SSCs and low DO in Year 1 during drawdown. Adults entering the Klamath River in the late winter and spring may be exposed to high suspended sediment concentrations and low DO for a portion of their migration period. If any adult eulachon spawn early in the year, the eggs may become smothered, and any surviving larvae will be temporarily exposed resulting in behavioral changes due to stress (Newcombe and Jensen 1996) as they drift towards the estuary and the ocean.

By April of Year 1, adults, eggs, and larvae are not likely to be affected by elevated sediment levels as we expect suspended sediment levels in the lower ten miles of the Klamath River to approximate background levels at that time (Figure 29).

2.5.3.2 Response

Limited information exists describing the effects of elevated suspended sediment concentrations and low DO on eulachon. Wildish and Power (1985) found that rainbow smelt (*Osmerus mordax*), an anadromous smelt of similar size and life history characteristics, avoided suspended sediment concentrations at about 22 mg/L and above. In addition, Chiasson (1993) found that rainbow smelt increased swimming activity when exposed to at least 10 mg/L of suspended sediment, and interpreted the increased activity as an alarm response.

NMFS lacks species specific information to assess the effects of suspended sediment concentrations and low DO on eulachon. Based on Wildish and Power (1985) and Chiasson (1993), it appears smelts and salmonids exhibit similar alarm and avoidance responses to elevated suspended sediment concentrations. Eulachon and juvenile salmonids also share similar morphological and physiological features, and similar life history strategies. Based on the available information, NMFS expects effects to eulachon and juvenile salmonids in the lower Klamath River from elevated SSC and low DO will be similar. Therefore, we use Newcombe and Jensen (1996) salmonid models for assessing impacts on eulachon. However, Newcombe and Jensen (1996) likely over estimates impacts to eulachon since eulachon are known to migrate in and spawn in turbid rivers (Hay and McCarter 2000), such as the Fraser River (Hay et al. 2003). As referenced in Table 25, high suspended sediment concentrations commonly occur in the lower Klamath River in January and February.

2.5.3.3 Risk to Individuals

The concentrations of suspended sediment during the proposed action that are likely to reach the lower Klamath River between January and February can range between 34 to 3,477 mg/L in a severe impact year with dissolved oxygen levels dipping to below 7 mg/L for up to two weeks in a “worst case” scenario (as defined in Section 2.5.1.1.8) for the month of January. In comparison, historical records indicate suspended sediment concentrations in a representative severe impact year would range from 1 to 1119 mg/L (Table 25). Eulachon present in the lower Klamath River during the earliest spawning migrations in mid- to late January of the drawdown year are likely to experience the most substantial effects. However, SSC modeling shows that even under background conditions, sublethal effects can occur. Therefore, we only focus on the responses that individuals may experience beyond background levels (i.e., in a severe impact year). Intermittent high levels of SSCs after January may alter fish behavior temporarily, but are expected to return to background levels by April. Because elevated SSCs will co-occur with reduced dissolved oxygen levels, it is impossible to separate out the two impacts. We assume the range of impacts provided in Table 25 are conservative and, therefore, would be inclusive of the added dissolved oxygen stressor to eulachon.

Table 25. 7-Day Median SSC (suspended sediment concentration), SEV (severity) Score, and Adult Eulachon Response Scenarios at the USGS Klamath Station. (FERC 2021a).

	Year 1 (Drawdown)		**Year 2**	
Scenario	Median SSC Range (mg/L)	Response	Median SSC Range (mg/L)	Response
Background (Median Impact)	46 - 1119	Sublethal effects, including major stress	11 - 1237	Sublethal effects, including moderate stress
Background (Severe Impact)	1 - 18	Sublethal effects, including moderate stress	46 - 514	Sublethal effects, including major stress
Proposed Action (Median Impact)	3 - 958	Sublethal effects including major stress	28 - 1241	Sublethal effects including moderate stress
Proposed Action (Severe Impact)	30 - 3477	Major stress and up to 20% mortality for 10% of the migration and spawning period	38 - 496	Sublethal effects, including major stress

For the severe impact year scenario, median SSC values for the proposed action in Year 1 are substantially higher than the background condition. These SSC values would result in a maximum of 20 percent adult eulachon mortality for approximately 10 percent of the migration and spawning period (FERC 2021a) if eulachon are not able to avoid the suspended sediment (Table 25). The number of adults exposed to severe conditions may be minimized because adult eulachon can avoid the Klamath River and migrate to other nearby rivers (e.g., Mad River or Redwood Creek), without compromising the overall spawning success for the species, because eulachon are not known to exhibit site fidelity or homing behavior (Gustafson et al. 2010).

Impacts to eggs and larval eulachon from elevated SSC are also expected to be higher during Year 1 for the proposed action compared to background conditions. However, because only 10% of the migration period will be impacted by the elevated SSCs as described above, we assume very few eggs will have been deposited by the end of January when the peak SSC levels would occur under the severe impact scenario. The small number of eggs that may be deposited in January are likely to have reduced fitness and survival, including the possibility of smothering any eggs and reducing DO levels on the spawning ground during drawdown. This degradation is likely to occur temporarily and intermittently during Year 1. However, as fall and winter inflows to the Klamath River are augmented by seasonal precipitation (NMFS 2019a), there is an increased likelihood that the freshet will remobilize the fine sediment to uncover eggs and enable them to adhere to gravel.

Additionally, increased SSCs may temporarily alter the quality and bury some of the sand and pea gravel substrate that eulachon rely on for spawning and incubation, also reducing the fitness of those eggs. Because the elevated rates of SSC are short term, occur early in the spawning migration, and there is evidence of eulachon spawning in turbid conditions, we conclude that eggs and larvae will experience only sublethal impacts during Year 1.

Although Table 25 describes sublethal impacts to Eulachon in Year 2, the levels of SSC are within the range of background conditions for that modeled impact years (11 – 1237 mg/L). Therefore, we conclude that the proposed action will not cause elevated SSCs resulting in mortality to eulachon beyond Year 1 (drawdown).

2.5.3.4 Effects of the Action on Critical Habitat

Critical habitat for eulachon in the Klamath River, as described in *Section 2.2.3.3*, Status of Critical Habitat, is designated from the mouth of the Klamath River upstream to the confluence with Omogar Creek at approximately river mile (RM) 10.5 from the mouth; however, critical habitat does not include any tribal land owned by the Yurok Tribe or the Resighini Rancheria. The Yurok reservation runs 44 miles along the river's lower reach, extending a mile from the Klamath's banks on either side, which would encompass the extent of critical habitat designated for eulachon. Critical habitat for the proposed action is discussed here, however, because some portion of land within the Yurok reservation includes a mixture of Federal, state, Tribal, and private ownerships.

The PBFs for southern DPS eulachon critical habitat as mentioned in *Section 2.2.3.3* are: (1) freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, (2) freshwater and estuarine migration corridors free of obstruction and with water flow, quality and temperature conditions supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yolk sac is depleted, and (3) nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival (50 CFR 226.222(b)). The proposed action has the potential to affect the first two PBFs of southern DPS eulachon critical habitat, which relate to freshwater spawning and incubation sites and freshwater migration corridors in the action area in the lower Klamath River. Nearshore and offshore marine foraging habitat is not designated as critical habitat for southern DPS eulachon in the action area; therefore, the PBF related to nearshore and marine foraging habitat will not be discussed. The potentially affected components of the freshwater and estuarine PBFs include substrate, water quality, passage, and forage.

Eulachon cannot successfully spawn and produce offspring without such habitat; the habitat allows adult fish to swim upstream to reach spawning areas, allows larval fish to proceed downstream to reach the ocean, and provides abundant forage species and suitable water quality. As described below, the freshwater spawning/incubation and migration corridor habitat types and associated PBFs are expected to be temporarily degraded by the increase in high sediment concentrations and low dissolved oxygen levels in the lower Klamath River related to the proposed action.

2.5.3.2.1 Spawning Habitat

Some of the finer suspended sediment released from the reservoirs during drawdown may settle out and reduce the quality of the river bed that eulachon rely on for spawning and egg adhesion. Additionally, low dissolved oxygen levels during the month of January may reduce the water quality in the spawning areas. Therefore, the proposed action is likely to intermittently degrade habitat suitability for spawning and incubation. This degradation is likely to occur temporarily (intermittent, but over a period of 1-2 years). However, as fall and winter inflows to the Klamath River are augmented by seasonal precipitation (NMFS 2019a), there is an increased likelihood that the freshet will remobilize the fine sediment to uncover eggs and enable them to adhere to gravel.

The temporary degradation of migratory habitat is expected to primarily occur during January and February of year one during dam drawdown, when the eulachon migration period has not peaked yet. Suspended sediment concentrations and dissolved oxygen levels are predicted to be similar to background levels within the lower Klamath River by year two of the eulachon spawning migration and spawning season (Figure 29). Therefore, the proposed action will have minimal effects on spawning and incubation habitat of eulachon in the short term, and is unlikely to impact spawning and incubation habitat in the long-term.

2.5.3.2.2 Migration

Safe and unobstructed migratory pathways are required for eulachon adults to pass from the ocean through estuarine areas to riverine habitats in order to spawn (76 FR 65324; October 20, 2011). Larval eulachon rear in estuaries and juvenile and adults require access to habitats in the ocean (76 FR 65324; October 20, 2011). The Klamath River contains essential migration habitat for adult upstream movement to spawning areas and larval transport downstream to the estuary and ocean. The increased suspended sediment related to the proposed action is likely to temporarily degrade habitat suitability for adult and larval migration and alter fish behavior. Therefore, the proposed action is likely to adversely affect the migration habitat of eulachon in the short-term.

Similar to spawning habitat effects, sediment concentrations should return to background levels in the lower Klamath River prior to year 2 of eulachon adult and larval migration periods. Eulachon are expected to avoid areas that are temporarily degraded by suspended sediments, but the migration corridor will be intermittently degraded during dam drawdown. Therefore, the proposed action will have minimal adverse impact on adult or larval migration habitat of eulachon in the short-term, with no long-term impact.

2.5.3.2.3 Prey Abundance

As discussed in Section 2.5.3.4, Effects of the Action on Critical Habitat, NMFS identified a PBF related to nearshore and offshore marine foraging habitat for the southern DPS of Pacific eulachon; however, there is no critical habitat designation for eulachon in nearshore or offshore marine habitat (50 CFR 226.222). NMFS also determined that water quality and available prey were specific components of PBFs for estuarine habitat and freshwater creeks and rivers (50

CFR 226.222). Adult eulachon enter rivers to spawn, and do not feed in fresh water during the few weeks they remain there (Rogers et al. 1990). The newly hatched young are carried to the sea by river currents where they feed on copepods and other plankton. While suspended sediment concentration may temporarily increase in the lower river, the increase in suspended sediment will be intermittent and not sufficient to reduce the suitability of the water quality for prey abundance.

2.5.3.2.4 Water Quality Effects on Habitat Changes

Water Temperature

Water temperatures during the proposed action are expected to be similar to existing conditions during the time of year when adult and larval migration occur (Reclamation 2012b). Eulachon spawning is reported to occur at temperatures over a range of 4° to 10°C (WDFW and ODFW 2001), and for the Klamath River, begins in January with peak spawning occurring in March and April. Eggs hatch 21-40 days after fertilization. The proposed action is expected to have very minimal effects on the water temperatures in the lower Klamath River (i.e., less than 0.2°C change [cooler or warmer depending on the month] for most months and up to 0.5°C cooler in November) (Risley et al. 2012).

Therefore, changes in water temperature resulting from the proposed action are unlikely to have more than a negligible impact on the lower Klamath River where eulachon are likely to occur during the adult or larval migration period.

Dissolved Oxygen

Dissolved oxygen levels are expected to dip below7 mg/L for up to two weeks in the "worst case" scenario (as defined in Section 2.5.1.1.8) for the month of January when Eulachon use the Klamath River for spawning. These water quality impacts will be most elevated closest to Iron Gate Dam and become less concentrated moving downstream as indicated by the sediment transport model (FERC 2021a). Although less severe downstream, these impacts will affect the entire mainstem Klamath River downstream t

The proposed action is not expected to change the dissolved oxygen concentration downstream of Clear Creek (RM 100) (DOI and CDFG 2012). Because Clear Creek is the upstream extent of designated eulachon critical habitat, the proposed action will not affect the dissolved oxygen concentration for adults and larvae in the lower river, or freshwater and estuarine migration corridors for eulachon critical habitat in the short- or long-term. This relationship between DO and increased sediment deposition are discussed further in *Section 2.5.1.1.8 Integration and Synthesis*.

2.5.3.5 Beneficial Effects to Eulachon and their Critical Habitat

Long-term beneficial effects of the proposed action for coho salmon (Section 2.5.1) in the action area also may benefit eulachon and their critical habitat. Once a more natural hydrograph and water temperature regime has been established in the river, it may improve spawning habitat for eulachon in the Klamath, although any upstream water quality improvements will be minimized by the time the waters reach the mouth and estuary of the Klamath. Eulachon surveys conducted by the Lower Elwha Klallam Tribe of the Elwha River after dam removal found the reconfiguring of sediment in the lower river has been favorable for improving spawning habitat for eulachon. Overall, for the long term, the proposed action is likely to have a beneficial effect for eulachon that spawn and rear in the Klamath River.

2.6 Cumulative Effects

"Cumulative effects" are those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation [50 CFR 402.02 and 402.17(a)]. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Some continuing non-Federal activities are reasonably certain to contribute to climate effects within the action area. However, it is difficult if not impossible to distinguish between the action area's future environmental conditions caused by global climate change that are properly part of the environmental baseline *vs.* cumulative effects. Therefore, all relevant future climate-related environmental conditions in the action area are described earlier in the discussion of environmental baseline (Section 2.4).

2.6.1 SONCC coho salmon

NMFS believes that the SONCC coho salmon ESU and its critical habitat may be affected by numerous future actions by State, tribal, local, or private entities that are reasonably certain to occur within the action area, or adjacent and upslope and have adverse effects on the action area. The following discussion provides information on the expected effects of these activities on coho salmon. Many of these future activities are continuing activities that have been discussed in the *Environmental Baseline* section (Section 2.4.1), and the effects of these future non-Federal actions on coho salmon and their designated critical habitat are likely to be similar to those discussed in the *Environmental Baseline* section.

2.6.1.1 Oregon Reintroduction Plan

The ODFW and the Klamath Tribes of Oregon have prepared a draft Implementation Plan for the Reintroduction of Anadromous Fishes into the Oregon Portion of the Upper Klamath Basin (Reintroduction Plan)(ODFW 2021). ODFW has made significant progress to secure funding and staff for purposes of implementing the Reintroduction Plan; thus, NMFS concludes that it is reasonably certain to occur. The Reintroduction Plan recommends species-specific approaches to guide the reintroduction of historically present anadromous fishes. When the dams are removed there is a high degree of confidence that coho salmon will repopulate newly available habitat as described in Section 2.5.1.2.5.8, Restored Access to Previously Blocked Habitat. This rapid repopulation response has been observed after barrier removal on the Elwha River (Liermann et al. 2017; Duda et al. 2021), White Salmon River (Allen et al. 2016; Hatten et al. 2016), Cedar River (Burton et al. 2013; Anderson et al. 2015), Rogue River (McDermott 2016), and the Penobscot River (Izzo et al. 2016). Therefore, this plan recommends a volitional approach to reintroduction of these fishes, in which no active measures will initially be taken to assist in repopulating habitat in the Upper Klamath Basin. The Reintroduction Plan includes a recommended strategy for monitoring reestablishment of coho salmon following the removal of the four Klamath Hydroelectric dams. The strategy for monitoring will be focused on fundamental questions. Immediately following the availability of passage, monitoring will focus on determining if coho salmon are migrating into habitat immediately above the dams. As fish populations become more widely established, monitoring will be more specific and focused on management objectives, such as determining adult escapement, juvenile productivity, and spatial distribution within each subbasin. Information gained through these Reintroduction Plan monitoring activities will advance and prioritize future restoration activities that promote improvements to fitness and survival of the Upper Klamath population of coho salmon.

2.6.1.2 Timber Management on Private Lands

Timber management, along with associated activities such as harvest, yarding, loading, log hauling, site preparation, slash burning, tree planting, thinning, and road construction occurs in the action area. Future private timber harvest levels in the action area cannot be precisely predicted; however, NMFS assumes that harvest levels on private lands within the action area in the foreseeable future will be similar to harvest levels that have occurred over the past 20 years.

Timber harvest is not regulated if the resulting timber is not sold. When timber is sold, timber harvest is regulated under the California Forest Practice Rules (CFPR). The CFPR has likely not consistently provided protection against an unknown amount or extent of unauthorized take of salmonids listed by NMFS under the ESA, such as listed SONCC ESU coho salmon. Timber harvest results in impairments in migration, shade, large woody debris, stream temperature, turbidity, and sediment levels (NMFS 2014a). These impacts will likely continue throughout the action area and for the duration of impacts resulting from the proposed action.

Reasonably foreseeable effects of timber harvest will likely continue to degrade conditions in designated SONCC coho salmon ESU critical habitat within the action area as described in the environmental baseline section of this Opinion.

2.6.1.3 Control of Wildland Fires on Non-Federal Lands

Climate change is increasing the frequency and severity of wildfires not only in California but also all over the world. Since 1950, the area burned by California wildfires each year has been increasing, as spring and summer temperatures have warmed and spring snowmelt has occurred earlier (CARB 2021). During the recent drought, unusually warm temperatures intensified the effects of very low precipitation and snowpack, creating conditions for extreme, high severity wildfires that spread rapidly. Of the 20 largest fires in California's history, eight have occurred in the past three years (since 2017) (CalFire 2021).

Control of wildland fires may include the removal or modification of vegetation due to the construction of firebreaks or setting of backfires to control the spread of fire. This removal of vegetation can trigger post-fire landslides as well as chronic sediment erosion that can negatively affect downstream coho salmon habitat. Also, the use of fire retardants may adversely affect salmonid habitat if used in a manner that does not sufficiently protect streams causing the potential for coho salmon to be exposed to lethal amounts of the retardant. This exposure is most likely to affect summer rearing juvenile coho salmon. State of California protective standards require 100-foot buffers reducing likelihood of fire retardants entering waterways. While we cannot predict precisely where and when wildfires will occur, we expect the rate and severity of wildland fires will increase. We expect degradation of coho salmon habitat from wildfires will occur during this action.

2.6.1.4 Construction, Reconstruction, Maintenance, and Use of Roads

Adjacent to the action area are thousands of miles of surface roads used to provide access to timber or private residences. Erosion from unmaintained roads increases fine sediment concentrations to waterways and can suffocate redds, degrade pool quality, and decrease pool depth (Newcombe and Jensen 1996; Suttle et al. 2004). As the road networks in the action area are already fairly well established, NMFS does not anticipate significant new miles of roads to be built in the near future. However, NMFS does anticipate that restoration efforts will continue to upgrade and or decommission existing roads to make them less inclined to road failures (landslides) and/or be a chronic source of sediment discharge to adjacent stream networks. Improvement of environmental conditions on private and state lands related to roads adjacent to the action area is expected in the future due to an increasing emphasis on watershed-scale inventory, assessment and treatment of road networks as regulatory sediment reduction requirements are implemented in the action area (e.g., TMDLs). However, funding for such efforts is limited and the thousands of miles of existing roads in total is expected to continue to adversely affect coho salmon and their habitat.

2.6.1.5 Mining, Rock Quarrying and Processing

Although mining activity is a relatively minor land use within the action area as compared to timber management, NMFS anticipates that upland mining and quarrying will continue to be conducted by non-federal parties adjacent or upslope to and affecting the action area. The effects of upland mines and quarries on aquatic resources in the action area depend on the type of mining, the size of the quarry or mine, and distance from waters. Mining can cause increased sedimentation, accelerated erosion, increased streambank and streambed instability, and changes to substrate. Surface mining may result in soil compaction and loss of the vegetative cover and humic layer, thereby increasing surface runoff. Mining may also cause the loss of riparian vegetation. Chemicals used in mining can be toxic to aquatic species if transported to waters. Because the effects of mines and quarries depend on several variables, while NMFS cannot precisely determine the extent of the effects that mines and quarries and other commercial rock operations adjacent or upslope of the action area will have on coho salmon in the action area, we anticipate minor effects will continue into the future.

As described in Section 2.4.1.1.13.4, Mining, in 2009 California suspended all instream mining using suction dredges (NMFS and USFWS 2013). The use of vacuum or suction dredge equipment, otherwise known as suction dredging, is currently prohibited and unlawful throughout California (https://wildlife.ca.gov/Licensing/Suction-Dredge-Permits, visited on November 29, 2021); see generally California Fish and Game Code 5653, 5653.1, 12000, subdivision (a)). Suction dredge mining in systems that support salmonids was known to cause locally significant adverse impacts on salmonids and their habitat. NMFS expects that the prohibition of suction dredging will allow for improved habitat conditions in the Klamath mainstem and larger tributaries, and will reduce the direct and indirect effects of this activity on SONCC ESU coho salmon in both the short and long term.

2.6.1.6 Water Withdrawals

An unknown number of permanent and temporary water withdrawal facilities exist within the action area. These include diversions for urban, agricultural, commercial, and residential use, along with temporary diversions, such as drafting for dust abatement. The nature of their impacts was discussed in the *Environmental Baseline* section. Approximately 81,070 acre feet of water is diverted from the Scott River annually (Van Kirk and Naman 2008). These and numerous other water diversions in the systems that feed the Klamath River decrease the quantity of mainstem flows on the Klamath River mostly during the summer months, when juvenile access to cooler tributaries and cooler mainstem water temperatures is essential. NMFS expects these activities to continue into the future with impacts similar to those described in the Environmental Baseline.

2.6.2 Southern Resident Killer Whales

Pertinent cumulative effects for salmonids in the freshwater environment that relate to the action area are described above in Section 2.6.1, Cumulative Effects for SONCC coho salmon. Cumulative effects on Klamath River basin Chinook salmon in the freshwater environment are likely to be similar to those described for SONCC coho salmon because, as noted earlier, Chinook and coho share similar life histories and are thus likely to be affected by cumulative effects in similar ways. In turn, these result in effects to prey resources of SRKWs in the action area as described in the Environmental Baseline section for SRKWs (Section 2.4.2). While many of the cumulative effects expected to affect coho salmon will also be relevant to Chinook salmon, there are some important differences between the species that need to be considered. First, Chinook salmon and coho salmon exhibit some differences in life history. For example, coho salmon juveniles almost exclusively spend one or more years in fresh water before emigrating to the ocean, while Klamath Basin Chinook salmon predominantly smoltify and emigrate soon after emergence. The impact of these life history differences between Chinook and coho salmon is minor, as they have similar freshwater habitat requirements for spawning, egg incubation, and rearing, so threats for one species are generally likely to be threats for the other. However, one important difference between the two species that is relevant to the effects of the proposed action is that Chinook salmon are expected to migrate significantly farther upstream once the dams are removed than are coho salmon. Chinook salmon are expected to repopulate over 303 miles of habitat upstream of Iron Gate Dam (see Section 2.5.2.2.2, Effects to Chinook salmon), while coho salmon are expected to repopulate up to 76 miles of habitat upstream of Iron Gate Dam (see Section 2.5.1.2.5.8, Restored Access to Previously Blocked Habitat, in the Effects to Coho Salmon Habitat section. NMFS coordinated with USFWS regarding activities that were reasonably certain to occur in the areas above Spencer Creek that would impact Chinook salmon future habitat, but not coho salmon, and did not identify activities that were likely to have an impact on Chinook salmon. There may be future activities authorized, funded, or carried out by Federal agencies in the area above Spencer Creek (e.g., restoration actions) that could impact Chinook salmon, but those would require additional ESA Section 7 consultation.

In addition, though not part of the proposed action, ODFW and Klamath Tribes (2021) have prepared a Draft Implementation Plan for the Reintroduction of Anadromous Fishes into the Oregon Portion of the Upper Klamath Basin that includes active reintroduction (outplanting of hatchery juveniles into areas above the dams) of spring-run Chinook salmon into the Oregon portion of the basin, which would be expected to jumpstart repopulation by Chinook salmon. ODFW has made significant progress to secure funding and staff for purposes of implementing the Reintroduction Plan; thus, NMFS concludes that it is reasonably certain to occur. Therefore, NMFS expects that this active reintroduction as part of the reintroduction plan is reasonably certain to occur.

Discussion of the planned active reintroduction of spring-run Chinook salmon bids the question: why not actively supplement all new habitat with hatchery fish? The answer is that natural (volitional) repopulation is generally considered the approach with the lowest risk of failure or unintended consequences because it minimizes the interruption or alteration of natural biological processes (George et al. 2009; Anderson et al. 2014). Active reintroduction by means of transplanting adults, juveniles, or fertilized gametes has the benefit of immediately placing fish in the reintroduction area, but has increased ecological risks relative to natural repopulation. The concern is that hatchery releases during active reintroduction may reduce the genetic fitness of wild fish (Araki et al. 2008) or induce density-dependent ecological processes affecting naturally spawning fish (Kostow 2009). When feasible, natural repopulation is considered most likely to maximize abundance and productivity in the long run. Fall-run Chinook salmon, coho salmon, steelhead trout, and Pacific lamprey are all found in habitat immediately downstream of Iron Gate Dam. When the dams are removed there is a high degree of confidence that individuals of these species will significantly repopulate newly available habitat on their own. However, because the timing and extent of volitional repopulation is uncertain, ODFW plans to allow three generations (estimated to be 9 years for coho salmon and 12 years for Chinook salmon) to pass following restored passage, after which an assessment will be conducted to determine if, where, and when active reintroduction is needed to help establish populations of these species. The only remaining populations of spring-run Chinook salmon in the Klamath Basin are located in the Trinity River and Salmon River sub-basins (150 and 128 miles downstream of Iron Gate Dam, respectively). Because of the long distance from Iron Gate Dam, and even further distance to newly available habitat, to the source populations of spring-run Chinook salmon (Trinity River and Salmon River sub-basins), these fish are unlikely to repopulate habitat in the upper basin on their own. The addition of new spring-run Chinook salmon populations in the Klamath Basin would represent an improvement in the availability of Chinook salmon prey resources for SRKWs. In addition to the general increase in the abundance of Chinook salmon that new populations could bring, we recognize the spring-run Chinook salmon that are aggregating to return or distributed along the coast during the winter and spring could provide enhanced resources of prey when SRKWs are most likely to be within the action area. This also coincides with the time of year that prey resources are believed to be most limited (NMFS and WDFW 2018).

Many of effects associated with activities that have occurred in the recent past that have affected the Status and Environmental Baseline of SRKWs as described in sections 2.2.2 and 2.4.2 are expected to continue in the future and contribute to adverse cumulative effects on SRKWs. These are considered reasonably certain to occur in the future because they occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Tribal, state and local government actions will likely be in the form of legislation, shoreline growth management, administrative rules, or policy initiatives and fishing permits. These actions may include changes in ocean policy and increases and decreases in the types of activities currently seen in the action area, including changes in the types of fishing activities, resource extraction, or designation of marine protected areas, any of which could impact SRKWs or their designated critical habitat. Government actions are subject to political, legislative and fiscal uncertainties. Private activities are primarily associated with other commercial and sport fisheries, construction, dredging and dredge material disposal, vessel traffic and sound, alternative energy development, offshore aquaculture/mariculture, and marine pollution. Although these factors are ongoing and reasonably certain to continue in the future to some extent, the extent that these factors will continue and the magnitude of their effects depends on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, while it is difficult to precisely assess the cumulative impacts and the relative importance of these effects, and given the types of effects, NMFS assumes the Environmental Baseline (Section 2.4.2) provides the best available information characterizing the type and magnitude of the effects these activities may be expected to have in the action area in the future during this proposed action. Most of these factors represent long running and/or ongoing human activities actions or natural processes that do not have expected or known timelines for when changes will occur.

One potential cumulative effect that we identified is related to State actions that can be expected to occur in response to the progress of the restoration of the Klamath River system following dam removal. CDFW, ODFW and the Klamath Tribes (2021) are drafting anadromous species reintroduction plans that discuss the potential for modified hatchery operations in the Klamath River to continue beyond the length of time proposed (eight years). Hatchery operations beyond eight years (or potentially cessation of hatchery operations earlier than eight years if warranted) will depend on the level of natural production that is occurring throughout the Klamath River (including newly available upstream habitat) as indicated by monitoring efforts. The response to what is observed following dam removal and commencement of restoration activities, and any potential changes in the timeline and/or extent of hatchery production that occurs will be decided in coordination with Klamath Basin fisheries managers including State regulatory agencies and Tribal partners. While the specific plans being prepared by CDFW and ODFW are not yet finalized, we are reasonably certain that hatchery production would continue to occur at some level beyond eight years if expectations for repopulation of newly available spawning habitat and improved productivity throughout the Klamath River system are not being met. We base this assumption on the expectation, based on past investment of resources State regulatory agencies and Tribal partners, that their investment of resources through staff and infrastructure will continue in place over the eight year period following dam removal. Also, Klamath River Chinook salmon are an important federally managed and tribal trust species that affects west coast fisheries opportunities. Klamath River Chinook salmon production has and will remain a priority for restorative actions by these agencies, and if natural production is deemed to be insufficient, continued hatchery production may be warranted despite the recognized potential negative impacts of hatchery releases on natural production. The result of this action would be the likely extension of the duration associated with the anticipated mid-term effects for SRKWs for some time period until the benefits of long-term restoration are being more fully realized.

Although it is not possible to precisely predict the timeline for the increase in natural production in the Klamath River, NMFS and other agencies will monitor progress and NMFS expects significant progress by the time the long-term effects period begins. General plans at this point are to allow for three generations (estimated to be 12 years for Chinook salmon) to pass following dam removal and restored access to the Upper Klamath River, after which an assessment will be conducted to determine if, where, and when active reintroduction may be needed to help establish populations of these species.

Numerous non-federal NMFS partners will continue to implement targeted management actions identified in the SRKW recovery plan (NMFS 2008) informed by research. For example, the Pacific Coastal Salmon Recovery Fund (PCSRF) was established by Congress in FY2000 to protect, restore, and conserve Pacific salmon and steelhead populations and their habitats. Under the PCSRF, NMFS manages a program to provide funding to states and tribes of the Pacific Coast region (including Oregon and California). Future projects funded by the PCSRF and conducted by states and tribes that will be implemented throughout the region will make important contributions to improve the status of ESA-listed salmon and protect currently healthy populations, which will help support the prey needs of SRKW in the action area. Additional actions by non-federal activities surrounding implementation of the SRKW recovery plan that are ongoing or expected to occur are described in the most recent 5-year review (NMFS 2016e).

Additional activities that may occur in the coastal waters off Oregon and California will likely consist of state or local government actions related to ocean use policy and management of public resources, such as changes to or additional fishing or energy development projects. Changes in ocean use policies as a result of non-federal government action are highly uncertain and may be subject to sudden changes as political and financial situations develop. Examples of changes to or additional actions that may occur include: development of aquaculture projects; changes to state fisheries which may alter fishing patterns; installation of hydrokinetic projects near areas where SRKWs are known to occur; designation or modification of marine protected areas that include habitat or resources that are known to affect marine mammals in general; and coastal development which may alter patterns of shipping or boating traffic. However, none of these potential state, local, or private actions, can be anticipated with any reasonable certainty in the action area at this time, and most of those described as examples would likely involve federal involvement of some type given the federal government’s role in regulating activity in the ocean across numerous agencies and activities.

In summary, most of the potential factors affecting Chinook salmon and SRKWs are ongoing and expected to continue in the future. However, the precise level of their future impacts is uncertain. As noted above, it is likely that the Environmental Baseline (Section 2.4.2) characterizes the type and likely magnitude of the effects these factors may be expected to have in the action area in the future during this proposed action. One cumulative effect (Section 2.6.2) that we find reasonably certain to occur is that, if sufficient natural production that is not occurring throughout the Klamath River as described above, hatchery operations would continue beyond eight years in some capacity based on investment of resources by state regulatory agencies and Tribal partners to help offset any delay in the realization of long term benefits associated with the proposed action.

2.6.3 Southern DPS Eulachon

The southern DPS of Pacific eulachon and its critical habitat in the action area may be affected by numerous actions by future State, tribal, local, or private entities that are reasonably certain to occur in or adjacent to the action area.

The cumulative effects (Section 2.6.1) discussed previously for coho salmon that occur in the lower river are expected to have similar, but reduced, effects on eulachon since eulachon are not in the action area yearlong.

In addition, NMFS believes the harvest of eulachon by tribal fisheries in the lower Klamath River is reasonably certain to occur within the action area in the future. The state of California does not list eulachon as endangered, but issued regulations prohibiting the take or possession of eulachon in recreational fisheries. In 2015 the Pacific Fishery Management Council adopted a Fishery Ecosystem Plan that states no directed fishery on eulachon in marine waters would be allowed without a NMFS-approved Fishery Management Plan. Although no information on harvest rates are available, seven total eulachon were captured or reported to the Yurok Tribal Fisheries Department in 2011 during surveys targeting this species. Yurok surveys found 40 fish for 2012, 112 for 2013, and approximately 1,000 in 2014, which indicate persistent low numbers of eulachon being found in the lower Klamath River. Assuming the current abundance of eulachon and the 2011- 2014 catch information is representative of future harvests, extremely small numbers of eulachon are likely to be harvested each year in the future. Therefore, harvest will result in a minimal reduction to the eulachon population in the Klamath River.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in assessing the risk that the proposed action poses to species and critical habitat. In this section, we add the effects of the action (Section 2.5) to the environmental baseline (Section 2.4) and the cumulative effects (Section 2.6), taking into account the status of the species and critical habitat (Section 2.2), to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.7.1 SONCC coho salmon

In the *Status of the Species* section (Section 2.2.1), NMFS summarized the extinction risk of the SONCC coho salmon ESU, and summarized the factors that led to the listing of the SONCC coho salmon ESU as a threatened species under the ESA. These factors include past and ongoing human activities and climatological trends and ocean conditions identified as influential to the viability of all populations of the SONCC coho salmon ESU. Beyond the continuation of the human activities affecting the species, NMFS also expects that ocean condition cycles and climatic shifts will continue to have both positive and negative effects on the species' ability to survive and recover. Specifically, we expect climate change will contribute to lower base flows in the summer, reduced snow pack in the winter, and more frequent flood flows associated with intense rain storms and rain-on-snow events.

The extinction risk criteria established for the SONCC coho salmon ESU are intended to represent how a species, including its constituent populations, is able to respond to environmental changes and withstand adverse environmental conditions. Thus, when NMFS determines that a species or population has a high or moderate risk of extinction, NMFS also understands that future environmental changes could have significant consequences on the species' ability to achieve recovery, depending on the extent of those changes. Also, concluding that a species has a moderate or high risk of extinction does not mean that the species has little or no potential to become viable, but that the species faces moderate to high risks from internal and external processes that can drive a species to extinction. With this understanding of the current risk of extinction of the SONCC coho salmon ESU, NMFS will analyze whether the added effects of the proposed action are likely to increase the species' extinction risk, while integrating the environmental baseline, the effects of other activities caused by the proposed action, and cumulative effects.

All four VSP parameters for the SONCC coho salmon ESU's populations are indicative of a species facing moderate to high risks of extinction from myriad threats. In order for the SONCC coho salmon ESU to be viable, all seven diversity strata that comprise the species must be viable and meet certain criteria for population representation, abundance, and diversity. Current information indicates that the species is presently vulnerable to further impacts to its abundance and productivity (Good et al. 2005; Williams et al. 2016a).

Known or estimated abundance of the SONCC coho salmon populations indicates most populations have relatively low abundance and are at high risk of extinction. Species diversity has declined and is influenced, in part, by the large proportion of hatchery fish that comprise the ESU. Population growth rates appear to be declining in many areas and distribution of the species has declined. Population growth rates, abundance, diversity, and distribution have been affected by both anthropogenic activities and environmental variation in climate and ocean conditions. The species' reliance on productive ocean environments, wetter climatological conditions and a diversity of riverine habitats to bolster or buffer populations against adverse conditions may fail if those conditions occur less frequently or intensely (as is predicted) or if human activities degrade riverine habitats.

In the *Environmental Baseline* section (Section 2.4.1), NMFS described the current environmental conditions that influence the survival and recovery of Klamath River coho salmon populations. Coho salmon in the mainstem Klamath River will continue to be adversely affected by the ongoing activities, such as agricultural water diversions, timber harvest, and mining. However, many of the impacts described in the Environmental Baseline are a result of the four dams that will be removed under the proposed action. These impacts include blockage of fish passage, blockage of sediment transport, reduction of flow variability, decreased water quality, and creation of conditions that increase rates of disease. In Section 2.5.1.2.5, *Beneficial Effects to Coho Salmon and their Critical Habitat*, we explain how these impacts will be partially or completely resolved through implementation of the proposed action.

In the *Cumulative Effects section* (Section 2.6.1), NMFS expects many of the non-Federal activities discussed in the *Environmental Baseline* section (Section 2.4.1) will continue (e.g., timber management, control of wildfire, use of roads, water withdrawals) with effects similar to those described in the environmental baseline. However, post dam removal, NMFS expects that the Reintroduction Plan drafted by ODFW and the Klamath Tribes (2021) will inform and guide restoration decisions such as prioritizing key projects to aid in repopulation of the Upper Klamath Basin after fish gain access to upstream reaches.

The Klamath River basin encompasses nine SONCC coho salmon populations and two diversity strata (i.e., Interior Klamath River and Central Coastal). As described in greater detail below, all nine coho salmon populations in the Klamath River basin will be affected by the proposed action; however, four out of five populations in the Interior Klamath Basin diversity stratum will be affected the most (i.e., the two mainstem Klamath River populations, as well as the Shasta River and Scott River populations). While the Salmon River population is in the Interior Klamath Basin diversity stratum, adverse effects related to the proposed action to this population are expected to be minimal. The populations within this stratum have a moderate to high extinction risk. Abundance estimates indicate that all of the populations within the stratum fall below the levels needed to result in a low risk of extinction. The large proportion of hatchery coho salmon to wild coho salmon reduces diversity and productivity of the wild species. IGH and TRH Chinook salmon smolts compete with wild coho salmon for available space and resources.

NMFS' (2014a) SONCC Coho Salmon Recovery Plan identifies a number of ways that dams pose a high threat to most coho salmon life stages in the ESU and specifically highlights the Klamath River Dams as adversely affecting numerous downstream populations in the Klamath Basin. For example, NMFS (2014a) identifies disease impacts to the SONCC ESU, describing how disease is likely to negatively impact all of the VSP parameters for the SONCC coho salmon ESU, especially in the Klamath River Basin, because both adults and juveniles can experience high mortality in some years. In Section 2.5.1.2.5.2, we discuss how the implementation of the proposed action will contribute to long term reduction in disease for the populations in the Klamath Basin. Additionally, NMFS (2014a) describes optimism in the proposal to remove the four Klamath River dams, because that would allow the Upper Klamath River population to occupy the full extent and range of its historic habitat, thereby increasing spatial structure of the entire ESU. Removal of Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle Dams is ranked as one of the highest priority recovery actions.

2.7.1.1 Interior Klamath Basin Stratum: Upper Klamath River Population

The boundaries of the Upper Klamath River population currently comprise mainstem habitat and tributaries between Portuguese Creek and Iron Gate Dam, excluding the Shasta and Scott rivers. IGH operations have a negative effect to this population's diversity and productivity because hatchery-origin coho salmon comprise a substantial proportion of the adult spawners in this population due to straying. Habitat conditions of the tributaries and mainstem within the population have been degraded through a number of anthropogenic factors including water withdrawals, the network of roads, and other land management activities that have reduced the quality and quantity of instream habitat. These factors, combined with the loss of historical habitat above Iron Gate Dam and environmental factors, including climate change, have contributed to the high risk of extinction of this population.

NMFS expects the risk of extinction of the Upper Klamath River Population to remain high for many years. However, as described in greater detail below, this population, compared to other coho salmon populations affected by the proposed action, is expected to benefit the most from its implementation, and NMFS expects the proposed action will increase this population's spatial distribution and diversity, which will increase productivity and abundance over time, and, therefore, decrease its extinction risk. As described in the *Environmental Baseline*, recent estimates of natural coho salmon spawners for the Upper Klamath River Population fall far short of the 8,500 Low Risk Abundance Level set by Williams et al. (2008b) for this population.

2.7.1.1.1 Proposed Action Effects on Population Extinction Risk

The proposed action will affect the Upper Klamath River population the most because the four dams proposed for removal are located within the population's boundary. As described in greater detail below, increased stress is expected and injury or mortality to individuals is likely from the effects of suspended sediment concentrations, decreased dissolved oxygen concentrations during reservoir drawdown, and fish relocation related to the proposed action. However, these effects will be temporary and implementation of the proposed action is expected to result in long term benefits to the population as described in Section 2.5.1.2.5.

Suspended Sediment

The largest cause of mortality as a result of the proposed action is expected to result from the increase in suspended sediment in the mainstem, with the level of mortality decreasing downstream of Iron Gate Dam and as time passes. All freshwater life stages of coho salmon from this population are expected to be adversely affected by the suspended sediment. Adults are expected to experience sub-lethal effects, such as increased stress. However, no mortality to adults is expected from the increased suspended sediment. In addition, some adults may avoid spawning in the mainstem and may migrate into tributaries, which will likely increase the reproductive success of these individuals relative to adults spawning in the mainstem in the next year or two after the project reservoirs are drawn down.

The relatively small number of redds created in the mainstem are expected to be buried by the addition of suspended and coarse sediment transported into the reach as a result of the proposed action. NMFS expects no more than six redds to be buried, with the number of embryos or pre-emergent fry that would die as a result representing a small fraction of the Upper Klamath River population since most redds will be located in tributaries.

Responses of sub-yearlings that may be rearing in the mainstem include major stress, reduced growth, and mortality under both the median impact year and severe impact year. Although rates of mortality are reduced for the most part in the median impact water year, we conservatively focus on the impacts expected in a severe impact year. The median year is presented for comparison purposes to identify a likely range of impacts. Only a fraction of the fish rearing in the mainstem during a small window of the rearing period are expected to die as a result of elevated SSCs based on modeled predictions (Table 26). Similarly, outmigrating smolt are expected to experience major stress and reduced growth which will decrease overall fitness. Smolt that enter the ocean at a smaller size due to reduced growth are expected to have a lower rate of survival in the marine environment (Russell et al. 2012). A fraction of the outmigrants are expected to die during a period of the spring outmigration window based on modeled predictions. However, rearing sub-yearling and yearling coho salmon are likely to move downstream or into clear water tributaries where the suspended sediment concentrations are lower. Additionally, minimization measures will further reduce mortality (e.g., relocation of mainstem rearing fish). Therefore, the adverse effects to each life stage are most likely less than the modeled predictions. Also, the adverse effects will be short-term and affect different year classes. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Upper Klamath River population in the year of drawdown and is not expected to eliminate any one-year class.

Table 26. Summary of adverse impacts to Upper Klamath River coho salmon population a result of suspended sediment effects related to the proposed action.

Life Stage	Median Impact Year	Severe Impact Year
Year 1		
Adults	Sublethal effects, including major stress and impaired homing	Sublethal effects, including major stress and impaired homing
Eggs/pre-emergent fry	100% mortality of 6 mainstem redds	100% mortality of 6 mainstem redds
Sub-yearling (0+)	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem 15% of the summer rearing period	Major stress, reduced growth, 0– 20% mortality of fish rearing in the mainstem for 31% of the summer rearing period and 20-40% mortality of fish rearing in the mainstem for 8% of the summer rearing period
Yearlings (1+)	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 20% of the winter rearing period and 0-40% mortality of fish rearing in the mainstem 20% of the winter rearing period	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 20% of the winter rearing period and 0-40% mortality of fish rearing in the mainstem 20% of the winter rearing period
Smolt (1+)	Major stress, reduced growth, and up to 20% mortality for approximately 30% of the outmigration period	Major stress, reduced growth, and up to 20% mortality for approximately 60% of the outmigration period
Year 2		
Adults	Sublethal effects, including moderate stress	Sublethal effects, including minor stress
Eggs/pre-emergent fry	Sublethal impacts	Sublethal impacts
Sub-yearling (0+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Yearlings (1+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Smolt (1+)	Sublethal effects, including reductions in feeding and moderate stress	Sublethal effects, including major stress and reduced growth

Dissolved Oxygen

Mortality due to depressed DO levels related to the proposed action will occur in conjunction with impacts from the increase in suspended sediment in the mainstem and will likely be indistinguishable from those impacts. The level of mortality will decrease downstream of Iron Gate Dam and as time passes. All life stages of coho salmon from this population are expected to be adversely affected by the depressed DO levels. Adults are expected to experience sub-lethal effects, such as delays in upstream movement. However, no mortality to adults is expected as they can detect low DO levels and will likely either wait until DO levels improve to continue migration or avoid spawning in the mainstem by migrating into tributaries, which will likely increase the reproductive success of these individuals relative to adults spawning in the mainstem in the next year or two after the project reservoirs are drawn down.

As described above, NMFS expects the relatively small number of redds created in the mainstem to be buried by the addition of suspended and coarse sediment transported into the reach as a result of the proposed action. Even if these redds are not buried by the addition of suspended and coarse sediment transported into the reach, these redds are expected to be affected by low DO levels. NMFS expects no more than six redds to be affected, with the number of embryos or pre-emergent fry that will perish representing a small fraction of the Upper Klamath River population since most redds will be located in tributaries.

Responses of sub-yearlings that may be rearing in the mainstem include major physiological stress, reduced growth and mortality under both the median impact year and severe impact year. However, rates of mortality and days of exposure are reduced for the most part in the median impact water year compared to the severe impact year. The elevated levels of suspended organic particles will exert an oxygen demand on the river causing an additive effect to the fish from the suspended sediment particles and co-occurring low DO levels. Studies detailed earlier (Ruggerone 2000; Henning et al. 2006; Beamer et al. 2010) show that salmonids may withstand short periods of depressed oxygen levels, meaning that all individuals exposed to these conditions may not be lost, but it is difficult to project a precise number or percent mortality. Similarly, outmigrating smolts are expected to experience major stress, reduced growth, and a fraction of the outmigrants are expected to die during a period of the spring outmigration window based on modeled SSC predictions. However, coho salmon are likely to move downstream or into well oxygenated tributaries where the DO levels are higher. Additionally, minimization measures will further reduce mortality (e.g., relocation of mainstem rearing fish). The adverse effects will be short-term and affect different year classes. Because mortality rates for elevated SSC s were estimated in a conservative fashion using a severe impact year, NMFS expects those rates presented in Table 26 sufficiently represent the range of mortality that will occur with the added stress of low dissolved oxygen. The estimated level of mortality from SSC and low dissolved oxygen are only a fraction of the fish rearing in the mainstem during a small window of the rearing period.

Herbicide Application

Due to the uncertainty associated with the effectiveness of the BMPs over a multiyear period including applications planned during the wet season and the mobility of some of the proposed chemicals, the use of herbicides and associated adjuvants in the three-year restoration program may result in exposure of coho salmon in the near shore habitats. Exposures are only expected to occur periodically within the former reservoir footprints and last for short periods of time (hours to days). As numerous BMPs are being used by the KRRC, it is expected that any herbicide treatment that results in exposure will be relatively minor and will be diluted within a few hundred feet of the point(s) of entry. Still, these exposures could result in sublethal effects to salmonid fitness affecting growth or habitat utilization, could affect the prey resources in the near shore areas being utilized or could affect the establishment of willows or other species planted in the riparian zone which contribute terrestrial insects to the river and tributaries. It is likely that only low numbers of individuals will be exposed because the newly accessible habitat will be at the early stages of repopulating and it is unknown if the reservoir footprint areas being treated will produce viable rearing habitat during the time period planned for the IEV management actions. Prey resources affected (benthic macroinvertebrates) are expected to rapidly recolonize exposed areas. In the long term, implementation of the IEV management plan and restoration of riparian and upland habitats in the reservoir footprint areas is expected to increase the viability of the Upper Klamath River coho salmon population because of the improved habitat conditions along the shorelines of the mainstem Klamath River and in the lower portions of the tributary streams in these areas.

Relocation Measures

The proposed relocation measures are expected to minimize the exposure of rearing juvenile coho salmon to increased SSC during drawdown (winter rearing fish) and construction impacts during instream restoration work. However, some fish are expected to die as a result of relocation efforts. Because 0+ coho salmon often redistribute from their natal streams into different summer and winter rearing locations, the fish relocated during the winter could be from a number of different populations. As described in the *Effects of the Action* section, NMFS expects one individual may be killed during pre-drawdown construction and three individuals from Upper Klamath population could be killed during winter relocation efforts. Relocation of outmigrant smolt may result in up to four individuals being killed (Table 27).

After dam removal, when upstream restoration and maintenance actions are occurring, a small number of coho salmon from the Upper Klamath River population are expected to be present in the newly accessible Hydroelectric Reach. NMFS expects up to 27 juvenile coho salmon from the Upper Klamath River population are estimated to die as a result of relocation over the course of the five year restoration period. Additionally, five juvenile coho salmon could die as a result of relocation during boat ramp construction at four different sites (Table 27).

The numbers of juvenile fish expected to die as a result of relocation efforts is very small in relation to the population’s size and will be spread out across different year classes since the relocation efforts associated with instream restoration post dam removal will be spread over the course of five years - further minimizing the population level impact.

Table 27. Estimated impacts of fish relocation in the Upper Klamath River population.

Timing	Location	Activity	Number Relocated	Number Killed
Pre-drawdown; summer	Iron Gate Dam to Lakeview Rd Bridge	Temporary road construction, temporary bridge construction, armoring of left bank access road, construction of fire access ramp	30	1
Pre-drawdown; winter	Mainstem Klamath	Relocation of mainstem-rearing juvenile coho salmon to minimize SSC impacts	250	3
During drawdown	Tributary confluences	Relocation of outmigrating smolt (1+) from tributary mouths	400	4
Post-dam removal (years 2-7)	Mainstem Klamath and tributaries in hydro reach	Instream habitat restoration projects	1200	12
Post-dam removal (years 2-7)	Mainstem Klamath and tributaries in hydro reach	Fish passage maintenance projects	1500	15
Post-dam removal (years 2-7)	J.C. Boyle, Copco, Iron Gate	Boat ramp construction	500	5

Beneficial Effects

While the short-term adverse effects will affect a portion of the exposed life stages and a portion of the exposed year classes, the beneficial effects will affect all life stages and all year classes. The beneficial effects will be long-term and result from the increase in flow variability, likely decrease in diseases, changes to water temperature, and restored access to approximately 76 miles of habitat upstream of Iron Gate Dam (DOI and CDFG 2012). The full list of habitat benefits and effects to each life stage of coho salmon in the Upper Klamath River population is described in Table 28.

Increased flow variability will increase the effectiveness of environmental cues and better enable juvenile coho salmon to adapt to short-term environmental changes. Juveniles make localized movements in response to changes in environmental conditions at temporal scales of hours to months. Increased flow variability, therefore, is expected to increase the likelihood of juveniles redistributing from marginal overwintering habitat in the mainstem to more suitable habitat downstream or upstream. In addition, dissolved oxygen is expected to increase between July and November because the proposed action eliminates the reservoir stratification and oxygen depleted reservoir water from the mainstem Klamath River and because of increased periphyton establishment in the reservoir footprint that will increase photosynthetic oxygen production in the Hydroelectric Reach. The increased dissolved oxygen concentration should increase juvenile coho salmon summer and fall survival. Higher dissolved oxygen concentrations should afford juvenile coho salmon greater foraging opportunities outside the confines of the existing thermal refugia, ultimately resulting in higher survival rates for juvenile coho salmon that rear downstream of Iron Gate Dam site during the summer and early fall.

The increase in flow variability and likely increased peak flows in the mainstem reach near the Iron Gate Dam site will increase sediment mobilization there, and destabilize polychaete habitat. Increased mobilization of substrate helps reduce the availability of habitat for polychaetes (Stocking and Bartholomew 2007). A more naturally flowing river with increased sediment transport and flow variability is likely to reduce densities of *C. shasta* and *P. minibicornis* in the mainstem, which should reduce infection rates, morbidities, and mortalities from these diseases.

The more natural diurnal water temperature variation will be more synchronous with historical migration and spawning periods for coho salmon, warming earlier in the spring, and cooling earlier in the late summer (Stillwater Sciences 2009; Hamilton et al. 2011). Increased fluctuations in diurnal water temperatures will enable juveniles to move between refugial areas, as well as forage in the mainstem Klamath River at night when temperatures cool (Dunne et al. 2011). Increased winter and spring water temperatures are expected to increase juvenile growth (Dunne et al. 2011; CSWRCB 2020b). Increased growth confers higher over-wintering survival (Quinn and Peterson 1996) and increases the size of smolts, which has been shown to increase ocean survival (Bilton et al. 1982; Henderson and Cass 1991; Lum 2003; Jokikokko et al. 2006; Muir et al. 2006). Furthermore, smolts are likely to move out earlier (Hoar 1951; Holtby 1988) and faster (Moser et al. 1991) during spring with warmer water temperatures, which will reduce their exposure to parasites and disease.

With the removal of the dams, gravel and large wood will be recruited into the mainstem Klamath River downstream of the Iron Gate Dam site from the Hydroelectric Reach. Increased gravel recruitment will enhance spawning habitat on the mainstem Klamath River and increased large wood will enhance rearing and migration habitat. Removal of the dams also eliminates the calm, unnaturally warm water environment that allows for blue-green algal blooms to develop and produce the toxin microcystin that is then released downstream. In addition, removal of the dams will enable coho salmon to access approximately 76 miles of additional habitat (DOI and CDFG 2012), which will increase the spatial structure of the population and enable the population to better adapt to spatial or temporal changes in the environment (McElhany et al. 2000).

Table 28. Summary of proposed action long-term benefits to coho salmon for the Upper Klamath River Population

Life Stage	Benefits	Effects
Adults	Increased flow variability	Enhanced cues for migration
	Restoration of temperature regime	Enhanced cues for migration, enhanced water quality for migration
	Increased dissolved oxygen	Enhanced water quality for migration
	Increased sediment transport	Enhanced spawning habitat in mainstem
	Reduced *C. shasta* disease	Increased fitness, decreased pre-spawn mortality
	Access to 76 mi of habitat upstream of Iron Gate Dam	Increased spawning habitat
Eggs/pre-emergent fry	Increased sediment transport	Increased incubation habitat quality
	Adult access to 76 mi of habitat upstream of Iron Gate Dam	Increased quantity of incubation habitat
Sub-yearlings, Yearlings, and Smolt	Increased flow variability	Enhanced cues for migration
	Restoration of temperature regime	Enhanced cues for migration, enhanced water quality for rearing and migration
	Increased dissolved oxygen concentrations	Increased fitness and survival and habitat carrying capacity
	Increased sediment transport	Increased rearing habitat
	Increased large wood recruitment	Increased rearing habitat quality and quantity
	Reduced *C. shasta* disease	Increased fitness and survival
	Access to 76 mi of habitat upstream of Iron Gate Dam	Increased rearing habitat quantity
	Reduced Chinook salmon hatchery production (years 1-8) and potential long term closure of hatchery (years 9+)	Reduced predation and competition from juvenile Chinook salmon

2.7.1.1.2 Consequences of fitness impacts on population viability parameters

The current status of the Upper Klamath population of coho salmon is that it is persisting at a low level of abundance, and partly supported by hatchery strays. Freshwater survival of juvenile coho salmon in the Upper Klamath Population is likely low due to myriad risks and habitat degradation described in the *Environmental Baseline* section. The adverse effects of the proposed action is likely to slightly lower the abundance of two year classes. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Upper Klamath River population. However, the proposed action will not eliminate any year class in the short term and is expected to increase this population's spatial distribution and diversity, which will increase productivity and abundance even in the short term. This population's extinction risk is expected to decrease starting in the year after dam removal because of the increased habitat access and improved conditions in the mainstem Klamath River.

NMFS expects that the long-term benefits of the proposed action will contribute to increased survival and recovery of the population, starting in the year after dam removal. As discussed above, the adverse effects will affect a portion of the exposed life stages and a portion of the affected year classes, while the beneficial effects will be long-term, and will significantly enhance the long-term status of the entire population. Furthermore, NMFS expects benefits to occur immediately (e.g., reduced disease transmission) after dams are removed and will positively affect the remaining individuals in the impacted year classes of each population. Therefore, these beneficial effects will help reduce the population's extinction risk and increase its viability potential.

The improved mainstem habitat conditions (e.g., increased dissolved oxygen concentrations, more natural temperature and flow patterns, and increased gravel and large wood recruitment) and access to approximately 76 miles of additional habitat are expected to improve survival for all life stages of coho salmon, which is expected to increase the abundance of all life stages. Coho salmon spawners will be able to access approximately 76 miles of habitat upstream of Iron Gate Dam, which will increase the spatial distribution of the population. Coho salmon spawners will be able to seek higher quality habitat for spawning, which should increase their reproductive success and enhance productivity of this population. Juveniles that outmigrate from the tributaries will have more favorable rearing conditions in the mainstem, especially during the summer and early fall. Improved mainstem habitat conditions should increase the number of smolts produced from this population.

With increased spatial distribution and the ability to use habitat upstream of Iron Gate Dam, coho salmon will be able to express greater life history diversity, and increased behavioral and genetic diversity in the long term. In addition, the reduction of Chinook salmon hatchery fish at IGH should help increase the reproductive fitness (because of less predation and competition) of the natural population. Both increased diversity and spatial structure will enable this population to be resilient towards localized catastrophic events and long term environmental shifts that result from climate change.

The beneficial effects on the four primary VSP parameters will be positive and long-term. The beneficial effects should promote a more robust, diverse and resilient population to repopulate the habitats above Iron Gate Dam. NMFS expects that these beneficial effects will persist into the long term. Collectively, the suite of population-level improvements is likely to increase the viability parameters and thereby decrease the extinction risk of the Upper Klamath River population.

2.7.1.2 Interior Klamath Basin Stratum: Shasta River Population

The Shasta River population is currently persisting at a high risk level (see *Environmental Baseline* section). From 2014-2020, the number of adult salmon have been 50 or less fish annually (Giudice and Knechtle 2021b) with a large percentage of those of hatchery origin. Freshwater survival of juvenile coho salmon in the Shasta River Population is likely low due to myriad risks and habitat degradation previously described in this biological opinion. The Shasta River Population has a high risk of extinction, with substantial genetic and other depensation risks associated with low numbers of adult spawners and the high hatchery stray component in the population.

Continued water diversion activities, combined with other anthropogenic and environmental factors, are expected to continue to adversely affect the current extinction risk of this population. Large proportions of Shasta River coho salmon juveniles will continue to outmigrate from the Shasta River Basin to the mainstem Klamath River in spring because of the poor water quality and quality in most of the Shasta River watershed. These fish will face increased risks of disease infection relative to juveniles that rear in the Shasta River watershed.

Ongoing restoration actions in the Shasta River sub-basin, such as those identified in the recently developed Shasta River Safe Harbor Agreement (NMFS 2020d), are expected to result in improvements to coho salmon habitat and will likely improve the overall viability of the population; however, NMFS does not expect the recently completed restoration actions to completely offset the impacts currently facing Shasta River coho salmon.

In summary, although some improvements are expected to occur in the Shasta River sub-basin, coho salmon are expected to experience continued degraded water quality conditions and low flow conditions in the Shasta River in the foreseeable future. A substantial proportion of the annual coho salmon fry and subyearlings leave the Shasta River and enter the Upper Klamath River reach of the mainstem Klamath River during the months of April and May as irrigation diversions commence and decrease the volume of flow. Because NMFS expects the Shasta River will continue to suffer from degraded habitat conditions, NMFS anticipates there will be continued reliance of Shasta River Population coho salmon on the Klamath River mainstem and associated non-natal tributaries for rearing. Mainstem rearing will continue to be an important component of the life history strategies expressed by this population.

2.7.1.2.1 Proposed Action Effects on Population Extinction Risk

NMFS expects that the magnitude and extent of effects from the proposed action on the Shasta River coho salmon population will be similar to those of the Upper Klamath Population. However, Shasta River coho salmon do not spawn in the mainstem Klamath River and, therefore, no adverse effects are expected for the egg to pre-emergent fry life stages. Coho salmon juveniles from the Shasta River population use the mainstem Klamath River for rearing and migration, and adult coho salmon use the mainstem as a migratory corridor. Shasta River Population juvenile coho salmon enter the mainstem Klamath River during the months of April and May as irrigation diversions commence.

As described in greater detail below, increased stress is expected and injury or mortality to individuals is likely from the effects of suspended sediment concentrations, decreased dissolved oxygen concentrations during reservoir drawdown, and fish relocation related to the proposed action.

Suspended Sediment
The largest injury or mortality to the population will result from the increase in suspended sediment in the mainstem, with severity of adverse effects decreasing downstream of Iron Gate Dam and as time passes. Except for eggs and pre-emergent fry (which are found in the Shasta

River watershed and not in the mainstem Klamath River), all freshwater life stages of coho salmon from this population are expected to be adversely affected by the suspended sediment. Adult spawners are expected to suffer sub-lethal effects, such as increased stress until they migrate into the Shasta River. As described in the *Effects of the Action* section above, no mortality to adults is expected from the increased suspended sediment.

Responses of juvenile fish that may be rearing in the mainstem include major stress, reduced growth, and mortality under both the median impact year and severe impact year. Although rates of mortality are reduced for the most part in the median impact water year, we conservatively focus on the impacts expected in a severe impact year. The median year is presented for comparison purposes to identify a likely range of impacts. Only a fraction of the fish rearing in the mainstem during a small window of the rearing period are expected to die as a result of elevated SSCs based on modeled predictions (Table 29). Similarly, outmigrating smolt are expected to experience major stress and reduced growth which will decrease overall fitness. Smolt that enter the ocean at a smaller size due to reduced growth are expected to have a lower rate of survival in the marine environment (Russell et al. 2012). A fraction of the outmigrants are expected to die during a period of the spring outmigration window based on modeled SSC predictions. However, rearing sub yearling and outmigrating yearling coho salmon are likely to move downstream or into clear water tributaries where the suspended sediment concentrations are lower. Additionally, minimization measures will further reduce mortality (e.g., relocation of mainstem rearing fish). Therefore, the adverse effects to each life stage are most likely less than the modeled predictions, regardless of impact year.

The adverse effects will be short-term and affect different year classes (e.g., mainstem rearing sub-yearlings and outmigrant yearlings). The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Shasta River population in the year of drawdown and is not expected to eliminate any one year class.

Table 29. Summary of adverse effects to the Shasta River coho salmon population a result of suspended sediment effects related to the proposed action

Life Stage	Median Impact Year	Severe Impact Year
Year 1		
Adults	Sublethal effects, including major stress and impaired homing	Sublethal effects, including major stress and impaired homing
Eggs/pre-emergent fry	none	none
Sub-yearling (0+)	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem 15% of the summer rearing period	Major stress, reduced growth, 0– 20% mortality of fish rearing in the mainstem for 31% of the summer rearing period and 20-40% mortality of fish rearing in the mainstem for 8% of the summer rearing period
Yearlings (1+)	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 20% of the winter rearing period and 0-40% mortality of fish rearing in the mainstem 20% of the winter rearing period	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 20% of the winter rearing period and 0-40% mortality of fish rearing in the mainstem 20% of the winter rearing period
Smolt (1+)	Major stress, reduced growth, and up to 20% mortality for approximately 30% of the outmigration period	Major stress, reduced growth, and up to 20% mortality for approximately 60% of the outmigration period
Year 2		
Adults	Sublethal effects, including moderate stress	Sublethal effects, including minor stress
Eggs/pre-emergent fry	none	none
Sub-yearling (0+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Yearlings (1+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Smolt (1+)	Sublethal effects, including reductions in feeding and moderate stress	Sublethal effects, including major stress and reduced growth

Dissolved Oxygen

Mortality due to depressed DO levels related to the proposed action will occur in conjunction with impacts from the increase in suspended sediment in the mainstem and will likely be indistinguishable from those impacts. The level of mortality will decrease downstream of Iron Gate Dam and as time passes. Adults are expected to experience sub-lethal effects, such as delays in upstream movement. However, no mortality to adults is expected as they can detect low DO levels and will likely either wait until DO levels improve to continue migration or will migrate into tributaries, which will likely increase the reproductive success of these individuals.

This population does not spawn in the mainstem and, therefore, redds, embryos and fry lifestages will not be impacted.

Responses of sub-yearlings that may be rearing in the mainstem include major physiological stress, reduced growth and mortality under both the median impact year and severe impact year. However, rates of mortality and days of exposure are reduced for the most part in the median impact water year compared to the severe impact year. The elevated levels of suspended organic particles will exert an oxygen demand on the river causing an additive effect to the fish from the suspended sediment particles and co-occurring low DO levels. Studies detailed earlier (Ruggerone 2000; Henning et al. 2006; Beamer et al. 2010) show that salmonids may withstand short periods of depressed oxygen levels, meaning that all individuals exposed to these conditions may not be lost, but it is difficult to project a precise number or percent mortality. Similarly, outmigrating smolts are expected to experience major stress, reduced growth, and a fraction of the outmigrants are expected to die during a period of the spring outmigration window based on modeled SSC predictions. However, coho salmon are likely to move downstream or into well oxygenated tributaries where the DO levels are higher. Additionally, minimization measures will further reduce mortality (e.g., relocation of mainstem rearing fish). The adverse effects will be short-term and affect different year classes. Because mortality rates for elevated SSCs were estimated in a conservative fashion using a severe impact year, NMFS expects those rates presented in Table 29 sufficiently represent the range of mortality that will occur with the added stress of low dissolved oxygen. The estimated level of mortality from SSC and low dissolved oxygen is only a fraction of the fish rearing in the mainstem during a small window of the rearing period.

Relocation Measures

The proposed relocation measures are expected to minimize the exposure of rearing juvenile coho salmon to increased SSC during drawdown (winter rearing fish) and potential poor water quality conditions in the summer (outmigrating smolt). However, some fish are estimated to die as a result of relocation efforts. Because 0+ coho salmon often redistribute from their natal streams into different summer and winter rearing locations, the fish relocated during the winter could be from a number of different populations, including the Shasta River population. As described in the *Effects of the Action* section, NMFS expects up to three individuals from Shasta River population could be killed during winter, pre-drawdown relocation efforts and up to four individuals could die during the late spring/early summer smolt relocation effort during the drawdown period. The numbers of juvenile fish expected to die as a result of relocation efforts is very small in context of the population.

Beneficial Effects

While the short-term adverse effects will injure or kill a portion of the exposed life stages and a portion of the exposed year classes, the beneficial effects will improve survival of all life stages that rear or migrate through the mainstem Klamath River (i.e., juveniles and adults) starting in the first year after dam removal and continuing in the long term. This population will receive the second greatest benefit from the proposed action since fish migrating to and from the Shasta

River will experience improved conditions in the upper reaches (near the Iron Gate Dam site) of the Klamath River. The beneficial effects will be long-term and result from the increase in flow variability, likely decrease in diseases, restoration to a more natural water temperature pattern, and gravel and large wood recruitment in the mainstem (Table 30).

Beneficial effects in the mainstem Klamath River will impact those juveniles that re-distribute from the Shasta River and rear there during the summer and/or winter. Increased flow variability will increase the effectiveness of environmental cues and better enable juvenile coho salmon to adapt to short-term environmental changes. Juveniles make localized movements in response to changes in environmental conditions at temporal scales of hours to months. Increased flow variability, therefore, is expected to increase the likelihood of juveniles redistributing from marginal overwintering habitat in the mainstem Klamath River to more suitable habitat downstream or upstream. In addition, dissolved oxygen is expected to increase, which should increase over-summer survival. Higher dissolved oxygen concentrations should afford juvenile coho salmon greater foraging opportunities outside the confines of the existing thermal refugia, ultimately resulting in higher survival rates for juvenile coho salmon that rear downstream of Iron Gate Dam during the summer and early fall.

The increase in flow variability and likely increased peak flows in the mainstem reach near the Iron Gate Dam site will increase sediment mobilization there, and destabilize polychaete habitat. Increased mobilization of substrate helps reduce the availability of habitat for polychaetes (Stocking and Bartholomew 2007). A more naturally flowing river with increased sediment transport and flow variability is likely to reduce densities of *C. shasta* and *P. minibicornis* in the mainstem Klamath River, which should reduce mortalities and morbidities from these diseases. Additionally, removal of the dams will also eliminate the calm, unnaturally warm water environment that allows for blue-green algal blooms to develop and produce the toxin microcystin that is then released downstream.

The more natural diurnal water temperature variation will be more synchronous with historical migration and spawning periods for coho salmon, warming earlier in the spring, and cooling earlier in the late summer (Stillwater Sciences 2009; Hamilton et al. 2011). Increased fluctuations in diurnal water temperatures will enable juveniles to move between refugial areas, as well as forage in the mainstem Klamath River at night when temperatures cool (Dunne et al. 2011). Increased spring water temperatures are expected to increase juvenile growth (Dunne et al. 2011; CSWRCB 2020b). Increased growth confers higher over-wintering survival (Quinn and Peterson 1996) and increases the size of smolts, which has been shown to increase ocean survival (Bilton et al. 1982; Henderson and Cass 1991; Lum 2003; Jokikokko et al. 2006; Muir et al. 2006). Furthermore, smolts are likely to move out earlier (Hoar 1951; Holtby 1988) and faster (Moser et al. 1991) during spring with warmer water temperatures, which will reduce their exposure to parasites and disease.

Table 30. Summary of proposed action long-term benefits to coho salmon for the Shasta River population.

Life Stage	Benefits	Effects
Adults	Increased flow variability	Enhanced cues for migration
	Restoration of temperature regime	Enhanced cues for migration, enhanced water quality for migration
	Increased dissolved oxygen	Enhanced water quality for migration
	Reduced *C. shasta* disease	Increased fitness, decreased pre-spawn mortality
Sub-yearlings, Yearlings, and Smolt	Increased flow variability	Enhanced cues for migration
	Restoration of temperature regime	Enhanced cues for migration, enhanced water quality for rearing and migration
	Increased dissolved oxygen concentrations	Increased fitness and survival
	Increased sediment transport	Increased rearing habitat
	Increased large wood recruitment	Increased rearing habitat quality and quantity
	Reduced *C. shasta* disease	Increased fitness and survival
	Reduced hatchery production of Chinook salmon (years 1-8) and potential long term closure of hatchery (years 9+)	Reduced predation and competition from juvenile Chinook salmon

2.7.1.2.2 Consequences of fitness impacts on population viability parameters

The current status of the Shasta River population of coho salmon is that it is persisting at an extremely low level, supported, in part, by hatchery strays. Freshwater survival of juvenile coho salmon in the Shasta River population is likely currently low due to habitat degradation in the sub-basin. The proposed action is likely to slightly lower the abundance of a single year class. However, the injury and mortality related to the effects of the proposed action will affect a portion of the affected life stages and a portion of the affected year classes. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Shasta River population during reservoir drawdown. The proposed action will not eliminate any year class and is expected to increase the long-term viability of the population starting immediately after dam removal because of the improved habitat conditions in the mainstem Klamath River.

NMFS expects that the long-term benefits of the proposed action will contribute to increased survival and recovery of the population. As discussed above, the adverse effects will affect a portion of the exposed life stages and a portion of the affected year classes, while the beneficial effects will enhance the long-term status of this population. Furthermore, NMFS expects benefits to occur immediately (e.g., reduced disease transmission) after dams are removed and will positively affect the remaining individuals in the impacted year classes of each population. Therefore, these beneficial effects will help reduce the population's extinction risk and increase its viability potential.

Juveniles that outmigrate from the tributaries will have more favorable rearing conditions in the mainstem Klamath River, especially during the summer and early fall. The improved mainstem Klamath River habitat conditions should improve survival for the juvenile life stages of coho salmon, which should generally increase the number of smolts produced from this population.

In addition, the reduction in Chinook salmon hatchery production should help increase the reproductive fitness of the natural population in the long term (because of reduced predation and competition). The increased viability of the Upper Klamath River population will contribute strays to the Shasta River population, which would increase the Shasta River population abundance and diversity. Both increased abundance and diversity will enable this population to have improved resiliency towards localized catastrophic events and long term environmental shifts that result from climate change.

The beneficial effects to the VSP parameters will be positive and long-term. The beneficial effects should promote a more robust, diverse and resilient population that can better endure conditions in the mainstem. NMFS expects that these beneficial effects will persist into perpetuity. The suite of population-level improvements are expected to increase the viability parameters and thereby decrease the extinction risk of this population.

2.7.1.3 Interior Klamath Basin Stratum: Scott River Population

The Scott River coho salmon population is currently persisting at a low level. The adult return estimates for the Scott River have been variable ranging between 81 and 2,752 individuals over the last twelve years. The Scott River Population has a high risk of extinction, with substantial genetic and other depensation risks associated with low numbers of adult spawners. Excessive sediment loads and elevated water temperatures impair habitat conditions of the Scott River and its tributaries. Summer water temperatures do not support suitable salmonid rearing habitat in the mainstem of the Scott River and many Scott River tributaries. Riparian vegetation has also been removed, or cannot grow due to the lowered water table, which exacerbates solar heating and water temperature. Agricultural operations, including surface water diversion and groundwater pumping, have contributed significantly to reductions in summer base flow of the Scott River (Van Kirk and Naman 2008) such that the river can become a series of disconnected and stagnant pools in the summer and fall. These conditions are not suitable for juvenile coho salmon rearing during these seasons, and also limit the effectiveness of cold water seeps and other thermal refugia. Low flows in the Scott River have been cited as a factor limiting the probability of recovery of coho salmon for the population (CDFG 2002b; NRC 2004).

Restoration actions in the Scott River sub-basin are ongoing. For example, in the Scott River watershed, a number of off-channel rearing sites have been developed to provide over winter and over summer refugia for coho salmon. Despite restoration actions, coho salmon are expected to experience continued degraded water quality conditions and low flows in the Scott River in the foreseeable future. Like the Shasta River, a substantial proportion of the annual coho salmon fry and subyearlings leave the Scott River and enter the Upper Klamath River reach of the mainstem Klamath River in the spring as irrigation diversions commence and sub-basin conditions become inhospitable (Chesney and Yokel 2003). Thus, the reliance of Scott River Population coho salmon on the Klamath River mainstem and associated non-natal tributaries for rearing will continue to be an important component of the life history strategies expressed by this population.

2.7.1.3.1 Proposed Action Effects on Population Extinction Risk

The magnitude and extent of effects from the proposed action on the Scott River coho salmon population will generally be less than those of the Shasta River population, which is farther upstream and closer to the area where the four dams will be removed. Like the Shasta River population, Scott River coho salmon do not spawn in the mainstem Klamath River and, therefore, no adverse effects are expected for the egg to pre-emergent fry life stages. However, coho salmon juveniles from the Scott River population use the mainstem Klamath River for rearing and migration, and adult coho salmon use the mainstem as a migratory corridor. As described in greater detail below, increased stress is expected and injury or mortality to individuals is likely from the effects of suspended sediment concentrations, decreased dissolved oxygen concentrations during reservoir drawdown, and fish relocation related to the proposed action.

Suspended Sediment

Adverse effects are expected from increased suspended sediment concentrations in the first two years after the project reservoirs are drawn down and potential injury or mortality are expected during fish relocation. These adverse effects will be temporary, generally lasting up to one or two years after the project reservoirs are drawn down and the dams are removed (Table 31).

The greatest adverse effect will result from the increase in suspended sediment in the mainstem, with severity of adverse effects decreasing downstream of Iron Gate Dam and as time passes. Except for eggs and pre-emergent fry, all freshwater life stages of coho salmon from this population are expected to be adversely affected by the suspended sediment. Returning adults are expected to suffer sublethal effects, such as increased stress until they migrate into the Scott River. No adult mortality is expected from the increased suspended sediment.

Responses of juvenile fish that may be rearing in the mainstem include major stress, reduced growth, and mortality under both the median impact year and severe impact year. Although rates of mortality are reduced for the most part in the median impact water year, we conservatively focus on the impacts expected in a severe impact year. The median year is presented for comparison purposes to identify a likely range of impacts. Only a fraction of the fish rearing in the mainstem during a small window of the rearing period are expected to die as a result of elevated SSCs based on modeled predictions (Table 31). Similarly, outmigrating smolts are expected to experience major stress and reduced growth which, in turn, can reduce marine survival after ocean entry (Russell et al. 2012). A fraction of the outmigrants are expected to die during a period of the spring outmigration window based on modeled SSC predictions. However, rearing sub yearling and yearling coho salmon are likely to move downstream or into clear water tributaries where the suspended sediment concentrations are lower. Additionally, minimization measures will further reduce mortality (e.g., relocation of mainstem rearing fish). Therefore, the adverse effects to each life stage are most likely less than the modeled predictions.

The adverse effects will be short-term and affect different year classes. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Scott River population in the year of drawdown and is not expected to eliminate any one year class.

Table 31. Summary of adverse effects to the Scott River coho salmon population as a result of suspended sediment effects related to the proposed action.

Life Stage	Median Impact Year	Severe Impact Year
Year 1		
Adults	Sublethal effects, including major stress and impaired homing	Sublethal effects, including major stress and impaired homing
Eggs/pre-emergent fry	none	none
Sub-yearling (0+)	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 8% of the summer rearing period	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 38% of the summer rearing period
Yearlings (1+)	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 40% of the winter rearing period	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 40% of the winter rearing period
Smolt (1+)	Major stress, reduced growth, and 0 - 20% mortality of smolts for 10% of the spring outmigration period	Major stress, reduced growth, and 0 - 20% mortality of smolts for 30% of the spring outmigration period
Year 2		
Adults	Sublethal effects, including moderate stress	Sublethal effects, including minor stress
Eggs/pre-emergent fry	none	none
Sub-yearling (0+)	Sublethal effects, including reductions in feeding and moderate stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Yearlings (1+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Smolt (1+)	Sublethal effects, including short – term reductions in feeding and moderate stress	Sublethal effects, including reductions in feeding and major stress

Dissolved Oxygen

Mortality due to depressed DO levels related to the proposed action will occur in conjunction with impacts from the increase in suspended sediment in the mainstem and will likely be indistinguishable from those impacts. The level of mortality will decrease downstream of Iron Gate Dam and as time passes. Adults are expected to experience sub-lethal effects, such as delays in upstream movement. However, no mortality to adults is expected as they can detect low DO levels and will likely either wait until DO levels improve to continue migration or will migrate into tributaries, which will likely increase the reproductive success of these individuals. This population does not spawn in the mainstem and, therefore, redds, embryos and fry lifestages will not be impacted.

Responses of sub-yearlings that may be rearing in the mainstem include major physiological stress, reduced growth and mortality under both the median impact year and severe impact year. However, rates of mortality and days of exposure are reduced for the most part in the median impact water year compared to the severe impact year. The elevated levels of suspended organic particles will exert an oxygen demand on the river causing an additive effect to the fish from the suspended sediment particles and co-occurring low DO levels. Studies detailed earlier (Ruggerone 2000; Henning et al. 2006; Beamer et al. 2010) show that salmonids may withstand short periods of depressed oxygen levels, meaning that all individuals exposed to these conditions may not be lost, but it is difficult to project a precise number or percent mortality. Similarly, outmigrating smolts are expected to experience major stress, reduced growth, and a fraction of the outmigrants are expected to die during a period of the spring outmigration window based on modeled SSC predictions. However, coho salmon are likely to move downstream or into well oxygenated tributaries where the DO levels are higher. Additionally, minimization measures will further reduce mortality (e.g., relocation of mainstem rearing fish). The adverse effects will be short-term and affect different year classes. Because mortality rates for elevated SSCs were estimated in a conservative fashion using a severe impact year, NMFS expects those rates presented in Table 31 sufficiently represent the range of mortality that will occur with the added stress of low dissolved oxygen. The estimated level of mortality from SSC and low dissolved oxygen is only a fraction of the fish rearing in the mainstem during a small window of the rearing period.

Relocation Measures

The proposed relocation measures are expected to minimize the exposure of rearing juvenile coho salmon to increased SSC during drawdown (winter rearing fish) and poor water quality conditions during the smolt outmigration in the summer. However, some fish are estimated to die as a result of relocation efforts. Because 0+ coho salmon often redistribute from their natal streams into different summer and winter rearing locations, the fish relocated during the winter could be from a number of different populations, including the Scott River population. As described in the *Effects of the Action* section, NMFS expects up to three individuals from Scott River population could be killed during winter, pre-drawdown relocation efforts and up to four individuals may be killed during the smolt relocation effort during the drawdown period. The numbers of juvenile fish expected to die as a result of relocation efforts is very small in relation to the population.

Beneficial Effects

While the short-term adverse effects will injure or kill a portion of the exposed life stages and a portion of the exposed year classes, the beneficial effects will improve survival of all life stages that rear or migrate through the mainstem Klamath River (i.e., juveniles and adults) starting in the first year after dam removal and continuing in the long term. The beneficial effects will result from the increase in flow variability, decrease in disease, restoration of the water temperature patterns, and the increase in gravel and large wood recruitment in the mainstem Klamath River (Table 32).

Beneficial effects in the mainstem Klamath River will impact those juveniles that re-distribute from the Scott River and rear there during the summer and/or winter. Increased flow variability will increase the effectiveness of environmental cues and better enable juveniles to adapt to short-term environmental changes. Juveniles make localized movements in response to changes in environmental conditions at temporal scales of hours to months. Increased flow variability therefore, is expected to increase the likelihood of juveniles redistributing from marginal, overwintering habitat in the mainstem Klamath River to more suitable habitat downstream or upstream. In addition, dissolved oxygen is expected to increase and should improve over-summer survival. Higher dissolved oxygen concentrations should afford juvenile coho salmon greater foraging opportunities outside the confines of the existing thermal refugia, ultimately resulting in higher survival rates for juvenile coho salmon that rear downstream of Iron Gate Dam during the summer and early fall.

The increase in flow variability and likely increased peak flows in the mainstem reach near the Iron Gate Dam site will increase sediment mobilization there, and destabilize polychaete habitat. Increased mobilization of substrate helps reduce the availability of habitat for polychaetes (Stocking and Bartholomew 2007). A more naturally flowing river with increased sediment transport and flow variability is likely to reduce densities of *C. shasta* and *P. minibicornis* in the mainstem Klamath River, which should reduce mortalities and morbidities from these diseases.

The more natural diurnal water temperature variation will be more synchronous with historical migration and spawning periods for coho salmon, warming earlier in the spring, and cooling earlier in the late summer (Stillwater Sciences 2009; Hamilton et al. 2011). Increased fluctuations in diurnal water temperatures will enable juveniles to move between refugial areas, as well as forage in the mainstem Klamath River at night when temperatures cool (Dunne et al. 2011). Increased spring water temperatures are expected to increase juvenile growth (Dunne et al. 2011; CSWRCB 2020b). Increased growth confers higher over-wintering survival (Quinn and Peterson 1996) and increases the size of smolts, which has been shown to increase ocean survival (Bilton et al. 1982; Henderson and Cass 1991; Lum 2003; Jokikokko et al. 2006; Muir et al. 2006). Furthermore, smolts are likely to move out earlier (Hoar 1951; Holtby 1988) and faster (Moser et al. 1991) during spring with warmer water temperatures, which will reduce their exposure to parasites and disease.

Table 32. Summary of proposed action long-term benefits to coho salmon for the Scott River population.

Life Stage	Benefits	Effects
Adults	Increased flow variability	Enhanced cues for migration
	Restoration of temperature regime	Enhanced cues for migration, enhanced water quality for migration
	Increased dissolved oxygen	Enhanced water quality for migration
	Reduced *C. shasta* disease	Increased fitness, decreased pre-spawn mortality
Sub-yearlings, Yearlings, and Smolt	Increased flow variability	Enhanced cues for migration
	Restoration of temperature regime	Enhanced cues for migration, enhanced water quality for rearing and migration
	Increased dissolved oxygen concentrations	Increased fitness and survival
	Increased sediment transport	Increased rearing habitat
	Increased large wood recruitment	Increased rearing habitat quality and quantity
	Reduced *C. shasta* disease	Increased fitness and survival
	Reduced hatchery production (years 1-8) and potential long term closure of hatchery (years 9+)	Reduced predation and competition from juvenile Chinook salmon

2.7.1.3.2 Consequences of fitness impacts on population viability parameters

The Scott River coho salmon population is currently persisting at an extremely low level. Freshwater survival of juvenile coho salmon in the Scott River population is likely low due to habitat degradation in the sub-basin. The temporary adverse effects of the proposed action are likely to slightly lower the abundance of a single year class. However, the injury and mortality related to the proposed action will affect a portion of the affected life stages and a portion of the affected year classes. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Scott River population during the year of reservoir drawdown. However, the proposed action will not eliminate any year class and is expected to increase the long term viability of the population starting in the year of dam removal because of the improved habitat conditions in the mainstem Klamath River.

As discussed above, the short-term adverse effects will affect a portion of the exposed life stages and a portion of the affected year classes. The beneficial effects will start the first year after dam removal and continue long-term, which will enhance the long-term status of this population. Furthermore, NMFS expects benefits to occur immediately (e.g., reduced disease transmission) after dams are removed and will positively affect the remaining individuals in the impacted year classes. Therefore, these beneficial effects will reduce this population's extinction risk and increase its viability potential. Improvements to mainstem water quality, especially potential decreases in diseases, are expected to increase abundance, diversity, and productivity of this population.

Juveniles that redistribute from the tributaries will have more favorable rearing conditions in the mainstem Klamath River, especially during the summer and early fall, relative to baseline conditions. The improved mainstem habitat conditions are expected to improve survival for juvenile coho salmon, which should generally increase the number of smolts produced from this population.

The increased viability of the Upper Klamath River population will contribute strays to the Scott River population, which will increase the Scott River population abundance and diversity. Both increased abundance and diversity will enable this population to have improved resiliency towards localized catastrophic events and long term environmental shifts that result from climate change.

The beneficial effects on three of the four VSP parameters will be positive and long-term. The beneficial effects should promote a more robust, diverse and resilient population that can better endure conditions in the mainstem Klamath River. NMFS expects that these beneficial effects will persist in the long term, and can take effect as soon as the dams are removed. Collectively, the suite of mainstem improvements is expected to increase viability parameters and thereby decrease the extinction risk of this population.

2.7.1.4 Interior Klamath Basin Stratum: Middle Klamath River Population

Only limited data for this population exists regarding coho salmon abundance; however, these data indicate abundances fall below the Low Risk threshold. The available estimates for the Middle Klamath River population are from Ackerman et al. (2006), which NMFS believes is still applicable because the environmental conditions and the overall status of the species remains relatively similar to the early 2000s. Applying Ackerman et al.'s (2006) estimates, NMFS believes the run size is above the high risk abundance threshold, but below the low risk threshold. Therefore, NMFS believes the Middle Klamath River Population is at moderate risk of extinction.

The lower reaches of tributaries within the Middle Klamath River Population (*e.g.,* Boise, Red Cap and Indian creeks) offer critical cool water refugia for juvenile coho salmon in the mainstem, which is especially important for survival when mainstem temperatures and water quality approach unsuitable levels. However, several anthropogenic factors limit the function and accessibility of refugia habitat in the area including timber harvest and road construction. Elevated water temperatures during summer months limit summer rearing for coho salmon in the Middle Klamath River reach to the limited areas of thermal refugia in the mainstem and aforementioned tributaries.

2.7.1.4.1 Proposed Action Effects to Population Extinction Risk

Effects to individuals diminish as the distance between populations and the dam removal area increases. NMFS believes that the magnitude and extent of effects from the proposed action on the Middle Klamath River coho salmon population will generally be less than those of the Scott and Shasta River populations. As described in greater detail below, increased stress is expected and injury or mortality is likely from the increase in suspended sediment concentrations and low dissolved oxygen related to the proposed action as well as fish relocation. However, these adverse effects will be temporary, generally lasting up to one to two years after the reservoir drawdown begins.

Suspended Sediment

The greatest adverse effect of the proposed action will result from increased suspended sediment in the mainstem Klamath River, with severity of adverse effects decreasing downstream of Iron Gate Dam and as time passes. The subyearling, yearling, and adult life stages of coho salmon from the population are expected to be adversely affected by the suspended sediment. Adults are expected to suffer sub-lethal effects, such as increased stress until they migrate into the Middle Klamath River tributaries. No adult mortality is expected from the increase in suspended sediment related to the proposed action. Very little data regarding mainstem spawning in the Middle Klamath River reach could be found and NMFS assumes most to all coho salmon of this population spawn in tributaries. Therefore, NMFS does not expect redds for this population to be impacted.

Responses of juvenile fish that may be rearing in the mainstem Klamath River include major stress, reduced growth, and mortality under both the median impact year and severe impact year. Although rates of mortality are reduced for the most part in the median impact water year, we conservatively focus on the impacts expected in a severe impact year. The median year is presented for comparison purposes to identify a likely range of impacts. Only a fraction of the fish rearing in the mainstem Klamath River during a small window of the rearing period are expected to die as a result of elevated SSCs as a result of modeled predictions (Table 33). Similarly, outmigrating smolts are expected to experience major stress and reduced growth which will reduce overall fitness and size at ocean entry. Smaller smolt size is expected to lead to lowered marine survival rates (Russell et al. 2012). A fraction of the outmigrants are expected to die during a period of the spring outmigration window based on modeled SSC predictions. However, rearing subyearling and yearling coho salmon are likely to move downstream or into clear water tributaries where the suspended sediment concentrations are lower. Additionally, minimization measures will further reduce mortality (e.g., relocation of mainstem rearing fish). Therefore, the adverse effects to each life stage are most likely less than the modeled predictions.

The adverse effects will be short-term and affect different year classes. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Middle Klamath River population in the year of drawdown and is not expected to eliminate any one year class.

Table 33. Summary of adverse effects to the Mid-Klamath River coho salmon population a result of suspended sediment effects related to the proposed action.

Life Stage	Median Impact Year	Severe Impact Year
Year 1		
Adults	Sublethal effects, including major stress and impaired homing	Sublethal effects, including major stress and impaired homing
Eggs/pre-emergent fry	none	none
Sub-yearling (0+)	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 8% of the summer rearing period	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 38% of the summer rearing period
Yearlings (1+)	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 40% of the winter rearing period	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 40% of the winter rearing period
Smolt (1+)	Major stress, reduced growth, and 0 - 20% mortality of smolts for 10% of the spring outmigration period	Major stress, reduced growth, and 0 - 20% mortality of smolts for 30% of the spring outmigration period
Year 2		
Adults	Sublethal effects, including moderate stress	Sublethal effects, including minor stress
Eggs/pre-emergent fry	none	none
Sub-yearling (0+)	Sublethal effects, including reductions in feeding and moderate stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Yearlings (1+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Smolt (1+)	Sublethal effects, including short – term reductions in feeding and moderate stress	Sublethal effects, including reductions in feeding and major stress

Dissolved Oxygen

Mortality due to depressed DO levels related to the proposed action will occur in conjunction with impacts from the increase in suspended sediment in the mainstem and will likely be indistinguishable from those impacts. The level of mortality will decrease downstream of Iron Gate Dam and as time passes. Adults may experience sub-lethal effects, such as delays in upstream movement. However, no mortality to adults is expected as they can detect low DO levels and will likely either wait until DO levels improve to continue migration or will migrate into tributaries, which will likely increase the reproductive success of these individuals. This population does not spawn in the mainstem and, therefore, redds, embryos and fry lifestages will not be impacted.

Responses of sub-yearlings that may be rearing in the mainstem include major physiological stress, reduced growth and mortality under both the median impact year and severe impact year.

However, rates of mortality and days of exposure are reduced for the most part in the median impact water year compared to the severe impact year. The elevated levels of suspended organic particles will exert an oxygen demand on the river causing an additive effect to the fish from the suspended sediment particles and co-occurring low DO levels. Studies detailed earlier (Ruggerone 2000; Henning et al. 2006; Beamer et al. 2010) show that salmonids may withstand short periods of depressed oxygen levels, meaning that all individuals exposed to these conditions may not be lost, but it is difficult to project a precise number or percent mortality.

Similarly, outmigrating smolts are expected to experience major stress, reduced growth, and a fraction of the outmigrants are expected to die during a period of the spring outmigration window based on modeled SSC predictions. However, coho salmon are likely to move downstream or into well oxygenated tributaries where the DO levels are higher. Additionally, minimization measures will further reduce mortality (e.g., relocation of mainstem rearing fish). The adverse effects will be short-term and affect different year classes. Because mortality rates for elevated SSCs were estimated in a conservative fashion using a severe impact year, NMFS expects those rates presented in Table 33 sufficiently represent the range of mortality that will occur with the added stress of low dissolved oxygen. The estimated level of mortality from SSC and low dissolved oxygen is only a fraction of the fish rearing in the mainstem during a small window of the rearing period.

Relocation Measures

The proposed relocation measures are expected to minimize the exposure of rearing juvenile coho salmon (i.e., winter rearing fish) in the Middle Klamath River population to increased SSC during winter, pre-drawdown activities. However, some fish are estimated to die as a result of relocation efforts. Because 0+ coho salmon often redistribute from their natal streams into different summer and winter rearing locations, the fish relocated during the winter could be from a number of different populations, including the Middle Klamath River population. As described in the *Effects of the Action* section, NMFS expects up to three individuals from Middle Klamath River population could be killed during winter, pre-drawdown relocation efforts. The numbers of juvenile fish expected to die as a result of relocation efforts is very small in relation to the population.

Beneficial Effects

While the short-term adverse effects will injure or kill a portion of the exposed life stages and a portion of the exposed year classes, the beneficial effects will improve survival of all life stages that rear or migrate through the mainstem Klamath River (i.e., juveniles and adults) starting in the first year after dam removal and continuing in the long term. The beneficial effects will result from the increase in flow variability, likely decrease in diseases, water temperature improvements, and increase in gravel recruitment in the mainstem. Benefits associated with the proposed action are most pronounced in the populations near Iron Gate Dam. Moving downstream, habitat benefits become more attenuated as tributary contributions have a greater influence on mainstem Klamath River habitat.

Dissolved oxygen is expected to increase slightly in the mainstem within this population and should slightly increase over-summer survival. Higher dissolved oxygen concentrations should afford juvenile coho salmon greater foraging opportunities outside the confines of the existing thermal refugia, ultimately resulting in higher survival rates for juvenile coho salmon that rear downstream of Iron Gate Dam during the summer and early fall.

The increase in flow variability in the Hydroelectric Reach and downstream of the Iron Gate Dam site will increase sediment mobilization, which should destabilize polychaete habitat downstream of the Iron Gate Dam site. Increased mobilization of substrate helps to reduce the availability of habitat for polychaetes (Stocking and Bartholomew 2007). A more naturally flowing river with increased sediment transport and flow variability is likely to reduce densities of *C. shasta* and *P. minibicornis* in the mainstem, which should reduce morbidity and mortality from these diseases.

2.7.1.4.2 Consequences of fitness impacts on population viability parameters

Currently, the Middle Klamath River coho salmon population is persisting at low to moderate levels. The short term adverse effects of the proposed action are expected to have minimal adverse effects on the abundance of one year class. The injury and mortality related to effects of the proposed action will affect a portion of the affected life stages and a portion of the affected year class. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Middle Klamath River population during the year of drawdown. However, the proposed action will not eliminate any year class and is expected to increase the long term viability of the population starting in the year following dam removal because of the improved habitat conditions in the mainstem Klamath River.

As discussed above, the adverse effects will affect a portion of the exposed life stages while the beneficial effects will be long-term, and enhance the long-term status of this population. Improvements to mainstem water quality, increased large wood recruitment, and decreases in diseases are expected to result in improvements to abundance, diversity, spatial structure, and productivity of this population. Furthermore, NMFS expects benefits to occur immediately (e.g., reduced disease transmission) after dams are removed and will positively affect the remaining individuals in the impacted year classes. Therefore, the improved mainstem habitat conditions are likely to improve survival for juvenile and adult coho salmon. Juveniles that outmigrate from the tributaries will have more favorable rearing conditions in the mainstem, especially during the summer and early fall and in upstream reaches, than baseline conditions. Both juveniles and adults are expected to have greater survival as disease transmission is reduced. Additionally, the reduction of hatchery fish is expected to reduce inter- and intra-specific competition and predation of juvenile coho salmon.

The beneficial effects on all four VSP parameters will be slightly positive and long-term. The beneficial effects are expected to promote a more robust, diverse and resilient population that can better endure long term environmental changes that are expected as a result of climate change in the basin. NMFS expects that these beneficial effects will persist into the long term. Collectively, the suite of mainstem improvements are expected to increase the viability parameters and thereby decrease the extinction risk of this population.

2.7.1.5 Interior Klamath Basin Stratum: Salmon River Population

Escapement surveys in the Salmon River have been inconsistent in recent years; however, when completed, very few adult coho salmon have been observed (<20). Without new information to show coho salmon spawner abundance has increased, NMFS continues to estimate the total Salmon River spawner abundance is fewer than 50. Therefore, the Salmon River coho salmon population is believed to be at high risk of extinction.

2.7.1.5.1 Proposed Action Effects to Population Extinction Risk

As the distance between a population and the dam removal area increases, the effects are expected to diminish. NMFS believes that the magnitude and extent of effects from the proposed action on the Salmon River coho salmon population will be less than those populations located farther upstream. Like all other tributary populations, the Salmon River coho salmon do not spawn in the mainstem Klamath River. Therefore, no exposure is expected for the egg to pre-emergent fry life stages. However, coho salmon juveniles from the Salmon River population use the mainstem Klamath River for rearing and migration, and adult coho salmon use the mainstem as a migratory corridor.

The greatest adverse effect of the proposed action will result from the increase in suspended sediment and associated low dissolved oxygen concentrations in the mainstem, with severity of adverse effects decreasing downstream of Iron Gate Dam and as time passes. Except for eggs and pre-emergent fry, all freshwater life stages of coho salmon from this population are expected to be adversely affected by the suspended sediment and low dissolved oxygen levels. Returning adults are expected to suffer sublethal effects, such as increased stress until they migrate into the Salmon River. No adult mortality is expected from the increased suspended sediment.

Responses of juvenile coho salmon that may be rearing in the mainstem include major stress, reduced growth, and mortality under both the median impact year and severe impact year. Although rates of mortality are reduced for the most part in the median impact water year, we conservatively focus on the impacts expected in a severe impact year. The median year is presented for comparison purposes to identify a likely range of impacts. Only a fraction of the fish rearing in the mainstem during a small window of the rearing period are expected to die as a result of elevated SSCs based on modeled predictions (Table 34). Similarly, outmigrating smolt are expected to experience major stress and reduced growth which will result in reduced fitness and smaller size at ocean entry. Smaller smolt are expected to have reduced marine survival rates (Russell et al. 2012). A fraction of the outmigrants are expected to die during a period of the spring outmigration window based on modeled SSC predictions. However, rearing subyearling and yearling coho salmon are likely to move downstream or into clear water tributaries where the suspended sediment concentrations are lower. Therefore, the adverse effects to each life stage are most likely less than the modeled predictions.

The adverse effects will be short-term and affect different year classes. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the

Salmon River population in the year of drawdown and is not expected to eliminate any one year class.

Table 34. Summary of mortality in the Salmon River coho salmon population as a result of suspended sediment effects related to the proposed action.

Life Stage	Median Impact Year	Severe Impact Year
Year 1		
Adults	Sublethal effects, including major stress and impaired homing	Sublethal effects, including major stress and impaired homing
Eggs/pre-emergent fry	none	none
Sub-yearling (0+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 15% of the summer rearing period
Yearlings (1+)	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 20% of the winter rearing period	Sublethal effects, including reduction in feeding and major stress for fish rearing in the mainstem
Smolt (1+)	Major stress, reduced growth, and 0 - 20% mortality of smolts for 10% of the spring outmigration period	Major stress, reduced growth, and 0 - 20% mortality of smolts for 20% of the spring outmigration period
Year 2		
Adults	Sublethal effects, including moderate stress	Sublethal effects, including minor stress
Eggs/pre-emergent fry	none	none
Sub-yearling (0+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Yearlings (1+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Smolt (1+)	Sublethal effects, including reductions in feeding and major stress	Sublethal effects, including reductions in feeding and major stress

2.7.1.5.2 Consequences of fitness impacts on population viability parameters

Currently, the Salmon River coho salmon population is persisting at a very low level of abundance. The short term adverse effects of the proposed action are expected to have minimal adverse effects on the abundance of two year classes. The injury and mortality related to the effects of the proposed action will affect a portion of the affected life stages and a small portion of the affected year classes. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Salmon River population during the year of drawdown. However, the proposed action will not eliminate any year class and will increase the long term viability of the population starting in the year following dam removal because of the reduced rates of disease in the mainstem Klamath River.

As discussed above, the adverse effects will affect a portion of the exposed life stages while the beneficial effects will be long-term and enhance the long-term status of this population. Decreases in diseases are expected to result in improvements to abundance and productivity of this population. Furthermore, NMFS expects benefits to occur immediately after dams are removed and positively affect the remaining individuals in the impacted year classes. Both juveniles and adults are expected to have greater survival as disease transmission is reduced. Additionally, the reduction of hatchery fish is expected to reduce inter- and intra-specific competition and predation of juvenile coho salmon. The improved mainstem conditions are expected to increase overall population resilience to long term environmental shifts that result from climate change and increase the viability parameters, thereby decreasing the extinction risk of this population.

2.7.1.6 Interior Trinity Stratum: Trinity River Populations

The South Fork Trinity River, Upper Trinity River, and the Lower Trinity River populations are discussed together because the effects of the proposed action to these populations are expected to be the same.

Based on the returns at the Willow Creek weir, the Trinity River adult coho salmon abundance has fallen significantly. From 2012 – 2015 the average number of adults returning to the Trinity River was 9,152 while the average number returning 2016-2019 was only 550 adults (Kier et al 2020). Most spawners on the spawning grounds are of hatchery origin and expected to belong to the Upper Trinity River population. The Lower and South Fork Trinity River populations are at a high risk of extinction while the Upper Trinity River population is at a moderate risk of extinction (NMFS 2014a).

2.7.1.6.1 Proposed Action Effects to Population Extinction Risk

Because of the significant distance (i.e., about 147 river miles) between the Trinity River and the area where four dams will be removed, the proposed action will have minimal effects to coho salmon from the Trinity River populations. Like the other tributary populations, the Trinity River coho salmon do not spawn in the mainstem Klamath River and, therefore, no adverse effects are expected for the egg to pre-emergent fry life stages. However, coho salmon juveniles from the Trinity River populations use the mainstem Klamath River for rearing and migration, and adult coho salmon use the mainstem Klamath River as a migratory corridor in the lower 43 miles.

Adverse effects of the proposed action are expected from the increase in suspended sediment concentrations and the associated low dissolved oxygen levels in the lower mainstem Klamath River during the year of reservoir drawdown, with severity of adverse effects decreasing downstream of Iron Gate Dam and as time passes. Except for the eggs and pre-emergent fry, all life stages of coho salmon from the Trinity River populations will be adversely affected by the suspended sediment and low dissolved oxygen. Adults are expected to suffer sub-lethal effects, such as increased stress until they migrate into the Trinity River. No adult mortality is expected from the increased suspended sediment.

Responses of juvenile fish that may be rearing in the mainstem Klamath River include major stress, reduced growth, and mortality under both the median impact year and severe impact year. Although rates of mortality are reduced for the most part in the median impact water year, we conservatively focus on the impacts expected in a severe impact year. The median year is presented for comparison purposes to identify a likely range of impacts. Only a fraction of the fish rearing in the mainstem Klamath River during a small window of the rearing period are expected to die as a result of elevated SSCs based on modeled predictions (Table 35). Similarly, outmigrating smolt are expected to experience major stress and reduced growth which will result in reduced fitness and smaller size. Smolt that enter the ocean at a smaller size due to reduced growth are expected to have a lower rate of survival in the marine environment (Russell et al. 2012). A fraction of the outmigrants are expected to die during a period of the spring outmigration window based on modeled predictions. However, rearing subyearlings and outmigrating yearling coho salmon are likely to move downstream or into clear water tributaries where the suspended sediment concentrations are lower. Therefore, the adverse effects to each life stage are most likely less than the modeled predictions.

The adverse effects will be short-term and affect different year classes. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Trinity River populations in the year of drawdown and is not expected to eliminate any one year class.

Table 35. Summary of adverse effects to the Trinity River coho salmon populations as a result of suspended sediment effects related to the proposed action.

Life Stage	Median Impact Year	Severe Impact Year
Year 1		
Adults	Sublethal effects, including major stress and impaired homing	Sublethal effects, including major stress and impaired homing
Eggs/pre-emergent fry	none	none
Sub-yearling (0+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 15% of the summer rearing period
Yearlings (1+)	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 20% of the winter rearing period	Sublethal effects, including reduction in feeding and major stress for fish rearing in the mainstem
Smolt (1+)	Major stress, reduced growth, and 0 - 20% mortality of smolts for 10% of the spring outmigration period	Major stress, reduced growth, and 0 - 20% mortality of smolts for 20% of the spring outmigration period
Year 2		
Adults	Sublethal effects, including moderate stress	Sublethal effects, including minor stress
Eggs/pre-emergent fry	none	none
Sub-yearling (0+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Yearlings (1+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Smolt (1+)	Sublethal effects, including reductions in feeding and major stress	Sublethal effects, including reductions in feeding and major stress

2.7.1.6.2 Consequences of fitness impacts on population viability parameters

Currently, the Trinity River coho salmon populations are persisting at a low level of abundance. The short term adverse effects of the proposed action are expected to have minimal adverse effects on the abundance of two year classes. The injury and mortality related to the effects of the proposed action will affect a portion of the affected life stages and a portion of the affected year classes. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Trinity River populations during the year of drawdown. However, the proposed action will not eliminate any year class and will increase the long term viability of the population starting in the year following dam removal because of the reduced rates of disease in the mainstem Klamath River.

As discussed above, the adverse effects will affect a portion of the exposed life stages while the beneficial effects will be long-term and enhance the long-term status of the populations. Decreases in diseases are expected to result in improvements to abundance and productivity of the populations. Furthermore, NMFS expects benefits to occur immediately after dams are removed and will positively affect the remaining individuals in the impacted year classes. Both juveniles and adults are expected to have greater survival as disease transmission is reduced. Additionally, the reduction of hatchery fish is expected to reduce inter- and intra-specific competition and predation of juvenile coho salmon. The improved mainstem conditions are expected to increase overall population resilience to long term environmental shifts that result from climate change and increase the viability parameters, thereby decreasing the extinction risk of the populations.

2.7.1.7 Central Coastal Stratum: Lower Klamath River Population

Recent abundance estimates of the Lower Klamath River population are not available. Using juvenile coho salmon abundance estimates and overwinter and marine survival rates, Ackerman et al. (2006) estimated adult returns in 2002 to 2006 for the Lower Klamath River. The estimates ranged from 14 to 1,483 adults. NMFS assumes the Lower Klamath River population is likely below the depensation threshold of 202 spawners and is, therefore, likely at a high risk of extinction.

2.7.1.7.1 Proposed Action Effects to Population Extinction Risk

Because of the significant distance between the Lower Klamath River population area and the area where four dams will be removed, the proposed action will have minimal effects to coho salmon from the Lower Klamath River population. Adult coho salmon in the population are not expected to spawn in the mainstem Klamath River and, therefore, no adverse effects are expected for the egg to pre-emergent fry life stages. However, coho salmon juveniles from the Lower Klamath River population use the mainstem Klamath River for rearing and migration, and adult coho salmon use the mainstem Klamath River as a migratory corridor.

Suspended Sediment

The largest adverse effect will result from the increase in suspended sediment in the mainstem Klamath River, with severity of adverse effects decreasing downstream of Iron Gate Dam. Except for the eggs and pre-emergent fry, all life stages of coho salmon from the Lower Klamath River population will be adversely affected by the suspended sediment. Adults are expected to suffer sub-lethal effects, such as increased stress, until they migrate into the tributaries to spawn. No adult mortality is expected from the increased suspended sediment.

Responses of juvenile fish that may be rearing in the mainstem Klamath River include major stress, reduced growth, and mortality under both the median impact year and severe impact year. Although rates of mortality are reduced for the most part in the median impact water year, we conservatively focus on the impacts expected in a severe impact year. The median year is presented for comparison purposes to identify a likely range of impacts. Only a fraction of the coho salmon rearing in the mainstem during a small window of the rearing period are expected to die as a result of elevated SSCs based on modeled predictions (Table 36). Similarly, outmigrating smolt are expected to experience major stress and reduced growth which will result in reduced fitness and body size at ocean entry. Smaller smolt are expected to have a reduced rate of marine survival (Russell et al. 2012). A fraction of the outmigrants are expected to die during a period of the spring outmigration window based on modeled SSC predictions. However, rearing subyearling and outmigrating yearling coho salmon are likely to move downstream or into clear water tributaries where the suspended sediment concentrations are lower. Therefore, the adverse effects to each life stage are most likely less than the modeled predictions.

The adverse effects will be short-term and affect different year classes. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Lower Klamath River population in the year of drawdown and is not expected to eliminate any one year class.

Table 36. Summary of adverse effects to the Lower Klamath River coho salmon population as a result of suspended sediment effects related to the proposed action.

Life Stage	Median Impact Year	Severe Impact Year
Year 1		
Adults	Sublethal effects, including major stress and impaired homing	Sublethal effects, including major stress and impaired homing
Eggs/pre-emergent fry	none	none
Sub-yearling (0+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 15% of the summer rearing period
Yearlings (1+)	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 20% of the winter rearing period	Sublethal effects, including reduction in feeding and major stress for fish rearing in the mainstem
Smolt (1+)	Major stress, reduced growth, and 0 - 20% mortality of smolts for 10% of the spring outmigration period	Major stress, reduced growth, and 0 - 20% mortality of smolts for 20% of the spring outmigration period
Year 2		
Adults	Sublethal effects, including moderate stress	Sublethal effects, including minor stress
Eggs/pre-emergent fry	none	none
Sub-yearling (0+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Yearlings (1+)	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Smolt (1+)	Sublethal effects, including reductions in feeding and major stress	Sublethal effects, including reductions in feeding and major stress

Dissolved Oxygen
Mortality due to depressed DO levels related to the proposed action will occur in conjunction with impacts from the increase in suspended sediment in the mainstem and will likely be

indistinguishable from those impacts. The level of mortality will decrease downstream of Iron Gate Dam. Adults may experience sub-lethal effects, such as delays in upstream movement. However, no mortality to adults is expected as they can detect low DO levels and will likely either wait until DO levels improve to continue migration or will migrate into tributaries, which will likely increase the reproductive success of these individuals. This population does not spawn in the mainstem and, therefore, redds, embryos and fry lifestages will not be impacted.

Responses of sub-yearlings that may be rearing in the mainstem include major physiological stress, reduced growth and mortality under both the median impact year and severe impact year. However, rates of mortality and days of exposure are reduced for the most part in the median impact water year compared to the severe impact year. The elevated levels of suspended organic particles will exert an oxygen demand on the river causing an additive effect to the fish from the suspended sediment particles and co-occurring low DO levels. Studies detailed earlier (Ruggerone 2000; Henning et al. 2006; Beamer et al. 2010) show that salmonids may withstand short periods of depressed oxygen levels, meaning that all individuals exposed to these conditions may not be lost, but it is difficult to project a precise number or percent mortality. Similarly, outmigrating smolts are expected to experience major stress, reduced growth, and a fraction of the outmigrants are expected to die during a period of the spring outmigration window based on modeled SSC predictions. However, coho salmon are likely to move downstream or into well oxygenated tributaries where the DO levels are higher. Additionally, minimization measures will further reduce mortality (e.g., relocation of mainstem rearing fish). The adverse effects will be short-term and affect different year classes. Because mortality rates for elevated SSCs were estimated in a conservative fashion using a severe impact year, NMFS expects those rates presented in Table 36 sufficiently represent the range of mortality that will occur with the added stress of low dissolved oxygen. The estimated level of mortality from SSC and low dissolved oxygen is only a fraction of the fish rearing in the mainstem during a small window of the rearing period.

2.7.1.7.2 Consequences of Fitness Impacts on Population Viability Parameters

Currently, the Lower Klamath River coho salmon population is persisting at a low level of abundance. The short term adverse effects of the proposed action are expected to have minimal adverse effects on the abundance of two year classes. The injury and mortality related to effects of the proposed action will affect a portion of the affected life stages and a portion of the affected year classes. The proposed action will likely kill a relatively small percentage of the total number of juvenile coho salmon in the Lower Klamath River population during the year of drawdown. However, the proposed action will not eliminate any year class and is expected to increase the long term viability of the population starting in the year following dam removal because of the improved habitat conditions in the mainstem Klamath River.

As discussed above, the adverse effects will affect a portion of the exposed life stages while the beneficial effects will be long-term and enhance the long-term status of this population. Decreases in diseases are expected to result in improvements to abundance and productivity of this population. Furthermore, NMFS expects benefits to occur immediately after dams are removed and will positively affect the remaining individuals in the impacted year classes. Both juveniles and adults are expected to have greater survival as disease transmission is reduced. Additionally, the reduction of hatchery fish is expected to reduce inter- and intra-specific competition and predation of juvenile coho salmon. The improved mainstem conditions are expected to increase overall population resilience to long term environmental shifts that result from climate change and increase the viability parameters, thereby decreasing the extinction risk of the populations.

2.7.1.8 Interior Klamath Diversity Stratum

As described above in this section, NMFS expects that the proposed action should increase the long-term viability parameters for each of the populations within the Interior Klamath Diversity Stratum, thereby decreasing these populations' extinction risk. The adverse effects of the proposed action will affect a portion of the exposed life stages and a portion of the affected year classes, and will not eliminate any affected year class. The beneficial effects of the proposed action will be long-term and significantly enhance the long-term status of the Upper Klamath River population, and to a lesser extent the Shasta River, Scott River, Middle Klamath River, and Salmon River populations. The beneficial effects will help these populations reduce their extinction risk and increase their viability potential. Access to approximately 76 miles of habitat upstream of Iron Gate Dam, improvements to mainstem water quality, increased large wood recruitment, increased spawning gravel input, and decreases in diseases, are expected to improve abundance, spatial distribution, diversity, and productivity of the Upper Klamath River population based on improved conditions for all life stages. In addition, improvements to mainstem water quality, increased large wood recruitment, and decreases in diseases, are expected to improve abundance, spatial distribution, diversity, and productivity of the Shasta River, Scott River, Middle Klamath River, and Salmon River populations based on improved mainstem Klamath River conditions for juveniles from these populations that use the mainstem habitat.

The improved mainstem Klamath River habitat conditions and re-established access to approximately 76 miles of habitat should improve survival for all life stages of coho salmon in the Upper Klamath River population, which is expected to increase the abundance of all life stages. Coho salmon spawners will be able to access approximately 76 miles of habitat upstream of Iron Gate Dam, which will then increase the spatial distribution of the Upper Klamath River population. Coho salmon spawners will be able to seek higher quality habitat for spawning, which should increase their reproductive success and enhance productivity of this population. Juveniles that outmigrate from the tributaries will have more favorable rearing conditions in the mainstem Klamath River, especially during the summer and early fall, than baseline conditions. Improved mainstem Klamath River habitat conditions should increase the number of juveniles produced from the Upper Klamath River population and should increase the number of smolts that survive to enter the ocean from this population. The long term increase in viability of the Upper Klamath River population will also help increase the abundance and diversity of adjacent populations, such as the Shasta and Scott rivers, via strays.

With increased spatial distribution and the ability to access habitat upstream of Iron Gate Dam, coho salmon will be able to express additional life history patterns, and increase behavioral and genetic diversity in the long term. In addition, cessation of hatchery fish production at FCH eight years after dam removal should help to increase the reproductive fitness of the natural population. Both increased diversity and spatial structure will enable this diversity stratum to be more resilient towards localized catastrophic events and long term environmental changes expected as a result of climate change. The beneficial effects of the proposed action resulting in improvements in the diversity, abundance, spatial distribution and productivity for this stratum will be positive and long-term.

2.7.1.9 Trinity River Stratum

As discussed above, the short term adverse effects of the proposed action are expected to have minimal adverse effects on the abundance of two year classes of Trinity River populations, and no affected year class will be eliminated. In the long term, NMFS expects improved abundance and productivity for the populations as a result of increased survival of migrating smolt and adults when disease transmission is reduced post dam removal. Additionally, improved mainstem conditions will improve resilience of the populations in the context of long term environmental shifts that result from climate change.

2.7.1.10 Central Coastal Basins Stratum

As discussed above, the short term adverse effects of the proposed action are expected to have minimal adverse effects on the abundance of two year classes of the Lower Klamath River population, and no affected year class will be eliminated. NMFS expects improved abundance and productivity for the Lower Klamath River population as a result of increased survival of migrating smolt and adult coho salmon when disease transmission is reduced post dam removal. Additionally, improved mainstem conditions will improve resilience of the populations in the context of long term environmental shifts that result from climate change.

2.7.1.11 SONCC Coho Salmon ESU Critical Habitat

When NMFS designated critical habitat for the SONCC coho salmon ESU, NMFS stated that the species' life cycle can be separated into five essential habitat types: (1) juvenile summer and winter rearing areas; (2) juvenile migration corridors; (3) areas for growth and development to adulthood; (4) adult migration corridors; and (5) spawning areas. Within these areas, NMFS stated that PBFs for SONCC coho salmon critical habitat include adequate: (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 (64 FR 24049, 24059; May 5, 1999).

When evaluating critical habitat within the action area, the analysis will be restricted to the Upper and Middle Klamath River reaches (occupied by the Interior Klamath Diversity Stratum). Critical habitat within the action area is not currently designated in the mainstem Klamath River downstream of the Trinity River (the Yurok Reservation, Karuk Reservation, and Resighini Rancheria are excluded) or in areas upstream of Iron Gate Dam (impassable barrier).

2.7.1.11.1 Condition of Critical Habitat at the ESU Scale

Section 2.2.1 of this biological opinion, *Status of the Species and Critical Habitat (SONCC coho salmon)*, details the condition of critical habitat at the ESU scale. In summary, the current condition of critical habitat of the SONCC coho salmon ESU is degraded. Although there are exceptions, the majority of streams and rivers in the ESU have impaired habitat. Additionally, critical habitat in the ESU often lacks the ability to establish PBFs due to ongoing and past human activities. For example, large dams, such as Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle stop the recruitment of spawning gravels and large wood, which impacts both essential habitat types (spawning and rearing areas) as well as a PBF of spawning areas (substrate). Water use in many regions throughout the ESU reduces summer base flows, which limits the establishment of several PBFs such as water quality and water quantity.

2.7.1.11.2 Condition of the Critical Habitat of the Interior-Klamath Diversity Stratum

The current condition of critical habitat in the Interior-Klamath Diversity Stratum is degraded. Sedimentation, low stream flows, poor water quality, stream habitat simplification, and habitat loss from poorly designed road crossings degrade critical habitat for coho salmon in this stratum. Additionally, critical habitat in the Interior Diversity stratum often lacks the ability to establish PBFs due to ongoing and past human activities. For example, Iron Gate Dam stops the recruitment of spawning gravels, which impacts both an essential habitat type (spawning areas) as well as a PBF of spawning areas (substrate). Water use in many regions throughout the diversity stratum (*e.g.,* Shasta and Scott rivers) reduces summer base flows, which limits the establishment of several PBFs such as water quantity and water quality.

2.7.1.11.3 Critical Habitat Condition within the Action Area

2.7.1.11.3.1 Effects of the Action on the Essential Habitat Types and PBFs in the Upper Klamath River Reach

Please see Section 2.4.1.1 of this biological opinion, *Status of (SONCC coho salmon) Critical Habitat in the Action Area*, which describes our current understanding of the condition and functions of critical habitat for the Upper Klamath River population.

The proposed action has the potential to affect the following three essential habitat types within the Upper Klamath River reach: spawning areas, juvenile summer and winter rearing areas and adult migration corridors.

Spawning Areas

The proposed action will likely make the mainstem between Iron Gate Dam and Cottonwood Creek unsuitable for spawning or incubation for one and possibly two years. Any redds constructed in the mainstem downstream of the Iron Gate Dam site will be vulnerable to burial and scour, potentially resulting in reduced survival-to-emergence for up to about two years after the dams are removed. However, the reduction in quality of spawning habitat will not only be short term, but also relatively short in distance (approximately 8 river miles). In addition, the current low quality of the mainstem spawning habitat (i.e., highly armored river bed due to reduced sediment recruitment past Iron Gate Dam and estimated low survival of embryos in the mainstem) and the low preference of this area by coho salmon (coho are primarily tributary spawners) will result in a relatively small and short term reduction in the conservation value to critical habitat. Long-term benefits to the spawning habitat will include increased natural flows, improved temperature regimes, and uninterrupted sediment supply downstream of Keno Dam. While there will be a relatively short in distance, short-term, degradation to spawning habitat, the proposed action will increase the conservation value of this essential habitat type in the long-term.

Juvenile Summer and Winter Rearing Areas

The proposed action will degrade juvenile rearing habitat in the mainstem Klamath River during the short term. The length of habitat degradation depends on the specific habitat elements that are degraded. Between the Iron Gate Dam site and Cottonwood Creek, a distance of approximately eight river miles, coarse sediment deposition may temporarily decrease pool depth or quantity. Within the entire designated critical habitat on the mainstem, benthic macroinvertebrate abundance may decrease temporarily for several months. Between Iron Gate Dam and the Shasta River, dissolved oxygen concentration may drop to stressful levels for coho salmon during reservoir drawdown. Suspended sediment will be elevated between Iron Gate Dam and Seiad Valley during reservoir drawdown.

Beneficial effects from the proposed action will occur starting as soon as dam removal occurs and continue for the long term as gravel and eventually large wood (i.e., from existing riparian vegetation in the mainstem and tributaries between Iron Gate and Keno dams as well as future sources along the reservoir areas upon revegetation) recruit downstream of the Iron Gate Dam site. A more natural sediment transport regime will return to the reaches downstream of the Iron Gate Dam site. The more natural sediment transport regime will increase complexity in the channel bed, including pool formation, to increase rearing habitat as well as facilitate lower incidence of pathogens that cause disease.

Long-term effects of the proposed action will also include overall increases in dissolved oxygen, as well as increased daily variability in dissolved oxygen, in the mainstem Klamath River, particularly for the reach immediately downstream of the Iron Gate Dam site, with possible increases of 3 to 4 mg/L during summer and late fall (PacifiCorp 2005). The increase in dissolved oxygen concentration on the mainstem Klamath River will diminish with distance downstream of Iron Gate Dam, but will benefit the entire reach of mainstem critical habitat (i.e., to the Trinity River).

A significant increase in the amount of food resources for coho salmon is expected in the long term. Food resources will benefit by restoration of the natural river processes that provide downstream migration access to benthic macroinvertebrates, increased leaf litter and woody debris for macroinvertebrates, increased marine derived nutrients, and coarse sediment replenishment that hosts macroinvertebrate habitat.

Adult Migration Corridors

Although migration corridors will not be physically blocked, adult coho salmon may avoid the elevated suspended sediment levels in the mainstem Klamath River downstream of Iron Gate Dam during drawdown. Overall, this relatively short-term migration impediment or delay is expected to result in a relatively small reduction of the conservation value of critical habitat in the action area because coho salmon will migrate into tributaries, using the mainstem Klamath River for only a short period of their migration. In the long term, improvements to the migratory corridor are expected as a result of lower incidence of pathogens that cause disease.

2.7.1.11.3.2 Effects of the Action on the Essential Habitat Types and PBFs in the Middle Klamath River Reach

Please see Section 2.4.1.1 of this biological opinion, *SONCC ESU Critical Habitat in the Action Area*, which describes our current understanding of the condition and functions of critical habitat for the Middle Klamath River population. The proposed action has the potential to affect the following three essential habitat types within the Middle Klamath River reach: spawning areas, juvenile summer and winter rearing areas, and adult migration corridors.

Spawning Areas

Any redds constructed in the mainstem Klamath River downstream of the Iron Gate Dam site (particularly in the 5-mile reach directly downstream of Iron Gate Dam) will be vulnerable to burial and scour, potentially resulting in reduced survival-to-emergence for up to about two years after the dams are removed. However, the low function and condition of spawning habitat in the mainstem will result in a relatively small and short term reduction in the conservation value to critical habitat. Long-term benefits of the proposed action to the spawning habitat will include increased natural flows, improved temperature regimes, and uninterrupted sediment supply downstream of Keno Dam. While there will be a relatively short in distance, short-term, degradation to spawning habitat, the proposed action will increase the conservation value of this essential habitat type in the long-term.

Juvenile Summer and Winter Rearing Areas

The proposed action will temporarily degrade juvenile coho salmon foraging habitat in the mainstem between Iron Gate Dam and Orleans (~ 134 mi); benthic macroinvertebrate abundance is expected to decrease temporarily for several months. Additionally, pool habitat used for rearing is expected to be filled temporarily in the approximately 8 mile reach downstream of Iron Gate Dam.

The beneficial effects of the proposed action will increase the conservation value of this essential habitat type in the long-term. An increase in the amount of food resources for coho salmon is expected in the long term. Food resources will benefit by restoration of the natural river processes that provide downstream migration access to benthic macroinvertebrates, increased leaf litter and woody debris for macroinvertebrates, and coarse sediment replenishment that hosts macroinvertebrate habitat.

Adult Migration Corridors

Although migration corridors will not be physically blocked, adult coho salmon may avoid the elevated suspended sediment levels in the mainstem Klamath River downstream of Iron Gate Dam during drawdown. Overall, this relatively short-term migration impediment or delay is expected to result in a relatively small reduction of the conservation value of critical habitat in the action area because coho salmon will migrate into tributaries, using the mainstem Klamath River for only a short period of their migration.

2.7.1.11.4 Critical Habitat Response at the Diversity Stratum and ESU Level

In the action area, the SONCC coho salmon ESU critical habitat includes only the Klamath River mainstem in the Upper Klamath and Middle Klamath River reaches, which is a small part of the Interior Klamath Diversity Stratum. At the diversity stratum scale, the proposed action will result in short-term degradation to spawning, juvenile rearing, and adult migration habitat on the mainstem Klamath River within the Interior Diversity Stratum. The minor, short-term reduction in the quality of PBFs for these essential habitat types will not be sufficient to result in an alteration that appreciably diminishes the value of critical habitat for the conservation of SONCC coho salmon at the diversity stratum and ESU level. Moreover, the beneficial effects of the proposed action will improve the function of rearing, migration and spawning habitat for this diversity stratum in the long-term. Because the Interior Klamath Diversity Stratum is a critical component of the SONCC coho salmon ESU, NMFS expects the long-term improvements to critical habitat associated with the proposed action will contribute to the conservation of this ESU.

2.7.2 <u>Southern Resident Killer Whales</u>

2.7.2.1 Reduction of Prey Availability

The Rangewide Status, Environmental Baseline, and Cumulative Effects for SRKWs described in sections 2.2.2, 2.4.2, and 2.6.2, respectively, are summarized below. As described in Section 2.5.1, Effects to SRKWs, our analysis of effects to SRKWs relies upon the expected impacts of the proposed action on the abundance and availability of Chinook salmon as prey for SRKWs. We consider how any expected changes in prey availability will affect the fitness of SRKWs over three different time periods of effects that are expected as a consequence of the proposed action, and ultimately their survival and reproduction overall. Considering that Chinook salmon productivity in the Klamath River is expected to be impacted by the proposed action variably over time, our assessment of the expected impacts of the proposed action focuses on the variable impacts to Klamath River Chinook salmon and how that impacts the abundance of availability of prey for SRKWs in the ocean over time.

As noted above, the SRKW population is made up of three pods (J, K, and L); two of which (K and L) are more likely to occur in the action area at times during the winter and spring. The limiting factors affecting this population include reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound. Over the last 5 decades, the SRKW population has generally remained at a similarly low population size of about 80-90 individuals, and currently consists of 74 individuals. Members of K and L pod constitute a sizeable portion of the entire SRKW population, with 50 of the 74 members. Chinook salmon has been confirmed to be the preferred prey of SRKWs, and both the survival and fecundity of SRKWs have previously been linked to the abundance of Chinook salmon that may be available for them as prey. The most recent population viability analyses project a downward trend over the next 25 years in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed recently. The analysis does not link population growth or decline to any specific threat, but reflects the combined impacts of all of the threats in the past.

Studies of the body condition and the health of SRKWs have provided evidence of a general decline in body condition across individual SRKWs. Although a number of factors including disease, physiological or life history status can influence body condition in SRKWs, prey limitation is a likely cause of observed changes in body condition in wild mammalian populations. All of the recent observations of poor body condition, along with limited reproductive success in recent years, are possible indications that nutritional stress may be occurring for individuals of this population at times.

Currently, the abundance of Chinook salmon in the action area is limited by numerous major influences on the freshwater environment (e.g., issues with increasing prevalence of disease in the Klamath River) and climate change. Harvest and other incidental or directed sources of Chinook mortality in the ocean also reduce the abundance of prey in marine waters for SRKWs. It is also likely that the accumulation of pollutants in SRKWs presents a significant risk of decreased fitness. No single threat has been directly linked to or identified as the cause of the relative lack of growth of the SRKW population over time, but the relatively small SRKW population size and limited reproductive success in recent years remains the primary source of concern for this species.

As described in Section 2.2.2.2.6, Climate Change, changes in freshwater habitats for Chinook salmon due to climate change are likely to reduce the abundance and further restrict the amount of suitable habitat for Chinook salmon productivity in river systems. This includes the Klamath River, although the proposed action is designed and anticipated to ameliorate these impacts over time by decreasing summer and fall water temperatures and increasing the available habitat for spawning and juvenile rearing in the Klamath River. In the marine system, warming of the ocean is expected to affect the base of the food web, ultimately decreasing the amount or shifting the distribution of prey available to SRKWs.

We considered new information regarding SRKW seasonal movements in assessing the overlap in space and time between SRKWs and Klamath River Chinook salmon where the effects of the proposed action will be felt by SRKWs (the action area for SRKWs). SRKWs occur throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska. Results of multiple studies suggest SRKWs (members of K and L pod primarily) are more likely to be present in coastal waters off the coast of California and Oregon where Klamath River Chinook salmon occur during the winter and spring than in other times of the year. The occurrence of SRKWs in this area does not necessarily occur every year, and may be influenced by the relative abundance of Chinook salmon resources in other areas.

Based on the analysis in section 2.5.1, Effects to SRKWs, we expect that the proposed action will result in reductions in the number of Klamath Chinook salmon in the ocean for the short term period (2-3 years) starting two years after dam removal. At worst, we expect that the abundance of Klamath Chinook salmon in the ocean as potential prey for SRKWs could be reduced by 27% during the short term period. This represents a reduction of up to 2.6% of the prey available for SRKWs in the U.S. EEZ, up to 1.9% of the total abundance of Chinook salmon in the ocean within the range of SRKWs, and up to 4.5% of the Chinook salmon available in the SOF for the short-term period after dam removal. All members of K and L pod could detect the reduced abundance of prey during foraging on a reduced prey field off the coast of California and Oregon. This short-term effect could lead to changes in behavior that can result in increased energy demands for foraging individuals as well as reductions in overall energy intake. This increases the risks of being unable to acquire adequate energy and nutrients from available prey resources (i.e., nutritional stress) during this short-term period, which can negatively affect the animal's growth, body condition, and health.

During the mid-term period (likely to be realized by SRKWs for a period of ~six years reflected by the subsequent changes in the number of adult Chinook salmon that are available in the ocean 4-10 years following removal of the dams), we expect the extent of potential adverse effects to be relatively limited. Generally, we anticipate that the availability of Chinook salmon prey for SRKWs will improve compared to current circumstances, even with the reductions in hatchery production in the Klamath River that are expected. However, we also assume that there could be scenarios where a reduction in Chinook that become potential prey two years later could occur. These years, if they did occur, are expected to be less impactful to the abundance of Chinook salmon in the ocean than during the short term effects to SRKWs. At worst, we expect that the abundance of Klamath Chinook salmon in the ocean as potential prey for SRKWs could be reduced by less than 10% during the mid term period. This represents no more than about a 1% (1.0%) reduction in the average abundance of Chinook salmon within the U.S. EEZ, and a less than 1% (0.7%) reduction in the average abundance of Chinook salmon in the ocean throughout the range of SRKWs. Off the coast of Oregon and California (SOF), this would represent a reduction of less than 2% (1.6%) in the average abundance of Chinook salmon during this period. Importantly, we do not expect SRKWs to be affected every year (if at all) by any reduced abundance of Klamath Chinook salmon in the ocean. As a result, we expect decreasing risk of localized prey depletions and behaviors that lead to increased energy expenditures during the mid term effects period, as prey reductions are only expected to occur during some years, and the extent of prey reductions that are expected during those years are diminished compared to the short term period (if they are occurring).

Over the long term, impacts to juvenile Chinook salmon include the expected cessation in hatchery supplementation from IGH and changing conditions within the Klamath River that include restoration and repopulation of upstream areas beyond the former dams that are potentially influencing survival/productivity of Chinook salmon throughout the Klamath River.

These effects will occur for an indefinite period of time starting eight years after dam removal, and are likely to be realized by SRKWs starting 10 years after dam removal as reflected by changes in the number of adult Klamath Chinook salmon that are available as potential prey for SRKWs in the ocean. We expect that the abundance of Klamath Chinook salmon in the ocean as potential prey for SRKWs is expected to increase over the long term, through realization of the long term beneficial effects of this proposed action. In addition to increased abundance, there are expected to be other improvements to Chinook salmon productivity in the Klamath River system associated with improved diversity of natural populations.

As described in Cumulative Effects (section 2.6.2), many of the same factors that have influenced the Status and Environmental Baseline of SRKWs are expected to continue and negatively affect SRKWs in the future. In addition, we identified other non-federal actions that are reasonably certain to occur, including continued production of Chinook salmon through hatchery operations if natural production is deemed to be insufficient, in which case continued hatchery production may be warranted despite the recognized potential negative impacts of hatchery releases on natural production, and active reintroduction of Chinook salmon to newly accessible habitat upstream of the former dams.

We have determined that adverse effects associated with local depletion and behavior changes/increased energy demand from the proposed action within a given year over the short term, and to a more limited extent occasionally within a given year over the mid term, are expected to occur. However, we conclude the extent and/or duration of these adverse effects is expected to be relatively limited. While Chinook salmon are the preferred prey with high nutritional value, SRKWs are capable of taking advantage of other prey sources to supplement their nutritional needs and are assumed to do so when Chinook salmon resources are limited. Prey sharing is likely to distribute more evenly any effects of prey limitation across individuals of the population than would otherwise be the case if most successful foragers did not share with other individuals. In addition, we recognize that SRKWs do not necessarily visit the action area off the coast of Oregon and California every year. This is expected to limit the extent of exposure to reduced prey as a result of the proposed action to only some years when they do occur in the action area. Further, during the midterm period, the extent of prey reductions are expected to be diminishing over time, and only occurring in some years which may not necessarily coincide with the occurrence of SRKWs in the action area. As a result, we do not anticipate severe adverse effects to SRKWs such as immediate or delayed mortality or diminished reproductive rates for individuals as a result of the short term or mid term effects associated with the proposed action.

During the short term and mid-term periods, there will be actions happening concurrently that should help mitigate any reductions in the ocean abundance of Chinook salmon in the action area that result from short or mid-term effects associated with the proposed action. Amendment 21 of the Pacific Coast Salmon Plan includes measures intended to limit the effects that ocean salmon fisheries have on SRKWs when Chinook salmon abundance is particularly low, including actions to reduce the impact of ocean harvest on SRKWs will occur off the coast of Oregon and California where Klamath Chinook salmon are a significant source of Chinook salmon abundance. As discussed in the Environmental Baseline for SRKWs (section 2.4.2), PST funding initiatives are expected to increase Chinook salmon prey abundance for SRKWs in the times and areas most important to SRKWs, including increased abundance in coastal areas during the winter.

Over the long-term period, we do not anticipate prey reductions or any adverse effects to SRKWs associated with behavior or energy intake. We expect the beneficial impacts of the proposed action to increase over time as Chinook salmon repopulate the upper Klamath River basin, and restored hydrologic and sediment transport processes improve conditions in the mainstem Klamath River downstream of where the dams were previously located. This should increase the amount of prey available in the ocean for SRKWs during the long term period, and improve the portfolio of prey resources that are available across their range. As a result, we conclude the long term effects of the proposed action will be beneficial, and should help improve the future status of the SRKW DPS along with the health of individual SRKWs that come to Oregon and California to forage on prey resources that include Klamath Chinook salmon.

Overall, our expectation is that the risk of modest levels of adverse effects of the proposed action to SRKWs that are expected to occur in some years following dam removal will abate fairly quickly over time, as the benefits of restoration of the Klamath River system as a result of the proposed action begin to be realized within a few years. We conclude that these adverse effects are likely to be limited in their extent and duration. These adverse effects may not be realized (in part or full) by SRKWs if Chinook salmon resources that originate from other areas are relatively high, and/or SRKWs do not spend much time foraging off the coast of Oregon and California during these few years. Although the current status of SRKWs suggest they are at risk of health impacts that could be exacerbated by prey reductions, there are additional factors described above in the Effects of the Action on SRKWs (Section 2.5.1) happening concurrently that should help mitigate adverse impacts associated with the proposed action. Over the long term, this proposed action is expected to improve conditions for SRKWs by increasing the productivity and improving the genetic and ecological diversity of Chinook salmon populations in the Klamath River. These benefits should contribute to increasing chances of survival and improved fecundity for individual SRKWs over time, which should improve the likelihood that the SRKW population will recover over time. As described in the Cumulative Effects for SRKWs (section 2.6.2), there are plans that are expected to maximize repopulation of newly accessible habitat and, if the beneficial effects of restoration related to Chinook salmon as prey for SRKWs as a result of the proposed action are delayed from being fully realized, are expected to extend hatchery production until the long-term beneficial effects are realized.

Based on these factors and available information, we conclude that the proposed action would likely not alter the fitness of individual SRKWs enough to further reduce their survival and reproduction rates as a consequence of the proposed action. Based on this conclusion regarding individual SRKWs, we conclude that the proposed action would not be expected to reduce the reproduction, numbers, or distribution of the SRKW population. Factoring in the status of the species, environmental baseline, and cumulative effects, we conclude the proposed action would not be expected to appreciably reduce the likelihood of both the survival and recovery of the SRKW DPS.

2.7.2.2 Designated Critical Habitat

On August 2, 2021, NMFS revised the critical habitat designation for the SRKWs by designating six new areas along the U.S. West Coast from the U.S. - Canada border to Point Sur, California (86 FR 41668). The revised critical habitat added approximately 15,910 square miles to the previous designation, including marine waters between the 6.1-meter and 200-meter depth contours from the U.S.-Canada border to Point Sur, California. The areas added are occupied and contain the three PBFs of SRKWs that were previously identified and included in the 2006 critical habitat designation for inland water of Washington.

All six distinct areas designated in marine waters occur within the boundary of the action area identified based on SRKW distribution overlapping with the distribution of Klamath Chinook salmon off the coast of Oregon and California. Specifically, the Northern California and Monterey Bay areas were identified as important feeding habitats for SRKWs that contain prey resources that rely significantly upon Chinook salmon that originate from the Klamath River. The proposed action has the potential to affect the quantity and availability of prey in these areas of designated critical habitat.

The extent of reductions in Chinook salmon in the action area due to prey removal have been described in detail in section 2.5.1, Effects to SRKWs. As described above, reductions in local abundance of prey from the proposed action over the short term, and to a more limited extent occasionally during the mid term, is expected to occur. These reductions are likely to result in the whales leaving certain critical habitat areas in search of more abundant prey in other areas that are designated critical habitat (or potentially in marine waters outside the range of designated critical habitat). This circumstance could occur if SRKWs spend time foraging off the coast of Oregon and California during the winter and spring during the short and mid term period years. As a result, we conclude the proposed action is likely to adversely affect the quantity and availability of prey resources (prey PBF) within designated critical habitat. We acknowledge that this adverse effect will not necessarily occur every year, and that the risk of this effect could be influenced by the relative abundance of other Chinook salmon resources in other coastal marine waters. As a result, we conclude that adverse effects to designated critical habitat where Klamath Chinook salmon are found could occur during an individual year during the short and mid term periods, although persistent adverse effects to designated critical habitat are not expected during these periods.

As described in section 2.5.1, Effects to SRKWs, the beneficial effects of the proposed action are expected to increase over time as Chinook salmon repopulate the upper Klamath River basin, and restored hydrologic and sediment transport processes improve conditions in the mainstem Klamath River below where the dams were previously located. This should ultimately increase the amount of prey available to SRKWs over the long term period within designated critical habitat in marine waters where Klamath Chinook salmon occur, and improve the portfolio of prey resources that are available across their range. As a result, we conclude the long-term effects of the proposed action to designated critical habitat off the coast of Oregon and California will be beneficial, and should help improve the future status of SRKW along with the health of individual SRKWs that forage on prey resources that include Klamath Chinook salmon. Consequently, we do not anticipate adverse effects to designated critical habitat for SRKWs over the long term.

The analysis of effects to SRKWs above considers pathways of effects that also apply to prey features. For reasons described in detail in the Integration and Synthesis of Reduction of Prey Availability for SRKWs (Section 2.7.2.1), our expectation is that the risk of modest level of adverse effects of the proposed action to SRKWs (and their designated critical habitat) that are expected to occur in some years following dam removal will abate quickly over time, as the beneficial effects of restoration of the Klamath River system begin to be realized within a few years. We conclude that these adverse effects to designated critical habitat are likely to be limited in their extent and duration. These adverse effects may not be realized (in part or full) by SRKWs if Chinook salmon resources that originate from other areas are relatively high, and/or SRKWs do not spend much time foraging in designated critical habitat where Klamath Chinook salmon are expected to occur during these few years. Over the long term, the beneficial effects of the proposed action are expected to improve conditions within designated critical habitat for SRKWs by increasing the productivity of Chinook salmon in the Klamath River along with other benefits. These beneficial effects should contribute to improving the overall condition of the prey PBF within designated critical habitat, which should improve the conservation value of this designated critical habitat over time. As described in the Cumulative Effects for SRKWs (section 2.6.2), there are plans that are expected to maximize repopulation of newly accessible habitat and, if the beneficial effects of restoration related to Chinook salmon as prey for SRKWs as a result of the proposed action are delayed from being fully realized, are expected to extend hatchery production until the long-term beneficial effects are realized.

Factoring in the status of the species, environmental baseline, and cumulative effects, we conclude the proposed action is not likely to directly or indirectly result in an alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of SRKWs.

2.7.3 Southern DPS Eulachon

2.7.3.1 Status

The southern DPS of eulachon is described as eulachon originating from the Skeena River in British Columbia south to and including the Mad River in northern California (50 CFR 223.102(e)). Four subpopulations—the Klamath River, the Columbia River, the Fraser River, and the British Columbia coastal rivers— are considered in NMFS' recovery plan as a minimum set of "populations" that are needed to meet biologically based (abundance, productivity, spatial distribution, and genetic and life-history diversity) and threats-based delisting criteria (NMFS 2017d).

As described in Section, 2.2.3.2, Status of the Species, Eulachon formerly experienced widespread, abundant runs and have been a staple of Native American diets for centuries along the northwest coast. However, these robust runs that were formerly present in several California rivers as late as the 1960s and 1970s (i.e., Klamath River, Mad River, and Redwood Creek) are thought to no longer occur (Larson and Belchik 1998). This decline likely began in the 1970s and continued, with the most recent observed and recorded Klamath River run in 1999 (Moyle 2002), after which there have not been consistent surveys conducted on the Klamath River.

Eulachon abundance appears strongly related to ocean conditions, and thus this species is considered extremely vulnerable to climate change. The recovery plan (NMFS 2017d) identifies recovery actions to be implemented, including estuary and freshwater habitat (e.g., water quality) actions and changes to the shrimp fishery. Effective implementation requires that the recovery efforts of diverse private, local, state, tribal, and Federal parties across two states be coordinated at multiple levels.

As noted in Section 2.2.3.2.1, Factors Responsible for Current Status of Eulachon*,* the status of eulachon is likely to be affected by climate change. Climate change is expected to impact Pacific Northwest anadromous fish during all stages of their complex life cycles. In addition to the direct effects of rising temperatures and drought, indirect effects include alterations in ocean conditions like ocean acidification that may impact changes in food webs for freshwater, estuarine, and marine habitats. There is high certainty that predicted physical and chemical changes will occur; however, the ability to predict bio-ecological changes to fish or food webs in response to these physical/chemical changes is extremely limited, leading to considerable uncertainty.

Pacific anadromous fish are adapted to natural cycles of variation in freshwater and marine environments, and their resilience to future environmental conditions depends both on characteristics of individual populations and on the level and rate of change. However, the life-history types that will be successful in the future are neither static nor predictable. Therefore, maintaining or promoting existing diversity that is found in the natural populations of Pacific anadromous fish is the wisest strategy for continued existence of populations, including eulachon.

2.7.3.2 Environmental Baseline

As described in Section 2.4.3.1, Status of Eulachon in the Action Area, the current run size in the Klamath River is very small relative to the number of eulachons in the DPS.

Habitat in the action area is degraded by the operation of water storage and diversion facilities and mainstem hydroelectric facilities. Reduced or lost habitat complexity, connectivity, quantity and quality (including water quality and toxics) in lower river tributaries and along the estuary floodplain remains a specific area of concern. The series of dams and reservoirs have also blocked natural sediment transport; the delivery of suspended particulate matter to the lower river and estuary has been reduced and has altered the development of habitat along the margins of the river.

2.7.3.3 Effects of the Action on the Species

As described in Section 2.5.3, Effects to Eulachon, NMFS expects that the only adverse effects to eulachon in response to the proposed action will be in the form of elevated SSCs and low dissolved oxygen. Other potential stressors like water temperatures and prey availability are not expected to negatively impact eulachon in the short or long term.

The lifestage most likely to be affected from an influx of suspended sediment would be spawning. Using a conservative analysis and a severe impact year scenario, the SSC values for the proposed action in Year 1 are expected to be substantially higher than the background condition and are expected to result in a small percent of adult eulachon mortality (20%) for approximately 10 percent of the migration and spawning period. The remaining adult eulachon that are not killed by the elevated suspended sediment are likely to experience some physiological stress for a small window if they are present in the lower Klamath River during the early winter peak, but suspended sediment concentrations in the lower Klamath River after April will begin to approximate baseline levels.

In addition, any eggs deposited during the early migration period may be exposed to physiological stress of elevated suspended sediment in the migration corridor. Eulachon are prey to many different species, and as such, they have a reproductive strategy that produces many offspring, suffering massive casualties throughout their lives, and only a few adults surviving to the reproduction stage can sustain the population.

Therefore, the maximum 20 percent of adult eulachon population that will be killed during 10 percent of the migration period in the Klamath River by the proposed action is a relatively minor loss to the overall abundance of the entire DPS, which stretches from Alaska to California, as described in Section 2.2.3.1, Range and Distribution. Eulachon are short lived, highly fecund, forage species that are resilient to large swings in population size and mortality rates. From 2000 through 2019, mean spawning stock biomass estimates in the Columbia River ranged from a low of about 783,000 fish in 2005 to a high of nearly 186 million fish in 2014, and in 2021 an estimated abundance of 100.7 million fish (Robert Anderson, NMFS, personal communication[25]). Spawning stock biomass estimates in the Fraser River (1995 to 2019) ranged from a low of about 110,000 to 150,000 fish in 2010 to a high of about 42 million to 56 million fish in 1996 (NMFS 2017d). In addition, the projected mortality rate is likely an overestimate as eulachon spawners will be able to avoid the suspended sediment related to the proposed action and use any of 75 other coastal rivers and streams for spawning (Gustafson et al. 2010).

Adult eulachon that migrate into the lower Klamath River after April of year 1, and their progeny, are not likely to be adversely affected by the proposed action because suspended sediment levels are expected to be reduced to background levels in the lower Klamath River by then. Impacts to eggs from elevated SSC are also expected to be higher during Year 1 for the proposed action compared to background conditions but not result in lethal impacts, as described in the *Effects to Eulachon* section.

Eggs that are exposed to the suspended sediment during the winter of year 1 may have reduced fitness because the excessive suspended sediment may reduce the quality of the coarse sand and pea-sized gravel substrate that eulachon rely upon for spawning and egg adhesion (WDFW and ODFW 2001). In addition, clay, which makes up the majority of sediment released from behind the dams (<0.002 mm) is considered poor spawning substrate and could coat and smother eggs. DO levels for incubating eggs could be impaired by sediment settling over eggs and creating a barrier to meeting viability thresholds (not known for eulachon, 8mg/l for intragravel DO for salmonids (Carter and Kirk 2008). For this analysis, we tie any DO effects to effects of SSCs, and address impacts together, not compounded as separate effects.

Impacts to egg survival will be variable and most likely low, depending on how many adults enter the lower river early in the spawning season, how many continue to spawn in the Klamath River when high SSCs are present as opposed to using an adjacent river, and how much flow from precipitation events like spring freshets re-mobilizes river sediments and uncovers any buried eggs.

[25] Email from Robert Anderson (NMFS) to Heather Wiedenhoft (NMFS). September 2, 2021

However, eulachon are a highly fecund species with each female eulachon producing between 7,000 and 31,000 eggs (WDFW and ODFW 2001). While the probability of each egg surviving for the species is less than 5 percent and in some cases less than 1 percent (Willson et al. 2006), the Klamath River is only one of 75 coastal rivers that the southern population uses for spawning, and one of low production in recent years (Larson and Belchik 1998), contributing to only a small proportion of the overall abundance for sDPS eulachon.

Eulachon are also different from salmon in that they are not known to exhibit site fidelity or homing behavior (Gustafson et al. 2010). Adult eulachon entering the Klamath River during periods of high SSCs during the proposed action may choose to alter their spatial structure to spawn in other nearby rivers (Mad River, Redwood Creek), without detriment to the overall spawning and productivity success for sDPS eulachon. Consequently, the ecological impact of reducing egg and larvae survival during the short period of spawning and incubation (i.e., about 8 weeks) in the Klamath River during drawdown in Year 1 will be fairly low.

While the proposed action is likely to slightly reduce the abundance, spatial structure, and productivity of eulachon in the Klamath River in Year 1, the proposed action is not likely to appreciably reduce the overall abundance, spatial structure, productivity, or diversity of the southern DPS of eulachon in the short term. In the long term, conditions in the lower Klamath River and estuary are not expected to be substantially different than under background conditions; therefore, no long term adverse effects due to the proposed action are expected to occur. In addition, the return of a more natural water temperature, flow, and sediment transport regime in the Klamath River expected after dam removal will most likely benefit eulachon in the long term.

2.7.3.4 Effects on critical habitat

As described in Section 2.2.3.3, Status of Critical Habitat, and Section 2.5.3.2, Effects of the Action on Critical Habitat, critical habitat for eulachon in the Klamath River is designated from the mouth of the Klamath River upstream to the confluence with Omogar Creek at approximately river mile (RM) 10.5 from the mouth; however, critical habitat does not include any tribal land owned by the Yurok Tribe or the Resighini Rancheria. In addition, there is no nearshore or offshore marine habitat in the action area designated as critical habitat. The proposed action has the potential to affect the first two PBFs of southern DPS eulachon critical habitat, which relate to freshwater spawning and incubation sites and freshwater and estuarine migration corridors in the action area in the lower Klamath River. Nearshore and offshore marine foraging habitat is not designated as critical habitat of southern DPS eulachon critical habitat in the action area. These potentially affected PBFs include substrate, water quality, passage, and forage. Freshwater spawning/incubation and migration corridor habitat types are expected to be temporarily degraded by the increase in suspended sediment and reduced DO related to elevated SSCs in the lower Klamath River related to the proposed action. Suspended sediment concentrations are expected to be slightly elevated compared to background levels for the first year of the proposed action in the lower mainstem Klamath River. Suspended sediment concentrations are predicted to return to background levels within the lower Klamath River by year 2 following drawdown.

The degradation of spawning habitat due to SSCs is expected to be temporary and intermittent during Year 1. With the seasonal influx of precipitation (winter freshet) some of the adverse effects of smothering could be mitigated with the increased flows, which may remobilize the fine sediment to enable egg adhesion to gravel. In addition, the temporary, short term degradation of spawning habitat represents less than 2 percent of the total designated critical habitat for the southern DPS of Pacific eulachon (DOI and CDFG 2012).

Suspended sediment will also degrade the migration corridor temporarily and intermittently during Year 1 for a small portion of early-spawning eulachon. The short term degradation of migratory habitat primarily occurs during winter and early spring of year 1, when the eulachon migration period has not yet peaked. Some adult eulachon are also expected to avoid areas with high SSCs.

Prey availability and water temperatures in the lower river are not expected to be negatively impacted by reservoir drawdown or have a harmful effect on eulachon in the lower river for the short or long term.

There are no long-term adverse effects expected to result from the proposed action for eulachon individuals or designated critical habitat in the lower Klamath River. Adult eulachon that migrate into the lower Klamath River after winter of year 1, and their progeny, are not likely to be affected by elevated sediment levels because the reservoir drawdown will have occurred in January and February, and the suspended sediment levels are expected to be reduced to background levels in the lower Klamath River by April of year 1).

2.7.3.5 Beneficial Effects to Eulachon and Critical Habitat

Long-term beneficial effects of the proposed action for coho salmon (Section 2.5.1) in the action area also may benefit eulachon and their critical habitat. Once a more natural hydrograph and water temperature regime has been established in the river, it may improve spawning habitat for eulachon in the Klamath, although any upstream water quality improvements will be minimized by the time the waters reach the mouth and estuary of the Klamath. Eulachon surveys conducted by the Lower Elwha Klallam Tribe of the Elwha River after dam removal found the reconfiguring of sediment in the lower river has been favorable for improving spawning habitat for eulachon. Overall, for the long term, the proposed action is likely to have a beneficial effect for eulachon that spawn and rear in the Klamath River and their critical habitat.

2.7.3.6 Cumulative Effects

When evaluating the effects of the action, those effects must be taken together with the effects on eulachon and eulachon critical habitat of future state or private activities, not involving Federal activities that are reasonably certain to occur within the action area. The cumulative effects discussed previously for coho salmon (Section 2.6.1) are expected to have similar, but reduced, effects on eulachon since eulachon are not in the action area yearlong, and unlike coho salmon, are only found in the lower river. NMFS also anticipates that human activities such as harvest will contribute to cumulative effects and are generally expected to have adverse effects on eulachon in the action area. Many of these activities and their effects occurred in the recent past and were included in the environmental baseline but are also reasonably certain to occur in the future. Habitat restoration efforts for salmon led by state and local agencies, tribes, environmental organizations, and local communities are likely to continue. Their focus on water quality and improved river functionality will also benefit eulachon habitat. Projects supported by these entities focus on improving general habitat and ecosystem function or species-specific conservation objectives that, in some cases, are identified through ESA recovery plans. These state and private actions have helped restore habitat, improve fish passage, and reduce pollution. While these efforts are reasonably certain to continue to occur, funding levels may vary on an annual basis.

2.7.3.7 Summary

Considering the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of other activities caused by the proposed action, and cumulative effects, while the proposed action is likely to slightly reduce the abundance and productivity of eulachon in the Klamath River in the short-term, the proposed action is not likely to appreciably reduce the abundance, productivity, spatial structure, or diversity of the southern DPS of eulachon. Therefore, the proposed action is not likely to reduce appreciably the likelihood of both the survival and recovery of the southern DPS of eulachon in the wild by reducing its numbers, reproduction, or distribution. The degradation of spawning habitat and migration corridor due to SSCs is expected to be temporary and intermittent during Year 1 and return to background levels by Year 2. A return to a more natural hydrograph that will follow the proposed action will likely improve temperature and flow regimes in the Klamath River for eulachon habitat in the long-term. Therefore, the proposed action is not likely to appreciably diminish the value of designated critical habitat as a whole for the conservation of the southern DPS of eulachon.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and the cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the SONCC coho salmon ESU, Southern Resident killer whale DPS, or southern DPS of eulachon or destroy or adversely modify their designated critical habitat.

2.9 Incidental Take Statement

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). “Harass” is further defined by interim guidance as to “create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering.” “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

2.9.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows:

2.9.1.1 SONCC Coho Salmon ESU

NMFS expects the proposed action will result in incidental take of SONCC coho salmon adults, embryos/pre-emergent fry, sub-yearlings, yearlings, and smolts.

2.9.1.1.1 Suspended Sediment and Dissolved Oxygen

As described in previous sections of this biological opinion, NMFS expects all freshwater life stages of coho salmon in all populations of the Klamath Basin to be harmed to some degree during year 1 (reservoir drawdown) and year 2 (post dam removal) due to elevated SSCs and associated decreases in dissolved oxygen.

The incidental take of coho salmon resulting from the suspended sediment concentrations related to the proposed action is not practicable to measure and impossible to separate out from the reduced levels of dissolved oxygen. Incidental take of coho salmon resulting from these impacts of the proposed action is not practicable to measure for the following reasons: the small size of many of the life stages, the number of individuals that will survive and return as adults in the Klamath River in any given year cannot be precisely determined, their occurrence in elevated suspended sediment concentrations that make them difficult to detect, the low likelihood of finding dead or impaired specimens, and the high rate of removal of injured or killed individuals by predators or scavengers. Because measuring the number of coho salmon that are expected to be harmed as a result of the elevated suspended sediment concentrations and low dissolved oxygen is not practicable, NMFS will use suspended sediment concentrations as a surrogate which we assume includes the added impact of co-occurring low dissolved oxygen (described in Table 37 and Table 38). Impacts of elevated SSCs and the causal link to incidental take is informed by the Newcombe and Jensen (1996) severity indices and further described in the Effects Section, Section 2.5.1.1.7. If the modeled suspended sediment concentrations described in Tables 38 and 39 are exceeded, the amount or extent of incidental take of coho salmon due to suspended sediment concentrations and low dissolved oxygen will be considered exceeded.

Bedload deposition during reservoir drawdown will be responsible for smothering embryos and pre-emergent fry in the gravel immediately downstream of Iron Gate Dam as described in Sections 2.5.1.1.7.3 and 2.5.1.1.9. The incidental take of coho salmon embryos or pre-emergent fry due to bedload deposition during drawdown is not practicable to measure due to the small size of these life stages and their occurrence in elevated suspended sediment concentrations that make them difficult to detect. Thus, we use the number of redds that are expected to be buried by bedload deposition as a surrogate for incidental take of coho salmon embryos and pre-emergent fry due to bedload deposition during drawdown. As described in Section 2.5.1.1.7.3, NMFS estimates that 100% of coho salmon eggs and pre-emergent fry in up to six redds will be killed as a result of deposition in Year 1. Therefore, if more than six redds in the mainstem Klamath River downstream of the Iron Gate Dam site are buried by bedload deposition during drawdown, then the amount or extent of incidental take of coho salmon eggs and pre-emergent fry due to bedload deposition will be considered exceeded.

Table 37. Summary of incidental take of SONCC coho salmon expected to occur as a result of SSC related to the proposed action in year 1 (reservoir drawdown) during a severe impact year.

Life History Stage (timing)	Populations	SSC (mg/l)[1]	Exposure Days	Type and Amount/Extent of Incidental Take[2]
Adult Migration (Sept 1 – Jan 1)	Upper Klamath, Shasta	52-194	14 days	Sublethal effects, including major stress and impaired homing
	Mid Klamath, Scott	30-170	14 days	Sublethal effects, including major stress and impaired homing
	Lower Klamath, Salmon, Trinity	18-133	14 days	Sublethal effects, including major stress and impaired homing
Embryos/pre-emergent fry[3]	Upper Klamath, Shasta		60 days	Bedload transport is expected to result in 100% mortality in up to 6 redds
Summer rearing 0+ juveniles	Upper Klamath, Shasta	39 - 2111	20 days	Major stress, reduced growth, 0–20% mortality of fish rearing in the mainstem for 31% of the summer rearing period and 20-40% mortality of fish rearing in the mainstem for 8% of the summer rearing period
	Mid Klamath, Scott	23 - 1510	20 days	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 38% of the summer rearing period
	Lower Klamath, Salmon, Trinity	18 - 679	20 days	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 15% of the summer rearing period
Winter rearing 1+ juveniles[4]	Upper Klamath, Shasta	33 - 2319	20 days	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 20% of the winter rearing period and 0-40% mortality of fish rearing in the mainstem 20% of the winter rearing period
	Mid Klamath, Scott	25 - 1739	20 days	Major stress, reduced growth, and 0 – 20% mortality of fish rearing in the mainstem for 40% of the winter rearing period
	Lower Klamath, Salmon, Trinity	17 - 992	20 days	Major stress, reduced growth, and 0-20% mortality of fish rearing in the mainstem for 20% of the winter rearing period
Outmigrating 1+ smolt	Upper Klamath, Shasta	250-2844	14 days	Major stress, reduced growth, and up to 20% mortality for approximately 60% of the outmigration period
	Mid Klamath, Scott	179-1899	14 days	Major stress, reduced growth, and 0 - 20% mortality of smolts for 30% of the spring outmigration period
	Lower Klamath, Salmon, Trinity	96-961	14 days	Major stress, reduced growth, and 0 - 20% mortality of smolts for 20% of the spring outmigration period

[1] Data for Upper Klamath and Shasta populations relied on USGS Iron Gate Dam station; data for Mid Klamath and Scott populations relied on USGS Seiad Valley station; data for Lower Klamath, Salmon, and Trinity populations relied on USGS Orleans station.

[2] Response was determined using Newcombe and Jenson (1996) Severity Index as described in the Approach to Analysis.

[3] Number of redds buried from bedload deposition is used as a surrogate as described above. [4]We use the impacts modeled for the “median impact year” for this life stage since they were determined to result in greater impacts to individuals than the “severe impact year”.

Table 38. Summary of incidental take of SONCC coho salmon expected to occur as a result of SSC related to the proposed action in year 2 (post dam removal) of a severe impact year

Life History Stage (timing)	Populations	SSC (mg/l)[1]	Exposure Days	Effects on Production[2]
Adult Migration (Sept 1 – Jan 1)	Upper Klamath, Shasta	14-14	14 days	Sublethal effects, including moderate stress
	Mid Klamath, Scott	8-9	14 days	Sublethal effects, including moderate stress
	Lower Klamath, Salmon, Trinity	7-7	14 days	Sublethal effects, including moderate stress
Summer rearing 0+ juveniles	Upper Klamath, Shasta	2-60	20 days	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
	Mid Klamath, Scott	2-45	20 days	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
	Lower Klamath, Salmon, Trinity	2-39	20 days	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Winter rearing 1+ juveniles	Upper Klamath, Shasta	39-354	20 days	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
	Mid Klamath, Scott	31-102	20 days	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
	Lower Klamath, Salmon, Trinity	26-74	20 days	Sublethal effects, including reductions in feeding and major stress for fish rearing in the mainstem
Outmigrating 1+ smolt	Upper Klamath, Shasta	6-165	14 days	Sublethal effects, including major stress and reduced growth
	Mid Klamath, Scott	12-59	14 days	Sublethal effects, including reductions in feeding and major stress
	Lower Klamath, Salmon, Trinity	13-49	14 days	Sublethal effects, including reductions in feeding and major stress

[1] Data for Upper Klamath and Shasta populations relied on USGS Iron Gate Dam station; data for Mid Klamath and Scott populations relied on USGS Seiad Valley station; data for Lower Klamath, Salmon, and Trinity populations relied on USGS Orleans station.

[2] Response was determined using Newcombe and Jenson (1996) Severity Index as described in the Approach to Analysis.

2.9.1.1.2 Relocation Measures

NMFS expects juvenile coho salmon from Upper Klamath, Shasta, Scott, and Middle Klamath River populations to be captured and relocated as method to minimize impacts of the proposed action at various times over the eight year implementation period. The number of fishes estimated to be relocated is based on estimates from the Renewal Corporation, review of relocation data from other projects, and our understanding of habitat occupancy (e.g., newly seeded habitat has low densities of fish) as described in Section 2.5.1.1.10. The amount of incidental take of coho salmon due to relocation measures will be considered exceeded if the number of coho salmon captured or killed as a result of relocation is greater than described in Table 39.

Table 39. Amount of incidental take associated with relocation activities for coho salmon

Timing	Effected Populations	Activity	Estimated Number of Coho salmon to be Relocated	Estimated Number of Coho Salmon Killed
Pre-drawdown Summer	Upper Klamath	Temporary road construction, temporary bridge construction, armoring of left bank access road, construction of fire access ramp	30	1
Pre-drawdown Winter	Upper Klamath, Shasta, Scott, Mid-Klamath	Relocation of mainstem-rearing juvenile coho salmon to minimize SSC impacts	1000	10
During drawdown	Upper Klamath, Shasta, Scott	Relocation of outmigrating smolt (1+) from tributary mouths	1200	12
Post-dam removal (years 2-7)	Upper Klamath	Instream habitat restoration projects	1200	12
Post-dam removal (years 2-7)	Upper Klamath	Fish passage maintenance projects	1500	15
Post-dam removal (years 2-7)	Upper Klamath	Boat ramp construction	500	5

2.9.1.1.3 Herbicide and Adjuvant Applications

Projects conducted under the Invasive Exotic Vegetation Management program will take place adjacent to aquatic habitats that are reasonably certain to be occupied by individuals of the upper Klamath River population of coho salmon. As described below, the proposed action is reasonably certain to cause incidental take. Juvenile life stages are most likely to be affected, although adults will sometimes also be present when the projects occur within or adjacent to the former reservoir footprints.

Herbicide applications, as constrained by the conservation measures, are reasonably certain to result in herbicide drift or movement into streams that will harm listed coho salmon. Incidental take caused by the habitat-related effects of this action cannot be accurately quantified as a number of fish because the distribution and abundance of fish that occur within the action area are affected by habitat quality, competition, predation and the interaction of processes that influence genetic, population and environmental characteristics both within and outside the action area. As the portion of the action area likely affected by herbicides has not been occupied by listed coho salmon since the construction of the four dams between 60 and 100 years ago, it is not certain how quickly or exactly where coho utilization will occur. In this unique environment, the distribution and abundance of fish within the program action area cannot be attributed entirely to habitat conditions, nor can NMFS precisely predict the number of fishes that are reasonably certain to be harmed or killed if fish or their prey are exposed to herbicides and their associated adjuvants. Additionally, there is no practical way to count the number of fishes exposed to herbicides without causing additional stress and injury to these fish. In such circumstances, NMFS can use the causal link established between the activity and the likely changes in habitat conditions affecting the listed species as a surrogate to describe the extent of take in terms of habitat disturbance.

Application of herbicides and associated adjuvants will result in short-term degradation of water quality, which is reasonably certain to cause injury to fish in the form of sublethal adverse physiological effects or temporary reduction in benthic macroinvertebrate prey resources. This is particularly true for herbicide applications in riparian areas that may deliver herbicides via drift to streams occupied by listed salmonids. These sublethal effects were described in the effect's analysis for this opinion. The best available indicator for the extent of take due to proposed IEV control and eradication program is the annual number of treated acres for the planned life of the IEV program. Thus, if more than 1,967 acres of treatment each year through the proposed three year reservoir restoration period is exceeded, incidental take of coho salmon due to herbicide application will be considered exceeded. This includes no more than 207 acres of irrigated riparian areas and recognizes that this entire acreage will not be broadcast treated but is subject to mostly spot treatments of IEV from the beginning of the site preparation through conclusion of the program. Although this surrogate is the number of treated acres for the planned life of the IEV program, it will serve as an effective reinitiation trigger because it can be accurately measured within each year of the IEV program, which will indicate if expected herbicide treatment and related incidental take is exceeded within each year of the IEV program.

2.9.1.2 Southern Resident Killer Whales (SRKWs)

2.9.1.2.1 Incidental Take Summary for SRKWs

NMFS anticipates that the reduction in the abundance of Klamath River Chinook salmon that will occur as a result of impacts to juvenile Chinook during dam removal and changes in hatchery production over the short term (2-3 year period beginning two years after dam removal) is reasonably certain to result in some level of harm to SRKWs; specifically, members of K and L pod (currently 50 individuals[26]) during that period. The harm is a consequence of subsequent reduced prey availability causing impairment in foraging behavior, leading SRKWs to forage for longer periods, travel to alternate locations, and increased risk of nutritional stress and related health effects.

Similarly, we expect that limited and occasional reduction in the abundance of Klamath River Chinook salmon could occur during some individual years within the mid term period (6+ year period starting four years after dam removal). This primarily would occur because of changes in juvenile Chinook salmon hatchery production. Reductions in hatchery production would be mitigated by anticipated improvements in Chinook salmon survival and productivity in response

[26] Based on the CWR 2021 Annual Census from surveys through July 1, 2021. The additional loss of L47 following the census leaves 49 individual whales in K and L pods.

to changing conditions in the Klamath River following dam removal. This scenario is reasonably certain to result in some level of harm to SRKWs, specifically members of K and L pod during this period. Our expectations are that SRKWs will not be harmed every year during the mid term as reduced abundance of Klamath Chinook in the ocean is not expected during most years during this period (if at all), and SRKWs do not necessarily occur in the proposed action area every year. We also expect the extent of harm during the mid term period should be less than the extent that is expected to occur during the short term period in terms of the magnitude of reduced prey that is reasonably likely to occur.

Currently, we cannot readily observe or quantify impacts to foraging behavior or any changes to the health of individual SRKWs that occur as a consequence of the general level of prey reduction that is expected as a result of the proposed action because we do not have the data or metrics needed to monitor and quantitatively establish relationships between the effects of the proposed action and individual SRKW health. Quantitative relationships between the health and productivity of the entire SRKW population and the changing abundance of prey species are complex and of limited utility as described in section 2.4.2 Environmental Baseline for Southern Resident Killer Whale DPS. As a result, we will rely on surrogates of the amount or extent of incidental take of SRKWs as a result of the proposed action in the form of the extent of effects to Chinook salmon described in the Chinook effects analysis (Sections 2.5.2 Effects to SRKWs and 2.7.2 Integration and Synthesis for SRKWs), and the surrogates used in Section 2.9.1 Incidental Take Summary for Coho Salmon, where applicable. Exceedance of the extent of effects to Chinook salmon would be viewed as an exceedance of the anticipated harm to SRKWs.

2.9.1.2.2 Surrogates for Incidental Take

Analysis indicates that the take of SRKWs is expected to occur through effects to Klamath River Chinook salmon resulting in the subsequent reduction of Chinook salmon available as prey for SRKWs. During the short term period, the anticipated effects to Chinook salmon include reductions in the survival and productivity of juvenile Chinook salmon by release of the sediment and other effects associated with dam removal. The effects also include reductions in the production of hatchery Chinook salmon associated with the modification to hatchery production in the Klamath River that have been proposed. During the mid term period, the anticipated effects to Chinook salmon include reductions in the production of hatchery Chinook salmon associated with modification to hatchery operations in the Klamath River, gradually offset by improvements in survival and production of Chinook salmon throughout the Klamath River in response to the improving conditions throughout the system associated with the proposed action.

As described in section 2.9.1.1 Amount or Extent of Take for SONCC Coho Salmon ESU, the incidental take of SONCC coho salmon during dam removal will be measured by surrogates of suspended sediment and the dissolved oxygen concentrations that will be measured during monitoring of the proposed action. Similarly, we will use the measures of suspended sediment concentrations and dissolved oxygen to describe the extent of impacts to Chinook salmon that have been analyzed in this Opinion given that these relate directly to the analysis of how the proposed action affects Chinook salmon in the Klamath River, and ultimately the future availability of Chinook salmon in the ocean as prey for SRKWs. The incidental take of SRKW resulting from impacts to Chinook salmon due to suspended sediment concentrations related to the proposed action is not practicable to measure and impossible to separate out from reduced levels of dissolved oxygen. Incidental take of SRKWs based on reduction in Chinook salmon prey related to these impacts of the proposed action is not practicable to measure for the following reasons: the small size of many of the Chinook salmon life stages, the number of Chinook salmon individuals that will survive and return as adults in the Klamath River in any given year cannot be precisely determined, the occurrence Chinook salmon in elevated suspended sediment concentrations that make them difficult to detect, the low likelihood of finding dead or impaired specimens of Chinook salmon, and the high rate of removal of injured or killed Chinook salmon individuals by predators or scavengers. Because measuring the number of Chinook salmon that are expected to be harmed as a result of the elevated suspended sediment concentrations and low dissolved oxygen is not practicable, NMFS will use suspended sediment concentrations as a surrogate which we assume includes the added impact of co-occurring low dissolved oxygen (described in Table 40). If the modeled suspended sediment concentrations described in Table 40 are exceeded, the amount or extent of incidental take of SRKW due to suspended sediment concentrations and dissolved oxygen impacts on their prey base (Chinook salmon) will be considered exceeded.

Bedload deposition during reservoir drawdown will be responsible for smothering embryos and pre-emergent fry in the gravel immediately downstream of Iron Gate Dam as described in Sections 2.5.2.2.2 and 2.5.2.3.1. The incidental take of SRKWs based on mortality of Chinook salmon embryos or pre-emergent fry due to bedload deposition during drawdown is not practicable to measure due to the small size of these Chinook salmon life stages and their occurrence in elevated suspended sediment concentrations that make them difficult to detect. Thus, we use the extent of bedload deposition as a surrogate for the incidental take of SRKWs based on mortality of Chinook salmon embryos and pre-emergent fry that are predicted to die during drawdown. As described in Section 2.5.2.2.2, NMFS estimates that 100% of Chinook salmon eggs and pre-emergent fry will be killed in 13% of the Chinook salmon redds in the mainstem Klamath River. The 13% of Chinook salmon redds will occur in the reach between Iron Gate Dam and Willow Creek (as described in FERC 2021a Appendix J-29) as a result of deposition in Year 1. Therefore, if deposition occurs beyond the reach between Iron Gate Dam and Willow Creek in Year 1, then the amount or extent of incidental take of SRKW based on mortality of Chinook salmon embryos/pre-emergent fry due to bedload deposition during drawdown will be considered exceeded.

Table 40. Summary of incidental take of SRKW resulting from impacts to Chinook salmon expected to occur as a result of SSC related to the proposed action in year 1 (reservoir drawdown) during a severe impact year (1973).

Life History Stage (timing)[1]	Populations/ Location	SSC (mg/l)[2]	Exposure Days	Type and Amount/Extent of Incidental Take
Embryos/pre-emergent fry[3]	Iron Gate to Willow Creek			Bedload deposition in the Iron Gate Dam to Willow Creek reach is expected to result in 100% mortality in up to 13% of Chinook salmon redds in the mainstem Klamath River
Age 0+ outmigrants	Upper Klamath	84-1433	20	Up to 13% mortality of fish passing Bogus Cr trap, 17% mortality of fish passing 1-5 trap, and 15% mortality of fish passing Shasta River trap
	Middle Klamath	68-1103	20	Up to 9% mortality of fish passing Kinsman trap, up to 11% mortality of fish passing the Scott River trap
	Lower Klamath	45-707	20	Up to 5% mortality for fish passing Trinity River trap, up to 2% mortality for fish passing the Blue Creek trap

¹ Adult migration has not been included since migration will be complete prior to drawdown.
² Data for Upper Klamath populations relied on USGS Iron Gate station, data for Middle Klamath populations relied on USGS Seiad Valley station, data for Lower Klamath populations relied on USGS Orleans station.
³ Bedload deposition will be used as a surrogate as described above.

For SRKWs, the extent of incidental take during the short term and mid term is also related to reductions in hatchery production of Chinook salmon in the Klamath River that have been proposed. While the proposed action includes modified (reduced) hatchery production goals for Chinook salmon at the Fall Creek hatchery during and after dam removal compared to the Chinook salmon hatchery production goals at Iron Gate hatchery prior to dam removal, we recognize that hatchery production goals cannot always be met. In the past, hatchery production at Iron Gate hatchery has not always met the goals, which was reflected in the analysis of potential reductions in the ocean abundance of Klamath Chinook salmon described in section 2.5.2.2.2 Effects to Chinook salmon. In the past, actual hatchery production compared to hatchery production goals has averaged approximately 63% over the last 5 years of available information (2016-2020). During this 5 year period, actual production compared to goals has been as low as 24% and as high as 93% (CDFW 2021d). Using this information, we expect that the hatchery production relative to the goals that are associated with the proposed action should fall within the same range as what has occurred at Iron Gate hatchery recently. Our analysis of how the proposed action affects Chinook salmon in the Klamath River, and ultimately the future availability of Chinook salmon in the ocean for SRKWs, is contingent upon expectations that hatchery production will occur at least at some reduced level scaled with the production that occurred before dam removal. Over the short term and mid term, we expect that actual hatchery production will not be less than 24% relative to the goals established by the proposed action during any year. Therefore, we will also use this threshold for actual hatchery production as a surrogate for the amount or extent of anticipated incidental take of SRKWs from reduced hatchery production goals for Chinook salmon at the Fall Creek hatchery as a result of the proposed action. Consistent with the recent average production at Iron Gate hatchery compared to goals (63% rate), we anticipate that the average actual production will meet or exceed this rate during the proposed action. Therefore, we will also use this threshold for actual hatchery production as a surrogate for the amount or extent of anticipated incidental take of SRKWs from reduced hatchery production goals for Chinook salmon at the Fall Creek hatchery as a result of the proposed action. Incidental take will likely be exceeded if hatchery production relative to the goals falls below 24% for any given year, or falls below an average of 63% during the proposed action. Throughout the proposed action, we expect that the annual hatchery production goals will remain similar to current goals. If these goals are adjusted in response to available information about natural Chinook salmon survival and productivity, we will continue to rely upon these relative performance standards as the applicable thresholds for incidental take.

Our use of hatchery production performance as a surrogate for the extent of incidental take of SRKWs is linked to our expectations for how the survival and production of Chinook salmon will improve throughout the Klamath River following dam removal. The anticipated benefits of the proposed action minimize the level of harm to SRKWs that we expect as a result of the reduction in the hatchery production of Chinook salmon. In order to effectively monitor the extent of incidental take using the hatchery production performance surrogate, information about the survival and production of Chinook salmon in the Klamath River, including but not limited to disease impacts, will need to gathered as available and be evaluated throughout the proposed action. Along these lines, our analysis of the surrogates described above as a threshold for anticipated incidental take of SRKW recognizes that adjustments of the proposed hatchery plan may be recommended by the applicant. Specifically, if hatchery production goals are reduced based on the improvement in the overall survival and production of Chinook salmon in the Klamath River as demonstrated by the available information, we will assume that the overall extent of SRKW incidental take occurring will not have been exceeded by these reductions in hatchery production goals unless performance of the hatchery relative to any new goals drops below the same relative performance levels established in this ITS. If the annual hatchery production goals change over time (e.g., are reduced based on increased survival of juvenile fish), we expect these changes will be reported to NMFS along with information on how the new goals were set (e.g., considerations of increases in juvenile Chinook salmon survival and productivity). This information, in concert with data on actual hatchery production compared to the new goals, overall abundance of Klamath Chinook salmon, and contribution of hatchery fish to Klamath Chinook salmon populations, will be used to inform a review of whether incidental take has been exceeded. The analysis in the biological opinion and ITS above indicates that the incidental take of SRKWs is not expected to occur over the long term through effects to Klamath River Chinook salmon resulting in the subsequent reduction of Chinook salmon available as prey for SRKWs. We expect the abundance of Klamath Chinook salmon in the ocean as potential prey for SRKWs to increase over the long term, through realization of the beneficial effects of the proposed action. In addition, we expect other improvements to Chinook salmon productivity and diversity in the Klamath River that will benefit the future prospect of available prey resources for SRKWs when they occur off the coast of Oregon and California. Our expectation is that Chinook salmon hatchery production will cease at a time when the natural productivity of

Chinook salmon in the Klamath River system no longer needs to be supplemented. We expect this condition to exist when repopulation of newly available upstream habitat is occurring in concert with improved survival/productivity of Chinook salmon throughout the entire system at a level that will compensate (or more than compensate) for the lost hatchery production. Since there is no incidental take of SRKWs expected as a result of the proposed action over the long term, we do not establish a surrogate for the extent of incidental take over the long term.

2.9.1.3 Eulachon

NMFS expects the proposed action is reasonably certain to result in incidental take of adult eulachon as a result of elevated SSCs and low dissolved oxygen during Year 1. For the reasons we describe in our discussion regarding incidental take of coho salmon in Section 2.9.1.1.1, it is not practicable to measure the incidental take of eulachon resulting from the suspended sediment concentrations related to the proposed action and impossible to separate out from incidental take resulting from the reduced levels of dissolved oxygen. Therefore, NMFS will use suspended sediment concentrations as a surrogate, which we assume includes the added impact of co-occurring low dissolved oxygen. If the modeled suspended sediment concentrations exceed 3,477 mg/L during the migration period of Year 1 (January – May), the amount or extent of incidental take of eulachon due to suspended sediment concentrations and low dissolved oxygen will be considered exceeded.

2.9.2 Effect of the Take

In the biological opinion, NMFS determined that the amount or extent of anticipated take, coupled with other effects of the proposed action, is not likely to result in jeopardy to the species or destruction or adverse modification of critical habitat.

2.9.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

2.9.3.1 SONCC Coho Salmon ESU and Southern DPS of Eulachon

NMFS believes that the following reasonable and prudent measures and terms and conditions are necessary and appropriate to minimize the impacts of the amount or extent of incidental take of SONCC ESU coho salmon and Southern DPS eulachon resulting from the proposed action.

1. Monitor and report on water quality and incidental take of coho salmon and eulachon in the Klamath River mainstem related to the proposed action.
2. Minimize incidental take associated with the IEV management program.
3. Ensure real-time decision making occurs using best available technical information during implementation and maintenance of the action.

4. Monitor mainstem coho salmon spawning to ensure the expected amount or extent of incidental take of coho salmon embryos and pre-emergent fry in redds is not exceeded.

2.9.3.2 Southern Resident Killer Whales (SRKWs)

NMFS believes that the following reasonable and prudent measures, and terms and conditions, are necessary and appropriate to minimize the impacts of the amount or extent of incidental take of SRKWs resulting from the proposed action.

5. Monitor and report on water quality and incidental take of SRKWs as it relates to impacts to Chinook salmon.
6. Minimize incidental take of SRKWs through ensuring both hatchery and wild Chinook salmon production and survival meets assumptions described in this Incidental Take Statement.
7. Ensure real-time decision making occurs using best available technical information during implementation and maintenance of the action.
8. Monitor sediment deposition to ensure the expected amount or incidental take of SRKWs as a result of mortality of Chinook salmon embryos and pre-emergent fry in redds is not exceeded.

2.9.3.3 General Reasonable and Prudent Measures

9. FERC shall include in any license surrender order or other authorization for the amended surrender application for the Lower Klamath Project a condition that makes the license order or other authorization subject to the reasonable and prudent measures and terms and conditions of this Incidental Take Statement.
10. FERC shall include in any license surrender order or other authorization for the amended surrender application for the Lower Klamath Project a reopener clause providing for the possible amendment of the order or other authorization to incorporate any reasonable and prudent alternatives, reasonable and prudent measures, and terms and conditions resulting from any reinitiated consultation on the authorized action.

2.9.4 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the Federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. The FERC or any applicant has a continuing duty to monitor the impacts of incidental take and must report the progress of the action and its impact on the species as specified in this ITS (50 CFR 402.14). The Renewal Corporation may develop agreements with partners such as CDFW to implement the terms and conditions. If the entity to whom a term and condition is directed does not comply with the following terms and conditions, protective coverage for the proposed action would likely lapse.

The Renewal Corporation describes the role of the ARG as a group that provides technical consultation during the implementation of the Aquatic Resources Management Plan. The ARG includes members from the Renewal Corporation's team as well as federal, state, and Tribal resource staff. In the following terms and conditions, NMFS relies on the Renewal Corporation to utilize the ARG to gather available data that provides information to the Renewal Corporation and NMFS regarding the accuracy of assumptions made within this ITS.

2.9.4.1 SONCC Coho Salmon ESU and Southern DPS of Eulachon

The following terms and conditions implement reasonable and prudent measure 1:

a) The Renewal Corporation shall provide NMFS real-time estimates (i.e., continuous updates every 15 minutes) of the turbidity at USGS stations at Iron Gate, Seiad Valley, and Orleans beginning on or before the commencement of reservoir drawdown, continuing through two years post dam removal. The Renewal Corporation shall establish an SSC rating curve using the turbidity data prior to June 1st of the drawdown year when such data will be used in decision making regarding rescue and relocation actions (described in FERC 2021a Appendix D).

b) The Renewal Corporation shall provide NMFS real-time estimates (i.e., continuous updates every 30 minutes) of the dissolved oxygen concentration at or near the current Iron Gate Dam gage and immediately upstream of the mouth of the Shasta River beginning on or before the commencement of reservoir drawdown through two years post dam removal.

c) The Renewal Corporation shall test in advance all measurement devices used for SSC and DO water quality monitoring (as identified in the California Water Quality Certification (CSWRCB 2020a)) and reporting systems to identify and resolve any concerns that arise.

d) Reporting Requirements:

The Renewal Corporation shall prepare and provide NMFS a summary annual report, by April 1st of each year, for the monitoring and maintenance period as defined in the Reservoir Area Management Plan (FERC 2021a Appendix C), that was conducted the previous calendar year. The report shall detail the following information:

- A comparison of the measured or estimated suspended sediment concentrations versus the modeled concentrations for the duration of the measured period.
- Total number and life stage of coho salmon captured.
- Total number and life stage of coho salmon injured by capture method.
- Total number and life stage of coho salmon killed by capture method.
- The dates when trapping of coho salmon occurred.
- Which BMPs were implemented and when.
- The dates when transport of coho salmon occurred and the total number and life stage of coho salmon killed in transport.
- Locations where captured coho salmon were released.

In addition, the Renewal Corporation shall report all observations of dead or injured coho salmon or eulachon coincident with dam removal activities (other than relocation activities) and the associated suspended sediment concentrations in the mainstem Klamath River to NMFS within 2 days of their observance, and include a concise description of the causative event (if known), and a description of any resultant corrective actions taken (if any) to reduce the likelihood of future mortalities or injuries. The report will include a discussion of implementation of the terms and conditions that implement reasonable and prudent measure 1 above.

Submit monitoring reports to:

National Marine Fisheries Service
Northern California Office
1655 Heindon Road
Arcata, California 95521.

If a sick, injured or dead specimen of a coho salmon or eulachon is found in the action area, the Renewal Corporation shall notify NMFS through the contact person identified in the transmittal letter for this biological opinion, or through the NMFS Office of Law Enforcement at 1-800-853-1964, and follow any instructions. In addition, the Renewal Corporation shall immediately report to NMFS any exceedance of the amount or extent of incidental take described in Section 2.9.1.

If the proposed action may worsen the coho salmon or eulachon's condition before NMFS can be contacted, the finder shall attempt to move the coho salmon or eulachon to a suitable location near the capture site while keeping the coho salmon or eulachon in the water and reducing its stress as much as possible. Do not disturb the coho salmon or eulachon after it has been moved. If the coho salmon or eulachon is dead, or dies while being captured or moved, the Renewal Corporation shall report the following information: (1) the NMFS consultation number for this opinion; (2) the date, time, and location of discovery; (3) a brief description of circumstances and any information that may show the cause of death; and (4) photographs of the coho salmon or eulachon and where it was found. The Renewal Corporation shall also coordinate with local biologists to recover any tags or other relevant research information. If the specimen is not needed by local biologists for tag recovery or by NMFS for analysis, the specimen shall be returned to the water in which it was found with appropriate marking to ensure that it is not subsequently recounted or otherwise discarded.

The following terms and conditions implement reasonable and prudent measure 2:

e) The Renewal Corporation shall prepare and provide NMFS a summary annual report, by April 1st of each year, addressing the invasive exotic vegetation control program that was conducted the previous calendar year. The report shall detail all the chemicals (herbicides and adjuvants) used in the program, where they were used (e.g., in which former reservoir footprint), how many acres in total treated by which method, and how many acres in total treated within 100 feet of the river or a wetted stream by which method. Any known incidents of exposure of a wetted waterbody or other problem that may have affected aquatic resources shall be documented in the summary report. This report may be combined with the report in term and condition d.

f) The Renewal Corporation shall not allow any broadcast application of dicamba as part of the IEV management program because of its issues associated with drift that can result in an uncontrolled exposure scenario. Spot spraying and hand application uses as proposed in Table C-2 in Appendix C of the FERC (2021a) BA are permissible with the proposed buffers.

g) The biological assessment did not propose buffers between application and aquatic sites for use of the remaining herbicides considered in this consultation (aminopyralid, chlorosulfuron, aminopyralid + chlorosulfuron, and triclopyr TEA). As the risk assessment methodology and results from the BPA HIP consultation (NMFS 2020a) are used in this analysis, the use of these chemicals shall be subject to the same avoidance and minimization measures – 100 foot buffer for broadcast applications, 15 foot buffer for spot spraying, and use up to the waterline for hand applications (wiping, wicking, injection) near waterbodies or ditches containing water. For dry streams, wetlands or ditches, broadcast applications shall be subject to a 50 foot buffer but spot spraying and hand applications may be done without a buffer. Only adjuvants on the May 15, 2017 revised table from the Washington State Department of Agriculture, Pesticide Management Division (WSDA 2017) that have the EPA toxicity classification of "practically non-toxic" to both rainbow trout and daphnids may be used. The Renewal Corporation shall inform NMFS before use of any other adjuvant to determine if reinitiation of consultation is needed.

The following terms and conditions implement reasonable and prudent measure 3:

h) The Renewal Corporation shall convene and consider the recommendations of the ARG frequently during implementation of the action to ensure real-time decision making uses the best available technical information for the protection of listed species and to maximize beneficial effects of the action on listed species to the extent practicable. The Renewal Corporation should convene the ARG at least once prior to reservoir drawdown and quarterly thereafter during the implementation, monitoring, and maintenance periods (as defined in FERC 2021a Appendix C). In addition, the Renewal Corporation shall convene the ARG when monitoring data indicates the amount or extent of incidental take as described above in section 2.9.1 is likely to be or has been exceeded.

The following terms and condition implements reasonable and prudent measure 4:

i) The Renewal Corporation shall perform at least one redd survey in the 5-mile reach downstream of Iron Gate Dam prior to reservoir drawdown to determine whether more than six coho salmon redds are present. If monitoring data are available from existing survey efforts, the Renewal Corporation may use it for the purposes of this term and condition. The Renewal Corporation shall provide information collected from the redd surveys to NMFS prior to drawdown.

2.9.4.2 Southern Resident Killer Whales (SRKWs)

The following terms and conditions implement reasonable and prudent measure 5:

j) The Renewal Corporation shall comply with terms and conditions a, b, c, and d (to the extent term and condition d requires a comparison of the measured or estimated suspended sediment concentrations versus the modeled concentrations for the duration of the measured period) to ensure suspended sediment concentrations are consistent with the SSC thresholds in Section 2.9.1.2.2, Surrogates for Incidental Take.

The following terms and conditions implement reasonable and prudent measure 6:

k) The Renewal Corporation shall annually evaluate the Chinook salmon hatchery production plan, including goals and performance, and provide an annual summary report of the evaluation to NMFS by April 1st of each year, for the previous calendar year, that the hatchery is operational continuing to the end of eight years post dam removal. The Renewal Corporation may utilize the ARG to collect and summarize data as well as make recommendations to the Renewal Corporation, CDFW, and other agencies in regards to future operations of the Chinook salmon hatchery. Data used for the evaluation shall include (but not be limited to):

    - Broodstock collection numbers for Chinook salmon.
    - Annual production achieved in context of the proposed hatchery production plan goals for Chinook salmon during each year of the proposed action. This shall be compared to the minimum hatchery production performance thresholds in Section 2.9.1.2.2 that measure the actual hatchery production of Chinook salmon relative to the hatchery plan goals for Chinook salmon.
    - Information relevant to Chinook salmon survival estimates (e.g., outmigrant trapping, disease infection rates).

l) If the minimum hatchery production performance thresholds in Section 2.9.1.2.2 that measure the actual hatchery production of Chinook salmon relative to the hatchery plan goals for Chinook salmon are not being met, the Renewal Corporation shall convene and coordinate with the ARG to specifically evaluate the cause(s) and recommend actions to remedy low Chinook salmon hatchery production to meet those thresholds. The Renewal Corporation shall submit a summary of the evaluation and the recommended actions to NMFS prior to implementation.

m) Before any changes in the Chinook salmon hatchery plan and goals for Fall Creek Hatchery are implemented, the Renewal Corporation shall develop and submit proposals for any such changes to the ARG for review. Subsequent to ARG review, the Renewal Corporation shall submit the proposals to NMFS prior to implementation. Proposals shall include all available information used to support the need and utility of the changes, such as:

- Updated information on juvenile Chinook salmon survival and disease rates;
- Updated information on Klamath basin-wide Chinook salmon productivity, including the status of repopulation upstream of the former dams;
- Updated information on the recent ocean abundance of Klamath Chinook salmon; and
- Updated information on the contribution of hatchery fish to the population(s) of Klamath Chinook salmon.

n) The Renewal Corporation shall utilize the ARG to gather available data regarding disease rates and other available information about juvenile Chinook salmon survival in the Klamath River. The Renewal Corporation shall prepare an annual summary report of such data and provide the report to NMFS by April 1st each year, for the previous calendar year, during the monitoring and maintenance periods (as defined in FERC 2021a Appendix C) to inform whether Chinook salmon survival meets assumptions described in Section 2.9.1.2.2 regarding the surrogate for incidental take for reductions in hatchery production of Chinook salmon. The Renewal Corporation shall coordinate with NMFS and Reclamation as needed to gain access to S3 modeling results to monitor and report on disease rates.

o) The Renewal Corporation shall utilize the ARG to gather available data as it relates to the access of Chinook salmon to newly available upstream habitat and repopulation of these habitats by Chinook salmon. The Renewal Corporation shall prepare an annual summary report of such data and provide the report to NMFS by April 1st of each year, for the previous calendar year, during the monitoring and maintenance periods (as defined in FERC 2021a Appendix C) to inform whether Chinook salmon survival meets assumptions described in Section 2.9.1.2.2 regarding the surrogate for incidental take for reductions in hatchery production of Chinook salmon. Such data may include that gathered through implementation of the:

i. Fish presence monitoring plan (FERC 2021a Appendix D);
ii. Fish passage barrier monitoring (FERC 2021a Appendix D);
iii. Escapement monitoring from basin-wide partners.

The following terms and conditions implement reasonable and prudent measure 7:

p) Comply with term and condition h.

The following terms and conditions implement reasonable and prudent measure 8:

q) The Renewal Corporation shall monitor the sediment deposition that occurs during drawdown to ensure it does not extend further than the Iron Gate to Willow Creek reach (as described in FERC (2021a) Appendix J). The Renewal Corporation shall use these data to ensure the applicable threshold in Section 2.9.1.2.2 (using the extent of sediment deposition as a surrogate) is not exceeded. If monitoring data are available from existing survey efforts, the Renewal Corporation may use it for the purposes of this term and condition. The Renewal Corporation shall prepare a summary report of such monitoring data and provide it to NMFS by December 31st of the year following reservoir drawdown.

2.9.4.3 General Terms and Conditions

The following terms and conditions implement reasonable and prudent measure 9:

r) FERC shall include in any license surrender order or other authorization for the amended surrender application a condition that makes the order or other authorization subject to the reasonable and prudent Measures and terms and conditions of this Incidental Take Statement.

The following terms and conditions implement reasonable and prudent measure 10:

s) FERC shall include in any license surrender order or other authorization for the amended surrender application a specific condition that authorizes reopening the order or other authorization to incorporate any reasonable and prudent alternatives, reasonable and prudent measures, and terms and conditions resulting from any reinitiated consultation on the authorized action based on circumstances listed in 50 CFR 402.16.

2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, “conservation recommendations” are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

NMFS makes the following recommendations:

2.10.1 Conservation Recommendations for SONCC coho salmon and Southern DPS eulachon

a) The Renewal Corporation should work closely with the NOAA Restoration Center to ensure restoration projects as described in Reservoir Area Management Plan (FERC 2021a Appendix C) are consistent with the terms of this biological opinion and improve coho and Chinook salmon habitat to the maximum extent practicable.

2.10.2 Conservation Recommendations for SRKWs

b) The Renewal Corporation should work with the ARG and/or other partners to evaluate and develop the potential utility of additional information streams and metrics for monitoring the overall survival and production of juvenile Chinook salmon from the Klamath River as available prey for SRKWs in the ocean following dam removal. These could include (but are not limited to) integration of models used to assess the ocean abundance of Klamath River Chinook salmon for harvest management, as well as other in-river data that may be collected by partners through monitoring efforts. These tools could be used to further inform decision-making surrounding progress and execution of the proposed action by the Renewal Corporation, as well as guiding additional actions taken by the States, Tribes, and/or NMFS during and beyond the proposed action in the future to maximize the beneficial impact of the proposed action and promote the recovery of SRKWs.

c) If the thresholds in section 2.9.1.2.2 regarding the surrogate for incidental take for reductions in hatchery production of Chinook salmon are not being met, the Renewal Corporation should convene and coordinate with the ARG to evaluate whether additional years of Chinook salmon hatchery production at Fall Creek Hatchery are necessary and appropriate, in conjunction with other factors being used to measure progress and success of action, including the status of Chinook salmon survival/productivity throughout the Klamath River system. Based on the evaluation, the Renewal Corporation in coordination with the ARG should make any recommendations regarding whether additional years of Chinook salmon hatchery production at Fall Creek Hatchery are necessary and appropriate to the appropriate agencies.

2.11 Reinitiation of Consultation

This concludes formal consultation for surrender and decommissioning of the Lower Klamath Project.

Under 50 CFR 402.16(a): “Reinitiation of consultation is required and shall be requested by the Federal agency or by the Service where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and: (1) If the amount or extent of taking specified in the incidental take statement is exceeded; (2) If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or written concurrence; or (4) If a new species is listed or critical habitat designated that may be affected by the identified action."

2.12 "Not Likely to Adversely Affect"' Determinations

FERC determined that the proposed action is not likely to adversely affect the southern DPS of North American green sturgeon or its critical habitat. Given the limited potential exposure of green sturgeon individuals, and the remote location of designated critical habitat relative to the geographic extent of expected impacts of the proposed action, the increases in turbidity from the proposed action are unlikely to have more than a negligible impact on any green sturgeon individuals, and are not likely to adversely affect any PBFs that comprise green sturgeon critical habitat.

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (50 CFR 402.02). In our analysis, which describes the effects of the proposed action, we considered 50 CFR 402.17(a) and (b). When evaluating whether the proposed action is not likely to adversely affect listed species or critical habitat, NMFS considers whether the effects are expected to be completely beneficial, insignificant, or discountable. Completely beneficial effects are contemporaneous positive effects without any adverse effects to the species or critical habitat. Insignificant effects relate to the size of the impact and should never reach the scale where take occurs. Effects are considered discountable if they are extremely unlikely to occur.

2.12.1 Southern DPS North American Green Sturgeon

The Southern DPS of North American green sturgeon is listed as a threatened species, and includes all green sturgeon originating from the Sacramento River basin and from coastal rivers south of the Eel River (exclusive) (50 CFR 223.102(e)). The only known spawning population is in the Sacramento River (71 FR 17757; April 7, 2006). Sub-adult and adult southern DPS of North American green sturgeon enter coastal bays and estuaries north of San Francisco Bay, CA, during the summer months to forage (Lindley et al. 2008). As such, individuals of the southern DPS of North American green sturgeon's potential occurrence in the lower Klamath River is limited to only the sub-adult and adult life stages, only during summer months, and only in the Klamath River estuary. Potential effects of the proposed action on the southern DPS of North American green sturgeon are related to elevated SSCs. However, the elevated suspended sediment concentration in the Klamath estuary and adjacent shore habitat will occur for approximately three months, and is expected to be minor given the relatively small amount of total sediment input, in comparison to the total annual sediment inputs to the nearshore environment, and given the fact that river plume sediment inputs are a naturally occurring process (DOI and CDFG 2012; Appendix K of FERC 2021a). During the summer foraging period of the drawdown year, monthly median SSC values for the 48-year modeling hydroperiod under the proposed action range from 20 to 496 mg/L, levels higher than under background conditions of 1 to 131 mg/L (FERC 2021a). Because green sturgeon are benthic foragers and rely on their barbels, not sight to find prey, the increased turbidity is not likely to impede their foraging abilities. In addition, sturgeon regularly occupy turbid estuaries (Moser and Lindley 2007), are tolerant of turbid water since they prefer it for spawning (Gessner and Bartel 2000), and are adapted to turbid waters (Perrin et al. 2003). By the summer of Year 2, SSC values at the Klamath Station are expected to be within the range of background conditions. Based on this analysis, the increases in turbidity from the proposed action are unlikely to have more than a negligible, insignificant impact on any Southern DPS green sturgeon individuals exposed to them. Therefore, based on this analysis, NMFS concurs with FERC that the proposed action is not likely to adversely affect the subject listed species.

Southern DPS of North American Green Sturgeon Critical Habitat

In 2009, NMFS designated critical habitat for the southern DPS of North American green sturgeon (74 FR 52300; October 9, 2009). The area identified as critical habitat includes: (1) all U.S. coastal marine waters out to the 60 fathom depth bathymetry line (relative to mean lower low water) from Monterey Bay, California north and east to include waters in the Strait of Juan de Fuca, Washington; (2) the following freshwater riverine areas in California: the Sacramento River, Lower Feather River, and Lower Yuba River; (3) the Sacramento-San Joaquin Delta; and (4) Suisun, San Pablo, San Francisco, and Humboldt bays in California (50 CFR 226.219(a)). The Klamath River and estuary is not designated as critical habitat for southern DPS green sturgeon. The expected effects of the action overlap with only a small portion of the coastal marine area of the designated critical habitat, adjacent to the mouth of the Klamath River. The specific PBFs of coastal marine areas include food resources, water quality, and migratory corridors (50 CFR 226.219(b)(3)). Fine sediment released as part of the proposed action is anticipated to initially deposit on the seafloor shoreward of the 60-meter isobath along the coast, with greater quantities depositing in close proximity to the mouth of the Klamath River (DOI and CDFG 2012). After this initial deposition, resuspension during the typical winter storms will likely occur before final deposition and burial. Much of this sediment will eventually be transported further offshore to the mid-shelf and into deeper water off-shelf through progressive resuspension and fluid-mud gravity flows. This sediment deposition and resuspension may affect benthic food resources of green sturgeon. Food resources in the nearshore environment include crabs, shrimp, clams, annelid worms, and other invertebrates, as well as small fish like anchovies and sand lances (74 FR 52300). Many of these food resources are mobile and will not be affected by sediment deposition. NMFS concurs with FERC's determination that the proposed action is anticipated to have minimal to no effect on critical habitat due to the dilutive effects of the marine environment. Based on NMFS' analysis of the information available, the quantity, quality, or availability of the PBFs of the coastal marine area designated critical habitat are not likely to decline as a result of being exposed to the mobilized sediment or any other stressors associated with the proposed action, and these stressors are not likely to exclude green sturgeon from designated critical habitat. Based on this analysis, NMFS concurs with FERC that the proposed action is not likely to adversely affect designated critical habitat for the southern DPS of North American green sturgeon.

3 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH [CFR 600.905(b)].

This analysis is based, in part, on the EFH assessment provided by the FERC (Appendix K of FERC 2021a) and descriptions of EFH for Pacific Coast groundfish (PFMC2005), coastal pelagic species (CPS) (PFMC 1998), and Pacific Coast salmon (PFMC 2014)) contained in the fishery management plans developed by the PFMC and approved by the Secretary of Commerce.

3.1 Proposed Action

The KRRC, as applicant and having been designated as the non-federal representative of FERC for the license surrender and decommissioning of the Lower Klamath Project, proposes to remove dams and other facilities at four developments on the Klamath River (i.e., Iron Gate, Copco No. 1 and No.2, and J.C. Boyle) as detailed in the FERC BA (FERC 2021a). This will include the complete removal of the dams, power generation facilities, water intake structures, canals, pipelines, ancillary buildings, and dam foundations. The proposed action also includes the restoration of the areas formerly inundated by reservoirs, reconnecting tributary streams to the mainstem, and stabilizing lands disturbed by the dam facilities. The outcome of the proposed action will be that the mainstem Klamath River will have no dams downstream from Keno Dam.

For a more detailed description of the proposed action, please see the Proposed Federal Action section (Section 1.3) of the accompanying biological opinion.

3.2 Essential Fish Habitat Affected by the Project

The action area includes the mainstem tributaries above Upper Klamath Lake to the upstream extent of anadromy, the Klamath River from Iron Gate Dam at RM 193.1 to the Klamath River mouth, up to the 100-year floodplain, and the Pacific Ocean 1.5 miles north, south, and west of the mouth of the Klamath River. This 1.5-mile buffer is a conservative estimate for the distance that sediment mobilized during the proposed action could extend. Therefore, the action area includes areas designated as EFH for various life-history stages of Pacific Coast groundfish, coastal pelagics, and Pacific salmon (PFMC 1999; PFMC 2014; PFMC 2020a; PFMC 2021d).

EFH for Pacific Coast groundfish is defined in PFMC (2020a), and includes the following Designated Habitat Areas of Particular Concern (HAPC): Estuaries, Canopy Kelp, Seagrass, Rocky Reefs, and Areas of Interest. The HAPC for Pacific Coast groundfish that could be adversely affected is Estuaries. EFH for coastal pelagic species is described in PFMC (2021d) and appendices. Although Pacific Coast groundfish and coastal pelagic EFH occurs in the Klamath River estuary and marine environments (PFMC 2020a; PFMC 2021d), the proposed action is expected to have only minimal effects to the physical, chemical, and biological resources in the Klamath River estuary and the marine environment (DOI and CDFG 2012; Appendix K of FERC 2021a). Therefore, this EFH analysis will focus primarily on Pacific salmon EFH, which was described and identified in PFMC (2014), and further described below.

EFH for Chinook salmon and coho salmon are managed under the MSA, under the authority of which EFH for coho salmon and Chinook salmon is described in Amendment 14 to the Pacific Coast Salmon Fishery Management Plan (FMP) (50 CFR 660.412). EFH for coho salmon and Chinook salmon in the Klamath Basin has been designated for the mainstem Klamath River and its tributaries from its mouth to Keno Dam, and upstream to Lewiston Dam on the Trinity River, tributary to the Klamath River. EFH includes the water quality and quantity necessary for successful spawning, fry, and parr habitat for coho salmon and Chinook salmon. HAPC have been identified in Appendix A to the Pacific Coast Salmon FMP (PFMC 2014). HAPC for salmon are: complex channel and floodplain habitat, spawning habitat, thermal refugia, estuaries, and submerged aquatic vegetation.

EFH for, and life history of, managed Pacific salmon species is discussed at length in Appendix A to the Pacific Coast Salmon Fishery Management Plan, as Modified by Amendment 18 to the Pacific Coast Salmon Plan (PFMC 2014), which is summarized here for coho salmon and Chinook salmon with specific life history information for the Klamath River summarized from the attached biological opinion.

3.2.1 Coho Salmon

Coho salmon in the Klamath Basin, including their general life history, are described in Section 2.2.1.1 above, Species Description and General Life History. Coho salmon freshwater EFH consists of four major components related to the species' life cycle: (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and holding habitat.

Freshwater EFH depends on lateral (e.g., floodplain, riparian), vertical (e.g., hyporheic) and longitudinal connectivity to create habitat conditions for spawning, rearing, and migration including: (1) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); (2) water quantity, depth, and velocity; (3) riparian-stream-marine energy exchanges (4) channel gradient and stability; (5) prey availability; (6) cover and habitat complexity (e.g., LWD, pools, aquatic and terrestrial vegetation, etc.); (7) space; (8) habitat connectivity from headwaters to the ocean (e.g., dispersal corridors, floodplain connectivity), (9) groundwater-stream interactions and (10) substrate composition.

3.2.2 Chinook Salmon

Chinook salmon in the Klamath Basin, including their general life history, are described in Section 2.5.2.2.1 above, Background on Klamath River Chinook Salmon. Chinook salmon freshwater essential fish habitat consists of four major components related to the species' life cycle: (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and holding habitat. Freshwater EFH depends on lateral (e.g., floodplain, riparian), vertical (e.g., hyporheic) and longitudinal connectivity to create habitat conditions for spawning, rearing, and migration including: (1) water quality (e.g., dissolved oxygen, nutrients, temperature, etc.); (2) water quantity, depth, and velocity; (3) riparian-stream-marine energy exchanges; (4) channel gradient and stability; (5) prey availability; (6) cover and habitat complexity (e.g., LWD, pools, aquatic and terrestrial vegetation, etc.); (7) space; (8) habitat connectivity from headwaters to the ocean (e.g., dispersal corridors); (9) groundwater-stream interactions; and (10) substrate composition.

3.3 Adverse Effects on Essential Fish Habitat

Based on information provided in the BA (FERC 2021a) and the analysis of effects presented in the accompanying biological opinion, NMFS concludes that proposed action will have the following adverse effects on EFH designated for Pacific Coast groundfish, coastal pelagics and Pacific salmon.

3.3.1 Pacific Salmon Essential Fish Habitat

Essential fish habitat for Chinook salmon and coho salmon in the action area includes the water quality and quantity necessary for successful adult migration and holding, spawning, egg-to-fry survival, and juvenile rearing and migration. Though some differences exist, the effects of the proposed action to Chinook salmon habitat and coho salmon habitat are similar. Although Chinook salmon are expected to migrate farther above Iron Gate once the facilities are removed than are coho salmon, EFH for both species ends at Keno Dam (RM 139.2), which is only 5.8 RM above the mouth of Spencer Creek (RM 233.4), which is anticipated to be the upstream extent of coho salmon habitat post dam removal. Thus, the effects to coho salmon habitat described in the accompanying biological opinion are similar to those listed below for EFH.

As described in the biological opinion above, water quality models predict the adverse effects will occur for approximately two years after the four Lower Klamath Project facilities are removed, especially near the Iron Gate Dam site. The proposed action will have the following adverse effects on EFH designated for Pacific salmon.

3.3.1.1 Adult and Juvenile Migration Habitat

SSCs in the mainstem Klamath River will be high enough, and dissolved oxygen levels will be low enough, to cause mortality of juvenile salmonids, and major physiological stress and impaired homing or delayed migration for adults in the fall of the year of reservoir drawdown, and immediately following removal of the dams in Year 1. However, the proposed action will also restore coho salmon migratory access to at least 76 miles of additional habitat upstream of the Iron Gate Dam site, and even farther for Chinook salmon, extending beyond the upstream extent of designated EFH (DOI and CDFG 2012; Appendix K of FERC 2021a).

Most natural origin smolts outmigrate to the mainstem Klamath during April and May (Wallace 2004). Under the proposed action, SSCs will be higher and dissolved oxygen levels will be lower during spring than under existing conditions, thereby reducing the quality of salmon smolt migration habitat in the short term.

Short term sediment wedges may be deposited during reservoir drawdown and immediately after dam removal. If these deposits occur at the mouth of tributaries, adult and juvenile migration could be impeded. However, fish passage maintenance and monitoring actions are expected to minimize the development and duration of depositional barriers to migration.

Herbicide applications in the areas of the former reservoir footprints will take place up to three years after reservoir drawdown during the late fall through early spring period. BMPs will be utilized to minimize or prevent exposure to EFH, but they do not eliminate the risk for the proposed action and we assume herbicides and associated adjuvants reaching surface waters may result in impacts in near shore areas that are used as migratory habitat. Potential impacts are detailed in Section 2.5.1.1.11, Herbicide Application. The infrequency of the applications and implementation of the BMPs will likely result in only short term and transient impacts to the near shore areas immediately adjacent to the application sites and not affect the long term quality of the EFH.

In the long term, the return to a more natural hydrologic regime is expected to result in river flows that are either the same or higher than the current condition for the months of March through July. The higher spring flows correspond to the smolt life history stage, appropriately cuing fish to start their outmigration at times that improve their rate of success in reaching the ocean.

3.3.1.2 Spawning and Incubation Habitat

Short-term impacts to spawning sites are expected to occur during the first two years of the proposed action. During the year of reservoir drawdown, fine materials will be deposited immediately downstream of Iron Gate Dam, destroying spawning sites. Following the final Iron Gate cofferdam breach and with increasing streamflow in the fall and winter of the year following reservoir drawdown, bedload movement may affect spawning sites between the former Iron Gate Dam site and Willow Creek (approximately 5 river miles downstream). As described in the Effects to Chinook Salmon section above, this could impact up to 8% of natural Chinook salmon redds in the Klamath basin. This cycling of bedload material from the former reservoir footprint into the depositional reach may persist for multiple years until a new channel equilibrium is reached.

In their BA, FERC (2021a) describes changes to substrate due to sediment deposition associated with reservoir drawdown, dam removal, and bedload transport. The impacts to mainstem spawning sites are expected to be negligible two years after drawdown. Only the reach (less than 0.5 mi in length) immediately downstream of Iron Gate Dam, extending to the mouth of Bogus Creek, is expected to have a moderate increase in sand content at the end of two years. However, spawning habitat in this reach is currently impaired. Bedload trapping by dams in the Hydroelectric Reach and winnowing of gravels downstream of Iron Gate Dam have resulted in a coarse, armored channel bed that is unsuitable for spawning salmonids. The lack of loose spawning gravel is especially critical downstream of Iron Gate Dam (Reclamation 2011b).

Short-term impacts to spawning sites are expected to occur during the first year only due to low dissolved oxygen levels when accumulated, detrital algal matter is mobilized during the reservoir drawdown process. Impacts to EFH from this stressor will co-occur with the sediment movement and deposition impacts noted above.

Herbicide applications in the areas of the former reservoir footprints will take place up to three years after reservoir drawdown during the late fall through early spring period. BMPs will be utilized to minimize or prevent exposure to EFH, but they do not eliminate the risk for the proposed action and we assume herbicides and associated adjuvants reaching surface waters may result in impacts in near shore areas that may be used as spawning and incubation habitat. However, it is unknown if these newly accessible former reservoir areas will be used for spawning during that period. Potential impacts are detailed in Section 2.5.1.1.11, Herbicide Application. The infrequency of the applications and BMPs will likely result in only short term and transient impacts to the near shore areas immediately adjacent to the application sites and not affect the long term quality of the EFH.

In the long term (≥ 2 years) spawning gravel availability downstream of Iron Gate Dam is expected to improve by reducing median substrate size to a more favorable size for spawning (DOI and CDFG 2012; Appendix K of FERC 2021a). The release of sediment from behind the dams will help create more natural substrate characteristics in the Hydroelectric Reach and increase the number of spawning sites available for coho and Chinook salmon relative to current conditions. Long-term benefits include increased natural flows and improved temperature regimes, and uninterrupted sediment supply downstream of Keno Dam. While there will be short-term, negative effects to spawning habitat, the long term effects to this essential fish habitat will be beneficial.

3.3.1.3 Rearing Habitat

The primary effects to rearing habitat will result from the sediment release downstream of Iron Gate Dam during drawdown. The release of sediment will result in elevated SSCs and associated decreased dissolved oxygen in the water column. Additionally, coarse sediment deposition is expected to degrade rearing habitat immediately downstream of Iron Gate Dam for an approximate 5-mile reach. Not only will the deposition of fine sediment impact pool availability, but it will reduce food resources in the form of benthic macroinvertebrates (FERC 2021a).

A small portion of the juvenile coho salmon use the mainstem to rear and will be impacted by water quality in the form of elevated SSCs and low dissolved oxygen. These water quality impacts will be most elevated closest to Iron Gate Dam and become less concentrated moving downstream as indicated by the sediment transport model (FERC 2021a). Although less severe downstream, these impacts will affect the entire mainstem Klamath River, downstream of Iron Gate Dam. Therefore, NMFS expects a temporary (< 2 years) reduction in quality of mainstem rearing habitat.

While specific changes are not entirely predictable, bedload transport modeling predicted a reduction in pool quantity and quality for the 5 mile reach downstream of Iron Gate Dam (FERC 2021a). An average of approximately 2.5 to 5 ft. of deposition of fine and coarse sediment will occur on the mainstem reach between the Iron Gate Dam site and Bogus Creek (0.5 mile long reach), decreasing to 1.0 to 1.5 ft. of deposition between Bogus Creek and Willow Creek (4.5 mile long reach). Reaches downstream of Willow Creek are expected to have less than 0.5 feet of reach-averaged bed elevation change (Reclamation 2011b). However, because the reach immediately downstream of Iron Gate Dam has had limited sediment supply, the coarse sediment deposition may increase habitat complexity in this reach (Kondolf et al. 2014). The loss of some pool quantity and quality in the reach between Iron Gate Dam site and Willow Creek represents a small and short-term reduction in the rearing habitat. This reach represents less than 3 percent of the total channel length of the mainstem Klamath River downstream of Iron Gate Dam (193.1 miles).

Food resources are also expected to be adversely impacted which would, in turn, reduce the quality of rearing habitat in the mainstem where juveniles may be feeding. Under the proposed action, increased SSCs are expected to affect benthic macroinvertebrate (BMI) production in the short term (FERC 2021a). The high concentrations of suspended sediments and low DO that occurs in the winter during drawdown will occur during the dormancy period of macroinvertebrates. However, elevated SSCs and low DO in the spring and summer are expected to cause physiological stress, reduced growth, and mortality to BMIs. Elevated SSCs could impact BMI as far downstream as Orleans, approximately 134 miles downstream of Iron Gate Dam (FERC 2021a). During summer of the drawdown year, high SSCs associated with cofferdam breaching activities and drawdown completion will be expected to impact macroinvertebrates during the peak of their feeding and reproductive period. Recolonization of affected BMI populations will occur relatively quickly (within weeks or months) due to the short life cycle of BMIs and rapid dispersal through drift and/or the flying stages of many BMI adults. In addition, repopulation is expected to occur rapidly through drift or dispersal of adult life stages from established BMI populations in the many tributaries to the Klamath River (FERC 2021a).

A more natural sediment transport regime will return to the reaches downstream of the Iron Gate Dam site (Hamilton et al. 2011; Reclamation 2011b; DOI and CDFG 2012), which will increase complexity in the channel bed, including pool formation, to increase rearing habitat. Depending on flow volume and velocity, the affected channel could develop a new scour pattern, and create new pools or deepen partially buried pools as soon as the winter following dam removal if flows are high. Additionally, the removal of dams will increase drift of food resources from upstream reaches, increasing prey availability in the long term.

Herbicide applications in the areas of the former reservoir footprints will take place up to three years after reservoir drawdown during the late fall through early spring period. BMPs will be utilized to minimize or prevent exposure to EFH, but they do not eliminate the risk for the proposed action and we assume herbicides and associated adjuvants reaching surface waters may result in impacts in near shore areas that are used as rearing habitat. Potential impacts are detailed in Section 2.5.1.1.11. The infrequency of the applications and BMPs will likely result in only short term and transient impacts to the near shore areas immediately adjacent to the application sites and not affect the long term quality of the EFH.

3.3.2 Pacific Coast Groundfish Essential Fish Habitat

The proposed action will have a small and temporary adverse effect on Pacific coast groundfish EFH from the elevated suspended sediment. The sediment plume is anticipated to rapidly dilute once it reaches and expands through the ocean (FERC 2021a). The elevated suspended sediment concentration in the Klamath estuary and adjacent shore habitat will occur for approximately three months, and is expected to be minor given the relatively small amount of total sediment input, in comparison to the total annual sediment inputs to the nearshore environment, and given the fact that river plume sediment inputs are a naturally occurring process (DOI and CDFG 2012; Appendix K of FERC 2021a). Long term effects are likely not adverse for Pacific coast groundfish EFH.

3.3.3 Coastal Pelagic Species

The proposed action will have a small and temporary adverse effect on Pacific coast groundfish EFH from the elevated suspended sediment. The elevated suspended sediment concentration in the Klamath estuary and adjacent shore habitat will occur for approximately three months, and is expected to be minor given the relatively small amount of total sediment input, in comparison to the total annual sediment inputs to the nearshore environment, and given the fact that river plume sediment inputs are a naturally occurring process (DOI and CDFG 2012; Appendix K of FERC 2021a). Long term effects are likely not adverse for Pacific coast groundfish EFH.

3.4 Essential Fish Habitat Conservation Recommendations

Although there are expected to be short term adverse effects associated with the proposed action, the quality of EFH will be enhanced over the long term, and the proposed action already contains a number of conservation/minimization measures. These measures, which are discussed in detail in Section 1.3.7, Conservation, Avoidance, and Minimization measures, include actions designed to minimize impacts to: (1) adult passage and spawning habitat (e.g., measures included in the Spawning Habitat Availability Report and Plan), (2) juvenile outmigration (e.g., aquatic resource measures), (3) water quality (e.g., as described in the Erosion and Sediment Control Plan), and (4) the restored reservoir footprints (e.g., the Reservoir Area Management Plan). These activities all include in-water work BMPs. These measures are designed to avoid or minimize short term adverse effects on aquatic species and habitat. Thus, NMFS provides no conservation recommendations.

3.5 Supplemental Consultation

FERC must reinitiate EFH consultation with NMFS if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for NMFS' EFH Conservation Recommendations [50 CFR 600.920(l)].

4 DATA QUALITY ACT DOCUMENTATION AND PRE-DISSEMINATION REVIEW

The Data Quality Act (DQA) specifies three components contributing to the quality of a document. They are utility, integrity, and objectivity. This section of the opinion addresses these DQA components, documents compliance with the DQA, and certifies that this opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended user of this opinion is FERC. Other interested users could include the KRRC. Individual copies of this opinion were provided to FERC. The document will be available within 2 weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR part 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

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