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

March 29, 2019

Refer to NMFS Nos: WCR-2019-11512
WCRO-2019-00113

Jeffrey Nettleton
Area Manager, Klamath Basin Area Office
Bureau of Reclamation
6600 Washburn Way
Klamath Falls, Oregon 97603-9365

Re: Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for Klamath Project Operations from April 1, 2019 through March 31, 2024

Dear Mr. Nettleton:

Thank you for your letter of December 21, 2018, providing the U.S. Bureau of Reclamation's biological assessment in connection with the reinitiated 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 Klamath Project Operations from April 1, 2019 through March 31, 2024, as revised and clarified by subsequent letters.

Thank you, also, for your request for consultation pursuant to the essential fish habitat (EFH) provisions in Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1855(b)) for this action.

This letter transmits NMFS' final biological opinion and EFH consultation pertaining to the proposed action. This biological opinion is based on information provided and considered throughout the reinitiated consultation, including the Bureau of Reclamation's December 21, 2018 transmittal letter and biological assessment, as revised and clarified by subsequent letters; discussions between NMFS and Reclamation 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), or the Southern Resident Killer Whale Distinct Population Segment (DPS) (Southern Residents), or destroy or adversely modify designated critical habitat for the SONCC coho salmon ESU. Critical habitat for Southern Residents is outside of the action area. However, NMFS anticipates non-jeopardizing incidental take of SONCC coho salmon and Southern Residents. An incidental take statement with non-discretionary terms and conditions is included with the enclosed biological opinion. Separately, NMFS concurs with the Bureau of Reclamation's determination that the proposed action is not likely to adversely affect Southern

DPS green sturgeon, Southern DPS eulachon, or designated critical habitat for Southern DPS eulachon, thereby concluding informal consultation for these species.

The enclosure includes an EFH consultation that was prepared pursuant to section 305(b) of the Magnuson- Stevens Fishery Conservation and Management Act. The action area includes areas designated as EFH for various life-history stages of Pacific Coast groundfish, coastal pelagics, and Pacific salmon. Based on our analysis, NMFS concludes that the project would adversely affect EFH for Pacific salmon, but is not expected to adversely affect Pacific Coast groundfish or coastal pelagic EFH. We have included a description of our EFH analysis, including EFH conservation recommendations, in Section 3 of the enclosed document.

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: Copy to ARN File # 151422WCR2019AR00036

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

Klamath Project Operations from April 1, 2019 through March 31, 2024

NMFS Consultation Number: WCR-2019-11512, WCRO-2019-00113

Action Agency: U.S. Bureau of Reclamation

Table 1. 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 green sturgeon (*Acipenser medirostris*)	Threatened	No	No	N/A	N/A
Southern DPS eulachon (*Thaleichthys pacificus*)	Threatened	No	No	No	No
Southern Resident DPS Killer Whale (*Orcinus orca*)	Endangered	Yes	No	N/A	N/A

Table 2. 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	Yes
Pacific Coast groundfish	No	No
Pacific Coast pelagics	No	No

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

Issued By:

Alecia Van Atta
Assistant Regional Administrator
California Coastal Office

Date: March 29, 2019

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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 USC 1531 et seq.), and implementing regulations at 50 CFR 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 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). A complete record of this consultation is on file at the NMFS' Northern California office in Arcata, California. Copies of this document may be requested by calling the NMFS' Klamath Branch Supervisor, Jim Simondet (707-825-5171). The document will also be available through the NOAA Institutional Repository (https://repository.library. noaa.gov/), after approximately two weeks.

This Opinion and determinations are based on information provided in the U.S. Bureau of Reclamation's[1] (Reclamation, USBR) Final Biological Assessment (BA) (USBR 2018a), Reclamation's amended BA (USBR 2019a), and other sources of the best scientific and commercial data available.

The Klamath Basin's hydrologic system currently consists of a complex of interconnected rivers, canals, lakes, marshes, dams, diversions, wildlife refuges, and wilderness areas. Alterations to the natural hydrologic system began in the late 1800s and expanded in the early 1900s, including water diversions by private water users, Reclamation's Project, and several hydroelectric dams operated by a private company, currently known as PacifiCorp.

PacifiCorp's Klamath Hydroelectric Project (KHP) was constructed between 1911 and 1962, and includes multiple power facilities and a network of dams and reservoirs. PacifiCorp operated the KHP under a 50-year license issued by the Federal Energy Regulatory Commission (FERC) until the license expired in 2006. PacifiCorp continues to operate the KHP under annual licenses based on the terms of the previous license. On September 23, 2016, PacifiCorp and the Klamath River Renewal Corporation (KRRC) submitted an application to FERC to amend the existing license for the KHP, establish an original license for the Lower Klamath Project consisting of four developments, and transfer the original license for the Lower Klamath Project to the KRRC. At that time, the KRRC also applied to surrender the license for the Lower Klamath Project,

[1] U.S. Bureau of Reclamation is referred to as Reclamation in text and USBR in references and citations hereinafter.

including removal of the four developments. On October 5, 2017, FERC issued notice of the application for amendment and transfer of the license and soliciting comments, motions to intervene, and protests. However, FERC indicated that it was not requesting comments at that time on the surrender application, and it will issue a notice requesting comments, protests and motions to intervene on the surrender application after receiving a supplemental filing regarding a decommissioning plan. FERC still has not issued such a notice on the surrender application yet. According to a Definite Plan that the KRRC submitted to FERC on June 28, 2018, decommissioning of the four developments is expected to commence on January 1, 2021. However, FERC has not yet submitted a biological assessment or requested initiation of formal consultation under Endangered Species Act section 7 with NMFS on any federal action that it would take to decide whether to approve decommissioning of the four developments. Therefore, the effects of FERC's action deciding whether to decommission the four developments is not part of the Environmental Baseline considered with this opinion (*see* the definition of "Effects of the action" in 50 CFR 402.02 ("The environmental baseline includes … the anticipated impacts of all proposed federal projects in the action area that have already undergone formal or early section 7 consultation ….")). However, this information about the proposed dam removal and related settlement efforts is relevant as part of the overall context of this consultation, including the five-year period of the proposed action (see USBR 2018a, Section 3.7.1 for details about dam removal and associated implications for this proposed action). In addition, 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 (IGD) to what the flow requirements would need to be as measured at Keno Dam to ensure consistency with this Opinion prior to decommissioning (USBR 2018a).

Federally-listed species that fall under the jurisdiction of the U.S. Fish and Wildlife Service (USFWS) that are also affected by Reclamation's proposed action include Lost River sucker (*Deltistes luxatus*, LRS) and shortnose sucker (*Chasmistes brevirostris*; SNS), which were both listed as endangered on July 18, 1988 and have designated critical habitat. USFWS is preparing a separate, but coordinated, opinion regarding the effects of the Project on these species.

NMFS listed the Southern Oregon/Northern California Coastal (SONCC) coho salmon on May 6, 1997. Between the late 1990's and 2010, NMFS and USFWS (collectively, the Services) completed a series of separate Opinions on the effects of Klamath Project operations on these listed species and designated critical habitat. Following USFWS's (2008) Opinion and NMFS' (2010a) jeopardy Opinion, Reclamation and the Services agreed that the conflicting provisions of the Services' Opinions complicated Reclamation's ability to meet the needs of ESA-listed species and critical habitat and meet the demands of the Klamath Project. Consequently, Reclamation formally reinitiated consultation in December 2012 and the Services elected to coordinate their Opinions on Project operations. The objective was to collaboratively develop a proposed action that would allow Reclamation to meet the needs of ESA-listed species and critical habitat under jurisdiction of both Services while operating the Project to store, divert, and convey water to meet authorized Project purposes and contractual obligations in compliance with applicable state and federal law in a coordinated manner. The final product, *Biological Opinions on the Effects of Proposed Klamath Project Operations from May 31, 2013, through March 31, 2024, on five Federally Listed Threatened and Endangered Species* was issued on May 31, 2013

(NMFS and USFWS 2013). More details on the specific consultations completed prior to 2013 and the associated litigation are provided in Reclamation's BA (USBR 2018a) and the 2013 coordinated opinions (NMFS and USFWS 2013).

1.2 Consultation History

On May 9, 2013, Reclamation sent a letter to NMFS documenting the mutual agreement between the agencies to extend the consultation period to complete the ESA section 7 consultation on the Southern Resident Killer Whale DPS (Southern Residents) for a period of one year and Reclamation's intention to request EFH consultation associated with proposed Klamath Project operations under the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (USBR 2013a).

On May 20, 2013, NMFS sent Reclamation a letter confirming the extension of Southern Resident ESA section 7 consultation and the intent to consult on the effects of project operations on EFH as described in Reclamation's May 9, 2013, letter (NMFS 2013).

On July 17, 2015, Reclamation sent NMFS a letter regarding modification, amendment clarification, and/or reinitiation of formal consultation on Klamath Project operations due to unprecedented, multi-year drought conditions that had persisted during implementation of the proposed action analyzed in the 2013 joint Opinion. The letter also addressed the need to complete the EFH consultation and ESA section 7 consultation on Southern Residents (USBR 2015).

On March 29, 2016, NMFS responded to Reclamation's July 17, 2015, letter notifying Reclamation that NMFS determined that the Chinook salmon *Ceratonova shasta (C. shasta)* infection rates used in the ITS of the NMFS' (2013) Opinion as a surrogate for the extent of incidental take of listed SONCC coho salmon from increased disease risk were exceeded in 2014 and 2015. NMFS also notified Reclamation of NMFS' intention to revise the 2013 Opinion ITS based on new information related to environmental variability that coho salmon experienced in the Klamath River in 2014 and 2015 and the impending availability of the Stream Salmonid Simulator (S3) model (NMFS 2016a).

Subsequently, several plaintiffs, including the Yurok and Hoopa Valley Tribes, filed complaints in the United States District Court for the Northern District of California against NMFS and Reclamation alleging, among other things, that NMFS and Reclamation failed to reinitiate formal consultation after the amount and extent of incidental take in NMFS' (2013) ITS were exceeded in 2014 and 2015 (Case No. 3:16-cv-06863 and Case No. 3:16-cv-04294).

On January 4, 2017, Reclamation sent a letter to NMFS clarifying that Reclamation had reinitiated formal consultation with NMFS and USFWS on the effects of the Klamath Project to address the exceedance of take associated with coho salmon disease infection rates that occurred during 2014 and 2015 pursuant to 50 CFR 402.14(i)(4) and 402.16. Reclamation stated in the letter that this consultation process was initiated in 2016 after Reclamation received the March 29, 2016, letter from NMFS (USBR 2017a).

On January 18, 2017, NMFS sent a letter to Reclamation confirming Reclamation's January 4, 2017, letter. In addition, NMFS clarified that, as a result of new information received since NMFS' March 29, 2016, letter, NMFS would conduct a new effects analysis and issue a new Opinion to Reclamation on the effects of the Klamath Project on SONCC coho salmon. Furthermore, NMFS and Reclamation had coordinated on a timeline to complete EFH consultation (NMFS 2017a).

The Federal district court granted the plaintiffs' motions for partial summary judgment on their failure to reinitiate consultation claims and issued an order for injunctive relief on February 8, 2017.[2] The court modified that order on March 24, 2017.[3] The court order required Reclamation to implement two types of flows until reinitiated consultation was completed: (1) winter-spring flushing flows designed to dislodge and flush out polychaete worms that host *C. shasta* and (2) emergency dilution flows (see *Environmental Baseline Section* (Section 2.2.3) for more details regarding the exceedance of incidental take and litigation).

On April 10, 2017, Reclamation provided the EFH assessment on the continued operations of the Klamath Project and requested initiation of EFH consultation under the MSA (USBR 2017b).

On June 8, 2017, NMFS responded to Reclamation's April 10, 2017, letter providing Reclamation with NMFS' MSA EFH Response. NMFS agreed with Reclamation's conclusion that the proposed operation of the Klamath Project would have adverse effects to Pacific Salmon EFH and provided Reclamation with EFH Conservation Recommendations in Section 1.4 of the MSA EFH Response (NMFS 2017b).

On July 7, 2017, Reclamation responded to NMFS' EFH Conservation Recommendation and committed to implement the three conservation recommendations that NMFS believes are necessary to avoid, mitigate or offset the impact of the proposed action on EFH to the greatest extent practicable (USBR 2017c).

This Opinion is the culmination of a multi-year collaborative effort among Reclamation, USFWS, and NMFS to develop a new proposed action for ongoing operations of the Project. A team of Federal resource managers was convened to establish an Agency Coordination Team (ACT). The ACT consists of hydrologists, biologists, managers from each agency, and support staff that met many times starting in January 2017 to develop a new proposed action that would address issues identified in the 2013 Opinion (Table 3). Reclamation also engaged in a process to include tribes and key stakeholders in the development process and a number of meetings were held and opportunities to provide feedback on draft documents were provided (Table 3).

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[2] *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 preliminary and issuing 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 preliminary and issuing injunction).*

[3] *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 (N.D. Cal. March 24, 2017), at 1 (order modifying injunction).

Table 3. Chronology of Agency Coordination Team meetings for development of Reclamation's proposed action.

Meeting Type	Date Held	Location
Reclamation and the Services Meetings and Work Sessions		
ACT	1/31/2017	webinar/teleconference
ACT	2/15/2017	Ashland, OR
ACT	4/5/2017	Ashland, OR
ACT	5/24/2017	webinar/teleconference
ACT	6/12/2017	webinar/teleconference
ACT	7/6/2017	webinar/teleconference
ACT	7/12/2017	webinar/teleconference
ACT	8/1/2017	webinar/teleconference
ACT	8/22/2017	Medford, OR
ACT	9/27/2017	Klamath Falls, OR
ACT	10/20/2017	webinar/teleconference
ACT	11/30/2017	webinar/teleconference
ACT	12/14/2017	webinar/teleconference
ACT	2/20/2017	webinar/teleconference
ACT	4/17/2018	webinar/teleconference
ACT	5/15/2018	Grants Pass, OR
ACT	6/22/2018	webinar/teleconference
ACT	7/25/2018	webinar/teleconference
ACT	8/7/2018	webinar/teleconference
ACT	8/23/2018	webinar/teleconference
ACT	9/21/2018	Selma, OR
ACT	10/24/2018	webinar/teleconference
ACT	11/27/2018	webinar/teleconference
Tri-Agency Hydro Team	10/11/2017	webinar/teleconference
Tri-Agency Hydro Team	11/2/2017	webinar/teleconference
Tri-Agency Hydro Team	11/30/2017	webinar/teleconference
Tri-Agency Hydro Team	12/4/2017	webinar/teleconference
Tri-Agency Hydro Team	12/12/2017	webinar/teleconference
Tri-Agency Hydro Team	1/11/2018	webinar/teleconference
Tri-Agency Hydro Team	1/29/2018	webinar/teleconference

Meeting Type	Date Held	Location
Tri-Agency Hydro Team	2/5/2018	Ashland, OR
Tri-Agency Hydro Team	2/21/2018	webinar/teleconference
Tri-Agency Hydro Team	4/17/2018	webinar/teleconference
Tri-Agency Hydro Team	4/24/2018	Ashland, OR
Tri-Agency Hydro Team	4/25/2018	Ashland, OR
Tri-Agency Hydro Team	5/14/2018	webinar/teleconference
Tri-Agency Hydro Team	6/8/2018	webinar/teleconference
Tri-Agency Hydro Team	6/21/2018	Klamath Falls, OR
Tri-Agency Hydro Team	7/11/2018	webinar/teleconference
Tri-Agency Hydro Team	7/16/2018	webinar/teleconference
Tri-Agency Hydro Team	7/24/2018	webinar/teleconference
Tri-Agency Hydro Team	8/6/2018	Klamath Falls, OR
Tri-Agency Hydro Team	8/16/2018	Klamath Falls, OR
Tri-Agency Hydro Team	8/22/2018	webinar/teleconference
Tri-Agency Hydro Team	8/28/2018	Klamath Falls, OR
Tri-Agency Hydro Team	8/29/2018	Klamath Falls, OR
Tri-Agency Hydro Team	8/30/2018	Klamath Falls, OR
Tri-Agency Hydro Team	9/11/2018	Klamath Falls, OR
Tri-Agency Hydro Team	9/12/2018	Klamath Falls, OR
Tri-Agency Hydro Team	9/19/2018	webinar/teleconference
Tri-Agency Hydro Team	9/24/2018	webinar/teleconference
Tri-Agency Hydro Team	10/3/2018	webinar/teleconference
Tri-Agency Hydro Team	10/4/2018	webinar/teleconference
Tri-Agency Hydro Team	10/11/2018	webinar/teleconference
Tri-Agency Hydro Team	10/25/2018	webinar/teleconference
Tri-Agency Bio Team	8/15/2017	Teleconference
Tri-Agency Bio Team	11/1/2017	Teleconference
Tri-Agency Bio Team	6/18/2018	Teleconference
Tri-Agency Bio Team	6/20/2018	Teleconference
Tribal and Key Stakeholder Workshops and Meetings		
Tribal and Key Stakeholder Policy Workshop	7/24/2017	Klamath Falls, OR
Tribal and Key Stakeholder Policy Workshop	7/25/2017	Klamath Falls, OR
Tribal and Key Stakeholder Policy Workshop	9/27/2017	Klamath Falls, OR

Meeting Type	Date Held	Location
Tribal and Key Stakeholder Policy Workshop	12/5/2017	webinar/teleconference
Tribal and Key Stakeholder Policy Workshop in the Morning with Individual Tribal and Key Stakeholder Meetings in the Afternoon	11/13/18	Klamath Falls, OR
Tribal and Key Stakeholder Technical Team (Hydro Members only)	10/17/2017	webinar/teleconference
Tribal and Key Stakeholder Technical Team	11/13/2017	Klamath Falls, OR
Tribal and Key Stakeholder Technical Team	12/15/2017	webinar/teleconference
Tribal and Key Stakeholder Technical Team	1/9/2018	Redding, CA
Tribal and Key Stakeholder Technical Team	2/6/2018	Ashland, OR
Tribal and Key Stakeholder Technical Team	11/8/18 and 11/9/18	webinar/teleconference

On December 5, 2018, the Yurok Tribe sent a letter (Yurok Tribe 2018a) to Reclamation and USFWS expressing the Tribe's concerns with Reclamation's proposed action, and requesting a meeting with the federal consulting agencies to discuss the proposed action.

On December 10, 2018, NMFS received an email (Tucker 2018) from C. Tucker, Karuk Tribe, on behalf of the Karuk, Hoopa Valley and Yurok Tribe, requesting a meeting to discuss the development of the proposed action.

On December 18, 2018, NMFS held a technical meeting in Arcata CA, with members of the Hoopa Valley, Karuk, and Yurok tribes to discuss the proposed action.

On December 21, 2018, Reclamation sent its biological assessment to NMFS pursuant to section 7(a)(2) of the ESA. Due to a lapse in Fiscal Year 2019 appropriations and no continuing resolution for the Department of Commerce, NMFS personnel assigned to ESA section 7 consultation on this project were furloughed effective December 22, 2018, until a continuing resolution was enacted on January 25, 2019, and assigned NMFS personnel were authorized to return to work. On February 15, 2019, Reclamation provided NMFS an addendum to the proposed action included in the Final BA (USBR 2019a) that includes modifications to, and clarifications of, components of the proposed action. The modifications and clarifications include revising the proposed action to augment May and June IGD flows with an additional 20,000 AF in years of concern for juvenile[4] coho salmon habitat and modifying the period of the proposed action from ten years to five years given the potential removal of four of PacifiCorp's hydroelectric developments on the Klamath River beginning on January 1, 2021 (USBR 2019a).

[4] Throughout this Opinion the term "juvenile(s)" is used to refer to all life stages of fish post gravel emergence and pre ocean entry, including fry, parr, and smolts. The term 0+ refers to fry and parr, and 1+ refers to smolts and fish transitioning from parr to smolt.

On January 31, 2019, the Hoopa Valley Tribe sent a letter (Hoopa Valley Tribe 2019) to NMFS and USFWS expressing concerns with the proposed action and the trajectory of the consultation. In their letter, Hoopa Valley Tribe requested a government to government meeting to discuss their concerns.

In response to the Hoopa Valley Tribe's request for government to government consultation, NMFS and USFWS met with the Hoopa Valley Tribe in Portland OR, on March 4, 2019.

On March 18, 2019, NMFS received a March 8, 2019, letter from Reclamation with an attached Addendum 2 to the Bureau of Reclamation's December 21, 2018, *Final Biological Assessment on the effects of the Proposed Action to Operate the Klamath Project from April, 1, 2019 through March 31, 2029 on Federally-Listed Threatened and Endangered Species, as modified on February 15, 2019*: Inclusion of and Request for Essential Fish Habitat Consultation Associated with Klamath Project Operations under the Magnuson-Stevens Fishery Conservation and Management Act (USBR 2019b).

On March 21, 2019, in Arcata CA, NMFS hosted a technical meeting with the Hoopa Valley, Karuk, Quartz Valley, and Yurok tribes to outline the approach and planned contents of this Opinion.

On March 22, 2019, Reclamation hosted, in coordination with NMFS and USFWS, a public meeting in Klamath Falls OR, to update the public on 2019 Klamath Basin water conditions and operational plans. Presentations included current and forecasted hydrologic conditions; outlook for the 2019 water year, including preliminary Klamath Basin project allocations; status of the reinitiated consultation under ESA section 7; and National Environmental Policy Act processes.

On March 25, 2019, NMFS received a letter from Reclamation entitled "Addendum 3 to the Proposed Action (PA) included in the Bureau of Reclamation's December 21, 2018, Final Biological Assessment on the Effects of the Proposed Action to Operate the Klamath Project (Project) from April 1, 2019 through March 31, 2029, on Federally-Listed Threatened and Endangered Species, as modified on February 15, 2019 (modified 2018 BA)" (USBR 2019c). In their letter, Reclamation clarified that the Klamath Basin Planning Model used to develop the proposed action did not account for 7,436 acre-feet (AF) of water (an annual average) assumed for Project irrigation diversions from the Klamath River. Reclamation further clarified that they will monitor actual volumes and ensure that diversions will be deducted from Project Supply, thus resulting in water management consistent with their proposed action. In their letter, Reclamation also clarified the proposed Klamath River Coho Restoration Program will be at a level of $700,000 in each of fiscal years 2019 and 2020, and $500,000 in each of the successive fiscal years beginning with fiscal year 2021 and ending with fiscal year 2024.

1.3 Proposed Federal Action

"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).

For EFH consultation, Federal action means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a Federal Agency (50 CFR 600.910).

"Interrelated actions" are those that are part of a larger action and depend on the larger action for their justification. "Interdependent actions" are those that have no independent utility apart from the action under consideration (50 CFR 402.02). NMFS has determined there are no interdependent or interrelated actions associated with Reclamation's proposed action considered in this Opinion.

Reclamation proposes to continue to operate the Project to store, divert, and convey water to meet authorized Project purposes and contractual obligations in compliance with applicable State and Federal law. Reclamation also proposes to carry out the activities necessary to maintain the Project and ensure its proper long-term functions and operation. The period covered by this proposed action is the signature date of this Opinion through March 31, 2024. Reclamation reduced the term of the proposed action from ten years to five years in an addendum to the proposed action included in the Final BA on February 15, 2019 (USBR 2019a). This 5-year period will provide a bridge between current operations, and operations during and after the expected removal of four PacifiCorp hydroelectric developments (JC Boyle, Copco 1 and 2, and Iron Gate) on the mainstem Klamath River. Currently, dam removal is expected to occur within the duration of this proposed action (beginning January 1, 2021). If dam removal occurs, the point of compliance would need to be shifted upstream from IGD to Keno Dam. Reclamation and the Services will need to identify appropriate releases at Keno Dam that would provide flows in the Iron Gate reach consistent with NMFS' expectations under the proposed action. This process would include close coordination with the Services to ensure that the compliance point shift would not result in effects outside those analyzed in the Opinions or consultation is reinitiated if necessary (see USBR 2018a, Section 3.7.1 for details about dam removal and associated implications for this proposed action).

Reclamation's Project in the Klamath Basin's hydrologic system consists of a complex network of storage and conveyance features including reservoirs, lakes, dams, diversion dams, canals, and drains (Figure 1). Major Project facilities include the A canal; Link River Dam (LRD); the Lost River Diversion Channel (LRDC) and Wilson Dam; North and Ady canals; and the Klamath Straits Drain (KSD). Area A1 includes Project lands served by A Canal and the LRDC including Klamath Irrigation District (KID), Tulelake Irrigation District (TID), and water supply contracts and Districts served by KID. Area A2 includes Klamath Drainage District (KDD) and the Lower Klamath National Wildlife Refuge (LKNWR) served by the Ady and North canals (Figure 1). Water made available through these facilities is delivered to Project lands through approximately 675 miles of canals and laterals.

Irrigation return flows and local runoff is collected from irrigated lands through approximately 545 miles of drains. In addition to Project facilities, locally and privately-owned irrigation works such as Harpold Dam on the Lost River and the Ady and North canals in the Lower Klamath Lake area, are also are used to divert and convey Project water (Figure 1).

The waters of the Upper Klamath and Lost River watersheds are used for irrigation and related purposes within the Project. Project water is stored in Upper Klamath Lake (UKL), Clear Lake Reservoir, or Gerber Reservoir, or diverted from natural flow in both the Klamath and Lost rivers. Total active storage capacity of the Project's three reservoirs is approximately 1,066,000 acre-feet (AF). Project water is also delivered from various sources to two USFWS National Wildlife Refuges (NWR).

PacifiCorp owns and operates the KHP (see Section 1.1 above for more information about KHP), located on the upper Klamath River in Klamath County in south-central Oregon and Siskiyou County in north-central California (Figure 2). PacifiCorp's operation of the KHP will influence the timing and magnitude of the hydrograph downstream of IGD due to water travel time through the reservoirs and due to facilities operations. IGD is a PacifiCorp facility and Reclamation does not have physical control over the implementation of operations at IGD. However, Reclamation will coordinate with PacifiCorp to ensure that implementation of the proposed action is consistent with this Opinion as required by PacifiCorp's Interim Operation Habitat Conservation Plan for Coho Salmon (HCP) (PacifiCorp 2012b).

The KHP consists of eight developments including: (1) East and (2) West Side power facilities at LRD; (3) Keno Dam; (4) J.C. Boyle Dam; (5) Copco 1 Dam; (6) Copco 2 Dam; (7) Fall Creek Dam; and (8) IGD. Seven of the developments are located on the Klamath River. One of the developments is on Fall Creek, a tributary of the Klamath River that flows into Iron Gate Reservoir (Figure 2). The LRD and UKL are not part of the KHP.

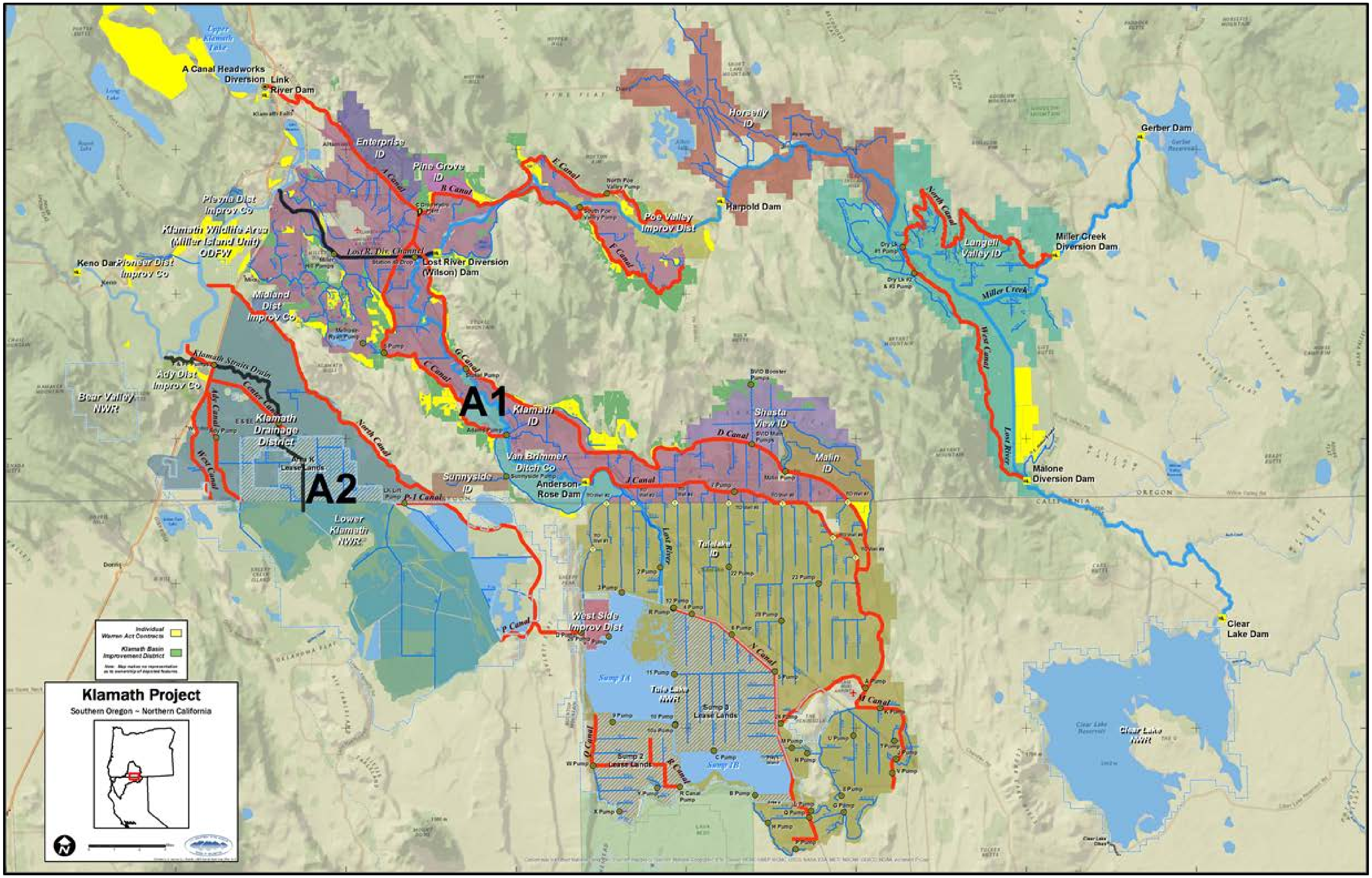

Figure 1. Project location, lands and facilities in the upper Klamath Basin of Oregon and California (USBR 2018a).

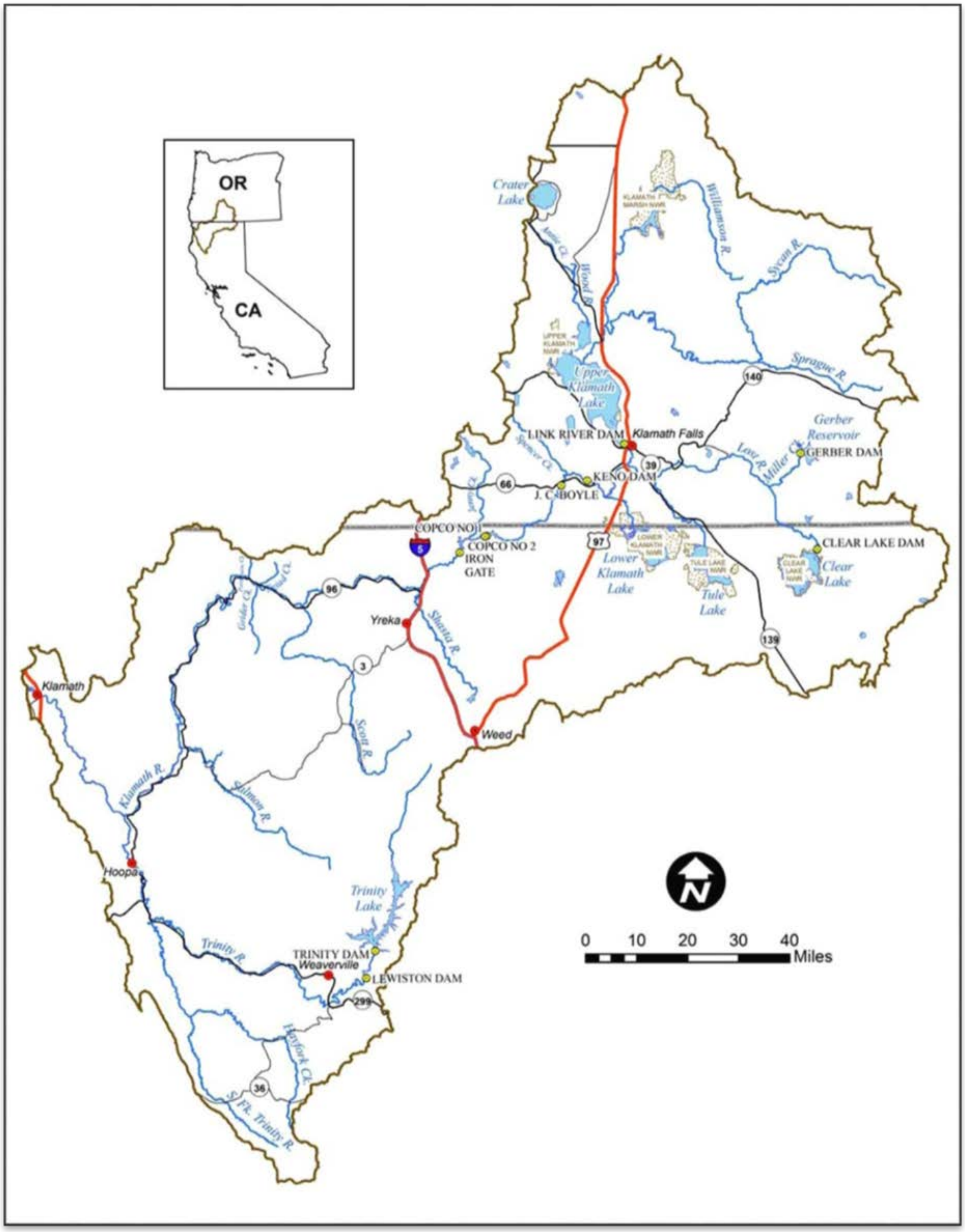

Figure 2. Klamath Basin map including relevant developments of PacifiCorp's Klamath Hydroelectric Project (PacifiCorp 2018a).

Reclamation's proposed Project Operations from April 1, 2019 to March 31, 2024 consists of three major elements:

1. Store waters of the Upper Klamath Basin and Lost Rivers.
2. Operate the Project, or direct the operation of the Project, for the delivery of water for irrigation purposes (including NWR needs), subject to water availability, and consistent with flood control purposes, while maintaining UKL and Klamath river hydrologic conditions that avoid jeopardizing the continued existence of listed species and adverse modification of designated critical habitat.
3. Perform operation and maintenance (O&M) activities necessary to maintain Project facilities to ensure proper long-term function and operation.

Each of the elements of the proposed action is described in detail in the following sections (Sections 1.3.1, 1.3.2, and 1.3.3).

Reclamation has managed UKL elevations (since 1991) and Klamath River flows at IGD (since 2001) in accordance with a series of Opinions from the Services. For the 2012 BA, Reclamation, in consultation with USFWS and NMFS, utilized the Klamath Basin Planning Model (KBPM) to simulate operations of the Project for the 1981 through 2011 period of record (POR) of historical hydrology for development of the proposed action. For the current consultation effort, Reclamation has incorporated recent hydrologic data to expand the POR from 2011 through 2016 (i.e., 1981 to 2016). Critical hydrologic data (e.g., Natural Resources Conservation Service (NRCS) forecasts) are not available prior to 1981 and data later than water year 2016 was not included in the POR because it was not available at the time of KBPM development. Reclamation has made substantial improvements to the KBPM structure and has incorporated data updates and refinements, including: revised accretions and UKL inflow datasets, incorporated a new UKL bathymetric layer, updated UKL net inflow estimates for the POR, and updated daily Project diversion data and return flows for the POR. Project operations using facilities that store and divert water from UKL and the Klamath River were simulated in the KBPM over a wide range of hydrologic conditions for the period of October 1, 1980 through November 30, 2016 using daily input data to obtain daily, weekly, monthly, and annual results for river flows, UKL elevations, and Project diversions, including deliveries to the LKNWR. The resulting simulations produced estimates of the water supply available from the Klamath River system (including UKL) for the POR. Under implementation of the proposed action, Reclamation will develop an operational model (i.e., the IGD calculator) that incorporates KBPM logic from the final proposed action model run titled 'Reconsultation Viewer_Final_PA_02142019' to be utilized for real-time operations (USBR 2019a).

Elevations used in this section are referenced to Reclamation's datum for the upper Klamath Basin, which is 1.78 feet (ft) higher than the National Geodetic Vertical Datum of 1929.

A complete and detailed explanation of the proposed action and the updates to the KBPM utilized in development of the proposed action can be found in Reclamation's amended proposed action section and Appendix 4 included in the addendum to the Klamath Project Operations Final BA (USBR 2019a).

1.3.1 Element One
Store waters of the Upper Klamath Basin and Lost River.

1.3.1.1 Annual Storage of Water

Reclamation operates three reservoirs for the purpose of storing water for delivery to the Project's service area - UKL, and Clear Lake and Gerber reservoirs.

Bathymetric data compiled by Reclamation in 2017 for UKL (including nearshore areas such as Upper Klamath NWR, and Tulana and Goose Bays), indicated an "active" storage volume of 562,000 acre-feet (AF) between the elevations of 4,136.0 and 4,143.3 feet above sea level (Reclamation datum), which is the historical range of water surface elevations within which UKL has been operated. See section 6.3 in USBR's 2018 BA for additional details regarding historical conditions in UKL.

Clear Lake Reservoir has an active storage capacity of 458,892 AF (between 4,521 and 4,543.0 feet above sea level, Reclamation datum).

Gerber Reservoir has an active storage capacity of 94,270 AF (between 4,780.0 and 4,835.4 feet above sea level, Reclamation datum). No storage capacity in Gerber Reservoir is reserved for flood control purposes.

Reclamation proposes to store water annually in UKL and Clear Lake and Gerber reservoirs with the majority of inflow occurring from October through April. In some years of high net inflows or atypical inflow patterns (i.e., significant snowfall or other unusual hydrology in late spring/early summer), contributions to the total volume stored can also be significant in May and June. The majority of water delivery from storage occurs during March through September, although storage releases for irrigation purposes occur year-round. Storing water through the winter and spring results in peak lake and reservoir storage between March and May. Flood control releases may occur at any time of year, as public safety, operational, storage, and inflow conditions warrant.

The Klamath Project's primary storage reservoir, UKL, is shallow with approximately 6 feet (1.8 meters [m]) of usable storage when at full pool (approximately 562,000 AF). Clear Lake and Gerber Reservoir also have limited storage capability. Thus, UKL, Clear Lake, and Gerber Reservoir do not have the capacity to carry over significant amounts of stored water from one year to the next. UKL also has limited capacity to store higher than normal inflows during spring and winter months, because the levees surrounding parts of UKL are not adequately constructed or maintained for that purpose. Therefore, the amount of water stored in any given year is highly dependent on net inflows in that year, and to a lesser extent, preceding years.

1.3.1.2 UKL Flood Prevention Threshold Elevations

Maximum UKL flood control elevations are utilized as a guideline in an attempt to provide adequate storage capacity in UKL to capture high runoff events, to avoid potential levee failure due to overfilling UKL, and to mitigate flood conditions that may develop in the Keno plain upstream of Keno Dam. The general process of flood control consists of spilling water from UKL when necessary to prevent elevations from increasing above flood pool elevations, which change throughout the year in response to inflow forecasts and experienced hydrology. Flood pool elevation is calculated each day to create a smooth UKL operation, allowing UKL to fill (i.e., approach 4143.3 ft) by the end of March in drier years and by the end of April in wetter years. The UKL flood control elevations are intended to be used as guidance, and professional judgment will be utilized in combination with hydrologic conditions, snowpack, forecasted precipitation, public safety, and other factors in the actual operation of UKL during flood control operations.

The flood control elevations are set at 4,141.4 feet in September and October and 4,141.8 feet from November 1 through December 31 (daily values are obtained through interpolation). In most years, there are no flood control releases during these months.

From January 1 through April 30, the UKL flood control elevations are determined based on the forecasted inflow and the day of the month. The NRCS UKL net inflow forecast is used to determine the end of month flood control elevation, and the daily flood control elevation is linearly interpolated between the current end of month elevation and the previous month's end of month flood control elevation.

Additionally, UKL flood control elevations vary between wet and dry year types. The distinction is based on the NRCS March through September 50 percent exceedance forecast for UKL net inflow issued in January, February, and March. A 50 percent exceedance forecast is defined as a forecast that is likely to be exceeded 50 percent of the time based on a period of record. The forecast issued in March is used for both March and April. If the forecast March through September net UKL inflow is greater than 710,000 AF, the water year is considered wet; the water year is considered dry if the forecast net inflow is equal to or less than 710,000 AF. Once the water year is determined to be wet or dry, the UKL flood control elevations identified in Table 4 will be used for operations in that given water year. The flood control curves and flood control operations are consistent with what was analyzed in the 2013 Opinion.

Reclamation retains sole discretion to determine when to initiate or cease flood control operations.

Table 4. UKL flood release threshold elevations for the last day of each month under dry or wet conditions.

Month	Drier Condition Elevation (Forecast ≤ 710,000 acre-feet)	Wetter Condition Elevation (Forecast >710,000 acre-feet)
October	4141.40 ft (1,262.30 m)	4141.40 ft (1,262.30 m)
November	4141.60 ft (1,262.36 m)	4141.60 ft (1,262.36 m)
December	4141.80 ft (1,262.42 m)	4141.80 ft (1,262.42 m)
January	4,142.30 ft (1,262.57 m)	4,142.00 ft (1,262.48 m)

Month	Drier Condition Elevation (Forecast ≤ 710,000 acre-feet)	Wetter Condition Elevation (Forecast >710,000 acre-feet)
February	4,142.70 ft (1,262.70 m)	4,142.40 ft (1,262.60 m)
March	4,143.10 ft (1,262.82 m)	4,142.80 ft (1,262.73 m)
April	4,143.30 ft (1,262.88 m)	4,143.30 ft (1,262.88 m)

1.3.2 Element Two

Operate the Project, or direct the operation of the Project, for the delivery of water for irrigation purposes (including NWR needs), subject to water availability, and consistent with flood control purposes, while maintaining UKL and Klamath river hydrologic conditions that avoid jeopardizing the continued existence of listed species and adverse modification of designated critical habitat.

1.3.2.1 General Description

The Klamath Project has two distinct service areas: the east side and the west side. The east side of the Project includes lands served primarily by water from the Lost River, and Clear Lake and Gerber Reservoirs. The west side of the Project includes lands that are served primarily by water from UKL and the Klamath River. The west side also may use return flows[5] from the east side. The Project is operated so that flows from the Lost River and Klamath River are controlled, except during flood operation and control periods. The Project was designed based on reuse of water. Therefore, water diverted from UKL and the Klamath River for use within the west side may be reused several times before it discharges back into the Klamath River via the Klamath Straits Drain. Return flows from water delivered from the reservoirs on the east side may also be reused several times.

A key determinant of water management on the west side of the Project are monthly NRCS seasonal water supply forecasts for UKL inflow. The water supply forecasts are developed based on antecedent streamflow conditions, precipitation, snowpack, current hydrologic conditions, a climatological index, and historical streamflow patterns (Risley et al. 2005). NRCS provides an official monthly forecast from the forecast month through September on, or soon after the first of each month from January to June; a mid-month forecast is also provided but not used for calculation of monthly water allocations. The forecasts are used to estimate seasonal net inflow to UKL and in models used to simulate water management scenarios for the Project, UKL, Klamath River, and refuges. The inflow forecasts are seasonal volumetric estimates; actual observed inflow volumes and timing may vary substantially from forecasted inflows, particularly over shorter time periods.

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[5] Return flows are diversion water that was not entirely consumed by irrigation practices. This excess diversion water drains off agricultural lands into catchments and is recirculated or returned to other points of diversion for reuse.

A detailed description of the NRCS inflow forecasting procedures is located at the following NRCS web sites: https://www.wcc.nrcs.usda.gov/about/forecasting.html and http://www.wcc.nrcs.usda.gov/factpub/intrpret.html.

For the purpose of estimating future Project needs, annual demands for irrigation supply and refuge deliveries are assumed to be similar to those that have occurred in the historical period POR, which encompasses water years 1981 through 2016. The irrigation demand is the amount of water required to fully satisfy the irrigation needs of the Project. Historical demand during the POR results from a large range of hydrologic and meteorological conditions and Reclamation expects historical demand to be a reasonable representation of future demand during the 5-year period of this proposed action.

1.3.2.2 Operation and Delivery of Water from UKL and the Klamath River

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.

Stored water and live flow in UKL are directly diverted from UKL, via the A Canal and smaller, privately-owned diversions. Consistent with state water law and as applicable to the Klamath Project, the term “live flow” encompasses surface water in natural waterways that has not otherwise been released from storage (i.e., “stored water”). Live flow can consist of tributary runoff, spring discharge, return flows, and water from other sources such as municipal or industrial discharges (USBR 2019a). The A Canal (1,150 cubic feet per second [cfs] capacity) and the connected secondary canals it discharges into (i.e., the B, C, D, E, F, and G canals) serve approximately 71,000 acres within the Project. In addition to the A Canal, there are approximately 8,000 acres around UKL that are irrigated by direct diversions from UKL under water supply contracts with Reclamation.

In addition to direct diversions from UKL, stored water and live flow is released from UKL through LRD, for re-diversion from the Klamath River between Klamath Falls and the town of Keno. PacifiCorp currently operates LRD under guidance from Reclamation to achieve required flows at IGD.

Water released from LRD flows into the Link River, a 1.5-mile waterbody that discharges into Lake Ewauna, which is the upstream extent of the Klamath River. The approximately 16-mile section of the Klamath River between the outlet of Link River and Keno Dam is commonly referred to as the Keno Impoundment.

There are three primary points of diversion along the Keno Impoundment that are used to re-divert stored water and live flow released from UKL via the LRD. Approximately three miles below the outlet of Link River, water is diverted into the LRDC where it can then be pumped or released for irrigation use. Pumping from the LRDC primarily occurs at the Miller Hill Pumping Plant (105 cfs capacity), which is used to supplement water in the C-4 Lateral for serving lands within Klamath Irrigation District that otherwise receive water through the A Canal. KID operates and maintains the Miller Hill Pumping Plant. In addition to the Miller Hill Pumping Plant, there are other smaller, privately-owned pumps along the LRDC that serve individual tracts within KID. Water diverted into the LRDC can also be released through Station 48 (650 cfs maximum capacity), where it is then discharged into the Lost River below the Lost River Diversion Dam for re-diversion and irrigation use downstream. TID makes gate changes at Station 48 based on irrigation demands in the J Canal system, which serves approximately 62,000 acres within KID and TID. To the extent that live and return flows in the Lost River at Anderson-Rose Dam and the headworks of the J Canal (810 cfs capacity) are insufficient to meet associated irrigation demands, water is released from Station 48 to augment the available supply.

The other two primary points of diversion along the Keno Impoundment that re-divert stored water and live flow from UKL are the North and Ady canals (200 cfs and 400 cfs capacity, respectively), which are owned and operated by Klamath Drainage District. In addition to lands within the boundaries of KDD, the Ady Canal also delivers water to the California portion of LKNWR. Together, the North and Ady canals deliver water to approximately 45,000 acres of irrigable lands in the Lower Klamath Lake area, including lands in KDD.

In addition to the lands served by the LRDC and Ady and North canals, Reclamation has entered into water supply contracts along the Keno Impoundment, including lands on the west side of the Klamath River and on Miller Island. The area covered by Project contracts is approximately 4,340 acres, including lands within Plevna District Improvement Company (523 acres), Pioneer District Improvement Company (424 acres), Midland District Improvement Company (581 acres), and Ady District Improvement Company. Another 1,090 acres are covered under eight separate contracts, for lands currently within the Miller Island Refuge Area, managed by the Oregon Department of Fish and Wildlife. The remaining lands (1,285 acres) irrigated as part of the Project are privately owned. Most of these diversions are pumped and can be measured by standard pump equations (hours run multiplied by assumed flow rate). Reclamation estimates annual irrigation diversions associated with these 4,340 acres under contract with Reclamation (excluding LRDC, North and Ady canals) to be approximately 8,000-15,000 AF, the maximum duty allowed under Oregon law being 15,185.5 AF.

There are other irrigation diversions not associated with the Project in the Keno Impoundment, most notably Keno Irrigation District, encompassing approximately 3,600 acres. Reclamation estimates these non-Project irrigation diversions to be approximately 9,000-12,000 AF annually.

Reclamation assumes demands for irrigation supply and refuge deliveries over the proposed lifetime of this proposed action are similar to those that have occurred in the 36-year POR for water-year 1981 through 2016. However, continued improvements in irrigation infrastructure and equipment combined with advances in irrigation practices and technology will likely help to reduce Project irrigation demand in the future. The irrigation “demand” is the amount of water required to fully satisfy the irrigation needs of the Project. While these historical demands are retained for analysis and comparison purposes, irrigation deliveries to the Project within this proposed action were modeled using the Agricultural Water Delivery Sub-model (see USBR 2019a, Appendix 4, Section A.4.4.4). Modeled deliveries during this 36-year POR generally fall within the range of historical Project deliveries. In addition, the POR exhibits a large range of hydrologic and meteorological conditions, and the various modeled deliveries during this period are reasonably expected to include the range of conditions likely to occur during the proposed term of this proposed action.

Water management in the fall/winter operations period (November 1 – February 28/29 for the Project and from October 1 – February 28/29 for the Klamath River), employs a formulaic management approach focused on maintaining conditions in UKL and the Klamath River that meet the needs of the ESA-listed species, and provide fall/winter water deliveries to the Project and LKNWR. This approach attempts to ensure appropriate water storage and sucker habitat in UKL while providing Klamath River flows that intend to represent current conditions in the upper Klamath Basin and meet the needs of ESA-listed species downstream of IGD.

Water management in the spring/summer operational period includes March 1 through September 30 for the Klamath River environmental water account (EWA) and includes March 1 through November 30 for Area A1 and March 1 through October 31 for Area A2 of the Project. Limited overlap between spring/summer operations in Area A1 and fall/winter operations in October and November remains; as in the 2012 BA and 2013 Opinion, Area A1 may continue diverting spring/summer Project water after October 1.

Generally, Reclamation proposes to determine the total available UKL Supply[6] (see section 1.3.2.6.1 below), accounting for sucker needs through the spring/summer period, and then distribute this supply between the Project and the Klamath River EWA. The division of the total available UKL water supply between EWA and Project Supply[7] (see section 1.3.2.6.2 below) was determined through an iterative modeling process, relying on input from Reclamation and the Services.

The proposed action management approach has two major components:

1. UKL elevations and storage, specifically the UKL control logic and UKL Credit, to protect sucker habitat and ensure adequate storage to meet the needs of listed species in UKL and the Klamath River and water supply for the Project; and

2. Klamath River flows, specifically EWA to support coho salmon needs and to produce flows for disease mitigation or protection of coho salmon habitat during the spring/summer operational period, and a formulaic approach for calculating IGD releases in the fall/winter.

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[6] The UKL Supply is calculated by adding end of February UKL storage to monthly UKL inflows observed since March 1 and forecasted monthly UKL inflows, while ensuring the end of September storage target is met.

[7] Project Supply is the volume of water from UKL available for delivery to the Klamath Project and LKNWR.

1.3.2.3 Upper Klamath Lake

Reclamation's operational approach seeks to fill UKL during the fall/winter to increase the volumes available for the EWA (including disease mitigation flows), UKL, and Project Supply during the spring/summer operational period. The proposed action operational model includes a "UKL control logic" that regulates releases from UKL storage with consideration of recent hydrologic conditions and in a manner that maintains UKL elevations required for listed suckers, plus a UKL buffer, defined as "UKL Credit". The purpose of the UKL Credit is to store water in UKL to allocate a Project Supply on April 1 with no later reductions, and the possibility of an increase in subsequent May 1 and June 1 allocations. Accrual of UKL Credit provides a buffer for UKL storage against forecast uncertainties, which may result in unforeseen reductions to UKL inflow. UKL Credit can only be accrued from March 1 through September 30 during controlled flow conditions (i.e., not during flood control operations), and is accumulated when LRDC flows and KSD discharges in excess of direct diversions for irrigation are utilized to meet IGD flow targets, resulting in a reduction in LRD releases. When Project irrigators do not divert LRDC flow or KSD return flows and these unused volumes are utilized to offset LRD releases, a volume of water (the UKL Credit, equal to the reduction in LRD releases for river flows) is stored in UKL. UKL Credit volumes greater than that necessary for full delivery of Project Supply will remain in UKL to facilitate refill of UKL in the ensuing fall/winter period. There is no carryover of accrued UKL Credit from season to season. As with current operations, Reclamation anticipates that PacifiCorp will adjust LRD releases as appropriate to meet IGD targets while accounting for these specific accretions to the Klamath River (i.e., if LRDC and KSD accretions increase, PacifiCorp would decrease LRD releases such that IGD targets are still met, but not exceeded). Reclamation will track accretions and IGD releases to accurately calculate UKL credit. All water that leaves UKL through either LRD or the A Canal is a component of either EWA or the Project Supply; this includes flood control releases but does not include spill of UKL credit, which is the first volume of water to spill during flood control operations.

UKL control logic helps to manage UKL elevations for endangered suckers while ensuring adequate storage in UKL for both Klamath River EWA and Project releases, utilizing a "central tendency" methodology. The central tendency is based on end-of-month UKL elevations that were arrived at through an iterative modeling process performed by the Tri-Agency Hydro Team and are not intended to change during operations under this proposed action. The central tendency end-of-month UKL elevations are subsequently interpolated to daily values resulting in an annual UKL hydrograph that accounts for seasonal needs of suckers, seasonal water demand for the Klamath River and Project, and end-of-season elevations to prepare for following year water needs. This annual UKL hydrograph is adjusted daily, based on a normalized 60-day trailing average of raw net inflow to UKL. If UKL elevations drop below the adjusted central tendency, releases to the Klamath River and winter deliveries to Area A2 are reduced until UKL elevations equal or exceed the adjusted central tendency line. Reductions to Klamath River releases due to UKL control logic may not result in flows at IGD less than the proposed minimum IGD target flows. EWA releases for disease mitigation and habitat flows, as well as IGD ramping flows are not subject to reduction under UKL control logic at any time. The adjusted central tendency is not a target to which UKL should be managed, but rather a guideline that maintains UKL elevations in line with both hydrologic conditions and the multiple demands placed upon UKL storage throughout the year. For more information regarding the UKL control logic and UKL credit, see USBR (2019a) Appendix 4, Section A.4.4.1.1.

The KBPM output graphs provided in Appendix A display the expected annual Klamath River hydrographs at IGD for the POR under the proposed action. Real-time operations will not exactly replicate the modeled results and actual flow and elevation variability will differ during real-time operations.

1.3.2.4 Klamath River

Reclamation proposes to retain IGD as a compliance point for Klamath River flows for the duration of this proposed action (see USBR 2018a, Section 3.7.1 for details about dam removal and associated implications for this proposed action). As in the 2013 Opinion, IGD target flows in the fall/winter and a portion of the spring/summer period are calculated in the IGD calculator using a hydrologic indicator of upper Klamath Basin conditions. The intent of this method is to create a hydrograph downstream of IGD that approximates a natural flow regime reflective of actual hydrologic conditions and variability occurring in the upper Klamath Basin. To approximate actual hydrological conditions, Reclamation and the Services selected net UKL inflow for this proposed action as the best representation of the range of inflow characteristics including the ground-water dominated Williamson and Wood Rivers, and snowmelt-runoff dominated tributaries originating in the Cascade Mountains. UKL net inflow is calculated using a number of gages maintained by the USGS with consistent and reliable datasets over the POR. Reclamation and the Services expect these gages to remain in operation and the continued reliability of this hydrologic data is an important consideration to retain the ability to implement the proposed action.

Specifically, Reclamation proposes to utilize UKL net inflow to calculate IGD target flows in the IGD calculator throughout the fall/winter period and from March 1 through June 30 of the spring/summer period. EWA allocations are updated in the IGD calculator on a monthly basis (March 1, April 1, May 1 and finalized on June 1) based on observed UKL net inflow and the corresponding monthly NRCS 50 percent exceedance UKL inflow forecasts. From July 1 through September 30, EWA distribution is based on EWA remaining and UKL control logic, while ensuring minimum IGD flows (Table 5) are met (see USBR 2019a, Section 4.3.2.2.2.3).

Table 5. Proposed average daily minimum Iron Gate Dam target flows (cfs).

Month	**Iron Gate Dam Average Daily Minimum Target Flows (cfs)**
October	1,000 (28.3 m^3/sec)
November	1,000 (28.3 m^3/sec)
December	950 (26.9 m^3/sec)
January	950 (26.9 m^3/sec)
February	950 (26.9 m^3/sec)
March	1,000 (28.3 m^3/sec)
April	1,325 (37.5 m3/sec)
May	1,175 (33.3 m3/sec)
June	1,025 (29.0 m3/sec)
July	900 (25.5 m^3/sec)
August	900 (25.5 m^3/sec)
September	1,000 (28.3 m^3/sec)

Daily IGD target flows will generally be experienced at IGD three days after the hydrologic conditions are observed in the upper Klamath Basin. The actual transit time for water released from UKL to be realized at IGD may be more or less than three days depending on the magnitude of the flow rate, elevation of UKL, and the hydrologic conditions downstream of UKL. The three-day delay is also in part due to operational constraints of PacifiCorp's KHP.

PacifiCorp's operation of the KHP will influence the timing and magnitude of the hydrograph downstream of IGD due to water travel time through the reservoirs and due to facilities operations. During flood control operations, the influence of PacifiCorp's KHP on water travel time is virtually non-existent because PacifiCorp's reservoirs are full and there are no operational constraints, as the KHP is essentially run-of-the-river. Under normal operating conditions (i.e., not flood control), KHP influences are expected to be minimal because PacifiCorp manages hydroelectric operations to meet IGD targets.

In the event of USGS gage failure, professional judgment will be used in combination with all relevant hydrologic data to estimate UKL elevation and inflow, IGD releases, and accretions. USGS gage failures occur infrequently and every attempt will be made to coordinate with USGS to appropriately estimate flow and/or elevation values whenever a gage failure occurs.

1.3.2.5 Fall/Winter Operations

Reclamation's fall/winter Project operational procedure distributes UKL inflows among the following:

1. UKL:
    a. Increase UKL elevation to meet sucker habitat needs throughout the fall/winter period and the following spring/summer period, as well as increase storage for spring/summer EWA releases and irrigation deliveries.
    b. This is achieved through a fall/winter UKL refill rate and the UKL control logic.

2. Klamath River:
    a. Release sufficient flow from IGD to meet ESA-listed species needs in the Klamath River downstream of IGD; this includes flows to support coho salmon spawning from October 1 – November 15.
    b. This is achieved through the fall/winter formulaic approach to calculating IGD targets.

3. Project:
    a. KDD (Area A2 – served by North Canal and Ady Canal)
    b. Lease Lands in Area K (Area A2 – served by Ady Canal)
    c. LKNWR (Area A2 – served by Ady Canal)

To the extent practicable, sufficient flood pool capacity is maintained in UKL to balance refilling UKL with the legal requirements of flood-related public safety issues. To satisfy these objectives, Reclamation proposes to calculate IGD target flows by means of a series of context-based real-time equations using the net UKL inflow as a hydrologic indicator.

Specific steps for calculating IGD target flows include:

1. Determine the LRD flow target, which is the maximum of either the minimum LRD flow target or the LRD release target to support IGD target flows (calculated as follows)
    a. October 1 – November 15
        i. Determine the IGD target necessary for coho spawning flows
    b. November 16 – February 28/29
        i. Determine yesterday's smoothed UKL net inflow
        ii. Subtract 1.5 times the average daily UKL fill rate necessary to attain a UKL elevation of 4,143 feet on February 28/29
    c. Adjust based on the difference in UKL storage between the UKL adjusted central tendency and UKL elevation
    d. Constrain by the maximum LRD release capacity, if applicable

2. Determine the IGD flow target, which is the maximum of either the minimum IGD flow requirement or the IGD flow target (calculated below)
    a. October 1 – November 15

        i. Determine the IGD target necessary for coho spawning flows
    b. November 16 – February 28/29
        i. To the LRD flow target calculated in step 1, add LRD to Keno Dam accretions from three days prior (i.e., the accretion that occurred in a single day three days ago)
        ii. Add the value for today's Keno Dam to IGD accretions that was forecast three days ago (i.e., the accretion forecast for the current day that was issued three days ago)
        iii. Add KSD discharge (assumes three-day lag)
        iv. Add the maximum of either LRDC flow towards the Klamath River minus diversion of LRDC water to North and Ady canals (assumes three-day lag), or zero

Relative to fall/winter irrigation needs, up to 28,910 and 11,000 AF of fall/winter water is made available to KDD and LKNWR, respectively, subject to the UKL control logic. Specifically, if UKL elevation is at or above the adjusted central tendency throughout the fall/winter period, the only modeled constraints to delivery would be the delivery cap (28,910 and 11,000 AF for KDD and LKNWR, respectively), conveyance capacity, and demand. However, if UKL elevation is below the adjusted central tendency, daily deliveries to KDD and LKNWR can be reduced incrementally on a daily basis up to 80 percent. Fall/winter water available for delivery to KDD and LKNWR will be assessed every 5 days, when the ratio determining the delivery adjustment (termed the "storage difference ratio") is calculated. Similarly, LRD releases comprising a portion of IGD target flows can be reduced incrementally on a daily basis up to a maximum of 80 percent when UKL elevation is below the adjusted central tendency. Maximum reductions generally occur when UKL elevations approach the lower bound of the central tendency "envelope", the range of elevations within which the central tendency may fluctuate. Reductions to LRD releases due to UKL control logic cannot result in IGD releases below the proposed IGD minimum flow requirements above in Table 5 or exceed ramp rates specified in section 1.3.2.7 (see USBR 2019a, Appendix 4, Section A.4.4.1.1 for additional details).

Output from KBPM for the POR indicate that reductions to LRD releases due to UKL control logic resulted in the maximum daily and maximum monthly reductions at IGD provided in Table 6 and Table 7. For IGD flows to remain within the effects we analyzed in this Opinion, NMFS does not expect reductions to LRD releases due to UKL control logic to result in reductions to IGD releases greater than identified in Table 6 and Table 7 during implementation of the proposed action.

Table 6. Average, maximum, and number of daily reductions in Iron Gate Dam flow due to UKL Control Logic.

Daily Reduction in Iron Gate Dam Flow due to UKL Control Logic						
Month	**AVG (# of Days)**	**MAX (# of Days)**	**AVG (CFS)**	**MAX (CFS)**	**AVG (%)**	**MAX (%)**
October	6	31	16	170	1	15
November	3	19	10	382	1	19
December	0	0	0	0	0	0
January	0	0	0	0	0	0
February	0	0	0	0	0	0
March	7	31	170	4165	7	73
April	5	27	123	4227	3	74
May	3	30	44	2810	2	69
June	0	3	2	810	0	32
July	1	31	6	348	1	28
August	1	22	3	366	0	28
September	3	30	17	465	1	32

Table 7. Average and maximum monthly total reduction in Iron Gate Dam flow due to UKL Control Logic.

Monthly Total Reduction in Iron Gate Dam Flow due to UKL Control Logic				
Month	**AVG (AF)**	**MAX (AF)**	**AVG (% Volume)**	**MAX (% Volume)**
October	1,000	8,000	1	11
November	1,000	6,000	1	7
December	0	0	0	0
January	0	0	0	0
February	0	0	0	0
March	10,000	136,000	6	55
April	7,000	154,000	3	54
May	3,000	56,000	2	37
June	0	4,000	0	5
July	0	14,000	1	20
August	0	7,000	0	10
September	1,000	22,000	1	27

It is possible to deviate from the fall/winter formulaic approach to calculating IGD flow targets during real-time operations. For instance, real-time hydrologic conditions, such as high flow events or emergency situations, or USGS rating curve adjustments may warrant the need to deviate from this formulaic approach. In addition, there may be specific ecologic objectives that water resource managers may want to address that can only be achieved by deviating from the formulaic approach to calculating IGD targets. For example, surface and deep flushing flow events have been shown to be effective at reducing risks to coho salmon associated with *C.*

shasta infection (see Section 2.2.3.2.3 *Disease* of the *Environmental Baseline* for more detailed descriptions of flushing flow effects). Any time a deviation from the formulaic approach occurs, either by necessity or to address a specific ecologic objective, or if it is determined that the formulaic approach results in conditions that are not consistent with the intent of the proposed action, the process detailed in Section 1.3.2.8 below will be followed.

Reclamation proposes to monitor real-time hydrologic conditions during the fall/winter to ensure that flood control elevations for UKL are not exceeded and adequate storage capacity remains in UKL to accommodate high runoff events, especially during rain-on-snow events. During high runoff events, deviations from the fall/winter management procedure may be required in real-time operations in order to protect public safety and the levees surrounding UKL. In addition, other unforeseen emergency and/or facility control issues could arise that would require deviations from the fall/winter management procedure. In such cases, Reclamation will return to the fall/winter management procedure as soon as the emergency or facility control issue is resolved. However, Reclamation retains ultimate discretion regarding the timing of a return to the formulaic approach. Some emergency situations may require the use of the ESA section 7 implementing regulations applicable to emergencies (50 CFR 402.05(b)). Such emergencies would be evaluated in a separate emergency consultation.

1.3.2.6 Spring/Summer Operations

Reclamation's specific objectives during the spring/summer operational period include:

1. provide irrigation deliveries to lands within the Project, including Tule Lake National Wildlife Refuge (TLNWR) and LKNWR, with a reasonable level of certainty; and

2. maintain conditions in UKL and the Klamath River that meet ESA-listed species needs consistent with Opinions under section 7.

The UKL Supply available from March through September is calculated by adding end of February UKL storage to monthly UKL inflows observed since March 1 and forecasted monthly UKL inflows, while ensuring the end of September storage target is met. Any UKL Supply that is not delivered to the Project or released for EWA will remain in UKL as storage.

Throughout the spring/summer operational period, Reclamation will track EWA usage, daily and monthly reductions of IGD releases due to UKL control logic, Project deliveries, remaining Project Supply, UKL elevation relative to the adjusted central tendency, LKNWR deliveries, and the anticipated remaining LKNWR deliveries every 5 days and adjust releases as necessary to maintain operations consistent with this proposed action.

1.3.2.6.1 UKL Supply

UKL Supply is calculated on the first of each month (or when Reclamation receives the NRCS UKL inflow forecast) from March through June. UKL Supply is calculated by adding the Mar50vol (50 percent exceedance volume of forecasted plus observed inflow) to the end of February UKL storage, and then subtracting the end of September UKL storage target.

The specific steps for calculating UKL Supply and Mar50vol are detailed below.

First calculate the "Mar50vol," a combination of forecasted and observed March through September UKL inflow. For each month, Mar50vol is calculated as follows:

1. March 1
   a. Equal to the March 1 NRCS 50 percent exceedance March – September UKL inflow forecast

2. April 1
   a. April 1 NRCS 50 percent exceedance April – September UKL inflow forecast, plus
   b. Measured March net inflows

3. May 1
   a. May 1 NRCS 50 percent exceedance May – September UKL inflow forecast, plus
   b. Measured March net inflows, plus
   c. Measured April net inflows

4. June 1
   a. June 1 NRCS 50 percent exceedance June – September UKL inflow forecast, plus
   b. Measured March net inflows, plus
   c. Measured April net inflows, plus
   d. Measured May net inflows

Next, calculate the end of September UKL storage target, which is dependent on the default end of September UKL central tendency elevation (4,139.1 feet), the end of September "envelope" around the UKL central tendency (+/- 0.4 feet), and the Mar50vol. The purpose of the end of September UKL storage target in determining UKL Supply is to constrain the amount of UKL storage used in a given year. Such constraint is necessary to balance near-term demand for irrigation diversion or EWA with the uncertainties associated with future hydrologic conditions.

1.3.2.6.2 Project Supply

Project Supply, defined as the volume of water from UKL available for delivery to the Klamath Irrigation Project and LKNWR, is calculated monthly from March through June, after volumes have been allocated to EWA and the UKL end of September storage target. To provide early-season certainty for Project irrigators, the calculated April 1 Project Supply is "locked in" such that Project Supply may increase as a result of increased NRCS UKL inflow forecasts on May 1 and June 1, but cannot decrease below the April 1 calculation. In the event that the NRCS UKL inflow forecasts are substantially lower in May and June, relative to the April forecast, UKL storage volume will be utilized to deliver the "locked-in" April 1 Project Supply.

Maximum Project Supply from UKL is 350,000 AF, which occurs when UKL Supply is greater than 1,035,000 AF. When UKL Supply is less than 1,035,000 AF, Project Supply is equal to UKL Supply minus EWA except in years when April 1 EWA is greater than 400,000 AF (407,000 AF in years 2020, 2022, and 2024 to meet additional flow needs for the Yurok Tribal Boat Dance) and less than 576,000 AF. In this case, the April 1 Project Supply estimate is reduced by 10,000 AF (see section 1.3.2.6.9). Project Supply is finalized after receiving the NRCS June 1 UKL inflow 50 percent exceedance forecast. Full Project Supply delivery is not guaranteed; Reclamation, in consultation with the Services, retains discretion to curtail deliveries from UKL to comply with legal requirements and hydrologic conditions as necessary, including ensuring minimum IGD flows are met.

In addition to Project Supply from UKL, the Klamath Irrigation Project receives water from discharge in the LRDC and return flows from the KSD. Since only water originating from UKL counts towards the Project Supply, Project diversions of LRDC discharge and KSD return flows will be evaluated daily and subtracted from the total Project diversion to compute the daily Project Supply usage.

Therefore, under the formulaic approach of the proposed action, the median annual Klamath Irrigation 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 POR (USBR 2019a). The majority of this 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 POR. The difference is supported by diversions from other sources, primarily LRDC and KSD return flows. The Project delivery values above do not include additional deliveries that may occur in years when a water call is made on Project water rights (see section 1.3.2.10).

In order to realistically distribute Project Supply over the irrigation period in the KBPM, which is critical in evaluating the effects of Project operations on listed species at specific times of the spring/summer period, Reclamation developed an Agricultural Water Delivery sub-model. The Agricultural Water Delivery sub-model simulated delivery of irrigation water on a 5-day timestep based on variables such as meteorological conditions, soil moisture, water availability, and deliveries in the previous 5-day timestep, scaled to Project Supply. To ensure that the sub-model would adequately simulate Project deliveries under this proposed action, the sub-model was first tested against historical Project deliveries and performed relatively well. This sub-model is a substantial improvement over past representations of agricultural deliveries in the KBPM (see USBR 2019a, Appendix 4, Section A.4.4.4).

Reclamation proposes to deliver Project Supply to LKNWR (not inclusive of Area K [Project Lease Lands served by Ady Canal which are served out of Project Supply]) in the spring/summer operational period. Proposed spring/summer LKNWR deliveries are likely to include a combination of water available from Project Supply and stored water from UKL available in wet years, as further described below.

Reclamation, and USFWS, in coordination with Project irrigators and other stakeholders, are currently undertaking a process to identify the relative priority of lands within LKNWR to available Project water, and to develop a shortage sharing agreement (pursuant to a 2017 memorandum from the Deputy Secretary of the Interior) to address delivery shortages to LKNWR. As that process is still on-going, the outcome from this process is not included in Reclamation's proposed action. However, because any volume identified for delivery to LKNWR through that process will be part of, and not increase Project Supply (which is already modeled as coming from UKL in the KBPM), Reclamation has concluded that the distribution of Project Supply will generally remain consistent with the simulated distribution pattern and magnitude and will not alter the effects of Project operations on ESA-listed species described herein. In other words, if in the future a shortage sharing agreement is finalized and deliveries to LKNWR are part of Project Supply, Reclamation concluded that the effects of that delivery to listed species should be no different than under the proposed action analyzed in this opinion and therefore reinitiation of consultation is not expected to be required under 50 CFR 402.16(a) or (c).

Until the process described above is complete, Reclamation proposes to coordinate with USFWS and other Project water users to determine when Project Supply during the spring/summer operational period can be made available to LKNWR consistent with Reclamation's and delivery agencies' contractual and other legal obligations. The model assumes delivery of the full Project Supply allocation in all years. When Reclamation determines that there is Project Supply not needed to meet other Project demands, that portion of Project Supply can be delivered to LKNWR.

In addition to a portion of Project Supply, LKNWR may also receive spring/summer deliveries in June and July if Project Supply is 350,000 AF and UKL elevations are above 4,142.5 and 4,141.5 feet, respectively, on the first of each month; daily values to be exceeded are linearly interpolated thereafter. When these conditions were met in the modeled POR (11 of the 36 years), a maximum of 3,000 AF was made available to LKNWR from this source. Note that this water is not considered Project Supply.

1.3.2.6.3 Environmental Water Account

The EWA volume is calculated on the first of each month (or when Reclamation receives the NRCS UKL inflow forecast) from March through June as a portion of UKL Supply. Graphical representations of the relationship modeled between EWA and Project Supply based on the UKL Supply are presented in Figure 3. Reclamation proposes a minimum EWA of 400,000 AF (407,000 AF in years 2020, 2022, and 2024 to meet additional flow needs for the Yurok Tribal Boat Dance), which occurs when UKL Supply is less than 660,000 AF. When UKL Supply is greater than 1,035,000 AF, EWA is calculated as UKL Supply minus the maximum Project Supply (350,000 AF). When UKL Supply is between 660,000 AF and 1,035,000 AF, EWA is calculated as a percentage of the UKL Supply. However, in years when April 1 EWA is less than 576,000 AF and greater than 400,000 AF (407,000 AF in years 2020, 2022, and 2024), an additional 20,000 AF of water is added to May and June IGD target flows (see section 1.3.2.6.9). The EWA volume is finalized after receiving the June 1, NRCS 50 percent exceedance forecast for UKL inflow, except in years with enhanced May/June flows in which July 1 EWA is supplemented with an additional 20,000 AF (see section 1.3.2.6.9 for more details). The formulaic approach to IGD targets may result in "overspend" or "underspend" of EWA volume. If EWA is overspent, UKL storage will be utilized to continue meeting IGD target flows through September 30. If EWA is underspent, the unused EWA volume remaining on September 30 will remain in UKL. There is no inter-annual carryover of EWA.

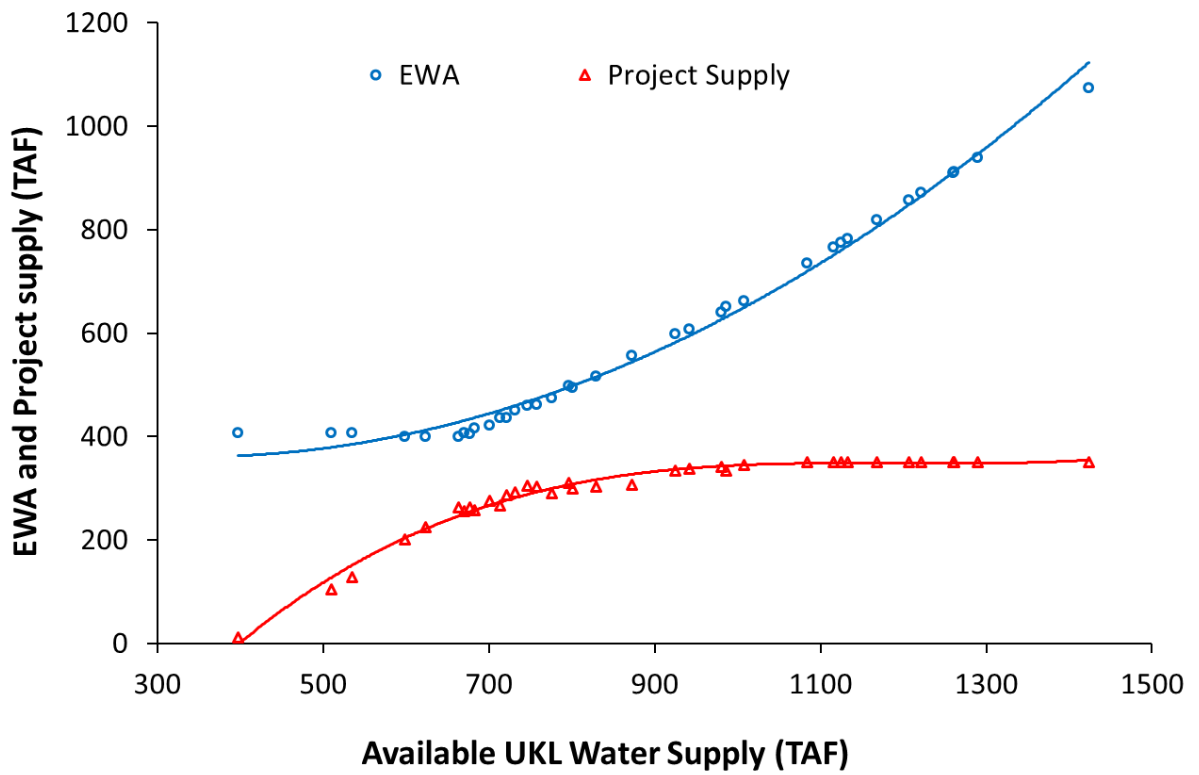

Figure 3. Modelled EWA and Project Supply, based on UKL Supply.

Output from KBPM illustrate the resulting EWA allocations in thousand acre-feet (TAF) under implementation of the proposed action for each water year in the POR in Table 8. The output indicates that besides water year 1997 (which had an unusually wet spring in late April and May), the maximum EWA 'underspend' was 5 percent and occurred twice in the POR. Accordingly, NMFS does not expect greater than a 5 percent 'underspending' of EWA to occur during implementation of the proposed action to remain within the effects we analyzed in this Opinion, unless a water year with extraordinary hydrologic conditions occurs.

Table 8. Proposed action calculated EWA allocations and EWA release volumes for the POR.

Water Year	EWA VOLUME (TAF)	EWA USED (TAF)	EWA UNDERSPEND (TAF)	EWA UNDERSPEND (%)	EWA OVERSPEND (TAF)	EWA OVERSPEND (%)
1981	441	469	0	0	28	6
1982	911	940	0	0	29	3
1983	1073	1061	12	1	0	0
1984	940	956	0	0	16	2
1985	639	629	10	2	0	0
1986	766	806	0	0	40	5
1987	482	489	0	0	7	1
1988	456	484	0	0	28	6
1989	818	815	4	0	0	0
1990	435	447	0	0	12	3
1991	400	430	0	0	30	8
1992	407	385	22	5	0	0
1993	783	791	0	0	8	1
1994	407	404	3	1	0	0
1995	663	644	19	3	0	0
1996	734	734	0	0	0	0
1997	607	522	85	14	0	0
1998	911	891	19	2	0	0
1999	857	848	9	1	0	0
2000	651	650	1	0	0	0
2001	400	412	0	0	12	3
2002	481	490	0	0	9	2
2003	495	495	0	0	0	0
2004	470	478	0	0	8	2
2005	435	434	1	0	0	0
2006	871	842	30	3	0	0
2007	536	529	7	1	0	0
2008	599	577	22	4	0	0
2009	514	512	2	0	0	0
2010	427	430	0	0	3	1
2011	775	737	38	5	0	0
2012	577	582	0	0	5	1
2013	424	418	6	1	0	0
2014	407	411	0	0	4	1
2015	400	404	0	0	4	1
2016	517	519	0	0	1	0

All LRD releases, including flood control releases, between March 1 and September 30 that are not diverted to the Project or LKNWR through LRDC and North and Ady Canals comprise the EWA. A portion of LRD releases for the EWA is diverted in the Keno Impoundment by dozens of ungauged private diversions, non-Project and Project-related diversions, and municipal and industrial uses. These diversions are a component of the EWA used to support IGD target flows; however, the reduction in EWA available for the Klamath River resulting from these diversions was accounted for in the proposed action KBPM logic. Therefore, NMFS expects that the diversions in Keno Impoundment reach will not result in lower IGD flows than modeled in the proposed action KBPM output (assuming these diversions are consistent with historical deliveries). Reclamation expects historical demand for these ungauged diversions in the Keno Impoundment to be a reasonable representation of future demand during the 5-year period of this proposed action.

Conversely, all stored water and live flow diverted at the A Canal, or released from UKL via LRD and diverted at the LRDC, and North and Ady Canals during the spring/summer period comprise the Project Supply. Measurements for these diversions will be obtained at the point of diversion or measured at the location identified by the state of Oregon in the Amended and Corrected Findings of Fact and Order of Determination (ACFFOD). For the measurement of these diversions below LRD, the UKL contribution will be the overall measurement less any flows from the LRDC and KSD.

During controlled flow conditions, LRDC and KSD flows are a component of EWA when LRDC and KSD discharges in excess of direct diversions for irrigation are utilized to meet IGD flow targets and offset LRD releases. The component of EWA is equivalent to the volumetric reduction in LRD releases that occur due to utilization of LRDC and KSD flows to meet IGD flow targets.

Flood control releases and LRD releases above minimums for the Klamath River made between March 1 and September 30 are a component of the EWA. However, releases made during March through June could potentially be large enough that the remaining EWA volume would not be considered adequate to provide acceptable fish habitat for the July through September period. Reclamation will ensure that the remaining EWA is sufficient to accommodate the formulaic IGD target releases and/or maintain minimum IGD flow requirements (see USBR 2019a, Appendix 4, Section A.4.4.8 for specific details).

EWA distribution is based on a spring/summer formulaic approach for calculating IGD flow targets. The formulaic approach is based on the EWA allocation, UKL control logic, UKL net inflow, and NRCS 50 percent exceedance UKL inflow forecasts for March through September period. Reclamation proposes to utilize monthly updated forecasts from March 1 through June 1 to determine EWA volumes and IGD releases. From July 1 through September 30, EWA distribution is based on EWA remaining and UKL control logic, while ensuring minimum IGD flows are met.

The specific steps for calculating IGD target flows in the spring/summer include:

1. Determine the LRD flow target as follows:
    a. March 1 – June 30
        i. Determine the release adjustment factor (termed “in_pct_Mar50vol”) that combines observed and forecasted net inflow, NRCS forecast error, and UKL Supply.
        ii. Multiply by the calculated EWA allocation, minus the 130,000 AF EWA volume reserved for the July to September baseflow period

(137,000 AF in Boat Dance years), minus the release correction that accounts for the difference between the previous day's actual and calculated LRD releases (termed "Link_release_ss_diff").

b. July 1 – September 30
    i. Divide the volume of EWA remaining for the current month by the number of days in the current month.
c. Adjust based on the difference in UKL storage between the UKL adjusted central tendency and UKL elevation.
d. Constrain by the maximum LRD release capacity, if applicable.

2. Determine the IGD flow target, which is the minimum of either the maximum IGD flow[8] or the IGD flow target.
    a. To the LRD flow target calculated in step 1, add LRD to Keno Dam accretions from three days prior (i.e., this step relies on the accretion that occurred in a single day three days ago).
    b. Add today's forecasted Keno Dam to IGD accretions from three days prior (i.e., this step relies on the accretion forecast for the current day that was issued three days ago).
    c. Increase to the minimum IGD flow requirement, if applicable.

Reclamation's implementation of the fall/winter and spring/summer formulaic approaches described in the proposed action above results in a probability of exceedance table of daily average flows at IGD for the POR (Table 9).

[8] Maximum IGD flow is a KBPM variable (IG_max) that does not allow releases to exceed a specified maximum IGD flow during July through September. Values for IG_max vary with EWA, ranging from 1000-1500 cfs in July, 1050-1250 cfs in August, and 1100-1350 cfs in September.

Table 9. Probability of exceedance table for proposed action daily average flows at Iron Gate Dam (cfs).

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
95%	1000	1000	950	950	950	1000	1325	1175	1025	900	900	1000
90%	1000	1000	950	950	950	1145	1325	1175	1025	900	900	1000
85%	1000	1000	950	950	950	1449	1325	1210	1025	900	900	1000
80%	1000	1000	950	950	952	1609	1359	1318	1025	900	900	1000
75%	1037	1000	950	950	1002	1724	1499	1367	1025	923	900	1000
70%	1063	1000	950	950	1049	1899	1637	1426	1070	953	900	1000
65%	1086	1000	950	977	1122	2130	1760	1479	1109	975	900	1000
60%	1096	1015	950	1028	1187	2334	1922	1515	1150	1000	900	1000
55%	1115	1067	950	1091	1282	2555	2131	1662	1187	1021	919	1007
50%	1129	1110	973	1184	1477	2782	2359	1806	1227	1037	942	1066
45%	1144	1181	1026	1332	1787	3026	2655	2003	1266	1045	972	1104
40%	1154	1208	1108	1503	2100	3301	2946	2204	1305	1060	1016	1141
35%	1169	1222	1250	1710	2449	3783	3214	2404	1403	1084	1068	1150
30%	1184	1233	1501	2044	2729	4075	3516	2617	1552	1118	1099	1161
25%	1201	1319	1681	2419	3117	4684	4151	2858	1670	1122	1108	1170
20%	1254	1376	1943	2734	3601	5512	4527	3112	1796	1157	1128	1196
15%	1288	1497	2292	3229	4110	6030	5060	3411	2058	1193	1150	1214
10%	1325	1639	2939	4216	5110	6440	5571	3840	2439	1229	1178	1225
5%	1427	2581	4149	5655	7383	7533	6094	4501	3018	1250	1550	1231

As with fall/winter operations, close coordination and communication between Reclamation and PacifiCorp on the operation of the KHP will be required to implement the EWA flow schedule. PacifiCorp will implement IGD releases based on target flows provided by Reclamation. Once implementation of the formulaic approach for EWA distribution is initiated on March 1 of each year, Reclamation will monitor IGD flows to ensure that the actual observed flows and volumes released are consistent with the EWA flow schedule (see section 1.3.2.9 for additional information regarding coordination with PacifiCorp).

In real-time operations, it is possible to deviate from the spring/summer formulaic approach to EWA distribution. Specifically, real-time hydrologic conditions, such as high flow events or emergency situations, may warrant the need to deviate from this formulaic approach. In addition, there may be specific ecologic objectives that water resource managers may want to address that can only be achieved by deviating from the formulaic approach to EWA distribution. Any time a deviation from the formulaic approach occurs, either by necessity or to address a specific ecological objective, or if it is determined that the formulaic approach results in conditions that are not consistent with the intent of the proposed action, the process detailed in section 1.3.2.8 will be followed. Reclamation expects the formulaic approach for EWA distribution considered in this proposed action will meet key ecological objectives; however, deviations from the formulaic approach described in sections 1.3.2.6.4 and 1.3.2.8 are expected to further reduce risks to coho salmon from disease and to further improve juvenile coho habitat conditions.

1.3.2.6.4 Disease Mitigation and Habitat Flows

Reclamation's proposed action provides flexibility to deviate in real-time from the spring/summer formulaic approach to deliver:

1. Approximately 50,000 AF of EWA in a manner that best meets coho salmon needs (e.g., disease mitigation, habitat) in below average to dry years (as defined below) or

2. An "opportunistic" surface flushing flow in average to wet years (as defined below) if hydrologic conditions allow.

3. An additional volume of 20,000 AF for enhanced May/June flows in years meeting specific criteria defined below in section 1.3.2.6.9).

Reclamation has modeled use of the approximately 50,000 AF of EWA in dry years as a disease mitigation flow, specifically a surface flushing flow. Surface flushing flows in the KBPM reflect those described as Disease Management Guidance #1 in the Disease Management Guidance document (Hillemeier et al. 2017) and constitute an average release of at least 6,030 cfs from IGD for at least 72 consecutive hours. The specific objective of the surface flushing flows is to disturb surface sediment along the river bottom and disrupt the life cycle of *Manayunkia speciosa* (a polychaete), which is a secondary host for the *C. shasta* parasite central to salmonid disease dynamics in the Klamath River.

Implementation of approximately 50,000 AF of EWA described above must not result in impacts to suckers in UKL outside of those analyzed by USFWS; if Reclamation believes implementation of this volume may result in impacts to suckers outside of those analyzed by USFWS, Reclamation will coordinate with the Services.

1.3.2.6.5 Below Average to Dry Years (March 1 and/or April 1 EWA less than 576,000 AF)

KBPM model logic incorporated "forced" surface flushing flows in below average to dry water years. However, this model logic does not limit NMFS' ability to request implementation of this 50,000 AF volume in an alternative distribution (i.e., NMFS may request distributions other than all at once). Reclamation proposes the following criteria for implementation of forced surface flushing flows:

1. March 1 and/or April 1 EWA is less than 576,000 AF;

    a. If March 1 EWA and April 1 EWA are less than 576,000 AF, a forced surface flushing flow will be implemented between March 1 and April 15.

    b. If March 1 EWA is greater than or equal to 576,000 AF, but April 1 EWA is less than 576,000 AF, a forced surface flushing flow will be implemented between April 1 and April 15 (unless an opportunistic surface flushing flow was implemented in March).

    c. If March 1 EWA is less than 576,000 AF and April 1 EWA is greater than or equal to 576,000 AF, a forced surface flushing flow will be implemented in March. However, if USBR, NMFS, and USFWS determine that delaying the release until after March 31 minimizes impacts to UKL and listed suckers, optimizes EWA efficiency, and maximizes benefits to coho salmon, then the forced surface flushing flow will be implemented between April 1 and April 15.

2. There is sufficient head behind LRD to produce 6,030 cfs for 72 hours at IGD; and

3. The previous day's UKL elevation is greater than or equal to 4,142.4 feet.

In the event that by April 15, a surface flushing flow (or other use of the 50,000 AF) has not been attempted and March 1 and/or April 1 EWA is less than 576,000 AF, Reclamation will initiate a forced surface flushing flow event regardless of UKL elevation, maximum LRD capacity, or IGD flow in a manner that, to the maximum extent practicable, approximates the magnitude and duration described in number 2 above.

1.3.2.6.6 Average to Wet Years (March 1 and April 1 EWA greater than or equal to 576,000 AF)

Reclamation proposes implementation of an opportunistic surface flushing flow in average to wet years. Specific criteria for implementing an opportunistic surface flushing flow include all of the following:

1. March 1 and April 1 EWA are greater than or equal to 576,000 AF;

2. There is sufficient head behind LRD, and accretions between LRD and IGD, to produce 6,030 cfs for 72 hours at IGD;

3. The previous day's UKL elevation is greater than or equal to 4,142.4 feet; and

4. The previous day's IGD flow is greater than or equal to 3,999 cfs.

1.3.2.6.7 Surface Flushing Flow Accounting Details

Reclamation proposes the following rules to account for surface flushing flows:

1. Any flow event producing an average of 6,030 cfs at IGD for 72 hours that occurs outside of the March 1 to April 15 window, does not fulfill surface flushing flow criteria incorporated into the KBPM logic.

2. All surface flushing flow volumes that meet the KBPM criteria for a surface flushing flow are a component of the annual EWA.

3. Surface flushing flows are not subject to reductions under UKL control logic.

4. Surface flushing flows are subject to ramp rates outlined in section 1.3.2.7.

Based on Reclamation's KBPM evaluation of the proposed action, either a forced or an opportunistic surface flushing flow (6,030 cfs from IGD for 72 hours at any time [i.e., inclusive of flows outside the March 1 to April 15 window]) would occur in 34 out of 36 years (i.e., the

POR). The two years in which modeling results indicated a surface flushing event was attempted, but not achieved are 1992 and 2005. Due to insufficient head in UKL, a maximum 3–day average flow of 4,233 cfs and 6,008 cfs were achieved in 1992 and 2005, respectively. See USBR (2019a), Appendix 4, Section A.4.4.7 for additional information regarding implementation of surface flushing flows in the KBPM.

1.3.2.6.8 Deep Flushing Flows

KBPM model logic does not incorporate "forced" deep flushing flows (11,250 cfs for 24 hours), described as Disease Management Guidance #2 in the Disease Management Guidance document (Hillemeier et al. 2017). However, Reclamation will attempt to implement deep flushing flows when hydrologic conditions and public safety allow. Specifically, infrastructure limitations and public safety issues (particularly release capacity at LRD and flood concerns in the middle and lower Klamath Basin) are such that a suite of conditions must be present in order to implement a flow of sufficient magnitude to accomplish the objectives of a deep flushing flow event. These conditions include, but are not limited to, UKL storage to allow for sufficient LRD release capacity, UKL storage sufficient to protect sucker needs, substantial accretions, and Klamath River tributary discharge that does not result in public safety and property concerns. Typically, this suite of conditions occurs when UKL is at flood curve in the late winter or early spring and there is a rain-on-snow hydrologic event. Maximum LRD capacity at the maximum allowable UKL elevation under the current flood curve (4,143.3 feet) is approximately 8,600 cfs, and additional accretions of up to approximately 2,650 cfs for 24 hours would be necessary to achieve 11,250 cfs from IGD at full UKL storage under this proposed action; accordingly, larger accretions are necessary if UKL elevation is less than 4,143.3 feet. Implementation of a deep flushing flow will require coordination with PacifiCorp and numerous public safety entities.

KBPM output indicates that implementation of the proposed action results in achieving a deep flushing flow (11,250 cfs for 24 hours) in 4 out of the 36 years in the POR (1982, 1986, 1996 and 1997).

1.3.2.6.9 Enhanced May/June Flows

In years in which April 1 EWA is greater than 400,000 AF (407,000 AF in years 2020, 2022, and 2024) and less than 576,000 AF, an additional 20,000 AF (10,000 AF from Project Supply and the balance from a combination of live flow and UKL) is distributed in May and June. This action is intended to improve coho habitat in specific years of concern to NMFS. NMFS has requested flexibility in the distribution of the 20,000 AF to maximize the benefit to listed coho, while maintaining UKL elevations/conditions necessary for listed suckers. However, for purposes of modeling effects of the enhanced May/June flows and Reclamation's planning needs (unless NMFS requests alternative management scenarios in a given water year), the specific "default" rules for implementing this 20,000 AF for enhanced May/June flows are as follows:

1. April 1 EWA is greater than 400,000 AF (407,000 AF in years 2020, 2022, and 2024) and less than 576,000 AF;

a. May 1 and June 1 EWA volume calculations do not affect the addition or delivery of 20,000 AF for enhanced May/June flows

2. Daily calculated May IGD flow targets are increased by 195 cfs (12,000 AF total in May);

3. Daily calculated June IGD flow targets are increased by 134 cfs (8,000 AF total in June); and

4. April 1, May 1, and June 1 Project Supply estimates are reduced by 10,000 AF.

20,000 AF is added to the July 1 EWA to ensure proper EWA accounting for the remainder of the spring/summer season. Additionally, the default rules assume that when enhanced May/June flows are implemented and IGD flow targets would otherwise be at minimums, Reclamation would implement flow variability (up to +/- 75 cfs around enhanced IGD flow targets).

Reclamation anticipates NMFS will recommend alternative distributions to default rules numbers 2 and 3 described above, based on information specific to environmental conditions and forecasts as a means to optimize the benefit to coho salmon. Reclamation will not provide alternative distributions to the default rules outlined above that result in impacts to suckers outside of those analyzed in USFWS' 2019 Opinion.

NMFS will lead annual efforts to evaluate and seek input from the Flow Account Scheduling Technical Advisory (FASTA) Team members on alternatives to deviate from default rules used to implement both the May/June 20,000 AF volume, and the 50,000 AF volume for disease mitigation and habitat flows. See section 1.3.2.8 for details regarding the FASTA Team and adaptive flow management process.

1.3.2.7 Ramp Rates at Iron Gate Dam

Ramp rates limit rapid fluctuations in streamflow downstream of dams. Reclamation proposes a ramping rate structure that varies by release rate at IGD. The ramp rates proposed below are as measured at the USGS gaging station located immediately downstream of IGD (USGS Station ID#: 11516530). IGD is owned and operated by PacifiCorp and the ramp rates will be implemented by PacifiCorp as part of IGD operations.

The target ramp-down rates at IGD, when possible, are as follows:

- When IGD flows are greater than 4,600 cfs: decreases in flows of no more than 2,000 cfs per 24-hour period, and no more than 500 cfs per six-hour period.

- When IGD flows are greater than 3,600 cfs but equal to or less than 4,600 cfs: decreases in flows of 1,000 cfs or less per 24-hour period, and no more than 250 cfs per six-hour period.

- When IGD flows are greater than 3,000 cfs but equal to or less than 3,600 cfs: decreases in flows of 600 cfs or less per 24-hour period, and no more than 150 cfs per six-hour period.

- When IGD flows are above 1,750 cfs but equal to or less than 3,000 cfs: decreases in flows of 300 cfs or less per 24-hour period, and no more than 125 cfs per four-hour period. (Note that ramp rates can be slower, such as 75 cfs per six-hour period, if Reclamation and PacifiCorp agree on a schedule).

- When IGD flows are 1,750 cfs or less: decreases in flows of 150 cfs or less per 24-hour period and no more than 50 cfs per two-hour period.

- Upward ramping (ramp-up) is not restricted.

Facility control limitations and stream gage measurement error may limit the ability to manage precise changes in releases from IGD. In addition, facility control emergencies may arise that warrant the exceedance of the proposed ramp-down rates. Therefore, Reclamation recognizes that minor variations in ramp rates (within 10 percent of targets) will occur for short durations and all ramp rates proposed above are targets. Reclamation expects some conditions will result in deviations from proposed ramp rates due to facility control limitations, stream gage error, and/or emergency situations; however, deviations will occur infrequently and through close coordination with PacifiCorp they will be corrected as quickly as practicable. For the reasons described above, Reclamation proposes to allow a maximum reduction of 5 percent below the minimum daily average flows at IGD, not to exceed 72 hours in duration.

NMFS acknowledges that the ramp rates (and proposed minimum daily average IGD flows) are targets PacifiCorp will follow to the greatest extent practicable. Iron Gate powerhouse has a maximum hydraulic capacity of approximately 1,750 cfs, and IGD only has an overflow spillway. At flows above 1,750 cfs, all IGD flows are managed by releases from upstream Copco No. 1 and Copco No. 2 developments. Copco releases are imprecise because flow is measured in megawatt generation, not cfs. NMFS also acknowledges that there are wind effects on Iron Gate reservoir and changing accretions, in addition to considerable travel time between Copco and IGD that can result in imprecise flow releases and ramp rates at IGD.

Under some circumstances (based on presence and abundance of ESA-listed species, life cycle stage, hydrologic conditions in the Klamath River and tributaries, and other considerations) the proposed ramp rates may be more stringent than necessary to prevent the stranding of ESA-listed species downstream of IGD. Reclamation, in coordination with NMFS, may explore more flexible ramp rates to determine under what conditions those rates would be appropriate to implement.

IGD is a PacifiCorp facility and Reclamation does not have physical control over the implementation of ramp rates and operations at IGD. However, Reclamation will coordinate with PacifiCorp as appropriate to ensure that implementation of the ramp rates is consistent with those proposed herein and required by PacifiCorp's Interim Operation Habitat Conservation Plan for Coho Salmon (HCP) (PacifiCorp 2012b).

1.3.2.8 FASTA Team and the Real-time, Adaptive Flow Management Process

There may be opportunities in real-time operations to benefit coho salmon through deviations from the formulaic approach to IGD targets in the fall/winter and EWA distribution in the spring/summer. Additionally, NMFS has recommended that Reclamation retain flexibility in shaping approximately 50,000 AF of EWA in years with March 1 and/or April 1 EWA volumes less than 576,000 AF, and 20,000 AF of water for enhanced May/June flows in years with April 1 EWA volumes greater than 400,000 AF (407,000 AF in years 2020, 2022, and 2024) and less than 576,000 AF. Reclamation, in coordination with the Services, will consider input from Klamath Basin technical experts relative to these actions and opportunities. Reclamation therefore proposes that the FASTA Team be the venue in which these technical experts provide input on real-time, adaptive flow management options.

The primary purpose of the FASTA Team is to share information on hydrologic, meteorological, disease, and other conditions among Klamath Basin technical experts. However, an important secondary function will be to serve as a venue for input on adaptive flow management options, including input or evaluations regarding the shaping of approximately 50,000 AF of EWA for disease mitigation or habitat improvement/protection in years with March 1 and/or April 1 EWA volumes less than 576,000 AF. Participants in the FASTA Team include technical specialists from Reclamation, USFWS, NMFS and various other entities (e.g., federal/state agencies, tribes, stakeholders, disease researchers, etc.) focused on meaningful participation facilitating timely implementation of the flow management process, and providing input to Reclamation. Operational or compliance decisions will not be made by the FASTA Team or during FASTA Team calls or meetings.

Reclamation retains decision-making authority relative to real-time, adaptive flow management and operations on and related to the Project, though Reclamation encourages input and feedback from the FASTA Team. Reclamation also retains discretion regarding FASTA Team participants.

Ultimately, Reclamation, acting under the authority of the Secretary of the Interior, makes flow management decisions affecting UKL and the Klamath River; the process outlined in this section does not relinquish this Secretarial responsibility. Additionally, Reclamation determines whether proposed flows are consistent with flood control, public safety, and operational constraints for UKL and the Klamath Project.

The specific process for providing flow management input via the FASTA Team is as follows:

1. A FASTA Team member (Services included) provides input regarding flow management during a FASTA Team call, or via email or call directly to Reclamation's Klamath River Manager.
    a. If the input is provided outside of a FASTA Team call, the Klamath River Manager may choose to schedule a call or otherwise discuss the input with other FASTA Team members prior to moving to step two.

2. The Klamath River Manager initiates internal Reclamation discussions to

determine if the proposed flows are operationally feasible. Specifically, this will include evaluating whether:
   a. The proposed flows are feasible given Reclamation infrastructure and operations, public safety, flood control, and other operational constraints;
   b. The proposed flows comply with applicable state and federal law; and
   c. The proposed flows are consistent with the proposed action.

3. If the proposed flows are determined by Reclamation to not be operationally feasible for the Klamath Project, the Services will be informed and no further action is necessary.

4. If Reclamation determines the proposed flows are operationally feasible, Reclamation will initiate conversations with PacifiCorp to determine if the proposed flows are operationally feasible for PacifiCorp's KHP.
   a. If the proposed flows are determined by Reclamation and/or PacifiCorp to not be operationally feasible, the Services will be informed and no further action is necessary.

5. If the proposed flows are operationally feasible for both Reclamation and PacifiCorp, Reclamation will initiate conversations with the Services to determine if the proposed flows are likely to provide additional ecological benefit to coho salmon, while maintaining UKL elevations/conditions necessary for listed suckers.
   a. If the proposed flows are determined by NMFS to not likely provide additional ecological benefit to coho salmon, no further action is necessary.

6. If the Services determine that the proposed flows are likely to result in additional ecological benefit to coho salmon and would not adversely affect listed suckers, then Reclamation will take steps to implement the proposed flows. Reclamation will be responsible for implementing the proposed flows, coordinating with PacifiCorp, issuing public safety notices, and any other coordination required to implement the proposed flows in a timely manner.

Reclamation retains discretion to deviate from the steps outlined above when considering flow management input. Additionally, Reclamation will communicate the outcome of the steps above with FASTA Team members as soon as possible.

Finally, the Klamath River Manager is the individual responsible for scheduling and holding FASTA Team calls (as needed, but typically weekly or every other week) and distributing relevant information (as needed, but typically weekly, typically in the form of a slide presentation). Weekly updates will typically include information such as EWA used and EWA remaining, Project deliveries, remaining Project Supply, UKL elevation, LKNWR deliveries, projected IGD target flows, NRCS forecasts, meteorological information, etc.

1.3.2.9 Coordination with PacifiCorp

As provided in its 2012 habitat conservation plan (PacifiCorp 2012b) and the corresponding incidental take permit, PacifiCorp will implement flow-related operations consistent with those analyzed in the biological opinion for Reclamation's Klamath Project. Given IGD is the compliance point for evaluations of Project releases to the Klamath River, close coordination between Reclamation and PacifiCorp is necessary for implementation of the proposed action. All IGD target flows will be determined and coordinated with PacifiCorp three days in advance. Reclamation will also provide an IGD target forecast for an additional 11 days using projections based on NRCS UKL inflow forecasts (if available), NOAA's California Nevada River Forecast Center hydrologic forecasts (namely, for accretions and some UKL tributaries), meteorological forecasts, measured flows, historical patterns, and professional judgement. If these information sources do not adequately predict flows for ongoing operations, Reclamation may ask PacifiCorp to provide accretion estimates between Keno and Iron Gate as they have since the 2013 Opinion. This additional 11 days of forecasted IGD flow targets is intended to provide additional advanced planning opportunities for resource managers and PacifiCorp. However, provisional flow targets provided for these additional 11 days are estimates and the actual IGD target flows will be determined after the upper Klamath Basin hydrologic conditions and LRD to IGD accretions are actually observed.

PacifiCorp has coordinated with Reclamation to implement the flows as described in the 2013 Opinion and Reclamation expects close coordination to continue for the implementation of Project operations analyzed in this consultation (PacifiCorp 2018b, USBR 2018b). During this action, emergencies may arise that necessitate PacifiCorp to deviate from the IGD release target. These emergencies may include, but are not limited to, flood control, and facility and regional electrical service emergencies. Reclamation will closely coordinate with PacifiCorp should the need to deviate from the IGD flow target be identified due to an emergency. Such emergencies occur infrequently and are not expected to significantly influence flows downstream of IGD.

On a weekly basis, Reclamation will assess how the actual observed IGD flows compare to the target flows and communicate any necessary adjustments of LRD releases to PacifiCorp. During periods of rapid hydrologic change and/or during an urgent in-season flow schedule adjustment, it may be necessary to coordinate with PacifiCorp more frequently. PacifiCorp will make every attempt to follow the flow schedule provided by Reclamation (and based on the EWA distribution/IGD formulaic approach) as closely as possible within the operational constraints of the KHP facilities and based upon their obligations under the existing HCP (PacifiCorp 2012b), except when requested otherwise by Reclamation for events such as flushing flows and enhanced May/June flows. If Reclamation determines that actual daily average IGD flows deviate from the flow schedule, Reclamation may need to coordinate with PacifiCorp, the Services, and the FASTA Team to take corrective action. This coordination may result in the need for a formal in-season deviation from the formulaic approach for IGD targets and EWA distribution. For example, if IGD flows are higher or lower than the calculated target flows (e.g., due to errors in forecasted Keno to IGD accretions or operational constraints), Reclamation will coordinate with the Services to identify the volumetric difference of water that was released resulting from the flow schedule deviation. Subsequently, the volumetric difference will be accounted for by adjusting future IGD releases to remain consistent with the proposed action.

Reclamation will provide PacifiCorp with adequate lead time when implementing deviations from the formulaic approach. Reclamation will make every attempt to provide two weeks advanced notice to PacifiCorp when requesting flow schedule adjustments. In some circumstances, Reclamation may request PacifiCorp to respond in less than two weeks if the adjustment to the flow schedule is urgent due to the need to respond to real-time and/or emergency conditions that warrant rapid response (e.g., fish disease, fish die-off, poor water quality, unexpected hydrologic conditions, imminent flooding or other health and safety issues, etc.). Finally, this summary is not inclusive of all possible Reclamation-PacifiCorp coordination needs and processes. Additional coordination details regarding specific management actions (e.g., ramp rates) are described in other sections of the BA.

1.3.2.10 Water Rights Regulation in the Upper Klamath Basin

The KBPM does not separately account for additional inflows to UKL that occur due to enforcement of water rights by the Oregon Water Resources Department (OWRD) in the upper Klamath Basin. See section 1.3.2 in the BA, regarding the ACFFOD, the doctrine of prior appropriation as applied in the State of Oregon, and water rights enforcement by OWRD. The KBPM treats all inflow the same for purposes of the proposed action, regardless of whether that inflow has been altered by upstream tributary water diversions (or the lack thereof).

Consistent with the laws of the State of Oregon, live flow that is physically available at the established point or points of diversion for a water right is subject to appropriation for beneficial use, subject to any restrictions that may exist on the exercise of that water right as a matter of state and/or Federal law. Accordingly, additional inflow to UKL resulting from water rights regulation in the Upper Klamath Basin is available for appropriation and beneficial use within the Project, just like any other live flow that may exist in UKL. However, as noted above, state and Federal law, including the ESA, may nevertheless limit the extent to which this water can be appropriated and applied to beneficial use. Accordingly, additional inflow to UKL due to water rights regulation in the Upper Klamath Basin is subject to the same operational regime as outlined in this proposed action, with respect to ESA requirements, as all other water in UKL.

There is one notable exception to this aspect of the proposed action, necessitated by Oregon law. As discussed in section 1.3.2 of the BA, Project water rights recognized in the ACFFOD are currently enforceable, absent a judicial stay. In accordance with the doctrine of prior appropriation, when the amount of live flow available for appropriation in UKL and the Klamath River is insufficient to meet the actual beneficial irrigation demands within the Project, a call may be made on the Project water rights determined in the ACFFOD. However, OWRD's administrative rules provide that an otherwise enforceable call may be disregarded if the water made available due to enforcement is not available for use or is not otherwise being used by the senior rights holder making the call. See Or. Admin. R. §690-250-0020. Accordingly, as part of this proposed action, to the extent a call is made on Project water rights, the additional inflow to UKL resulting from the call may be delivered for irrigation purposes within the Project in addition to the Project Supply.

Reclamation proposes the following process to quantify and deliver for irrigation purposes available UKL inflow resulting from a Project call:

- Reclamation will quantify inflow to UKL as a result of a Project call. Reclamation retains discretion regarding the quantification method.

- Reclamation will review the quantification method with the Services and UKL inflow rates and volumes resulting from a Project call.

- Reclamation will make the final determination whether, and to what extent, the additional water resulting from a Project call can be delivered from UKL for irrigation use within the Project consistent with Reclamation's obligations under the ESA.

- Reclamation will continue to monitor deliveries of Project Supply, including any deliveries as a result of a Project call for consistency with the proposed action and terms and conditions from the Opinions, including potentially adjusting UKL central tendency to account for these inflows.

The OWRD is responsible for regulating water rights in the State of Oregon. Reclamation has no role in this process except to the extent of making a call on Project water rights when the amount of water physically available at the designated points of diversion for the Project is inadequate to meet beneficial irrigation demands within the Project. This process described above explains how and to what extent Reclamation will determine and make additional water available to the Project due to water rights regulation, consistent with the ESA.

1.3.3 Element Three

Perform the operation and maintenance activities necessary to maintain Klamath Project facilities to ensure proper long-term function and operation.

The O&M activities that are related to the proposed action are described in this section. These activities have been ongoing during the history of the Project, and have been implicitly included in previous consultations with the Services on Project operations. No new O&M activities are proposed; rather, ongoing activities are described to provide a more complete understanding of Project maintenance activities so the potential effects of these activities on listed species during the effects of the proposed action can be analyzed. Reclamation has attempted to include the activities necessary to maintain Project facilities and ensure proper long-term functioning and operation. Reclamation recognizes this is not an exhaustive list and there may be items omitted inadvertently. However, Reclamation believes that if any activities were omitted, they are similar in scope and will not cause an effect to listed species or critical habitat outside the effects analyzed for the activities described herein.

O&M activities are carried out either by Reclamation or the appropriate irrigation district, based on whether the facility is a reserved or transferred work, respectively. Operation of non-Federal facilities by non-Federal parties is not included as part of this proposed action.

1.3.3.1 Exercising of Dam Gates

The gates at Gerber, Clear Lake, Link River, and Lost River Diversion Dams, and the A Canal, Ady Canal, and Link River Dam headgates are exercised twice annually, before and after each irrigation season, to be sure they operate properly. The gates are usually exercised between

March 1 to April 15, and October 15 to November 30, and potentially in conjunction with any emergency or unscheduled repairs. Exercising gates takes from 10 to 30 minutes depending on the facility. Associated maintenance activities performed when exercising gates at specific facilities are as follows:

1. Link River Dam is operated by PacifiCorp, and scheduled exercising of the gates does not occur because the dam is operated continuously. As such, gates are considered exercised whenever full travel of the gates is achieved. A review of O&M inspection is performed every 6 years.

2. Clear Lake Dam activities include exercising both the emergency gate and the operation gate. Depending on reservoir elevations and conditions, water may be discharged to allow for sediment flushing at the dam face. Flushing requires flows less than or equal to 200 cfs (5.7 m^3/sec) for approximately 30 minutes. Maintenance occurs once a year, generally in March or April.

The frost valves at Gerber Dam are exercised annually in order to prevent freezing of dam components. Valves are opened in the fall, at the end of irrigation season, at a flow rate of approximately two cfs and closed in the spring once persistent freezing temperatures have ceased.

1.3.3.2 Dam Facilities

Dam conduits associated with irrigation facilities typically have an average lifespan of 30 years, and are replaced on an as-needed basis. O&M activities include land-based observation and deployment of divers to determine if replacement is necessary. Divers are deployed at Clear Lake, Gerber Reservoir, and Link River Dam every 6 years prior to the Comprehensive Facilities Review for inspection of underwater facilities. If replacement is necessary, Reclamation will evaluate the potential effects to federally listed species and determine if additional ESA consultation is required.

At LRD, the replacement of the remaining wood stop logs with concrete stop logs is proposed to occur over the next three to five years. This action may require in-water work; a floating caisson (i.e., a watertight chamber) will be placed in front of the stop log bay and then filled with water in order to submerge and seal the bay. Once sealed, the bay would be de-watered to allow for maintenance and stop log replacement. When work is completed, air would be pumped into the caisson so that it floats to the surface, and the caisson would be moved to another bay to begin work. Appropriate Reclamation staff would be on-site during the de-watering process to conduct fish salvage as needed.

At the LRDC, the removal and rebuild of the headgates is currently required. A stop log bay will need to be created at the channel headworks to isolate the headgates for replacement. Creation of the stop log bay will involve installation of structural "C" channel beams in the channel walls and pier noses to allow for placement of a steel bulkhead. With a bulkhead in place, water flow can be controlled and allow for the removal of the gates. No de-watering is necessary for this activity; however, some in-water work will be required.

Design Operation Criteria, which outlines O&M guidelines for facilities maintenance, is required at Link River Dam, Clear Lake Dam, Gerber Dam, and the Lost River Diversion Channel gates. The Design Operation Criteria is used to develop Standard Operating Procedures for Reclamation facilities. The Standard Operating Procedures outline the maintenance procedures, requirements, and schedule. The activities address the structural, mechanical, and electrical concerns at each facility. Some of the components of facilities that require maintenance are typically reviewed outside of the irrigation season and include, but are not limited to, the following:

- Trash racks—Maintained when necessary. Trash racks are cleaned and debris removed daily or as needed. Maintenance is specific to each pump, as individual pumps may or may not run year round. Cleaning can take from 1 to 8 hours.

- Concrete repair occurs frequently and as needed. The time necessary to complete repairs to concrete depends on the size and type of repair needed.

- Gate removal and repair or replacement is conducted as needed. Inspections of gates occur during the dive inspection prior to the Comprehensive Facilities Review every 6 years. Gates are visually monitored on a continuous basis.

1.3.3.3 Gage and Stilling Well Maintenance

Gage maintenance is required at various project facilities to ensure accurate measurement of flow. Gage maintenance generally includes sediment removal from the stilling well, replacement of faulty equipment, modification, and/or relocation of structural components, and/or full replacement of the structure, as necessary. Reclamation estimates that one structure is replaced every 5 to 10 years. Stilling wells are cleaned once a year during the irrigation season.

1.3.3.4 Boat Ramps

Boat ramps and associated access areas at all reservoirs are maintained, as necessary, to provide access to Project facilities throughout the year. Gravel boat ramps are maintained on an approximately 5-year cycle. Concrete boat ramps are maintained on an approximately 10-year cycle. Maintenance may include grading, geotextile fabric placement, and gravel augmentation, or concrete placement.

1.3.3.5 Canals, Laterals, and Drains

An inspection of canals, laterals, and drains occurs on an annual basis, or as needed. All canals, laterals, and drains are either dewatered after the irrigation season or have the water lowered for inspection and maintenance every 6 years as required as part of the review of O&M. More frequent maintenance is on a case-by-case basis, as needed. Inspection includes examining the abutments, foundations, other concrete, mechanical facilities, pipes, and gates.

Historically, dewatering of canals, laterals, and drains has included biological monitoring and salvage of listed species, as needed. This practice will continue under the proposed action.

Canals, laterals, and drains are also cleaned to remove debris, sediment, and vegetation on a timeline ranging from annually to every 20 years. Animal burrows that may affect operations or facility structures are dug out, then refilled and compacted. Trees that may affect operations or facility structures, or present a safety hazard, are removed and the ground returned to as close to previous conditions as practicable.

All gates, valves, and equipment associated with the facilities are exercised once or twice annually, before and/or after the irrigation season. Pipes located on dams or in reservoirs have an average lifespan of 30 years, and are replaced when needed. Reclamation replaces approximately 10 sections of pipe a year, and prefers to perform this activity when canals are dry. Associated maintenance activities performed when exercising gates at specific canals are described as follows:

1. The A Canal has six headgates that are maintained. The A Canal headgates are only operated and exercised when fish screens are in place. However, if the fish screens fail, the A Canal will remain operational until the screen is repaired or replaced. Screen failure occurs under certain circumstances, such as when water pressure is too high, and the screens break away so as not to ruin the screen or other infrastructure. Fish screens typically fail once or twice a year during normal operation, and Klamath Irrigation District is notified by means of an alarm. Fish screens are repaired as quickly as practicable.

2. The A Canal headgates are typically exercised in February or March, and in October or November when bulkheads are in place and the A Canal is drained and empty.

3. The Lost River Diversion Channel diagonal gates and banks are scheduled for inspection every 6 years. Inspection is conducted during the winter, which requires drawdown of the Lost River Diversion Channel. However, drawdown of the Lost River Diversion Channel leaves sufficient water to ensure that fish are not stranded. The appropriate water levels are coordinated between O&M staff and Reclamation fish biologists. Biological monitoring is incorporated to ensure flows are adequate for fish protection.

4. The Ady Canal headgates are exercised annually, typically between July and the end of September.

1.3.3.6 Fish Screen Maintenance

The A Canal fish screens have automatic cleaners. Cleaning is triggered by timing or a head difference on either side of the screen. Automatic cleaner timing intervals are typically set at 12 hours, but may be changed as conditions warrant.

Fish screens at the Clear Lake headworks are cleaned before the irrigation season and when 6 to 12 inches (in) (15 to 30 centimeters (cm)) of head differential between forebays 1 and 2 is observed. The frequency of cleaning is dictated by water quality and lake elevation, and varies from year to year. For example, in 2009 the screen was cleaned every other day from late June through September. In 2011 cleaning was not required during the irrigation season. An extra set of fish screens is used while the working fish screens are cleaned to prevent fish passing the headworks. Cleaning the fish screens at Clear Lake may take up to 10 hours. Fish screens are not used during flood releases when Clear Lake elevations are greater than or equal to 4,543.00 ft (1,384.71 m), but the maximum lake elevation observed during the POR for this water body (4,539.55) is nearly 3.5 feet (1.1 m) below this elevation.

1.3.3.7 Fish Ladder Maintenance

Link River Dam fish ladder O&M includes exercising both the headgate and the attraction flow gate. Gates are exercised twice a year in February or March and in November or December. Exercising the gates typically takes approximately 15 minutes. This activity includes monitoring by Reclamation biologists.

1.3.3.8 Roads and Dikes

Road and dike maintenance, including gravel application, grading, and mowing, occurs as necessary from April through October. Pesticides and herbicides are also used on Reclamation managed lands, primarily canal rights-of-way to control noxious weeds on an annual basis from February through October (in compliance with the Pesticide Use Plan). Techniques used to control noxious weeds may include cultural, physical, and chemical methodologies for aquatic and terrestrial vegetation. The products are still being used to minimize take and comply with current Integrated Pest Management Plans required by the Reclamation Manual's Directive and Standard ENV 01-01. At this time, there have been no changes to the action.

1.3.3.9 Pumping Facilities

All pumping plants are monitored yearly by visual inspection. Dive inspections occur every 6 years according to the review of O&M inspection. This activity includes dewatering of the adjacent facility and installation of coffer dams. Dive inspections and dewatering of the facilities typically occurs in August to December. Biological monitoring occurs daily during dewatering, and will be continued in this proposed action to ensure the protection of fish. Aquatic weeds that collect on trash racks and around pump facilities are removed on a daily basis.

All pumps are greased, cleaned, exercised, and oil levels checked monthly if they are not in regular use. Pumps are greased and oiled according to the manufacturer's specifications. Excess grease and oil is removed. When oil is changed, oil spill kits are available and used as necessary. Pumps used for irrigation are maintained daily during the irrigation season. Drainage pumps are maintained and operated on a daily basis throughout the year.

Should a pump require repair, the pump chamber would be isolated from the water conveyance facility by placement of a gate, bulkhead, or coffer dam. The chamber would then be de-watered to allow for maintenance access. Appropriate staff would be on-site to perform fish salvage, as necessary.

NMFS does not expect any activities associated with Element Three will have effects on listed species or their designated critical habitat in this Opinion, because the activities and effects of those activities will occur upstream of IGD, which is the upstream extent of the distribution of listed anadromous fish species and designated critical habitat for those species under NMFS' jurisdiction in the Klamath Basin. Thus, no further analysis of effects related to Element Three is presented in this Opinion.

1.3.4 Water Shortage Planning

Reclamation generally follows an established process for identifying and responding to the situation where available water supplies are inadequate to meet beneficial irrigation demands within the Project.

During the fall-winter period, Reclamation coordinates directly with KDD and the USFWS regarding Project water availability and demands (for both refuge and irrigation purposes). Reclamation does not make any public announcement of the volume of water available during the fall-winter period for delivery to the Project, including LKNWR.

Near the beginning of the spring-summer irrigation season, Reclamation issues an annual Operations Plan, which identifies the anticipated volume of water available from the various sources utilized by the Project, and the associated operating criteria applicable that year. The Operations Plan is posted on Reclamation's website, a press release is issued, and copies are sent by letter to Project water users and affected Tribes.

In the event of an anticipated shortage in the volume of water available for irrigation use from Clear Lake and Gerber reservoirs, Reclamation coordinates the allocation and delivery of limited supplies with LVID, HID, and others with a contractual right to receive stored water from these reservoirs.

In the event of an anticipated shortage in the volume of water available for irrigation use from UKL and the Klamath River, Reclamation will coordinate with irrigation districts and water users regarding anticipated irrigation demands within the Project. If the volume of water or the timing when it is available is less than the anticipated demands of these two districts, Reclamation may determine it necessary to issue an Annual Drought Plan (Drought Plan), which identifies and explains how water from UKL and the Klamath River is to be allocated among various entities with different contractual priorities to Project water. The Drought Plan is posted on Reclamation's website, a press release is issued, and affected Project water users are provided a copy and notified by letter of the volume of water available under their respective contract.

The Drought Plan will identify an initial allocation for entities and individuals with a secondary priority to Project water from UKL and the Klamath River. Reclamation then updates the allocation (either increasing or decreasing the water available) as the irrigation season progresses and hydrologic conditions change, again notifying affected contractors by letter. Reclamation attends district board meetings, calls contractors by telephone, and answers direct inquiries related to the Drought Plan allocation.

In addition to possibly allocating the available water through the Drought Plan, there are other actions that Reclamation can take or directly facilitate, in response to a shortage in water available from the Project.

Consistent with Reclamation policy, Reclamation may administratively approve the transfer of water between districts and individual water users within the Project. Such transfers do not increase the amount of water available to the Project or expand the Project's service area but rather simply change the place of use within the Project. Prior to approval, Reclamation reviews each application on a case-by-case basis to make sure these basic conditions are met.

These internal transfers are generally used by irrigators to address a shortage in the water available under a given contract, based on the contractual priority it provides to Project water. Overall, these types of transfers promote the efficient and economical use of water.

Internal Project transfers are also available for irrigable lands within Lower Klamath and Tule Lake NWRs, subject to the approval of the USFWS. Water made available to a NWR through an internal transfer approved by Reclamation is separate from any water that may be available for delivery to the NWR consistent with the terms of this proposed action.

As has occurred in the past, Reclamation may also engage in irrigation demand reduction activities within the Project, on a year-by-year basis. There is no program currently in place for such activities, but such efforts have occurred periodically over the last two decades, subject to proper legal authority and the availability of federal appropriations. In the past, these activities have included agreements with individual landowners to forgo use of Project water or to produce supplemental groundwater.

1.3.5 Conservation Measures

The term "conservation measure" is defined by the Endangered Species Act Consultation Handbook (USFWS and NMFS 1998) as an action to benefit or promote the recovery of listed species that are included by the federal agency as an integral part of the proposed action. These actions will be taken by the federal agency or applicant, and serve to minimize or compensate for, project effects on the species under review. These may include actions taken prior to the initiation of consultation, or action which the federal agency or applicant have committed to complete in a BA or similar document. Reclamation proposes the conservation measures to assist Reclamation in best meeting the requirements under section 7 of ESA by (1) utilizing its "authorities in furtherance of the purpose of this Act by carrying out programs for the conservation of endangered species and threatened species…" and (2) avoiding actions that jeopardize the continued existence of listed species.

1.3.5.1 Coho Restoration Grant Program

Reclamation will provide $700,000 annually in 2019 and 2020, and $500,000 from 2021 through 2023 for program administration and projects that address limiting factors for SONCC coho salmon in the Klamath Basin contingent upon Reclamation's annual budget process and appropriations. The program targets projects that have both the greatest impact on promoting survival and recovery and provide sustainable and lasting ecological benefits in the Klamath River Basin for coho salmon. Projects given the highest priority under this program include access improvement and barrier removal, improved habitat and access to coldwater refugia, instream habitat enhancement and protections, and water conservation. Restoration projects minimize habitat related effects of the Project by individually and comprehensively improving critical habitat conditions for coho salmon individuals, populations, and overall.

As described in Reclamation's BA, Reclamation includes conservation measures proposed to benefit or promote the recovery of ESA-listed suckers. This listed species is under the jurisdiction of USFWS. NMFS analyzed the conservation measures Reclamation proposed for ESA-listed suckers. NMFS determined that the proposed conservation measures for suckers do not have any effects to ESA-listed species or designated critical habitat under the jurisdiction of NMFS because the actions will all occur above IGD where there are no such listed species or designated critical habitat. Thus, NMFS has not included these measures in this Opinion's project description or effects analysis.

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 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 provides 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 non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

Reclamation determined the proposed action is not likely to adversely affect both the southern DPS of north American green sturgeon (*Acipenser medirostris*) and the southern DPS of Pacific eulachon (*Thaleichthys pacificus*) or critical habitat for the southern DPS of Pacific eulachon (USBR 2018a). Our concurrence is documented in the "*Not Likely to Adversely Affect" Determinations* section (Section 2.8). Therefore, an ITS for these species is unnecessary.

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 "to jeopardize the continued existence of" a listed species, which is "to engage in an action that 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.

While this analytical approach specifically refers to our analysis of coho salmon, it also applies to our analysis of effects of the proposed action on Southern Residents, which focuses on effects of the proposed action on Klamath River Chinook salmon, the primary food source of Southern Residents. Later in this Opinion, we analyze the effects of the proposed action on Southern Residents, including additional elements specific to our analysis of Southern Residents such as the importance of Klamath River Chinook salmon to the available prey base of Southern Residents and the magnitude of effects from the proposed action on Chinook salmon survival to ocean entry.

This biological opinion relies on the definition of "destruction or adverse modification," which "means a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214 (February 11, 2016)).

The designations of critical habitat for the species addressed in this opinion use the term primary constituent element (PCE) or essential features. The new critical habitat regulations (81 FR 7414 (February 11, 2016)) replace 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.

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

- Identify the rangewide status of the species and critical habitat expected to be adversely affected by the proposed action.
- Describe the environmental baseline in the action area.
- Analyze the effects of the proposed action on their habitat.
- Analyze the effects of the proposed action on species using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors by: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is adversely modified.
- If necessary, suggest a RPA 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 individual, interactive, or cumulative direct and indirect 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 can include 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 are 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). Reductions in one or more of these 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). If NMFS concludes that listed species are not likely to be adversely affected, NMFS would conclude the assessment.

2.1.1.2 Effects Analysis for the SONCC coho salmon ESU

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 4). 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

SONCC coho salmon ESU 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 rearing, and smolt outmigration.

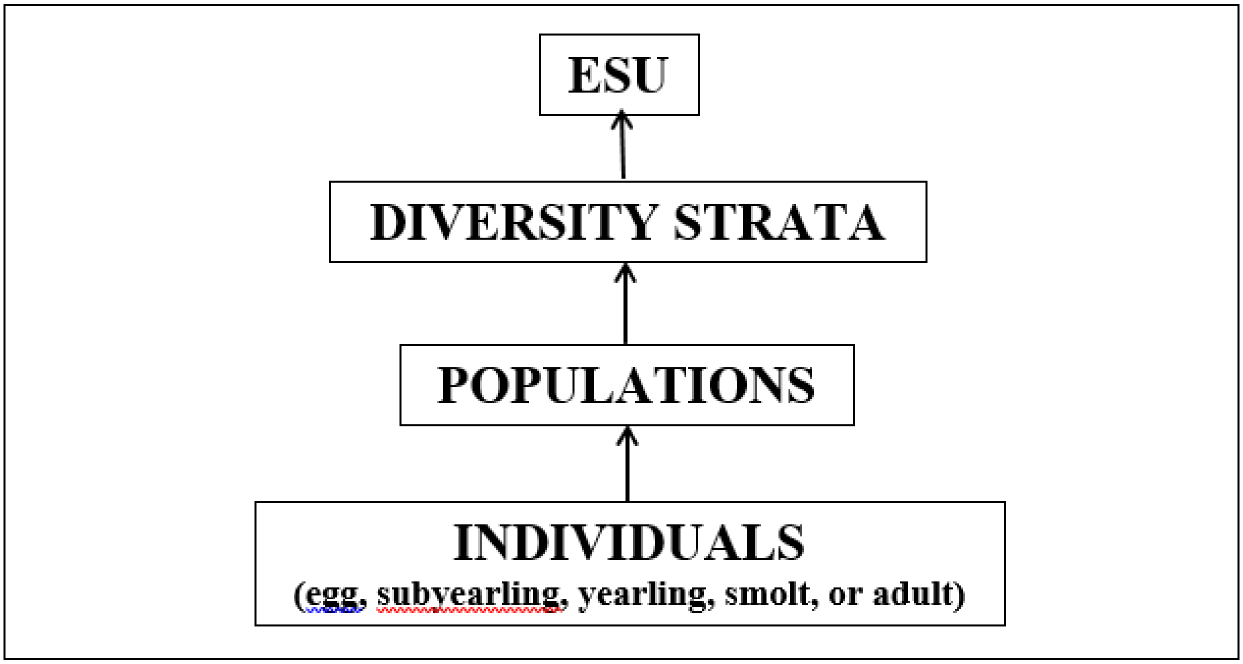

Figure 4. Conceptual model of the hierarchical structure that is used to organize the jeopardy risk assessment for the SONCC coho salmon ESU.

2.1.1.3 Viable Salmonid Populations Framework for Coho Salmon

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 viable salmonid population (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 SONCC coho salmon ESU.

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. 2008).

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 smolting, 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.

A viable population (or species) is not necessarily one that has recovered as defined under the ESA. To meet recovery standards, a species may need to achieve greater resiliency to allow for activities such as commercial harvest and the existing threat regime would need to be abated or ameliorated as detailed in a recovery plan. Accordingly, 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 coho salmon (McElhany et al. 2000). These four parameters are consistent with the “reproduction, numbers, or distribution” criteria found within the regulatory definition of jeopardy (50 CFR 402.02) and are used as surrogates for numbers, reproduction, and distribution. The fourth VSP parameter, diversity, relates to all three jeopardy criteria. For example, numbers, reproduction, 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.

2.1.2 Hydrological Data used to Analyze the Proposed Action

Throughout this Opinion, NMFS uses the concepts of a natural flow regime (Poff et al. 1997) to guide our analytical approach. 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). Variability of the natural flow regime is inherently critical to ecosystem function and native biodiversity (Poff et al. 1997, Puckridge et al. 1998, Bunn and Arthington 2002, Beechie et al. 2006).

The analysis by Williams et al. (2006b) suggested that substantial environmental variability (e.g. wet coastal areas and arid inland regions) within the Klamath River Basin resulted in nine separate populations of coho salmon. Because aquatic species have evolved life history strategies in direct response to natural flow regimes (Taylor 1991, S. Waples et al. 2001, Beechie et al. 2006), maintenance of natural flow regime patterns is essential to the viability of populations of many riverine species (Poff et al. 1997, Bunn and Arthington 2002).

When flow regimes are altered and simplified, the diversity of life history strategies of coho salmon are likely to be reduced because life history and genetic diversity have a strong, positive correlation with the extent of ecological diversity experienced by a species (S. Waples et al. 2001).

Reclamation’s KBPM and resulting output files used to analyze Project effects in the 2019 BA include analyses of the POR and an alternative model run of the POR applying all of the rules associated with the proposed action. The resulting alternative POR reflects what the hydrological condition would have been if water had been managed under the proposed action from 1981 through 2016. Since 2017, Reclamation has operated the Project under a court order, which is described in the Section 1.2 *Consultation History* and Section 2.2.3 *Environmental Baseline*. Therefore, NMFS also uses hydrological data from 2017 and 2018 to describe the current hydrological baseline.

2.1.3 Flow and Rearing Habitat Analysis

NMFS used the relationships of flow and habitat formulated by Hardy (2012) and Hardy et al. (2006) to quantify how coho salmon fry and juvenile habitats vary with water discharge in the mainstem Klamath River below IGD. NMFS is not aware of any other studies that quantify the relationship between discharge and habitat in the Klamath River mainstem.

Empirical data on juvenile coho salmon in the mainstem Klamath River are limited. While juvenile outmigration monitoring (e.g., downstream migrant traps) provides information on distribution and emigration timing on the mainstem Klamath River, there are few observations of juvenile coho salmon utilizing micro-habitat. Consequently, Hardy et al. (2006) developed literature-based habitat suitability criteria to quantify habitat availability for juvenile coho salmon within the mainstem Klamath River. Habitat suitability criteria were validated using the limited empirical observations of coho salmon fry and parr in the mainstem Klamath River (Hardy et al. 2006).

Using simulated hydrodynamic variables at intensive study sites, Hardy developed composite suitability indices for each site from the habitat suitability criteria data, which incorporated species and life-stage specific preferences with regard to specific microhabitat features, such as flow, depth, velocity, substrate, and cover characteristics. The composite suitability indices were later converted into a combined measure known as the weighted usable area (WUA) to characterize the quality and quantity of habitat in terms of usable area per 1,000 linear feet of stream (NRC 2008). Reclamation (2019a) then scaled up WUA results from the individual sites to the larger reach-level scale. WUA is a measure of habitat suitability, predicting how likely a habitat patch is to be occupied or avoided by a species life stage at a given time, place, and discharge (i.e., the suitability of the habitat for a specific species and life-stage of fish) (Hardy et al. 2006, NRC 2008).

NMFS uses reach-level WUA curves to gauge the general amount of instream habitat quantity and quality within the mainstem Klamath River resulting from the proposed action, and characterizes the change as a difference in suitable habitat volume. NMFS uses WUA curves from reach-level study sites for the Upper Klamath and Middle Klamath River reach effects analyses (Table 10).

Table 10. Hardy et al. (2006) and Hardy (2012) reach-level study sites used by NMFS for analysis.

Klamath River Reach	Coho Salmon Fry	Coho Salmon Juvenile*
Upper Klamath River Reach	IGD to Shasta River reach	Trees of Heaven
	Shasta to Scott River reach	
	Scott to Salmon River reach	Seiad Valley
Middle Klamath River Reach	Scott to Salmon River reach	Rogers Creek

*While Hardy et al. (2006) developed WUA curves for coho salmon juveniles at seven reaches in the Klamath River, NMFS uses only the Trees of Heaven, Seiad Valley, and Rogers Creek reaches because these reaches have relatively high habitat availability and are the reaches most influenced by the proposed action (i.e., closest to IGD).

As in previous opinions (NMFS 2010a, NMFS and USFWS 2013), NMFS expects that at least 80 percent of maximum available habitat provides for the conservation needs of coho salmon, and flows that provide at least 80 percent of maximum available habitat are considered beneficial for maintaining PBFs of critical habitat and meeting habitat needs of coho individuals. NMFS then highlights the time periods and flow exceedances when the proposed action will reduce habitat availability below 80 percent of maximum available habitat for each reach. Instream maximum available habitat of 80 percent has been used to develop minimum flow needs for the conservation of anadromous salmonids (Sale et al. 1981, NMFS 2002, Hetrick et al. 2009). Therefore, NMFS expects that at least 80 percent of maximum available habitat provides a wide range of conditions and habitat abundance in which populations can grow and recover. Where habitat availability is 80 percent or greater under the proposed action, habitat is not expected to limit individual fitness or population productivity or distribution nor adversely affect the function of PBFs of coho salmon critical habitat.

NMFS is aware of the limitations of focusing solely on WUA analysis when analyzing an individual coho salmon or coho salmon population's response to an action (e.g., NRC 2008). For example, whether or not individuals actually occupy suitable habitat is dependent on a number of factors that may preclude access, including connectivity to the location, competition with other individuals, and risks due to predation (Hardy et al. 2006). Like all models, the instream flow model developed by Hardy et al. (2006) is an imperfect representation of reality (NRC 2008), and uncertainty exists in the model. Thus, NMFS' analysis focuses not solely on habitat availability, but also on other important components of the flow regime, like water quality, channel function, and hydrologic behavioral cues, and how they affect coho salmon individual fitness.

2.1.4 Evidence Available for the Consultation

To conduct these analyses, NMFS considered all lines of evidence available through published and unpublished sources that represent evidence of adverse consequences or the absence of such consequences. The following provides a list of some of the main resources NMFS considered:

- Final rule affirming the listing of the SONCC coho salmon ESU as threatened (70 FR 37160 (June 28, 2005))
- Final rule designating critical habitat for the SONCC coho salmon ESU (64 FR 24049 (May 5, 1999))
- The SONCC coho salmon recovery plan (NMFS 2014a)
- NMFS' 2010 opinion on the Klamath Project (NMFS 2010a)
- NMFS and USFWS joint (2013) opinion on the Klamath Project
- The most recent NMFS five-year status review for SONCC coho salmon (NMFS 2016b)
- The Natural Research Council (NRC)'s assessment of Klamath River Basin fishes and hydrology (NRC 2008)
- US Fish and Wildlife technical memorandum addressing prevalence of *C. shasta* infections in salmonids (USFWS 2016a)
- US Fish and Wildlife technical memorandum addressing polychaete distribution and infection (USFWS 2016b)
- US Fish and Wildlife technical memorandum addressing Ceratonova shasta waterborne spore stages (USFWS 2016c)
- US Fish and Wildlife technical memorandum addressing sediment mobilization and flow history in the Klamath River below IGD (USFWS 2016d)
- Measures to Reduce *Ceratanova Shasta* Infection of Klamath River Salmonids. A Guidance Document (Hillemeier et al. 2017)
- Final rule listing the Southern Resident killer whale DPS as endangered (70 FR 69903 (November 18, 2005))
- The recovery plan for Southern Resident Killer Whales (NMFS 2008a)
- The most recent 5-year status review for Southern Resident Killer Whales (NMFS 2016e)

2.1.5 Critical Assumptions

To address the uncertainties related to the proposed action effects and species responses, NMFS relied on a set of key assumptions that are critical to our effects analysis on listed species and their critical habitats. While other assumptions can be found elsewhere in this Opinion, the assumptions listed here are especially critical to analyzing effects of the proposed action. If new information indicates an assumption listed below (or in other sections of the Opinion) is invalid, Reclamation and NMFS may be required to reassess the effects of the proposed action on listed species and their critical habitat, and reinitiate consultation, if warranted.

Restoration Activities

- Reclamation will provide at least $700,000 in 2019 and 2020, and $500,000 in years 2021-2013, for fish habitat restoration in the action area, and habitat restoration will be implemented each year of the proposed action.

Klamath Project Operations

The KBPM is the planning model used to evaluate water management strategies that resulted in the proposed action. Through development of the KBPM logic, and for the purpose of our effects analysis on the KBPM output as a result of the proposed action, many critical assumptions were identified. Below is a bulleted list of these critical assumptions that have been identified for the KBPM and are assumed in our analysis.

- The upper Klamath River basin will experience water year types and UKL inflows within the range observed in the POR.
- Accretions from Link River Dam to IGD will be consistent with accretion timing, magnitude, and volume for the POR.
- Accretions from Link River Dam to IGD will be routed through PacifiCorp's KHP hydroelectric reach in a manner that is consistent with the proposed action modeled results for the POR.
- NRCS inflow forecasts will be within the range and accuracy of historical inflow forecasts for the POR.
- UKL bathymetry in the model accurately represents actual UKL bathymetry and storage capacity.
- Water deliveries to the Project and off the Project will be consistent with average historical distribution patterns for the POR.
- Link River Dam releases, for the purpose of meeting flow targets at IGD, will not be regulated by UKL control logic at a greater magnitude or duration than was observed in the KBPM results.
- Facility operational constraints/limitations, and maintenance activities will be within the historical range for the POR.
- Implementation of the proposed action will not exactly replicate the modeled results, and actual IGD flows and UKL elevations will differ during real-time operations.

The listed species that are expected to be adversely affected by the action under consideration are the SONCC coho salmon ESU and Southern Resident Killer Whale DPS (Southern Residents).

The critical habitat that is expected to be adversely affected by the action under consideration is that designated for the SONCC coho salmon ESU (64 FR 24049 (May 5, 1999)).

This Opinion includes background and analysis material for SONCC coho salmon first (Section 2.2), followed by material for Southern Residents (Section 2.3)

2.2 Southern Oregon/Northern California Coastal (SONCC) coho salmon

2.2.1 Rangewide Status of the Species and Critical Habitat

This Opinion examines the status of each species that would 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' current "reproduction, numbers, or distribution" as described in 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 essential PBFs that help to form that conservation value.

2.2.1.1 Species Description and General Life History

SONCC coho salmon have a generally simple 3-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. 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 3-year old fish to renew the cycle.

2.2.1.2 Status of Species and Critical Habitat

In this Opinion, 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 essential PBFs that help to form that conservation value.

2.2.1.2.1 Status of SONCC Coho Salmon

2.2.1.2.1.1 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. 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 general, declining productivity equates to declining population abundance. Available data show that the 95 percent confidence intervals for the slope of the regression line include zero for many populations in the SONCC coho ESU, indicating that whether the productivity is decreasing, increasing, or stable cannot be determined (McElhany et al. 2000, NMFS 2014a).

2.2.1.2.1.2 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 2001a, 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 and is inadequate to contribute to a viable ESU, given the significant reductions in abundance and distribution.

2.2.1.2.2 Status of Critical Habitat

In designating critical habitat for the SONCC coho salmon ESU, NMFS identified the following five essential habitat types (PBFs): (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, essential features of 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 (May 5, 1999)). 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, many of which are noted above under *Status of Critical Habitat*, 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. Ocean conditions have been unfavorable in recent years (2014 to present) due to both the El Nino in 2015 and 2016, and the existence of a northeast Pacific marine warming phenomenon, in 2013 through 2015, referred to as “the blob” (Cavole et al. 2016). Reduced flows can cause increases in water temperature, resulting in increased heat stress to fish and thermal barriers to migration.

New information since this SONCC coho salmon ESU was listed suggests that the earth’s climate is warming, and that this change could significantly impact ocean and freshwater habitat conditions (Intergovernmental Panel on Climate Change 2014), which affects survival of coho salmon. Of all the Pacific salmon species, coho salmon are likely one of the most sensitive to climate change due to their extended freshwater rearing. Additionally, the SONCC coho salmon ESU is near the southern end of the species’ distribution and many populations reside in degraded streams that have water temperatures near the upper limits of thermal tolerance for coho salmon.

Average annual Northwest air temperatures have increased by approximately 1°C since 1900, or about 50 percent more than the global average warming over the same period (Independent Scientific Advisory Board 2007). The latest climate models project a warming of 0.1°C to 0.6°C per decade over the next century. According to the Independent Scientific Advisory Board’s

(ISAB) recurring reports (https://www.nwcouncil.org/fw/isab/), these effects may have the following physical impacts within approximately the next 40 years:

- Warmer air temperatures will result in a shift to more winter/spring rain and runoff, rather than snow that is stored until the spring/summer melt season.

- With a shift to more rain and less snow, snowpack will diminish in those areas that typically accumulate and store water until the spring/summer melt season.

- With a smaller snowpack, these watersheds will see their runoff diminished and exhausted earlier in the season, resulting in lower stream flows in the June through September period.

- River flows in general and peak river flows are likely to increase during the winter due to more precipitation falling as rain rather than snow.

For Northern California and southern Oregon, most models project heavier and warmer precipitation. Extreme wet and dry periods are projected, increasing the risk of both flooding and droughts (DWR 2013). Annual precipitation could increase by up to 20 percent over northern California. A greater proportion of precipitation events occurring during the mid-winter months is likely to occur as intense rain and rain-on-snow events that are likely to lead to higher numbers of landslides and greater and more severe floods (Luers et al. 2006, Doppelt et al. 2008). Overall, there will be earlier and lower low-flows and earlier and higher high-flows. Increased flooding is likely to scour salmon eggs from their redds and displace overwintering juveniles, while lower low flows are likely to increase summer water temperatures and decrease available salmon habitat.

Water temperature is likely to increase overall, with higher maximum temperatures along with higher minimum temperatures in streams. Increases in winter and spring temperature regimes are likely to include, but are not limited to, depletion of cold water habitat, variation in quality and quantity of tributary rearing habitat, alterations to migration patterns, accelerated embryo development, premature emergence of fry, increased bio-energetic and disease stresses on fish, and increased competition among species. In addition, the increase in summer water temperatures are likely to be especially dramatic since flows in many streams are expected to continue decreasing as a result of decreasing snowpack (Luers et al. 2006, Crozier et al. 2008, Doppelt et al. 2008, Crozier 2016). This loss of snowpack will continue to create lower spring and summertime flows while additional warming will cause earlier onset of runoff in streams.

Marine ecosystems and habitats important to juvenile and adult salmonids are likely to experience changes in temperatures, circulation, water chemistry, and food supplies (Feely 2004, Osgood 2008, Turley 2008, Abdul-Aziz et al. 2011, Doney et al. 2012). These changes are likely to have deleterious impacts on coho salmon growth and survival while at sea. Ocean acidification also has the potential to affect the phytoplankton community due to the likely loss of most calcareous shell-forming species such as pteropods (Crozier 2016). Related direct effects to coho salmon likely include decreased growth rates due to ocean acidification and increased metabolic costs due to the rise in sea surface temperature (Portner and Knust 2007).

The threat to coho salmon from global climate change will increase in the future. In general, conditions in the climate and within the ecosystems on which coho salmon rely will change dramatically over the next several decades. Climate change is having, and will continue to have, an impact on salmonids throughout the Pacific Northwest and California (Crozier 2016). Overall, climate change represents a growing threat for the SONCC coho salmon ESU, and will challenge the resilience of coho salmon (NMFS 2014a).

2.2.2 Action Area for SONCC Coho Salmon

"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 action area includes the mainstem Klamath River from IGD at River Mile (RM) 190 to the Klamath River mouth (Figure 5). Tributaries accessible to anadromous salmonids between IGD and the Klamath River mouth may be affected by the proposed action through Reclamation's coho restoration grant program, and are also included as part of the action area, with the exception of the Trinity River. Not all Klamath River tributaries are shown in Figure 5; however, all tributaries between IGD and the Klamath River mouth are eligible for funding through the coho restoration grant program, with the exception of the Trinity River. The Trinity River is not included in the action area because Reclamation and NMFS have determined that flow effects of the proposed action on water quantity and quality are ameliorated by tributary contributions in the locations and at the times when Trinity River coho salmon could be exposed to them. The Trinity River is also not eligible for funding through the coho restoration grant program because projects are prioritized to improve conditions to benefit coho salmon populations that are likely to experience the greatest adverse effects from the proposed action. Additionally, a large-scale Trinity River Restoration Program supports coho salmon restoration in the Trinity River basin.

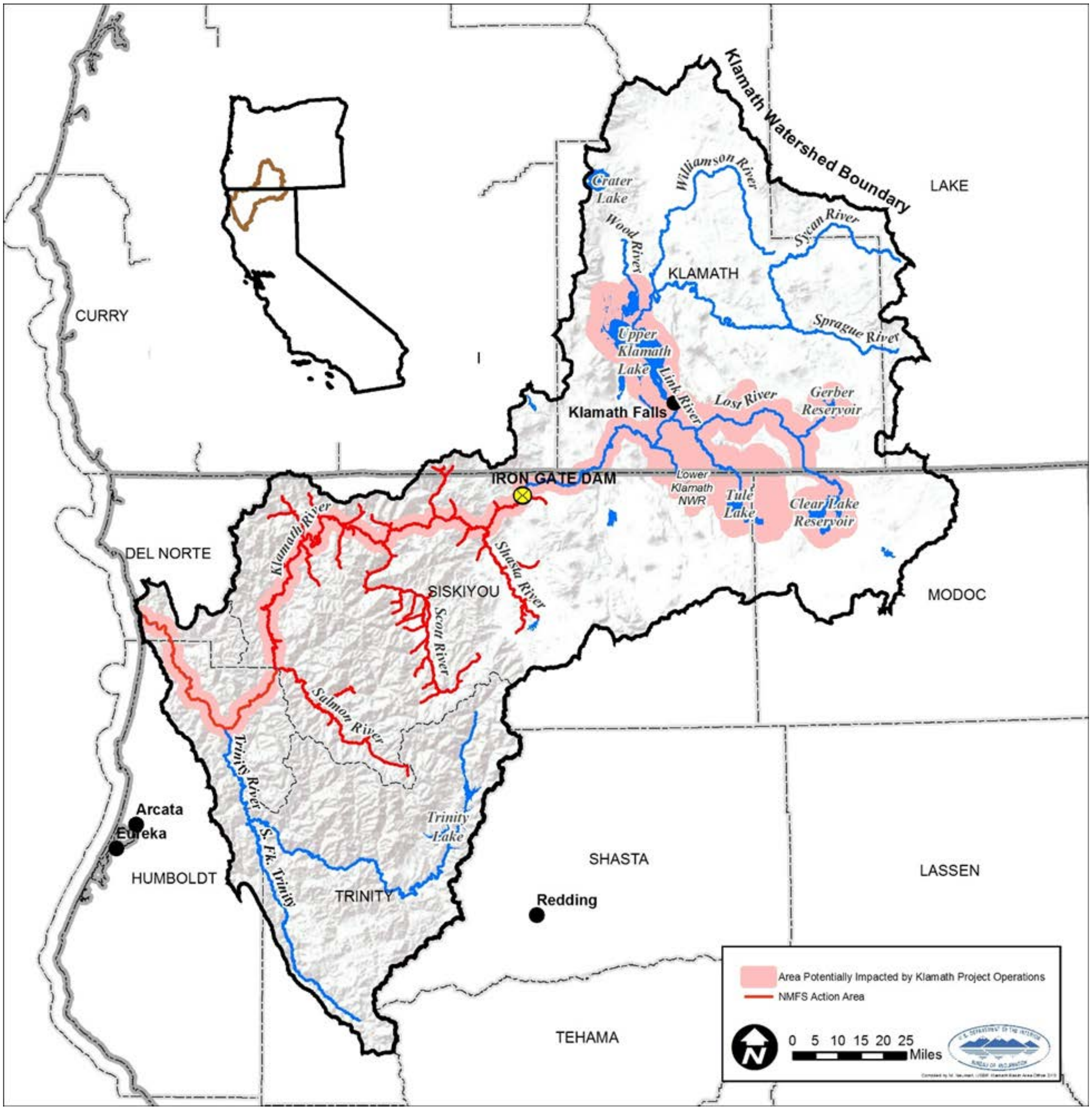

Figure 5. The action area for Reclamation's proposed action.

2.2.3 Environmental Baseline

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 consultation, and the impact of state or private actions that are contemporaneous with the consultation in process (50 CFR 402.02).

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, which includes the mainstem Klamath River to the Pacific Ocean and the major tributaries of the Klamath River between IGD and the Salmon River (inclusive).

Coho salmon were once numerous and widespread within the Klamath River basin (Snyder 1931). Today, due to migration barriers (Figure 6), habitat degradation, and other factors, the small populations that remain occupy a fraction of their historical area, in limited habitat within the tributary watersheds (i.e. Shasta River, Scott River, and Salmon River) and the mainstem Klamath River just below IGD (NRC 2004). In recent years, the highest recorded escapement of adult coho salmon in the action area has been to the Scott River sub-basin. The extent and quality of coho habitat in each sub-basin is discussed in greater detail below.

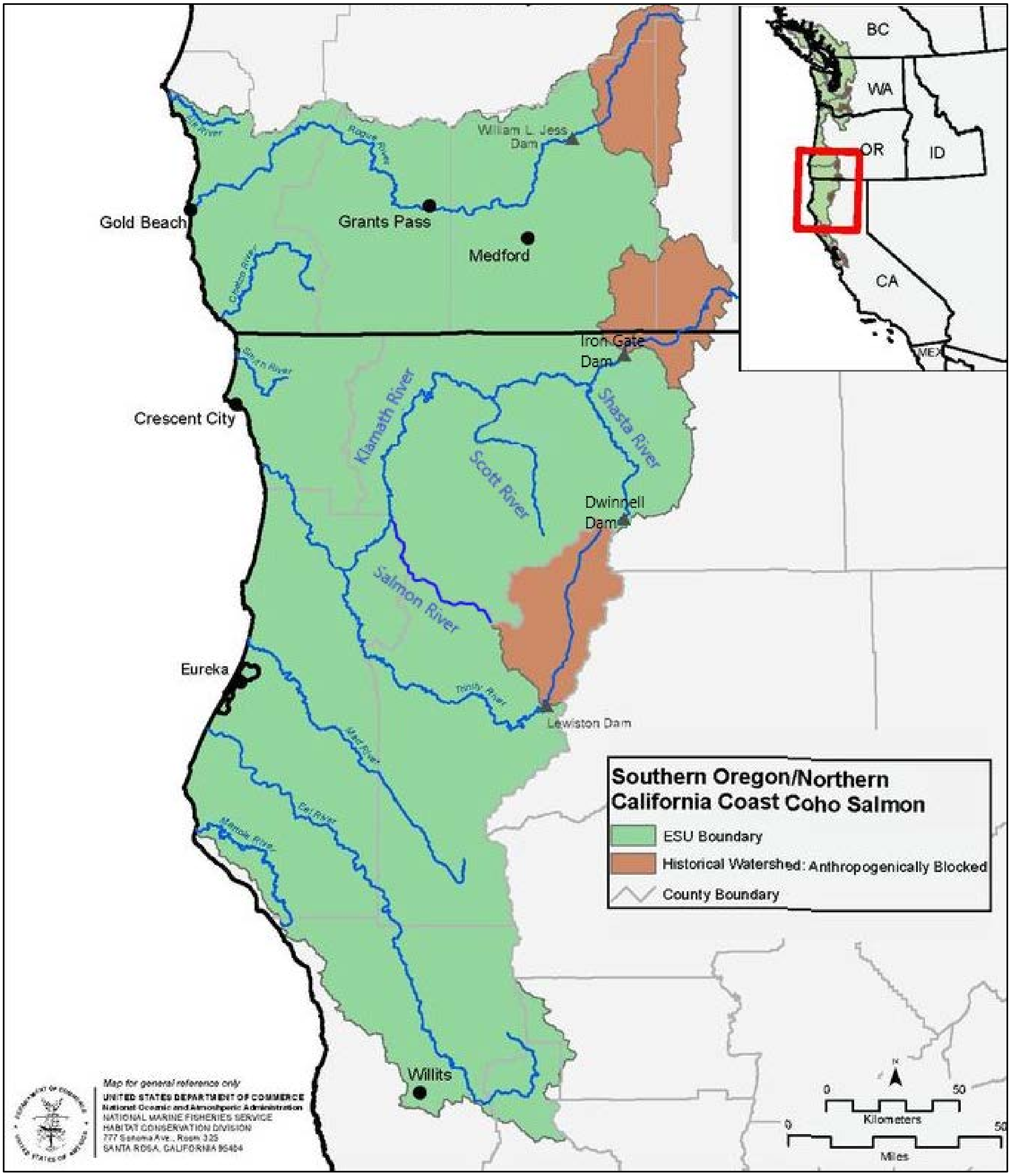

Figure 6. Map showing the SONCC coho ESU boundary and major barriers in the action area including IGD on the Klamath River and Dwinnell Dam on the Shasta River.

Coho salmon in the action area occupy temperate coastal regions and arid inland areas stretching an approximated 190.1 river miles from IGD downstream to the estuary. Coho salmon in the action area belong to two (i.e. the Interior Klamath and the Lower Klamath) of the seven diversity strata that comprise the SONCC coho salmon ESU. All five populations of the Interior Klamath Diversity Stratum, and one population of the Lower Klamath River Diversity Stratum, occur in the action area (Figure 7). Populations in the action area include: the Upper Klamath River (comprised of tributaries and mainstem Klamath River from the mouth of Portuguese Creek at RM 128 upstream to IGD at RM 190 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), the Salmon River (RM 66), the Scott River (RM 144), and the Shasta River (RM 177).

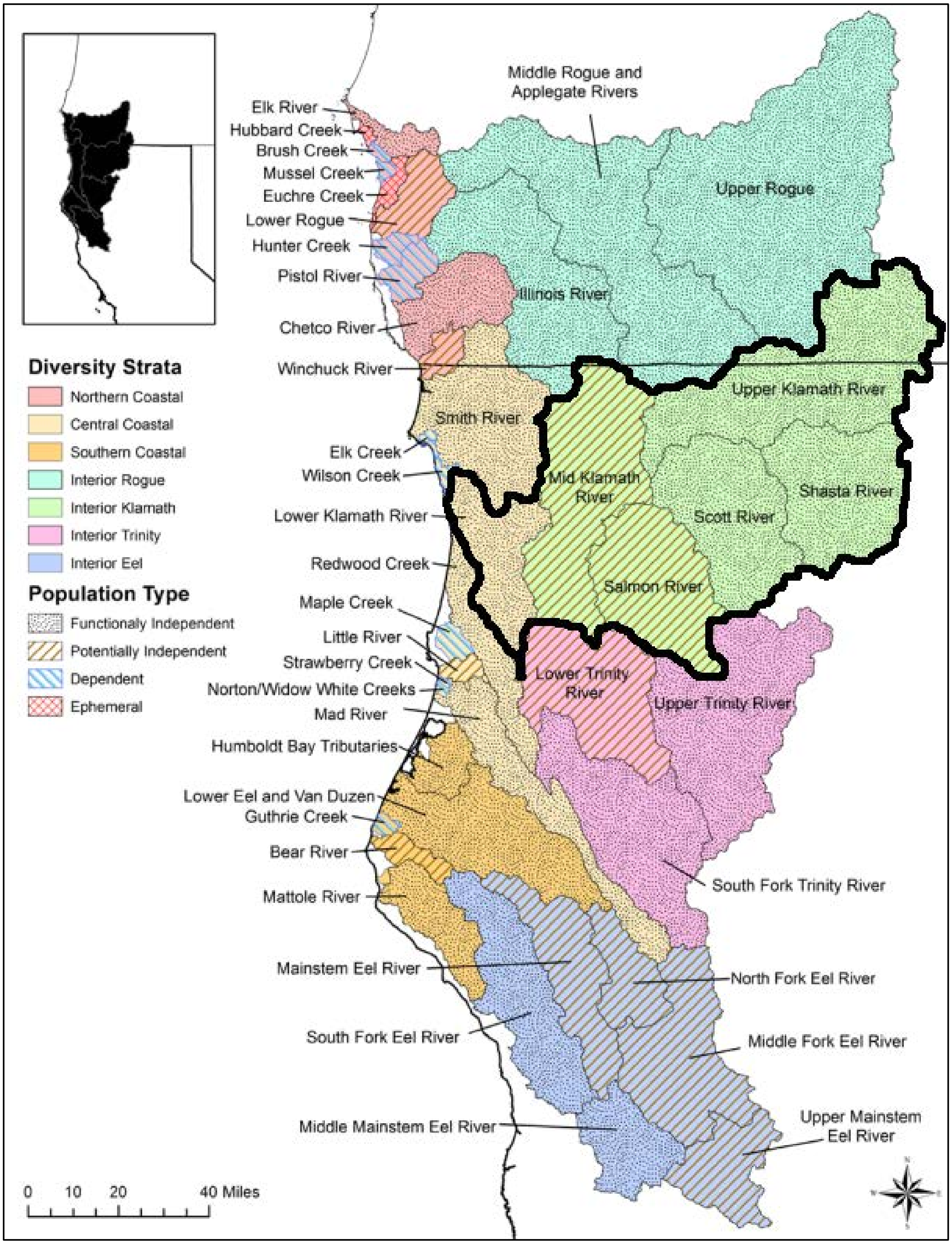

Figure 7. Historic population structure of the SONCC coho salmon ESU, including populations and diversity strata, as described in Williams et al. (2016a). Action area enclosed in bold outline.

2.2.3.1 Status of Critical Habitat in the Action Area

Here NMFS describes the status of abiotic factors affecting critical habitat, and habitat factors affecting specific life stages of coho salmon, in the action area.

2.2.3.1.1 Water Quality Conditions

Here, NMFS describes overarching water quality conditions in the action area.

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 and quality 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 the action area (NMFS 2014a).

Table 11: 303(d) impaired water bodies and stressors within the action area.

Water Body	Water Temperature	Sedimentation	Organic Enrichment/Low Dissolved Oxygen	Nutrients
Klamath River (Oregon-California State line to IGD)	x		x	x
Klamath River (IGD to Scott River*)	x		x	x
Klamath River (Scott River to Trinity River**)	x		x	x
Klamath River (Trinity River to mouth)	x	x	x	x
Shasta River	x		x	
Scott River	x	x		
Salmon River	x			
*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).				

2.2.3.1.2 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 water, sub-optimal, and lethal 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 below IGD (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 the action area (Romberger and Gwozdz 2018). Downstream from IGD, 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 2004, Dunsmoor and Huntington 2006, NCRWQCB2010, Risley et al. 2012). Farther downstream, water temperatures are more influenced by solar energy, the natural heating and cooling regime of ambient air temperatures, and tributary inputs of surface water. Downstream, at the Salmon River (RM 66), the effects of IGD on water temperature are significantly diminished.

2.2.3.1.3 Dissolved Oxygen

As with temperature, optimal and sub-optimal levels of DO are life stage specific for coho salmon (Carter 2005). In addition, there is an interaction effect among DO and other stressors, including water temperature and turbidity. Carter (2005) reviewed effects of various DO concentrations on salmonids and identified a minimum of 6 mg/L DO before production impairment was observed for most life stages, and a minimum 3 mg/L DO for acute mortality.

Generally, DO concentrations in the Klamath River below IGD 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 IGD, 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 IGD and RM 100 (approximately the location of Happy Camp, CA). Similarly, PacifiCorp (2018c) indicated that seasonal minima (approaching 5 mg/L) occurred in August and mid-September within one river mile downstream of IGD; DO concentrations at all other monitored Klamath River sites were above 8 mg/L during calendar year 2017 (PacifiCorp 2018c).

2.2.3.1.4 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 can lead to toxic algal blooms and reduced dissolved oxygen levels. Total phosphorus values typically range from 0.1 to 0.25 mg/L in the

Klamath River between IGD and Seiad Valley (RM 129), with the highest values occurring just downstream from the dam. Total nitrogen concentrations in the river downstream from IGD generally range from <0.1 to over 2.0 mg/L, and are generally lower than those in upstream reaches due to reservoir retention and dilution by springs in the Klamath Hydroelectric Reach (Asarian et al. 2010). Further decreases in total nitrogen occur in the mainstem Klamath River due to a combination of tributary dilution and natural in-river nutrient removal processes such as uptake by aquatic plants and algae growing on the riverbed (periphyton). However, concentrations of both nitrogen and phosphorous are high enough that other factors (i.e., light, water velocity, or available substrate) are likely more limiting to primary productivity than nutrients, particularly in the vicinity of IGD (FERC 2007, Asarian et al. 2010). Therefore, there is limit on the extent to which high concentrations of these nutrients can cause periphyton growth in this portion of the Klamath River.

Downstream from the confluence with the Salmon River, nutrient concentrations continue to decrease in the Klamath River due to tributary dilution and nutrient retention. For total nitrogen, Asarian et al. (2010) demonstrated a general upward trend in concentrations from June – October at sites below IGD.

2.2.3.1.5 Suspended Sediment Concentrations

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 polychaete worms) have been observed in these habitats (Hillemeier et al. 2017, Som and Hetrick 2017). Currently, suspended sediment concentrations are more likely to be flushed out of in the mainstem portion of the Upper Klamath River reach from annual surface flushing flow events. In addition, tributary rearing habitat currently accessed by Klamath River coho salmon is compromised to some degree, most commonly by high instream sediment concentrations or impaired riparian communities (see NMFS 2014a for review).

2.2.3.1.6 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 8). Emigration rate tends to increase as fish move downstream (Stutzer et al. 2006).

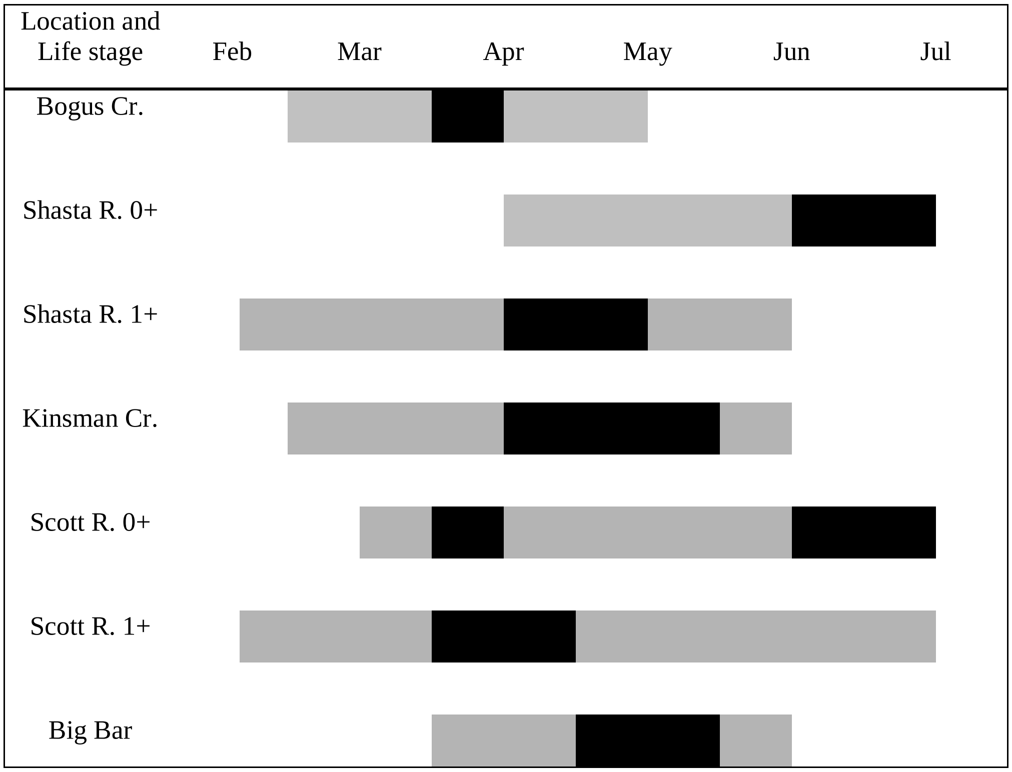

Figure 8. General emigration timing for coho salmon smolt within the Klamath River and tributaries. Black areas represent peak migration periods, those shaded gray indicate non-peak periods. 0+ refers to young-of-year while 1+ refers to smolts (Pinnix et al. 2007, Daniels et al. 2011).

Juvenile migratory habitat conditions by sub-basin in the action area are described as follows:

2.2.3.1.6.1 Upper Klamath River Reach

In the Upper Klamath River reach, 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 170), have been found to have had a substantial impact on the survival of 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.

Many of the tributaries comprising the Upper Klamath River reach population unit 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. By early spring, when emigration of smolt coho salmon typically occurs, tributary flows are elevated and connectivity to the mainstem Klamath River allows the smolt to emigrate (NMFS 2014a).

2.2.3.1.6.2 Middle Klamath River Reach

Similar to the mainstem portion of the Upper Klamath River reach, low flows 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. In part due to this concern, flow releases to increase the volume of water in the Middle Klamath Reach were incorporated into the NMFS and USFWS (2013) joint opinion. Higher velocities resulting from these flow releases have somewhat addressed the water quality concern by reducing “dead zones” within the channel that can harbor disease pathogens (Hardy et al. 2006), thereby reducing the overall impact of disease infection on coho salmon. Still, summer water diversions downstream of IGD, which further decrease flows, contribute to degraded habitat and/or fish passage issues at tributaries such asStanshaw, Red Cap, Boise, Camp, Elk Creek, and Fort Goff creeks during low water years.

2.2.3.1.6.3 Shasta River

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.

2.2.3.1.6.4 Scott River

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 example, during the summer of 2014 when flows were disconnected in the mainstem Scott River, large numbers of juvenile coho salmon were left stranded, unable to migrate to suitable rearing habitat. A large rescue-relocation effort led to 115,999 coho salmon being moved to cold water habitats; however, monitoring of this effort showed that relocation did not increase the survival of rescued fish (CDFW 2016). 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 which cause juvenile fish stranding and mortality.

2.2.3.1.6.5 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.

2.2.3.1.7 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 in the action area are described as follows:

2.2.3.1.7.1 Upper Klamath River Reach

The current physical and hydrologic conditions of the adult migration corridor in the Upper 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 and USFWS (2013) joint opinion, flow volume is above the threshold at which physical barriers to migration are likely to form.

2.2.3.1.7.2 Middle Klamath River Reach

Implementation of the flows analyzed in the NMFS and USFWS (2013) joint opinion has likely alleviated many of the adult migration issues observed in the past and improved critical habitat in the Middle 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.

2.2.3.1.7.3 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. However, access to spawning habitats in Parks Creek can be delayed until base flow levels increase following the first series of fall storm events that typically occur during November. The irrigation season in Parks Creek does not end until November 1, a month later than irrigation diversions for the majority of the Shasta River watershed. In addition, there are several stock water diversions that continue to divert substantial volumes of water throughout the winter season. In dry water years, these diversions exacerbate low flow conditions in Parks Creek and can adversely impact or delay adult migration of coho salmon entering Parks Creek.

2.2.3.1.7.4 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 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. In dry years, a lack in connectivity, particularly in the mine tailings reach of the mainstem, can prevent adults from migrating upstream and inhibit access between the Scott River and major tributary streams along the west side of Scott Valley (i.e., Shackleford Creek, Kidder Creek, French Creek and Sugar Creek, etc.). For example, the mine tailings reach and adjacent tributary, Sugar Creek, were not connected until the last week of December during the winter of 2018. This delay in connection likely led adult coho salmon to spawn in the less suitable habitat of Scott River mainstem.

2.2.3.1.7.5 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).

2.2.3.1.8 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 in the action area are described as follows:

2.2.3.1.8.1 Upper Klamath River Reach

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 IGD 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 IGD with the potential and opportunity for summer rearing. Overwinter rearing habitat may be a limiting factor for juvenile coho salmon in the Upper Klamath River each. 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 Upper 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).

Unlike many of the other tributary streams within the Upper 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 2018a).

Over approximately the last 10 years, there has been a large effort to improve over winter habitat for juvenile coho salmon in the Upper 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).

2.2.3.1.8.2 Middle Klamath River Reach

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.

2.2.3.1.8.3 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). Dwinnell Reservoir was constructed on the Upper Shasta River in 1928 with the purpose of storing water for irrigation use during the growing season. MWCD holds appropriative water right permits (Permit Numbers 2452 and 2453) which give MWCD the right to divert and store a total of 49,000 acre-feet of water from the upper Shasta River (35,000 acre-feet) and Parks Creek (14,000 acre-feet) annually. 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 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. The environmental water will be used to support fisheries habitat enhancements through a combination of (a) releases of stored water from Dwinnell Reservoir to the upper Shasta River,

(b) bypassing additional flows at its Parks Creek Diversion, (c) augmenting flows in the upper Shasta River through groundwater releases, and (d) potential water exchanges with downstream diverters. MWCD also proposes to implement other infrastructure improvements to support fisheries enhancement and recovery within the upper Shasta River and lower Parks Creek. These improvements include the enlargement of its Cross Canal that delivers released flow from Dwinnell Reservoir to the Shasta River and construction of wetland and cold water refugia habitat immediately downstream of Dwinnell Dam. All of these efforts will improve rearing conditions for coho salmon downstream of Dwinnell Dam.

Large woody debris (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.

2.2.3.1.8.4 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 the 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 beaver dam analogue structures (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.

2.2.3.1.8.5 Salmon River

The Salmon River watershed has little private landownership and is dominated by public U.S. Forest Service land. Therefore, human-caused stressors are minimal with few diversions, agriculture, or channel modification.

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 were observed (0 in 2015, 53 in 2016, 36 in 2017), primarily within the South Fork or its tributaries. In 2018, 54 juvenile coho were observed at the mouth of and within Methodist Creek, a tributary to the South Fork (Amy Fingerle, 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).

2.2.3.1.9 Spawning Habitat Conditions

Spawning habitat conditions by sub-basin in the action area are described as follows:

2.2.3.1.9.1 Upper Klamath River Reach

While coho salmon are typically tributary spawners, low numbers of adult coho salmon annually spawn in the Upper 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 below IGD (FERC 2007). However, water temperatures and water velocities are generally sufficient in this reach for successful adult coho salmon spawning. Gravel augmentation implemented under the PacifiCorp habitat conservation plan will partially restore spawning habitat in the Upper Klamath River reach, particularly between IGD and the confluence with the Shasta River (PacifiCorp 2012b). Downstream of IGD, 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 2004). Key Upper Klamath River reach spawning tributaries to which adult coho salmon return annually to spawn include 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.

2.2.3.1.9.2 Middle Klamath River Reach

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. Key Middle Klamath River reach spawning tributaries to which adult coho salmon return annually to spawn include Red Cap and Camp creeks.

2.2.3.1.9.3 Shasta River

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 DWR performed similar work in the Shasta basin. Greenhorn Dam blocks the movement of gravel down Yreka Creek, and alters the Yreka Creek hydrograph.

2.2.3.1.9.4 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 have 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.

2.2.3.1.9.5 Salmon River

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). Coho salmon habitat includes the mainstem Salmon River, Wooley Creek, the North Fork and South Fork Salmon Rivers, and the lower reaches of a few smaller tributaries.

2.2.3.2 Factors Affecting Critical Habitat in the Action Area

2.2.3.2.1 Climate Change

In the action area, 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.

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 (2011a) 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.

Analysis of climatologic and hydrologic information for the upper Klamath Basin indicates UKL inflows, particularly base-flows, have declined over the last several decades (Mayer and Naman 2011). Analyses completed in our 2013 opinion confirm the trend in declining inflow to UKL and also demonstrate declining flows in the Williamson and Sprague rivers (major tributaries to UKL) from 1981 through 2012. Net inflow to Upper Klamath Lake and flow in the Williamson and Sprague rivers are strongly dependent on climate, particularly precipitation (Mayer and Naman 2011). Part of the decline in flow is explained by changing patterns in precipitation; however, other factors are very likely involved as well, including increasing temperature, decreasing snow water equivalent, increasing evapotranspiration, or possible increasing surface water diversions or groundwater pumping upstream of the lake (Mayer 2008, Mayer and Naman 2011).

Projections of the effects of climate change in the Klamath Basin suggest temperature will increase in comparison to 1961 through 2000 time period (Barr et al. 2010, USBR 2011a). Projections are based on ensemble forecasts from several global climate models and carbon emissions scenarios. Anticipated temperature increases during the 2020s (generally corresponding to the period of effects of the proposed action) compared to the 1990s range from 0.9 to 1.4° F (0.5 to 0.8° C)(USBR 2011a). 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 (2011a) projects an annual increase in precipitation of approximately 3 percent compared to the 1990s. Reclamation (2011a) 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 (2011a) 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 (USBR 2011a).

Reclamation (2011a) also projects annual increases in runoff during the 2020s compared to the 1990s, based on the global climate models. The annual volume of flow in the Williamson River is expected to increase by approximately 8 percent, with increases of approximately 22 percent during December through March and decreases of approximately 3 percent during April through July. The Klamath River below IGD is expected to experience an approximate 5 percent increase in annual flow volume, with increases of approximately 30 percent during December through March and decreases of approximately 7 percent during April through July (USBR 2011a). The apparent contradiction between decreasing snow water equivalent and increasing runoff is resolved by projections suggesting a greater proportion of precipitation will fall as rain instead of snow, and the increase in overall precipitation will be greater in the winter than in the summer. Summer flows are still likely to be lower in both projections.

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 (2011a) and Woodson et al. (2011) suggest that projected climate change 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 (USBR 2011a).

- Water demands for endangered species and other fish and wildlife could increase due to increased air and water temperatures and runoff timing changes (USBR 2011a).

- 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, 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 (USBR 2011a). These predicted changes are part of our analysis in Section 2.2.6 *Integration and Synthesis.*

2.2.3.2.2 Hydrology

2.2.3.2.2.1 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). Variability of the natural flow regime is inherently critical to ecosystem function and native biodiversity (Poff et al. 1997, Puckridge et al. 1998, Bunn and Arthington 2002, Beechie et al. 2006)

Salmonid life history evolved to take advantage of the natural flow regimes in west coast rivers (Beechie et al. 2006, Waples et al. 2008). Arthington et al. (2006) stated that simplistic, static, environmental flow rules are misguided and will ultimately contribute to further degradation of river ecosystems. Flow variability is an important component of river ecosystems that can promote the overall health and vitality of both rivers and the aquatic organisms that inhabit them (Poff et al. 1997, Puckridge et al. 1998, Bunn and Arthington 2002, Arthington et al. 2006). Variable flows trigger longitudinal dispersal of migratory aquatic organisms and other large events allow access to otherwise disconnected floodplain habitats (Bunn and Arthington 2002), which can increase the growth and survival of juvenile salmon (Jeffres et al. 2008).

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). Life history diversity of Pacific salmonids *Oncorhynchus spp*. substantially contributes to their persistence, and conservation of such diversity is a critical element of recovery efforts (Beechie et al. 2006). 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).

2.2.3.2.2.2 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. Congress facilitated development of the Klamath Project by authorizing the Secretary to raise or lower the level of Lower Klamath and Tule Lakes and to dispose of the land uncovered by such operation for use under the Reclamation Act of 1902. 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 Upper 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.

Starting around 1912, construction and operation of the numerous facilities associated with Reclamation's Klamath Project significantly altered the natural hydrographs of the upper and lower Klamath River. In 1922, the level of UKL was raised by the Link River dam. Reclamation's Klamath Project now consists of an extensive system of canals, pumps, diversion structures, and dams capable of routing water to approximately 200,000 ac (81,000 ha) of irrigated farmlands in the upper Klamath Basin (USBR 2012).

Hecht and Kamman (1996) analyzed the hydrologic records for similar water years (pre- and post-Project) at several locations. The authors concluded that the timing of peak and base flows changed significantly after construction of the Project, and that the operation increases flows in October and November and decreases flows in the late spring and summer as measured at Keno, Seiad, and Klamath USGS gage sites. Their report also noted that water diversions also occur in areas outside the Project boundaries. IGD was completed in 1962 to re-regulate flow releases from the Copco facilities. However, IGD did not restore the pre-Project hydrograph. Fall flows were slightly increased in some years while winter, spring and summer flows were substantially reduced in nearly all years. The modeled data for Iron Gate, California, clearly shows a decrease in the magnitude of peak flows, a 2-month shift in timing of flow minimums from September to

July, as well as reduction in discharge volume in the summer months. By truncating the range of flows that led to diverse coho salmon life history strategies, changes in the annual hydrology likely adversely affected coho salmon populations.

Although monthly flow values can be useful for general river-basin planning, they have limited utility for ecological modeling of river habitats because monthly average flows mask important flow variability utilized by salmonids that likely exist only for a few days or less (NRC 2008). In order to address this shortcoming in analyzing monthly flow data, Figure 9. Average daily Klamath River discharge at Keno, Oregon, during three different time periods. The 1905 to 1913 dataset represents historical, relatively unimpaired riverflow, while two more modern time periods represent discharge after implementation of the Project. Figure 9 is presented to examine daily historical and current Klamath River discharge patterns at Keno, Oregon.

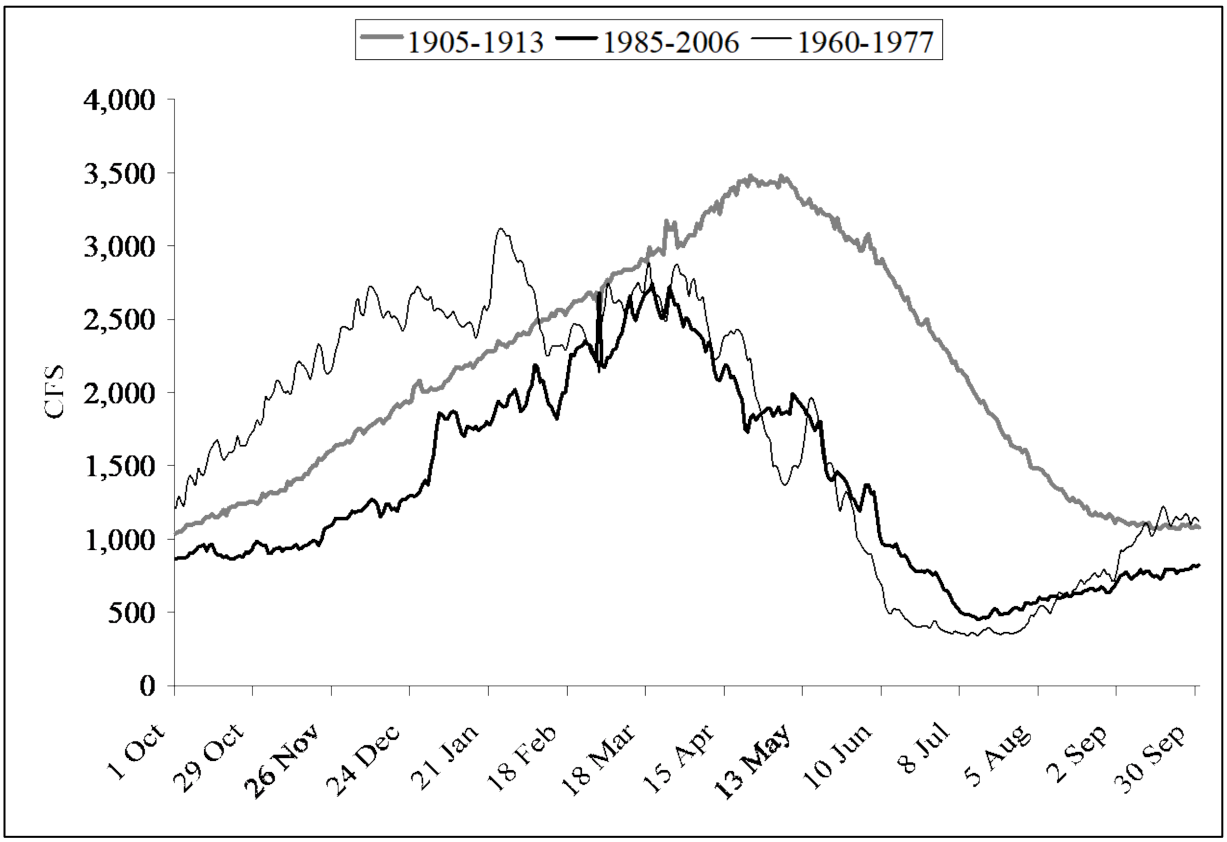

Figure 9. Average daily Klamath River discharge at Keno, Oregon, during three different time periods. The 1905 to 1913 dataset represents historical, relatively unimpaired riverflow, while two more modern time periods represent discharge after implementation of the Project.

Data in Figure 9 are averages of daily discharge across years for three different time periods. The 1905 to 1913 period represents historical unimpaired flows in the Klamath River at Keno, OR. However, diversions to the A Canal of Reclamation's Klamath Project began in 1906, so the 1905 to 1913 period does not represent completely unimpaired flow, rather the closest approximation to unimpaired flows. Two more modern periods, 1960 to 1977 and 1985 to 2006, can provide some insight into the effects of Reclamation's Klamath Project. These time periods were chosen because the climatic patterns cycled through a cool phase (increased snowpack and streamflow) from the mid-1940s to 1976 and through a warm phase (decreased snowpack and streamflow) from 1977 through at least the late 1990s (Minobe 1997, Mote 2006). By using these two time periods, the effects of Reclamation's Klamath Project may be examined under relatively wet (1960 to 1977) and relatively dry (1985 to 2006) climate conditions.

Data presented in Figure 9 show that there has been a shift in both the magnitude and timing of average peak flows in the Klamath River at Keno, Oregon. 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.

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. Historically, river discharge did not reach base (minimum) flow until September in most years. After implementation of Reclamation's Klamath Project and factoring other off-Project diversions, minimum flows for the year now occur as early as June in dry years and beginning of July in average and wet years, which is a shift in base flow minimum of approximately two months earlier. These altered flows likely also reduce the amount of rearing habitat available. Additionally, off-channel habitat along the mainstem Klamath River has been significantly reduced due to the lack of variable flows that would otherwise inundate floodplains and side channels, creating important rearing habitat (NMFS and USFWS 2013).

Reclamation has managed UKL elevations (since 1991) and Klamath River flows at IGD (since 2001) as described in a series of opinions from the Services. For the 2012 BA, Reclamation, in consultation with USFWS and NMFS, utilized the KBPM to simulate operations of the Project for the 1981 through 2011 period of record of historical hydrology for development of the proposed action. The corresponding 2013 joint opinion was signed on May 31, 2013 by the Services (NMFS and USFWS 2013). The Klamath Basin immediately experienced two of the driest years in the period of record consecutively in 2014 and 2015. The exceptionally dry water years of 2014 and 2015 contributed to factors resulting in Reclamation exceeding the Chinook salmon *Ceratanova shasta (C. shasta*) infection rates used in the incidental take statement of the 2013 opinion as a surrogate for incidental take of SONCC coho salmon from increased disease risk (hereinafter referred to as the "incidental take statement metric for *C. shasta*").

Subsequently, several plaintiffs, including the Yurok and Hoopa Valley Tribes, filed complaints in Federal district court against NMFS and Reclamation alleging, among other things, that NMFS and Reclamation failed to reinitiate formal consultation after the incidental take statement metric for *C. shasta* was exceeded in 2014 and 2015. On February 8, 2017, the court granted the plaintiffs' motions for partial summary judgment on their failure to reinitiate claims and determined the plaintiffs were entitled to injunctive relief.[9] The court ordered (as modified in an order dated March 24, 2017)[10] Reclamation to implement two types of flows until formal consultation is completed: (1) winter-spring flushing flows designed to dislodge and flush out polychaete worms that host *C. shasta* and (2) emergency dilution flows. The court order indicated that the winter-spring flushing flows and emergency dilution flows should be modeled after Disease Management Guidance measures #1, #2, and #4 as described in the Disease Management Guidance document prepared by representatives of the Yurok, Karuk, and Hoopa Valley Tribes (Hillemeier et al., 2017). The court ordered flows are summarized as follows: (1) Management Guidance #1: 6,030 cfs release at IGD for 72 hours prior to April 30 annually, (2) Management Guidance #2: 11,250 cfs at IGD for 24 hours prior to May 31 bi-annually and (3) Management Guidance #4: Reserve 50 TAF for disease dilution flows when specified disease criteria thresholds outlined in the Disease Management Guidance document and the court order have been met.

Water year 2017 was a relatively wet year so Management Guidance #1 was implemented on multiple occasions in February, March and April. Management Guidance #2 was attempted on three different occasions in February and March, but the full 11,250 cfs for 24 hours was not achieved due to insufficient hydrologic conditions, operational constraints, and flooding downstream of IGD. However, an instantaneous flow of approximately 10,000 cfs or higher was achieved in all three occasions and a daily average flow of 10,100 cfs was achieved for 48 hours on March 23-24th. Emergency dilution flows were not implemented in water year 2017 due to the disease criteria thresholds not being met. As further described below in Section 2.2.4.2.1.5 *Disease*, decreased incidence of infection in 2017 was attributed in part to the combination of high magnitude and sustained duration of peak discharge.

In contrast, water year 2018 was a relatively dry water year so Management Guidance #1 was implemented only once on April 6, 2018 and Management Guidance #2 was not attempted. In early May, disease criteria thresholds were exceeded, triggering the release of flows based on Management Guidance #4, which includes a reserve of 50 TAF for emergency dilution flows. On May 8, 2018, the release of 50 TAF for emergency dilution flows began; IGD flows were increased to 3,000 cfs and maintained at this flow rate for 12 days. On May 20, 2018, IGD flows began ramping down to the monthly minimum flow for May (1,175 cfs), which was achieved on May 29, 2018. Overall, the implementation of Management Guidance #4 used a volume of 50,474 AF of water. As in 2017, prevalence of *C. shasta* infection by histology was low in 2018 (Voss et al. 2018).

For this consultation, Reclamation has made substantial improvements to the KBPM structure and has incorporated recent data to expand the period of record from 2011 through 2016 (i.e., 1981 to 2016). For the 1981 to 2016 period of record, the median annual Klamath Irrigation 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

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[9] *Hoopa Valley Tribe v. National Marine Fisheries Service, et al.*, 230 F.Supp.3d 1106, 1146 (N.D. Cal. 2017); *Yurok Tribe, et al. v. U.S. Bureau of Reclamation, et al.*, 231 F.Supp.3d 450, 490 (N.D. Cal. 2017).

[10] *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 (N.D. Cal. March 24, 2017), at 1 (order modifying injunction).

maximum of 490,000 acre-ft (USBR 2018a). Deliveries of irrigation water to the Klamath Project from UKL are trending upward during the period of record (USBR 2018a), and water demands increase in dry years (Mayer 2008). While the trends suggest increases in Project deliveries when considered in isolation, they may also be examined with respect to other water-related trends in the upper Klamath Basin. As previously described, average annual air temperature in the upper Klamath Basin has been increasing over several decades, snow water equivalent has been declining, and both these trends are predicted to worsen due to climate change. In addition, annual net inflow to UKL has been declining over the period of record and the trend is statistically significant (USBR 2018a). Therefore, the increase in Project deliveries is likely to be caused by changes in irrigation and cropping patterns, additional land under irrigation, decadal shifts in weather, global climate change, conjunctive uses of surface water and groundwater, or a combination of factors.

2.2.3.2.3 Disease

Since the late 1990s, fish disease research and monitoring has been conducted extensively in the Klamath River Basin. Several documents provide extensive overviews of aquatic diseases that affect salmonids in the Klamath River, including:

- USFWS and NMFS (2013) 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),
- documents pertaining to the court orders referenced above,
- 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*. There is a lack of information concerning the presence of infectious haematopoietic necrosis and bacterial kidney disease either above or below IGD. *Columnaris* is common worldwide and present at all times in the aquatic environment. *Columnaris* disease in cold water fishes is generally seen at water temperatures above 15 ^{o}C. In natural infections, the disease is often chronic to subacute, affecting skin and gills (CDFG 2004). Ich infestation of gill tissue results in hyperplasia, a condition that reduces the ability of the fish to obtain oxygen. Ich can be found on any fish at any temperature, but typically only causes disease and mortality at water temperatures above

14ºC and in crowded conditions (Belchik et al. 2004). 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 IGD, 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 polychaete worm intermediate host.

The life cycles of both *C. shasta* and *P. minibicornis* involve an invertebrate 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 polychaete worm, *Manayunkia speciosa* (Bartholomew et al. 1997, Bartholomew et al. 2006). Once the polychaetes 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. As actinospore viability increases, actinospore distribution may increase, raising the infectious dose for salmon over a larger area of the river (Bjork and Bartholomew 2010). Actinospore abundance, a primary determinant of infectious dose, is controlled by the number of polychaetes and the prevalence and severity of infection within their population.

Salmon become infected when the actinospores enter the gills, and eventually reach the intestines. At that point, the parasite replicates and matures to the myxospore stage. Myxospores are shed by the dying and dead salmon, and the cycle continues with infection of polychaete worms by the myxospores (Bartholomew and Foott 2010). Transmission of the *C. shasta* and *P. minibicornis* parasites is limited to areas where the invertebrate host is present.

Susceptibility to *C. shasta* is also influenced by the genetic type of *C. shasta* that a fish encounters. Atkinson and Bartholomew (2010a, 2010b) conducted analyses of the genotypes of *C. shasta* and the association of these genotypes with different salmonid species, including Chinook and coho salmon, steelhead, rainbow trout, and redband trout. The *C. shasta* genotype affecting coho salmon in the river below IGD is characterized as Type II; the genotype that affects Chinook salmon is Type I.

The polychaete 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 below IGD has resulted in atypically stable river bed, which provides favorable habitat for the polychaete worm. Slow-flowing habitats may have higher densities of polychaetes, and areas that are more resistant to disturbance, such as eddies and pools with sand and *Cladophora,* may support increased densities of polychaete populations (Bartholomew and Foott 2010), especially if flow disturbance events are reduced or attenuated. High polychaete densities increase parasite loads, which leads to higher rates of infection and mortality for coho salmon.

Stocking and Bartholomew (2007) noted that the ability of some polychaete populations to persist through disturbances (e.g., large flow events) indicates that the lotic populations are influenced by the stability of the microhabitat they occupy. In the Lower Klamath River, the polychaete host for *C. shasta* and *P. minibicornis* is aggregated into small, patchy populations mostly concentrated between the Interstate 5 Bridge and the Trinity River confluence, and especially above the Scott River (Stocking and Bartholomew 2007). The reach of the Klamath River from the Shasta River (RM 177) 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 this infectious zone may vary geographically (True et al. 2016, Voss et al. 2018).

The Shasta River to Seiad reach of the Klamath River contains dense populations of polychaetes in low-velocity habitats with *Cladophora* (a type of green algae), sand-silt, and fine benthic organic material in the substrate (Stocking and Bartholomew 2007). High parasite prevalence in the mainstem Klamath River is considered to be a combined effect of high spore input from heavily infected, spawned adult salmon that congregate downstream of IGD and the proximity to dense populations of polychaetes (Bartholomew et al. 2007). The highest rates of infection occur in the Klamath River within approximately 50 miles downstream of IGD (Stocking and Bartholomew 2007, Bartholomew and Foott 2010). Infection prevalence in polychaete 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).

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. Coho salmon migrating downstream have been found to have infection rates as high as 50 percent (Bartholomew and Foott 2010). During the 2013-2018 period in the Shasta to Salmon River reach, infection rates of natural Chinook salmon varied between 5 and 100 percent (Voss et al. 2018). High infection rates can result in high mortality of juvenile salmonids. 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 IGD. Their studies suggest that higher spring discharge increased smolt survival (Beeman et al. 2008, Beeman et al. 2012).

As previously mentioned, reinitiation of consultation on the joint USFWS and NMFS (2013) opinion was triggered when the prevalence of *C. shasta* infection exceeded the metric in the

Incidental Take Statement. Chinook salmon infection rates were used as a surrogate for incidental take of SONCC coho salmon from increased disease risk; specifically, "[if] the percent of *C. shasta* infections for Chinook salmon juveniles in the mainstem Klamath River between the Shasta River and the Trinity River during May to July exceed these levels (i.e., …49 percent infection via [quantitative polymerase chain reaction]), reinitiation of formal consultation will be necessary." In 2014 and 2015, the prevalence of infection during this period was 81 and 91 percent, respectively. A 2017 court order required several IGD flow release actions to be taken until formal consultation is completed.

Since 2013, 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. 2018). 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.

In the February through mid-April 2017 period several high flow releases from IGD occurred, including about 10,000 cfs three times in February and March, and about 6,000 cfs in mid-April. This coincided with low levels of mortality in sentinel studies of salmon below IGD. Also, polychaete densities and prevalence of *C. shasta* infection were lower than in previous years at all index sites, which were attributed to the combination of high magnitude and sustained duration of peak discharge, and low spring temperatures (True et al. 2017). Infection assays demonstrated that prevalence of *C. shasta* infection ranged from 0.03 - 0.06 percent which was both lower than levels observed in previous years and corroborated results of water samples and sentinel fish exposures, which all demonstrated that parasite levels and disease risk were low in 2017. The majority (80 percent) of the samples with polychaetes present were low density samples (2564 - 5685 individuals per m^2[11]). Prevalence of infection was less than 1 percent in all samples, and the extrapolated densities of infected polychaetes were low in comparison to previous years (e.g., 2014-2015) (True et al. 2017).

In 2018, *C. shasta* prevalence of infection exceeded the emergency dilution flow criteria of 20 percent in the Shasta to Scott reach on April 30th. However, juvenile Klamath River Chinook salmon were assayed from late March to August 2018, and *C. shasta* prevalence of infection above the Trinity River confluence during the peak out-migration period (May-July) was 20 percent; lower than 26 percent observed in 2017, and 48 percent in 2016. In 2018, the annual *C. shasta* prevalence of infection, historical comparison, and prevalence of infection in Iron Gate Hatchery (IGH) fish, were all lower compared to 2017 (Voss et al. 2018).

Disease effects are likely to negatively impact all of the VSP parameters of the Interior-Klamath 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.

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[11] 1 m^2 = 1.19 yd^2; 2564 - 5685 individuals per m^2 equates to approximately 2153 – 4775 individuals per yd^2.

2.2.3.2.4 Hatcheries

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. The coho salmon propagated at IGH are part of the listed SONCC coho salmon ESU. While production of Chinook salmon and coho salmon has been maintained, the production of steelhead at IGH tapered off and then ceased in 2012, due to low adult returns. Of the six million Chinook salmon that are released from the IGH, about 5.1 million are released as smolts from mid-May through early June and about 900,000 are released as yearlings from mid-October through November. The 75,000 coho salmon are released 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 IGD.

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).

A Hatchery and Genetic Management Plan (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, 78 FR 1200 (January 8, 2013), 78 FR 6298 (January 30, 2013), 79 FR 69428 (November 21, 2014)). The 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 demographic extinction 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.

The exact effects on juvenile coho salmon the Klamath River from the annual release of 6,000,000 hatchery-reared Chinook salmon smolts 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).

2.2.3.2.5 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 recent Yurok Tribe Fall Harvest Management Plan (Yurok Tribe 2018b) includes weekly fishing closures intended to protect coho salmon from harvest. The majority of coho salmon captured by Hoopa Valley tribal fisheries are Trinity River Hatchery 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. 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 (PFMC 2018). In summary, while major steps have been taken to limit effects of harvest on SONCC coho salmon, the population is still impacted by incidental mortality associated with various Chinook salmon fisheries, and by subsistence and ceremonial tribal fisheries.

2.2.3.2.6 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 action area 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, given the small number of wild-born juvenile coho salmon, predation at any level may be having an adverse effect on coho salmon in the action area (NMFS 2014a).

2.2.3.2.7 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 Interior Klamath Diversity Stratum. 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 growth and survival (Cooperman et al. 2006, Ebersole et al. 2006, Witmore 2014, Yokel et al. 2018). 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 (approximately $3 million) 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 Salmon River Basins. Restoration projects are typically implemented by state, tribal, local, or private non-governmental organizations. Reclamation has supported three grant cycles (2016, 2017, and 2018) via funding through NFWF for restoration and research/monitoring projects, whereas a total of 21 projects have been selected for full or partial funding. Of these projects, seven have started implementing their projects for the grant years of 2016 and 2017, and three have begun or completed restoration activities:

1. Parks Creek Fish Passage Design and Planning: Cardoza Ranch with design plans developed;

2. Lower French Creek Off-Channel Habitat Development with in-stream habitat structures installed and several off-channel ponds restored;

3. Bogus Creek Fish Passage with passage barriers removed, providing additional habitat for coho salmon.

- 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 (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: the Shasta River Coordinated Resource Management Planning Group (Shasta sub-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). Some key restoration actions that have been implemented in these sub-basins include:

1. 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.

2. Construction of 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.

3. Placement of large wood jams in tributaries to improve floodplain connectivity, provide winter, and summer refugia for juvenile salmonids.

4. Remediation of mine tailings and reconstruction of stream reaches to improve sinuosity and floodplain connection.

5. 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.

- 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.

2.2.3.2.8 Land Use/Management Activities

2.2.3.2.8.1 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 (e.g., 2013 Salmon Complex and Butler Fire, 2014 Beaver Fire, 2014 Whites Fire, 2014 Happy Camp Complex, 2015 River Complex, 2015 Route Complex, 2015 Fork complex, 2016 Tully Fire, 2016 Dillon Fire, 2016 Pony Fire, 2017 Eclipse Complex, 2017 Salmon-August Complex, 2017 Abney Fire, and 2018 Natchez Fire (CalFire 2019). 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), and other factors. However, effects from water drafting are minimized by the NMFS (2001b) Water Drafting Specifications which, when followed, avoid dewatering drafting sites while also avoiding fish impingement on, and entrainment into, water drafting hardware.

2.2.3.2.8.2 Timber

Timber harvesting in the action area has resulted in long-lasting effects to fish habitat conditions. Most notably, 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 Forest Service 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 a Habitat Conservation Plan (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 2007). 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.

2.2.3.2.8.3 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). Irrigated agricultural land in the Shasta River and Scott River valleys consist of approximately 51,600 acres and 33,000 acres, respectively. Estimated consumptive use of irrigation water by crops in the Shasta and Scott River valleys is approximately 100,000 and 71,000 acre-feet per year, respectively (Reclamation 2009). Actual diversions would exceed the consumptive use of the crops due to irrigation application methods, conveyance losses in the system and surface evaporation. Agricultural diversions in both the Shasta and Scott rivers in some years, especially dry water years, can virtually dewater sections of these rivers, impacting coho salmon and their critical habitat within these streams as well as those in the Klamath River.

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 (USBR 2013b). 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.

There has been a decline in UKL outflows since the 1960s, which is likely due to increasing diversions, decreasing net inflows, or other factors (Mayer 2008). There have been declines in winter precipitation in the upper Klamath Basin in recent decades and declines in UKL inflow and tributary inflow, particularly base flows (Mayer 2008). Declines in tributary base flow could be due to increased consumptive use, in particular, groundwater use, and/or climate change. Agricultural diversions from the lake have increased over the 1961 to 2007 period, particularly during dry years (Mayer 2008). Declines in Link River flows and Klamath River at Keno flows in the last 40-50 years have been most pronounced during the base flow season (Mayer 2008), the time when agricultural demands are the greatest. Due to warmer and drier than average hydrologic conditions prevailing over the last ten years, NMFS expects that these trends have likely continued since 2007.

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 2002, 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.

2.2.3.2.8.4 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).

2.2.3.2.8.5 PacifiCorp Habitat Conservation Plan

Covered activities under the PacifiCorp Klamath Hydroelectric Project Interim Operations Habitat Conservation Plan (HCP) for Coho Salmon (PacifiCorp 2012b) 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, or prior to implementation of mandatory fishways that would be required under any new license for the Klamath Hydroelectric Project if the Klamath Hydroelectric Settlement Agreement is terminated for any reason. NMFS issued the incidental take permit in 2012 for a term of ten years. Many of these activities are governed by the existing FERC license or agreements with other entities (e.g., Reclamation), or through voluntary commitments from PacifiCorp. Detailed information on habitat conservation plan's covered activities can be found in Chapter 2 of the PacifiCorp HCP (PacifiCorp 2012b).

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 2012b):

- Offset biological effects of blocked habitat upstream of IGD by enhancing the viability of the Upper Klamath coho salmon population
- Enhance coho salmon spawning habitat downstream of IGD
- Improve instream flow conditions for coho salmon downstream of IGD
- Improve water quality for coho salmon downstream of IGD
- Reduce disease incidence and mortality in juvenile coho salmon downstream of IGD
- 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.

Continued implementation of the PacifiCorp HCP is expected to benefit the conservation of the Klamath River coho salmon populations. Protection of the very limited thermal refugia sites in the Klamath River mainstem should help improve juvenile-to-smolt survival rates which will likely aid in improving viability for coho salmon and other salmonids during the ESA section 10(a)(1)(B) permit duration (NMFS 2012a).

The PacifiCorp HCP includes measures that comprise the coho salmon conservation program, which includes the following:

- Implementation of turbine venting at IGD to enhance dissolved oxygen concentrations in surface waters downstream of IGD;

- Implementation of measures to provide instream flow, flow variability, and flow ramping rate measures to benefit listed coho salmon downstream of IGD consistent with NMFS's 2010 opinion on Reclamation's Klamath Project as well as future instream flow-related consultations between Reclamation and NMFS;

- Retrieving large woody debris trapped at or near the Four Facilities (Iron Gate, Copco 1 and 2, and J.C. Boyle) and placing it in mainstem or tributary waters downstream of IGD;

- Habitat restoration projects designed to enhance the survival and recovery of listed coho salmon, funded through the coho enhancement fund, and conducted by third parties;

- Research studies on fish disease conditions and causal factors downstream of IGD, funded through the Klamath River fish disease research fund, and conducted by third parties; and

- Funding and participation in IGH measures developed to support a HGMP to maximize conservation benefits of the hatchery program to coho salmon.

As of January 2018, PacifiCorp has provided funding of over $4,900,000 into the Coho Enhancement Fund (CEF). Starting in 2009 and running through the 2017 grant cycle, 42 grants have been selected to receive funding for projects that benefit coho salmon downstream of IGD. These projects have a combined grant value of about $4.3 million. When the projects are considered collectively, the CEF has resulted in (PacifiCorp 2018a):

- Over 2,300 linear feet of channel restoration

- Creation of over 163,000 square feet of off-channel ponds

- Installation of three fish screens

- Removal of 73 passage barriers

- Improved access to over 71 miles of coho salmon habitat

- Installation of over seven miles of riparian fencing

- Implementation of 29 separate water leases providing improved flows in almost 36 miles of stream

- Implementation of 71,000 square feet of other types of habitat enhancement projects, including large wood enhancement.

Turbine venting at IGD is likely improving dissolved oxygen immediately downstream of IGD. PacifiCorp has implemented turbine venting on a trial basis beginning in 2009, and turbine venting testing in combination with a forced air blower (fall 2010) demonstrated that dissolved oxygen saturation rose by 14.9 percentage points (a 29 percent increase) and average dissolved oxygen concentration rose by 1.81 mg/L (a 33 percent increase) during venting treatment as compared to no treatment (PacifiCorp 2011). If dissolved oxygen is increased, higher nighttime dissolved oxygen concentrations are likely to increase juvenile coho salmon foraging opportunities outside the confines of the existing thermal refugia areas, potentially resulting in higher survival rates for juvenile coho salmon that rear within a six mile reach from IGD each summer.

PacifiCorp developed a Gravel Augmentation Plan as required by their HCP. Gravel augmentation immediately below IGD has taken place in 2014, 2016, and 2017. The material placed in 2014 and 2016 was moved downstream by subsequent high flows (PacifiCorp 2018a). Gravel augmentation in the mainstem Klamath River downstream from IGD will partially restore conditions for coho salmon spawning in the river during fall. Properly functioning spawning substrate provides ample interstitial flow through redds, and is of suitable size to permit efficient redd excavation by spawning adults. The Project-related effects on gravel, and the concomitant benefits of gravel augmentation, are expected to be largely restricted to the uppermost several miles of the Upper Klamath River reach below IGD. Overall, NMFS expects that implementation of the gravel augmentation measures will improve the functionality and conservation value of critical habitat for adult spawning below IGD as compared to previous conditions (NMFS 2012a).

The quarterly augmentation of LWD recruitment to the Upper Klamath River reach will add to the habitat complexity below IGD, resulting in improvements to the conservation value of critical habitat for rearing juveniles. The transport of trapped LWD on a quarterly basis either to the Klamath mainstem directly or for use in constructed habitat features, will improve habitat complexity or, in some cases, provide localized thermal refugia in the form of shade. Both of these habitat features enhance survival of juvenile coho by affording protection from predators and cooling water during critical periods in the late summer and fall.

Restoration actions implemented under the coho salmon conservation strategy throughout the duration of the ESA section 10(a)(1)(B) permit are expected to increase over-summer survival for juvenile coho salmon. Projects that create, maintain, or improve access by coho salmon to habitats downstream of IGD are expected to increase the distribution of coho salmon and improve the spatial structure of the population. Increasing available habitat below IGD will help ensure that coho salmon populations remain stable and improve while parallel actions are taken to address volitional fish passage issues in the longer term.

Reclamation’s and PacifiCorp’s projects are intertwined, and as described in their HCP and corresponding incidental take permit, Goal III commits PacifiCorp to improving instream flow conditions downstream of IGD. As a result, in September of 2015, PacifiCorp began implementing a diurnal flow fluctuation program (PacificCorp 2015). The program was designed to enhance flow variability below IGD consistent with existing flow requirements during periods of relatively low, stable flows. The diurnal flow program was designed to mimic the changes in flow that naturally occur on a diurnal cycle due to natural hydrologic fluctuations (e.g., snowmelt, evapotranspiration). PacifiCorp created the flow program at the Iron Gate Powerhouse to automatically ramp up flows starting in the early morning, reaching a peak at 6 percent above the targeted daily release around mid-day. Flows then gradually ramp down to a minimum value of 3 percent less than the targeted daily release in the early evening (PacificCorp 2015). This pattern repeats on a daily cycle and all ramp rates were followed in accordance with the 2013 Opinion. From 2015 through 2018, PacifiCorp has implemented this diurnal flow fluctuation program during the drier months of the year at IGD flows of 1,650 cfs or less. This flow program cannot be implemented at IGD flows greater than 1,650 cfs due to Iron Gate Powerhouse facility constraints. NMFS expects that the diurnal flow fluctuation program has provided benefits to coho salmon and expects PacifiCorp to continue to implement this program for the duration of this proposed action.

2.2.3.3 Status of Coho Salmon in the Action Area

2.2.3.3.1 Periodicity

The biological requirements of SONCC ESU coho salmon 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 10 depicts the seasonal periodicities of coho salmon in the action area.

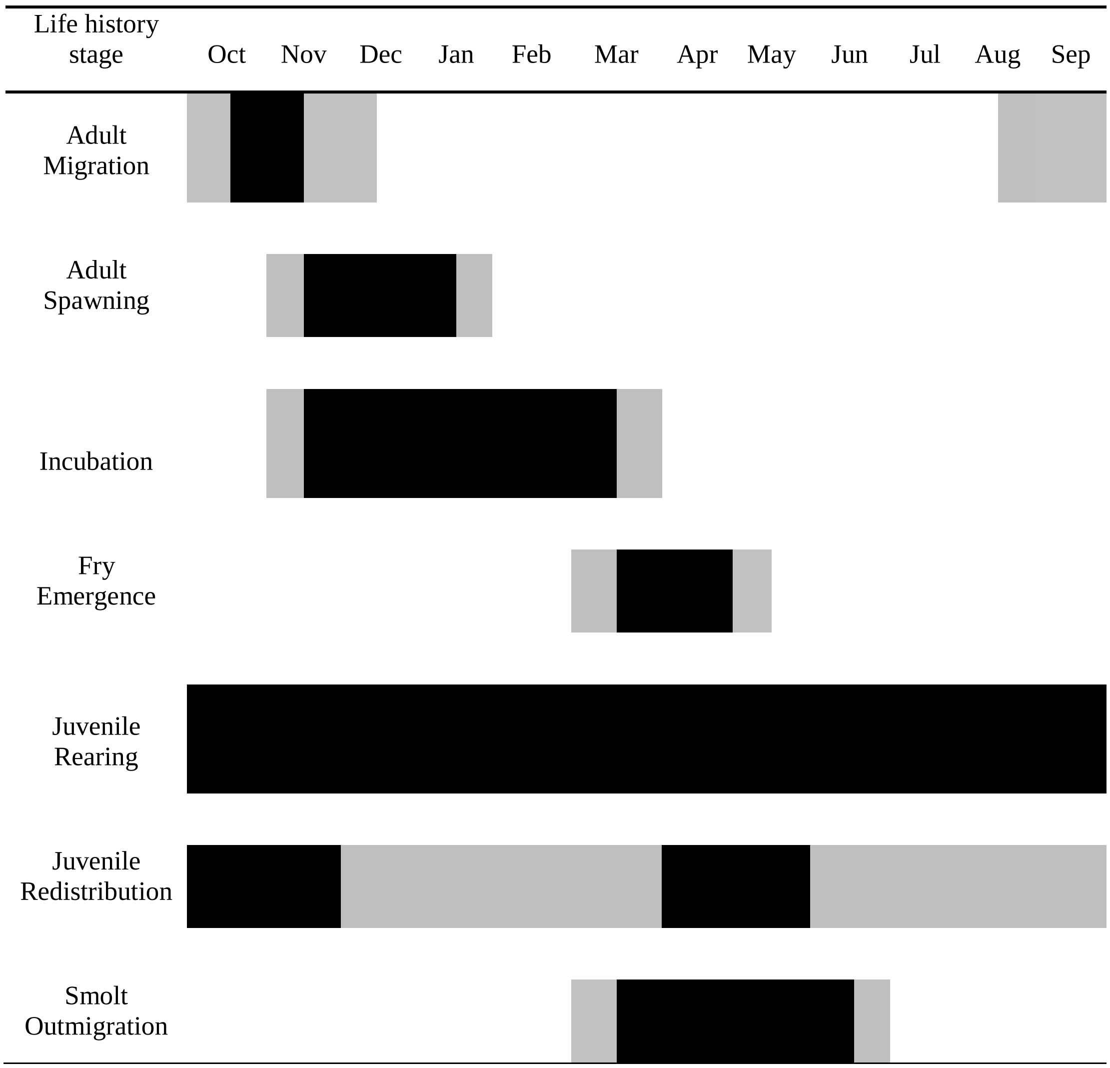

Figure 10. Life stage periodicities for coho salmon within the Klamath River Basin. Black areas represent peak use periods, those shaded gray indicate non-peak periods (Leidy and Leidy 1984, NRC 2004, Justice 2007, Carter and Kirk 2008).

2.2.3.3.2 Abundance and Distribution

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. 2008). Juvenile coho salmon (parr and smolts) have been observed residing within the mainstem Klamath River between IGD 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).

Robust abundance estimates are not available for all populations of coho salmon in the action area. However, population estimates of adult coho salmon in the action area that are available are all reduced from historic numbers and are all estimated to be below the viability threshold each year since 2009 (Table 12; NMFS (2014a), updated through 2019).

Table 12: Estimated naturally spawning coho salmon abundance for populations in the action area.

Stratum	Population	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018[a]	Spawners Required for ESU Viability[b]
Interior – Klamath River	Upper Klamath [c]	< 200	<350	<300	<300	<300	<300	<300	<300	<300	<300	8,500
	Bogus Creek [d]	7	154	142	185	446	97	14	85	48	23	NA
	Middle Klamath [e]	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	450
	Shasta River [f]	9	44	62	114	163	46	45	48	41	39	4,700
	Scott River [f]	80	918	358	199	2,644	504	290	250	368	681	6,500
	Salmon River[g]	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	450

[a] 2018 numbers are preliminary as of March 11, 2019. 2018 numbers for Bogus Creek, Shasta River, and Scott River are based on unpublished data provided by Morgan Knechtle.

[b] NMFS 2014a

[c] Estimates based on Bogus Creek counts, which are shown in the row below (Knechtle and Giudice 2018a) plus small numbers of mainstem and tributary spawners (Corum 2011).

[d] The Bogus Creek population is a subset of the Upper Klamath population.

[e] Projected using the highest estimates (i.e., 2004) from (Ackerman et al. 2006)(see discussion below).

[f] (Giudice and Knechtle 2018, Knechtle and Giudice 2018b)

[g] Continues from Ackerman et al. (2006) estimates for the Salmon River.

In summary, seasonal distribution of coho salmon by sub-basin in the action area is as follows:

2.2.3.3.2.1 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 IGD. 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 within 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 IGD, including Horse and Seiad creeks. Coho salmon presence was confirmed in six surveyed tributary streams in or near to the Project action area, 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 is 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) (Table 12) and the proportion of hatchery coho present in the run has ranged between 0.22 (2017) and 0.88 (2012). Since 2014 the total number of adult coho salmon observed has been less than 100 fish, and the numbers appear to be decreasing over time (Knechtle and Giudice 2018a).

Due to the low demographics 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.

2.2.3.3.2.2 Middle Klamath River Population

Little data on adult coho are available for this stretch of river. Adult spawning surveys and snorkel surveys have been conducted by the US Forest Service 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 judgment based estimates. While, based on these run size approximations, Table 12 indicates that the Middle Klamath River population may be above the spawners required for ESU viability threshold in some years, 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 is restricted by water quality, flow, and sediment issues. Although its 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.

2.2.3.3.2.3 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 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 2018). From 2014 through 2017 the number of adult coho salmon have been less than 50 fish annually. To reduce the risk of demographic extinction 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 demographics 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 portion of hatchery origin adults in the spawning population is unknown for the most recent three years (2015 to 2017) because sampling efforts were unable to recover any adult carcasses during this time.

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).

2.2.3.3.2.4 Scott River

Abundance estimates on the Scott River are also relatively robust due to the presence of a video fish counting weir (Knechtle and Giudice 2018a). Since 2007, a video weir was placed in the Scott River, alleviating concerns about data collection methods. In 2016 and 2017, 250 and 368 adult coho salmon were estimated to have returned to the river, respectively. 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).

2.2.3.3.2.5 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 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, 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.

2.2.3.4 Federal Actions in the Action Area 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. Some key formal consultations that NMFS has performed for Federal actions in the action area include:

- Consultation with Klamath National Forest in 2018 on fire related activities (see *Wildfire* section 2.2.3.2.8.1) 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 NOAA Fisheries 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 2.2.3.2.4) 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 USACE in 2017 on Montague Water Conservation District's CHERP Program (see the *Shasta River Juvenile Rearing Habitat Conditions* section (Section 2.2.3.1.8.3) above), including issuance of a Clean Water Act Section 404 Permit, and upgrade and replacement of structures, 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 take of juvenile coho salmon in the form of capture during fish relocation and diversion activities, with potential mortalities of juvenile coho salmon of no more than two individuals. Most projects, in addition to short-term incidental take of listed fish also have long-term restoration components that are expected to improve the conservation value of critical habitat (NMFS 2017c).

- 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 2016c).

2.2.4 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

For our effects analysis, NMFS first analyzes the effects of the action on critical habitat (Section 2.2.4.1), then NMFS analyzes the effects of the action on SONCC coho salmon individuals (Section 2.2.4.2), and finally, NMFS analyzes the effects of the proposed Coho Restoration Grant Program. Since most of Reclamation's effects are associated with water management, NMFS first analyzes the hydrologic effects to the Klamath River in our *Effects to SONCC Coho Salmon ESU Critical Habitat* section (Section 2.2.4.1). The Effects to *Physical or Biological Features* (Section 2.2.4.1.4) and *Effects to Individuals* (Section 2.2.4.2) sections will overlay the described Klamath River hydrologic effects on PBFs of SONCC coho salmon ESU critical habitat and SONCC coho salmon individuals, respectively.

2.2.4.1 Effects to SONCC Coho Salmon ESU Critical Habitat

The proposed action is expected to affect SONCC coho salmon critical habitat in the action area through the project operations and habitat restoration activities that will be funded by the Coho Restoration Grant Programs, which provides annual restoration funding of $700,000 in years 2019 and 2020, and $500,000 in years 2021 through 2023. Note that the use of the term "proposed action" in the Project Operations Analysis section represents the Klamath Project operations component of the proposed action, while the use of the term "proposed action" in the

Restoration Activities section represents the habitat restoration component of the proposed action.

2.2.4.1.1 Project Operations

The hydrologic effects analysis is based on the KBPM results from the formulaic approach described in the proposed action and on the proposed real-time management (adaptive flow management) where details are sufficient. The model results include the use of approximately 50,000 AF of EWA as a disease mitigation flow, specifically a surface flushing flow in below average to dry water years when March 1 and/or April 1 EWA is less than 576,000 AF. The model results also include the additional 20,000 AF of EWA in years of concern distributed in May and June according to the default rules described earlier in Element 2 of the *Proposed Action* section (Section 1.3.2). However, the KBPM logic does not limit NMFS' ability to request implementation of the 50,000 AF and the 20,000 AF volumes in alternative distributions that deviate from the formulaic approach using the adaptive flow management process described in the *Proposed Action* section (Section 1.3.2). Except for the proposed in season flow management (e.g., for minimizing disease risks), the precise frequency and magnitude of these deviations from the formulaic approach using the adaptive flow management process cannot be predicted at this time; however, in our effects analysis of critical habitat and coho salmon individuals (Section 2.2.4), we describe the likely effects of these adaptive management approaches on IGD releases in a qualitative manner. Lastly, implementation of PacifiCorp's diurnal flow variability program described in the Environmental Baseline is not included in the modeled IGD daily flow output; however, the benefits of this enhanced flow variability to coho salmon are addressed below.

NMFS recognizes that deviations from the formulaic approach via the proposed adaptive management process, when they occur, would be used to minimize adverse effects to SONCC coho salmon and its critical habitat. The adaptive management process currently relies on recommendations made by the FASTA team that are presented to Reclamation for approval and implementation. Considerations of the FASTA will include balancing the costs and benefits of deviations from the formulaic approach on both listed suckers and coho salmon.

Under the formulaic approach of the proposed action, 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 POR (USBR 2018a). 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 POR. The rest of Project water is supported by diversions from other sources, primarily LRDC and KSD return flows.

2.2.4.1.2 Hydrologic Effects

To analyze the hydrological effects of the Project, NMFS first considers the natural flow regime of the Klamath River under which coho salmon evolved. The natural flow regime of a river is characterized by the pattern of flow quantity, timing, duration and variability across time scales, all without the influence of human activities (Poff et al. 1997). Operation of the Project affects all components of the natural flow regime. In this Opinion, NMFS recognizes the environmental and human caused factors that have influenced the hydrological shift from the natural flow regime, including the effects of the Klamath Project. Here NMFS assesses the Project's effects on flow volume, magnitude, timing, duration, flow variability, and sediment maintenance and geomorphic flows with consideration of the other factors contributing to the current Klamath River hydrology. For these analyses, NMFS used the proposed action modeled daily average discharge at Keno and IGD provided from KBPM output (USBR 2018a).

As in the previous Opinion (NMFS and USFWS 2013), Reclamation did not model a No-Project flow scenario. Therefore, the proposed action hydrograph at IGD is evaluated with respect to the relatively unimpaired conditions defined by the 1905-1913 discharge dataset at Keno, and with respect to the Klamath natural flow regime at IGD that NMFS would expect to occur under natural hydrologic conditions (with no Project deliveries) because an unimpaired, historic daily discharge dataset at IGD is not available. For these analyses, NMFS assumes that accretions from Keno to IGD in the POR are a reasonable representation of future accretions during the 5-year period of this proposed action because accretion data is limited and there is no information to indicate otherwise. As the basis for our conclusions in this Opinion regarding hydrologic effects of the action, NMFS considers the effects of the proposed action in relation to the Klamath River natural flow regime.

NMFS acknowledges that the historic discharge dataset at Keno is limited and likely does not represent the full range of hydrologic conditions that occurred in the 1981-2016 POR. The long-term rainfall record for Klamath Falls, Oregon suggests that the 1905-1913 period had slightly above average precipitation (i.e., 104 percent of average for the period 1905 through 1994), with slightly above average runoff for much of the upper Klamath Basin (Hecht and Kamman 1996). The 1905-1913 annual hydrographs are likely not representative of the full range of hydrologic conditions because very wet and very dry annual hydrographs appear to be absent from this period (Trush 2007). However, the 1981-2016 POR does contain both extremely wet (e.g., 1982, 1983, and 1984) and extremely dry (e.g., 1992, 1994, and 2015) water years which likely encompasses the full range of hydrologic conditions expected to occur during the period of effects of the proposed action.

2.2.4.1.2.1 Proposed Action Flow Regime

As described above, the natural flow regime of a river is the characteristic pattern of flow quantity, timing, rate of change and variability of hydrologic conditions, all without the influence of human activities (Poff et al. 1997). Variability of the natural flow regime is inherently critical to ecosystem function and native biodiversity (Poff et al. 1997, Puckridge et al. 1998, Bunn and Arthington 2002, Beechie et al. 2006).

Reclamation proposes to manage flows in the Klamath River in a manner that approximates the natural hydrograph, represented by real-time hydrologic conditions (Appendix A). For this discussion, the 1905-1913 discharge dataset at Keno, Oregon is used to represent the natural hydrograph. (Figure 11). The 1905-1913 Keno discharge dataset includes historic and relatively unimpaired river flow before implementation of the Klamath Project and other human caused factors influencing the current hydrological baseline (e.g., PacifiCorp's dams, off-Project water users). There is no similar dataset at IGD. Therefore, NMFS describes below the hydrologic effects of the proposed action at both Keno, which provides a more direct comparison with the 1905-1913 discharge dataset at Keno, and IGD, which is the upstream extent of SONCC coho salmon distribution and SONCC coho salmon ESU critical habitat in the Klamath River. Reclamation's proposed action of storing and delivering Project water limits the volume of water available to approximate the natural hydrograph. NMFS recognizes that other factors, such as actions necessary to meet needs of endangered ESA-listed suckers as described in the biological assessment and effects that are not a result of Reclamation's proposed action (e.g., effects of PacifiCorp's KHP and off-Project water users) also limit the water available to approximate the natural hydrograph. This hydrologic effects analysis analyzes the effects of the proposed action in the context of these other factors, which are part of the environmental baseline. Based upon our evaluation of the POR, approximately 40 percent of the median annual UKL net inflow (1,050 TAF) is diverted to the Project annually (408 TAF). Overall, the proposed action results in a hydrograph that resembles the shape of the natural hydrograph and retains some key elements of the natural flow variability of the upper Klamath Basin. However, in large part as a result of operating the Project, the Klamath River annual flow volume, spring peak magnitude and duration, and flow variability are reduced relative to the natural hydrograph.

Under the proposed action, the average daily hydrograph at Keno, Oregon has a similar shape to the natural hydrograph; however, the peak discharge magnitude is reduced and the timing is shifted nearly two months earlier, from the end of April to early March, relative to the historic average daily hydrograph at Keno for the 1905-1913 period (Figure 11). Additionally, fall, spring and summer discharge is substantially reduced. Historically, Klamath River discharge did not reach base (minimum) flow until September. After factoring in implementation of the proposed action as well as other factors described above, minimum flows now typically occur in early June in dry years and beginning of July in average and wet years, a shift in base flow minimum timing of approximately two months earlier. The proposed action hydrograph at IGD has the same shape as the proposed action hydrograph at Keno and illustrates the characteristics of the flow regime (shape, timing, and variability) evidenced at Keno, but IGD has a higher peak magnitude and flow volume due to accretions between Keno and Iron Gate dams (Figure 11). Note that the short duration flow event near the end of August in the proposed action hydrographs at Keno and IGD is associated with increased releases for the bi-annual Yurok Tribal Boat Dance flows, which will likely serve as an environmental cue for early returning coho salmon adults and parr coho salmon and enhance passage opportunities as discussed in later sections.

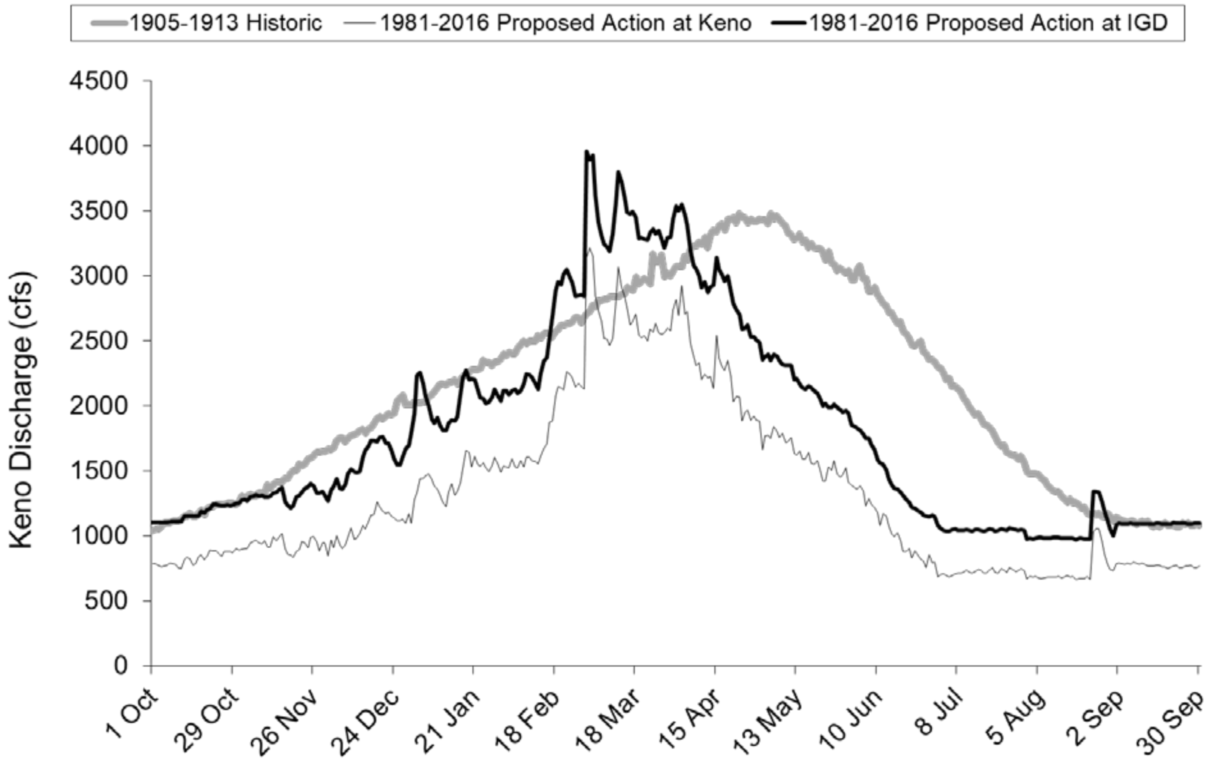

Figure 11. Proposed action at Keno and IGD, and historic average daily Klamath River discharge at Keno, Oregon. The 1905-1913 dataset represents historic and relatively unimpaired river flow before implementation of the Klamath Project.

The proposed action will have lower base flows, and relatively smaller incremental increases from October through mid-February compared to the natural hydrograph (Figure 11). This departure from the natural flow regime is partly a result of the proposed action's prioritization of refilling UKL during this period. Without the Project operating, end of summer UKL elevations would be higher, resulting in higher base flows in the Klamath River that would incrementally increase in the fall and winter as inflow and precipitation increase because a smaller percentage of UKL inflow would be required for storage in UKL. Instead, particularly in below average and dry years, the majority of fall and winter inflows are stored in UKL rather than released to the Klamath River until the storage deficit in UKL (caused by Project deliveries the previous irrigation season) is refilled. Conversely, in average and wetter years (≤50 percent exceedance; see Table 13), IGD flows under the proposed action are expected to incrementally increase through the fall/winter period with more opportunities for flow variability because in average and wetter years there is enough UKL inflow to provide additional storage in UKL and to support increased variable flows below IGD (Appendix A).

The proposed action hydrograph at Keno indicates an earlier and lower peak discharge in the spring (Figure 11). Spring peak flow timing is critical to reduce smolt transit time through disease prone areas. The relationship between increasing discharge and faster smolt migration has been identified for salmonid species in other regulated rivers (Berggren and Filardo 1993, Giorgi et al. 1997). Increased migration speed likely also reduces exposure time to predators, thereby improving smolt survival (NMFS 2012a). The proposed action hydrograph also demonstrates an earlier return to base flows, and flows that are generally lower in magnitude relative to the natural hydrograph (Figure 11). These changes to the hydrograph are in large part a result of the proposed action storing and delivering Project water, although these changes are also a result of other factors described above that are part of the environmental baseline. Once again, this hydrologic analysis analyzes the effects of the proposed action in the context of the environmental baseline.

Additionally, the Project's inter-annual water year effects from diverting and consuming a large portion of approximately 408,000 acre-feet annually, lowers the elevation of UKL throughout the spring, summer and fall, thereby increasing the amount of storage required to refill UKL. Therefore, the effects of the proposed action on flows in the Klamath River are often a result of water use by the Project not only in the current year, but also in previous years. The Klamath River is especially susceptible to the risk of sequential dry hydrologic conditions due to limited storage capacity in UKL (PacifiCorp 2012a) and a drier climate in the upper watershed as suggested by the more recent five to ten years of data (PacifiCorp 2012a). Because of the annual, and inter-annual effects of water diversion for Project irrigation, the proposed action creates drier conditions in the Klamath River, and increases the likelihood of consecutive drier years in the Klamath River than under natural hydrologic conditions (e.g., the proposed action converts average water years in the upper Klamath Basin into below average water years in the mainstem Klamath River). This effect is demonstrated in the probability of exceedance (POE) table for proposed action daily average flows at IGD (Table 13). The POE table below describes the likelihood of a specified flow to be met or exceeded in a given month. Probabilities of exceedance can be used as an indicator of hydrologic conditions for the POR (e.g., 95 percent POE represents a dry year, 50 percent POE represents an average year, and 5 percent POE represents a wet year). The yellow highlighted cells in Table 13 identify the wide range of probabilities of exceedance (i.e., hydrologic conditions) for the POR when proposed action IGD flows will be at Reclamation's proposed biological minimum flows[12]. The effects of minimum flows on the PBFs of critical habitat vary seasonally and are described in detail later in the effects analysis. For example, during the September through January time period minimum flows are sufficient for spawning, and juvenile coho salmon mainstem migration corridors are functional at minimum flows.

[12] Reclamation's proposed biological minimum flows are the minimum flows that will be released at IGD under the proposed action. A table of the minimum IGD flows for each month can be found in the Proposed Action section.

Table 13. Exceedance table for proposed action daily average flows (cfs) at Iron Gate Dam. The yellow highlighted cells identify the wide range of probabilities of exceedance for the POR when proposed action IGD flows will be at Reclamation's proposed biological minimum flows.

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
95%	1000	1000	950	950	950	1000	1325	1175	1025	900	900	1000
90%	1000	1000	950	950	950	1145	1325	1175	1025	900	900	1000
85%	1000	1000	950	950	950	1449	1325	1210	1025	900	900	1000
80%	1000	1000	950	950	952	1609	1359	1318	1025	900	900	1000
75%	1037	1000	950	950	1002	1724	1499	1367	1025	923	900	1000
70%	1063	1000	950	950	1049	1899	1637	1426	1070	953	900	1000
65%	1086	1000	950	977	1122	2130	1760	1479	1109	975	900	1000
60%	1096	1015	950	1028	1187	2334	1922	1515	1150	1000	900	1000
55%	1115	1067	950	1091	1282	2555	2131	1662	1187	1021	919	1007
50%	1129	1110	973	1184	1477	2782	2359	1806	1227	1037	942	1066
45%	1144	1181	1026	1332	1787	3026	2655	2003	1266	1045	972	1104
40%	1154	1208	1108	1503	2100	3301	2946	2204	1305	1060	1016	1141
35%	1169	1222	1250	1710	2449	3783	3214	2404	1403	1084	1068	1150
30%	1184	1233	1501	2044	2729	4075	3516	2617	1552	1118	1099	1161
25%	1201	1319	1681	2419	3117	4684	4151	2858	1670	1122	1108	1170
20%	1254	1376	1943	2734	3601	5512	4527	3112	1796	1157	1128	1196
15%	1288	1497	2292	3229	4110	6030	5060	3411	2058	1193	1150	1214
10%	1325	1639	2939	4216	5110	6440	5571	3840	2439	1229	1178	1225
5%	1427	2581	4149	5655	7383	7533	6094	4501	3018	1250	1550	1231

The proposed action will lower base flows and provide less variability in the fall/winter period due to prioritization of refilling UKL in this period, particularly in below average and dry years. Figure 12 illustrates this pattern where UKL net inflows incrementally increase and are highly variable, whereas flows at IGD remain relatively low and stable. In the period of the effects of the proposed action (the proposed action is for a period of five years and the effects of the proposed action may extend to the return of the last cohort affected by the proposed action; based on the three-year life cycle of coho salmon, the period of the effects of the proposed action is eight years), consecutive years of relatively dry climatological conditions will be especially susceptible to extended periods of relatively low flows with minimal variability at IGD as in water years 1991 and 1992 (Figure 12).

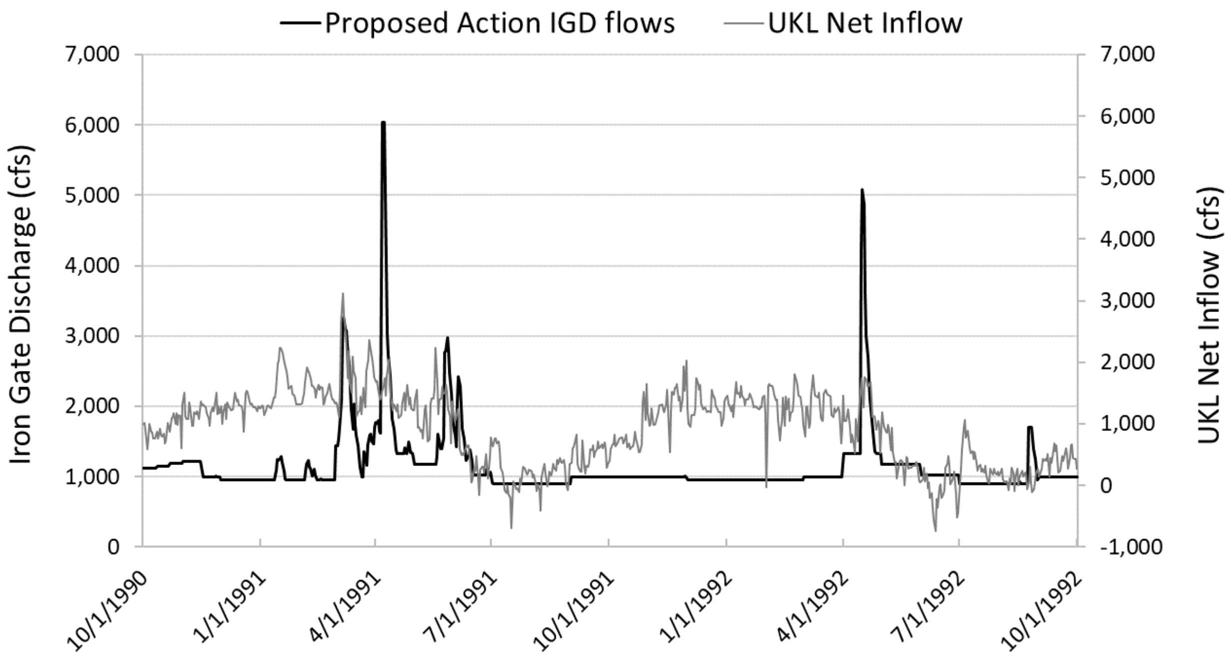

Figure 12. Proposed action IGD flows and UKL net inflow for consecutive dry water years 1991 and 1992.

While in general, the proposed action results in Klamath River flows that are lower than the natural hydrograph, there are exceptions. For example, the proposed action reduces fall releases from Link River Dam during periods of relatively high UKL inflows to accelerate refill of UKL. This can potentially cause UKL elevations to meet or exceed flood threshold elevations earlier than would have naturally occurred in some years. UKL elevations meeting flood thresholds earlier in the winter in some years causes additional releases from UKL to maintain flood detention capacity and results in increased discharge and enhanced flow variability in the Klamath River in the winter and spring in those years. Additionally, in critically dry years such as 1991 and 1992, accelerated refill of UKL in the fall enhances available UKL Supply in the spring providing increased EWA volumes to attempt to implement surface flushing flows as seen in April of each year in Figure 12. KBPM output indicates that a surface flushing flow (6,030 cfs from IGD for 72 hours), would occur in 34 out of 36 years (i.e., the POR). 1992 and 2005 were the two years modeling results indicated that a surface flushing event would be attempted, but could not be achieved due to insufficient head in UKL; however, a maximum 3–day average flow of 4,233 cfs and 6,008 cfs were achieved in those years, respectively. Surface flushing flows disturb surface sediment along the river bottom and disrupt the life cycle of *Manayunkia speciosa* (a polychaete), which is a secondary host for the *C. shasta* parasite central to salmonid disease dynamics in the Klamath River (Hillemeier et al. 2017). Surface flushing flow events implemented in 2016, 2017 and 2018 have been shown to be effective at reducing risks to coho salmon associated with *C. shasta* infection (see *Sediment Maintenance Flows* section (Section 2.2.4.2.1.5.2)).

EWA volumes are comprised of all LRD releases, including flood control releases, between March 1 and September 30 that are not diverted to the Project and/or LKNWR. EWA, combined with non-diverted accretions downstream of Link River Dam, results in the volume of water released at IGD. Figure 13 illustrates the relationship of EWA volume and Project Supply based on the available UKL Water Supply. UKL Water Supply is defined primarily by three key natural hydrologic indicators in the upper Klamath Basin, including UKL storage, UKL inflow and NRCS forecasted UKL inflow. It is evident that EWA volumes increase at an exponential rate with increasing UKL water supplies and decrease with decreasing UKL water supplies (Figure 13); thus, EWA volume allocations proposed by Reclamation under the proposed action are proportionally representative of hydrologic conditions as represented by the three natural hydrologic indicators defining UKL Water Supply. The relationship between EWA volume and the three hydrologic indicators ensures that spring and summer flows in the mainstem Klamath River reflect water supply conditions and some key elements of the natural flow variability in the upper Klamath Basin, even though the EWA volumes are reduced relative to the natural flow regime (Appendix A).

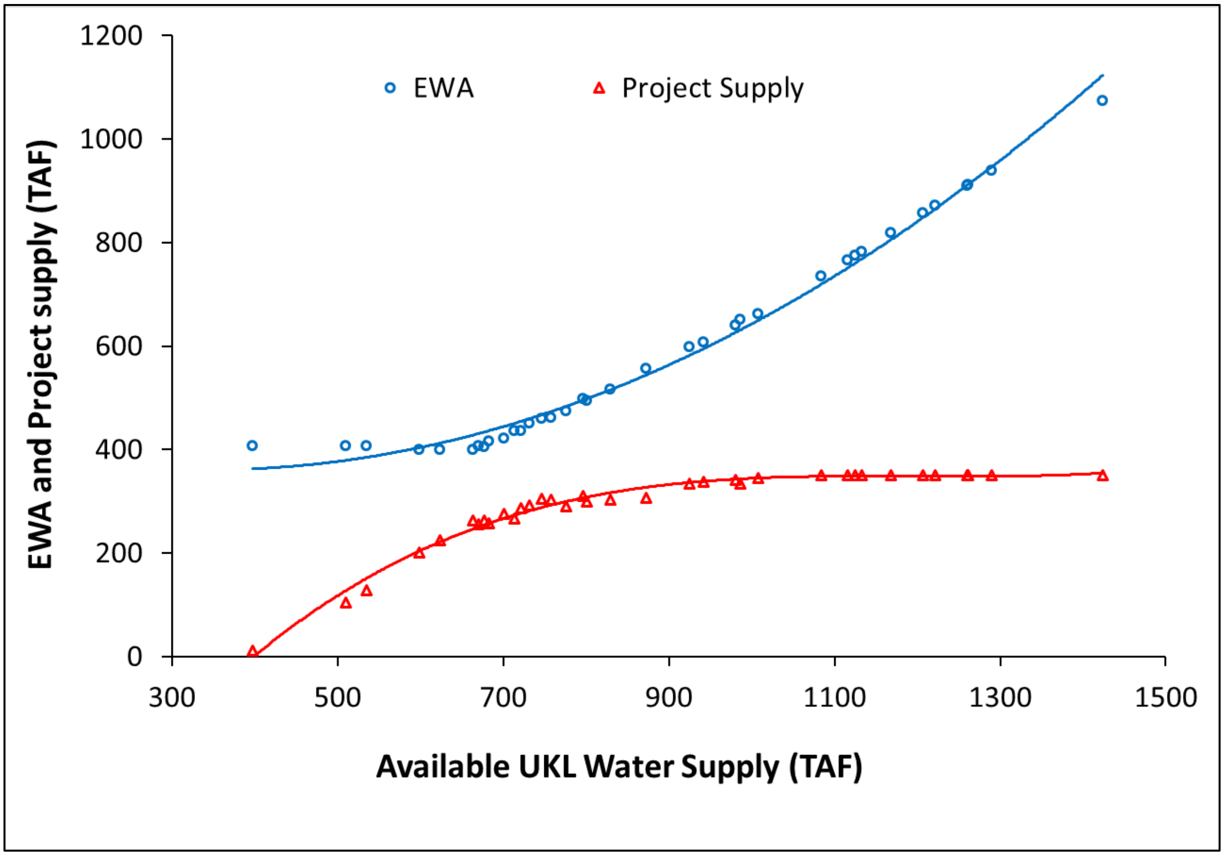

Figure 13. Modeled EWA and Project Supply, based on UKL Supply.

In general, the proposed action reduces Klamath River flows relative to the natural hydrograph. The proposed action also shifts volumes of water from the fall/winter period to the spring/summer period. This redistribution of water is important because the proposed action ultimately shifts water to the critical spring and summer period to meet coho salmon needs during a critical period of their life history.

2.2.4.1.2.2 Flow Variability

Flow variability is an important component of river ecosystems, which can promote the overall health and vitality of both rivers and the aquatic organisms that inhabit them (Poff et al. 1997, Puckridge et al. 1998, Bunn and Arthington 2002, Beechie et al. 2006). Variable flows trigger longitudinal (upstream and downstream) dispersal of migratory aquatic organisms and large events allow access to otherwise disconnected floodplain habitats (Bunn and Arthington 2002), which can increase the growth and survival of juvenile salmon (Jeffres et al. 2008). Arthington et al. (2006) stated that simplistic, static, environmental flow rules are misguided, and will ultimately contribute to further degradation of river ecosystems.

The proposed action employs a formulaic management approach that attempts to ensure appropriate water storage and sucker habitat in UKL while providing Klamath River flows that are intended to represent current hydrologic conditions in the upper Klamath Basin (Appendix A). However, due to Project deliveries reducing UKL elevations and increasing the amount of storage required to refill UKL on an annual basis, the proposed action will continue to contribute to diminished daily flow variability (e.g., reduction of incremental increases of fall and winter base flows) relative to a natural Klamath River flow regime, particularly in below average and dry water years. Given the network of dams and operational constraints of managing flow through multiple reservoirs, achieving relatively unimpaired flow variability is not feasible.

The spring period of March, April and May is naturally a period of high flow variability in the Klamath River. Water storage in UKL and PacifiCorp KHP reservoirs generally peaks in these months. In average and wetter years, rainfall events and sudden increases in snowmelt can result in variable flows at IGD in the spring period as Reclamation and PacifiCorp treat hydrological fluctuations as 'run-of-the-river' when UKL elevations reach flood control thresholds (Appendix A). This means that when UKL elevations reach flood control thresholds, any additional inflow to UKL or PacifiCorp's KHP reach is passed through the system so flood control thresholds are not exceeded. However, in large part as a result of the proposed action storing and delivering Project water, UKL elevations will not reach flood control thresholds in some dry years, resulting in a reduction in daily flow variability at IGD in those years.

The effects of the proposed action on flow variability will be greatest closest to IGD and diminish downstream, as tributary flows (i.e., accretions) contribute to the volume of water and impart additional flow variability to the mainstem. By early April, contributions from the Shasta River are expected to be reduced by water diversions for agricultural practices, and tributaries provide relatively minor contributions downstream for approximately 47 river miles at which point the Scott River increases flow variability. By mid-June, as Scott River flows decrease substantially from water diversions and lack of snowmelt, the loss of flow variability at IGD will be evident throughout the upper Klamath River reach. With a strong likelihood that current climatological trends and warm spring conditions will continue over the period of the effects of the proposed action (Hamlet et al. 2005, Regonda et al. 2005, Stewart et al. 2005, Knowles et al. 2006, Meehl et al. 2007, Mayer and Naman 2011), NMFS anticipates earlier peak flows and reduced late spring accretions than observed historically from the snowmelt driven Scott River watershed, further reducing flow variability in the mainstem Klamath River.

In previous consultations on Reclamation's Project, the ability to model and evaluate the range of daily flow variability has been constrained to monthly or biweekly time-step output. Under the proposed action, IGD flows are a result of daily calculations that incorporate several key indicators of natural hydrologic conditions (UKL net flow, UKL storage, NRCS forecasts, accretions below Link River Dam, etc.). NMFS evaluated the daily change in flow at IGD by comparing the percentage of days that proposed action IGD flows are at or near (plus 5 percent) biological minimums for the POR (Table 14). This evaluation was completed using Reclamation's proposed action biological minimum IGD flows while acknowledging the Hardy Phase II report, which stands as the most comprehensive instream flow and habitat study completed for the Klamath River (Hardy et al. 2006). Hardy et al. (2006) discussed the concept of an Environmental Base Flow (EBF) for the Klamath River. The EBF represents the minimum flow where any further anthropogenic reductions would result in unacceptable levels of risk to the health of aquatic ecosystem (Hardy et al. 2006). By definition, flow conditions at or near the EBF threshold have an infrequent recurrence interval, but as Hardy et al. (2006) asserted, serve as an "*important environmental stressor for long-term population genetics*" (USFWS 2019a). Hardy et al. (2006) adopted EBF flows for the Klamath River that are equivalent to the monthly 95 percent exceedance level of their instream flow recommendations.

With regard to Hardy et al. (2006) instream flow recommendations, including the EBF, for the mainstem Klamath River, NMFS notes the different objectives and standards for analyses in Hardy et al. (2006) and this Opinion. Specifically, Hardy et al. (2006) used a multi-species approach to develop flow recommendations for conserving the entire suite of anadromous salmonids inhabiting the Klamath River basin. In contrast, NMFS must focus its effects analyses here upon the effects of the proposed action on listed SONCC coho salmon and critical habitat designated for this species (as noted above, NMFS analyzes effects of the proposed action on Chinook salmon, which are prey for listed Southern Residents, later in this Opinion). Nevertheless, Hardy et al. (2006) instream flow recommendations provide NMFS with a useful reference when analyzing expected flows under the proposed action. Hardy et al. (2006) instream flow recommendations were based on the natural flow paradigm that concludes effective instream flow prescriptions should mimic processes characteristic of the natural flow regime (Poff et al. 1997, NRC 2004). Therefore, the Hardy et al. (2006) instream flow recommendations, particularly the EBF, are useful in our analysis as an indicator of how closely the expected outcomes of the proposed action align with the patterns and processes of a natural flow regime.

Reclamation's proposed action biological minimums are below Hardy et al. (2006) EBF flows for the Klamath River for the months of October through March, are equal to Hardy et al. (2006) EBF flows for the months of April through June, and exceed Hardy et al. (2006) EBF flows for the months of July through September (Table 14). Table 14 demonstrates that the percentage of days at which proposed action IGD flows are at or near (plus 5 percent) Reclamation's proposed biological minimums in June through February is substantial[13]. Specifically, proposed action IGD flows are at or near Reclamation's proposed biological minimums between 24 and 53 percent for October through February, and between 29 and 50 percent for July through September periods. October through February is an important period to implement flow variability to provide habitat characteristics that will enhance spawning habitat, enhance embryo incubation and reduce impediments to fish passage. Providing flow variability in the July through September period is important for summer rearing habitat and access to thermal refugia, which will likely increase juvenile coho salmon foraging opportunities outside the confines of the existing thermal refugia areas, potentially resulting in higher survival rates for juvenile coho salmon. In the March through June period, proposed action IGD flows are at or near Reclamation's proposed biological minimums for the lowest percentage of days (i.e., between 8

[13] IGD flows are greater than 5 percent above Reclamation's proposed biological minimums for the remainder of the time under the proposed action.

and 30 percent) in the POR (Table 14). Therefore, NMFS expects the greatest likelihood of flow variability to occur below IGD during this period. March through June is a critical time period for flow variability to enhance juvenile rearing habitat, enhance foraging opportunities, reduce disease, and enhance outmigration. The reduced flows in March through June provide less spring discharge volume for smolt outmigration and likely reduce available rearing and off-channel habitat for juvenile coho salmon relative to that provided under a natural flow regime. The increased percentage of days with stable base flows reduces opportunities to inundate floodplains and side channels as well, which would create important rearing habitat and provide terrestrial food sources and nutrients to rearing fish (NMFS 2010a).

Table 14. Hardy et al. (2006) EBF flows and Reclamation's proposed action minimums by month. Percentage of days that proposed action daily average IGD flows are at or near (plus 5 percent) Reclamation's proposed biological minimums.

Percentage of days that proposed action daily average IGD flows are at or near (plus five percent) Reclamation's proposed biological minimums			
MONTH	Hardy's EBF (CFS)	Proposed Action Minimums (CFS)	Percentage of days at or near Proposed Action Minimums
October	1,395	1,000	28
November	1,500	1,000	43
December	1,260	950	53
January	1,130	950	37
February	1,415	950	24
March	1,275	1,000	8
April	1,325	1,325	22
May	1,175	1,175	15
June	1,025	1,025	30
July	805	900	29
August	880	900	50
September	970	1,000	49

Additionally, the yellow highlighted cells in Table 13 above identify the wide range of probabilities of exceedance (i.e., hydrologic conditions) when proposed action IGD flows will be at Reclamation’s proposed biological minimums for the POR. Overall, under the proposed action, annual hydrographs at IGD include a much greater percentage of daily flows at or near biological minimum base flows, with little to no variability, than the Klamath River hydrograph would include under a natural flow regime. KBPM results for the April through June POR under the proposed action (when Reclamation’s proposed action biological minimums are equal to Hardy et al. (2006) EBF flows for the Klamath River) indicate IGD releases would have occurred between 15 and 30 percent of the days (Table 14), whereas under a natural flow regime, biological minimum flows would likely only occur approximately 5 percent of the time in the

Klamath River (95 percent exceedance flows). As mentioned earlier, Hardy et al. (2006) adopted EBF flows for the Klamath River that are equivalent to the monthly 95 percent exceedance level of their instream flow recommendations. Note that the key spring time period for coho fry and juveniles is expected to experience the greatest likelihood of flow variability. The months of March (8 percent), April (22 percent) and May (15 percent) have the lowest percentage of days at or near Reclamation's proposed minimum flows (Table 14).

2.2.4.1.2.3 Sediment Maintenance and Geomorphic Flows

The role of sediment maintenance and geomorphic flows in managed river systems to maintain the integrity and ecology of ecosystems and aquatic organisms and to facilitate sediment transport has been widely recognized (Petts 1996, USFWS and HVT 1999, Bunn and Arthington 2002, NMFS 2010a, Poff and Zimmermann 2010, USFWS 2016d). Consistent with USFWS (2016d), flow regimes designed to provide geomorphic changes are divided into two categories for the following evaluation: (1) sediment maintenance flows (i.e., surface and deep flushing flows) are intended to remove sediment from a channel or otherwise modifying substrate composition; and (2) geomorphic flows (i.e., flows > 15,000 cfs) are intended to maintain channel form and floodplains. Sediment maintenance and geomorphic flows are critical in creating and maintaining in-channel and riparian habitat by providing over-bank flows, which can augment floodplain development, remove accumulated fine sediment, maintain sediment balance, scour vegetation and remobilize gravels to form bars (USFWS 2016d). Additionally, sediment maintenance and geomorphic flows are critical for disease mitigation, specifically to disrupt the *C. shasta* life cycle by adversely impacting the secondary host, an annelid polychaete worm, *Manayunkia speciosa*. In contrast, protracted drought conditions without supplemental sediment maintenance and geomorphic flows will result in extended periods of low velocity flows, an immobile bed, and subsequent fine sediment deposition downstream from IGD (Holmquist-Johnson and Milhous 2010, USFWS 2016d). Immobile bed conditions cause suspended mineral sediment and organic material released from IGD to settle and accumulate on the streambed and are not re-suspended until subsequent flushing flows occur (USFWS 2016d). NMFS evaluates the effects of: (1) the duration of immobile bed conditions, and (2) the frequency and magnitude of sediment maintenance and geomorphic flows expected to occur during the period of the effects of the proposed action relative to the Klamath River natural flow regime.

Three past studies have developed estimates of sediment transport thresholds for the Klamath River below IGD: (1) Ayres Associates (1999), (2) Holmquist-Johnson and Milhous (2010), and (3) Reclamation (2011b). USFWS (2016d) synthesized the relevant sediment transport thresholds identified by the three studies in their Sediment Mobilization technical memorandum. Subsequently, the Disease Management Guidance document (Hillemeier et al. 2017) used the information provided in these three studies, and the Sediment Mobilization technical memorandum (USFWS 2016d), to develop criteria for describing sediment maintenance flows (i.e., surface and deep flushing flows) below IGD.

NMFS' evaluation of the frequency, magnitude and duration of sediment maintenance flows under the proposed action utilizes the criteria for surface and deep flushing flows as described in the Disease Management Guidance document (Hillemeier et al. 2017). NMFS also utilizes Reclamation's contracted independent science review (Atkins 2018) of Hillemeier et. al. (2017). As such, NMFS considers two types of sediment maintenance flows in our analysis: (1) surface flushing flows constitute an average IGD release of at least 6,030 cfs from IGD for at least 72 consecutive hours, and (2) deep flows constitute an average IGD release of 11,250 cfs for 24 hours (Hillemeier et al. 2017).

Additionally, consistent with USFWS (2016d), NMFS considers IGD discharges in excess of 15,000 cfs as geomorphic flows. Note that the 15,000 cfs threshold is an approximate estimate that provides a general order of magnitude for a flow that will cause channel migration and create diverse geomorphic surfaces (USFWS 2016d). Geomorphic flows are likely to remove accumulated riparian and aquatic vegetation, widen the channel where vegetation encroachment has occurred, and sort the gravel armor layer and substrate layer (USFWS 2016d). The effectiveness of geomorphic flows are dependent on duration and magnitude of flows above the 15,000 cfs threshold (USFWS 2016d).

Finally, NMFS considers daily average IGD discharges of 2,500 cfs or less as the flow range at which immobile bed conditions occur, as described in USFWS (2016d). Extended periods of immobile bed conditions can cause fine sediment to settle on spawning gravels and provide habitat conditions conducive to the establishment of aquatic vegetation, two conditions that are favorable to the spread of *C. shasta* in the Klamath River Basin (Stocking and Bartholomew 2007).

Under the proposed action, using the POR,

Figure 14 graphically represents the percentage of each water year that IGD daily average flows are 2,500 cfs or less, the flow range at which immobile bed conditions occur USFWS (2016d). For most years in the POR, immobile bed conditions occur for greater than 70 percent of each water year, and in all years (besides 1984, a very wet year), immobile bed conditions occur in greater than 50 percent of each water year under the proposed action (

Figure 14). Given that the proposed action would continue these conditions, it will continue the increased duration of IGD flows of 2,500 cfs or less relative to the natural flow regime.

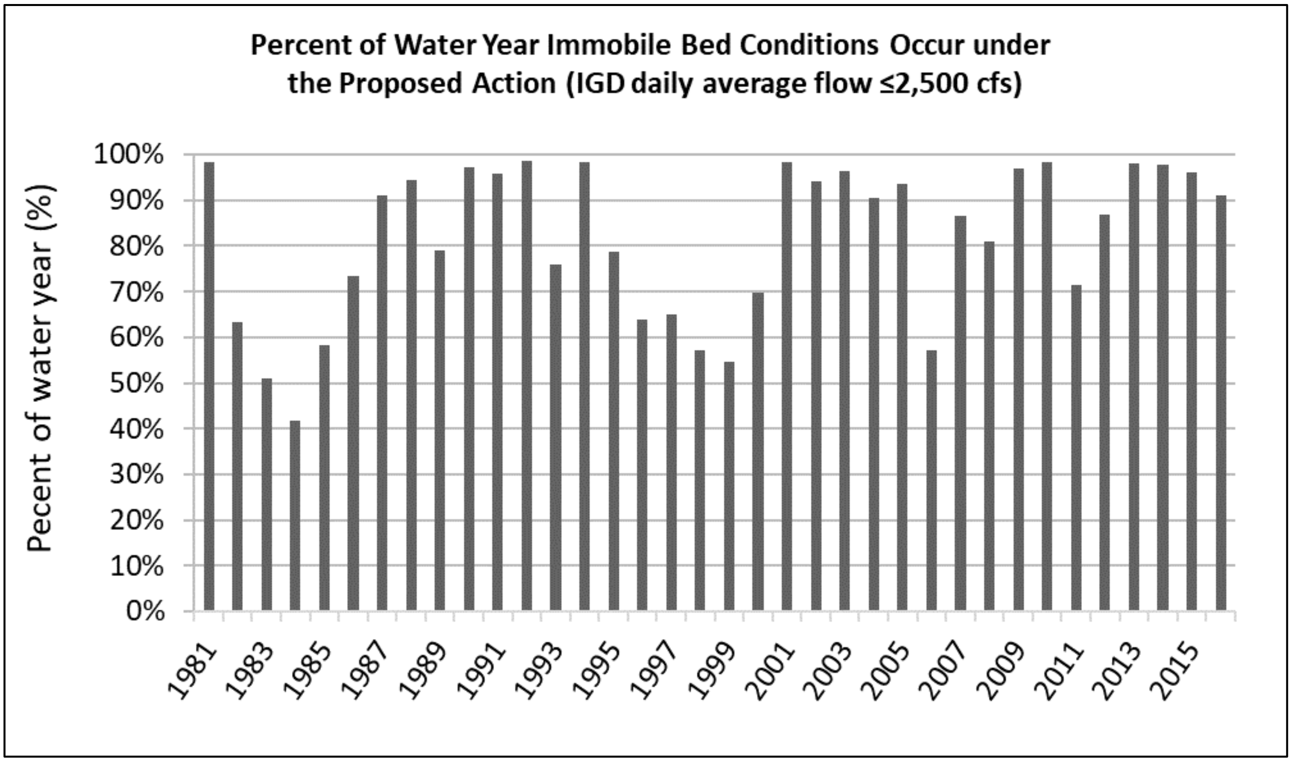

Figure 14. Percent of water year where immobile bed conditions occur at IGD under the proposed action (USFWS 2019b).

Reclamation provided NMFS with a flood frequency analysis applying the Log-Pearson Type III distribution to the observed daily discharge and the modeled proposed action daily discharge for the POR at IGD (Table 15). Generally, the flood frequency analysis shows that the magnitude of 1.5 and 2-yr flood frequency flows have increased under the proposed action relative to the observed; whereas the magnitude of 5, 10 and 25-yr flood frequency flows have decreased under the proposed action relative to the observed (Table 15).

Table 15. Flood frequency analysis on Klamath River for IGD gaging station observed daily discharge and proposed action daily discharge for the period of record from 1981-2016.

Flood Frequency	IGD Gaging Station Discharge (cfs)	
	Observed Daily	Proposed Action Daily
1.5-yr Flood	3,590	5,994
2-yr Flood	4,898	6,528
5-yr Flood	9,110	8,688
10-yr Flood	12,520	10,727
25-yr Flood	17,498	14,129

KBPM output under the proposed action indicates that a surface flushing flow (6,030 cfs from IGD for 72 hours), would occur in 34 out of 36 years in the POR. Implementation of surface flushing flows at this frequency has essentially increased the 1.5-yr flood (5,994 cfs) and the 2-yr flood (6,528 cfs) under the proposed action compared to the observed flood frequency values for the POR (Table 15). Implementation of surface flushing flows in nearly all years is likely to be of a similar frequency and magnitude relative to the natural flow regime; however, surface flushing flows likely did not occur under the natural flow regime in protracted drought conditions with consecutive dry years. Surface flushing flow events have been shown to be effective at reducing risks to coho salmon associated with *C. shasta* infection as recently as water years 2016, 2017 and 2018. Therefore, as noted below, NMFS concludes that this element of the proposed action will provide an adequate magnitude and frequency of surface flushing flows that will likely help reduce disease risks to coho salmon associated with *C. shasta*.

KBPM output indicates that implementation of the proposed action results in achieving a deep flushing flow (11,250 cfs for 24 hours) in 4 out of the 36 years in the POR (1982, 1986, 1996 and 1997). Additionally, model results show that no deep flushing flows would be implemented for 19 consecutive years from 1998 through 2016. However, in mid-March 2016, IGD released approximately 11,000 cfs for several days. Polychaete densities were found to be lower following the flow event (Bartholomew et al. 2017). Implementation of deep flushing flows at this frequency under the proposed action results in a 5-yr flood of 8,688 cfs and a 10-yr flood of 10,727 cfs, which are both of a lesser magnitude than the magnitude of a deep flushing flow (11,250 cfs) (Table 15). Reclamation's proposed action will attempt to implement deep flushing flows when hydrologic conditions and public safety allow. However, NMFS concludes it is unlikely that a deep flushing flow will be implemented under the period of effects of the proposed action (unless a wet year occurs), and that the frequency, magnitude and duration of deep flushing flows is reduced under the proposed action relative to the Klamath River natural flow regime. The decreased frequency, magnitude and duration of deep flushing flows under the proposed action relative to the natural flow regime is due, in part, to the fact that KBPM does not incorporate "forced" deep flushing flows in the model logic. This model logic, annual diversions for Project irrigation, and the inter-annual effect of increasing the amount of storage needed to refill UKL each year, reduces opportunities for deep flushing flows.

The proposed action is likely to result in minimal reductions to the magnitude, frequency and duration of large, less frequent geomorphic flows (i.e., flows >15,000 cfs) relative to the natural flow regime. Hardy et al. (2006) concluded that the combined effect of Reclamation's Project, the network of Klamath River reservoirs, and limited storage capacities in the upper Klamath Basin maintained the likelihood of experiencing adequate geomorphic flows that provide riverine restorative function. Reclamation does not propose substantive changes to the approach to storing water analyzed by Hardy et al. (2006) such that NMFS would expect changes to the magnitude, frequency and duration of overbank flood events above 15,000 cfs in the five-year action period. Geomorphic flows in late fall and winter are likely to redistribute spawned-out adult salmonid carcasses[14], and will also disturb the channel armor and substrate layers. These actions help reduce the prevalence of *P. minibicornis* and *C. shasta*, the organisms tied to health related impacts on coho salmon.

2.2.4.1.2.4 Summary of Hydrologic Effects

The proposed action results in a hydrograph that resembles the shape of the natural flow regime and retains some key elements of the natural flow variability of the upper Klamath Basin (Appendix A). However, in large part as a result of operating the Project, the Klamath River annual flow volume, spring peak magnitude and duration, deep flushing flows, and flow variability are reduced relative to the natural hydrograph. Overall, under the proposed action, the Klamath River will have lower base flows in the fall and winter, lower and earlier peak discharge, reduced spring and summer discharge, and an earlier return to base flow relative to the natural hydrograph, particularly in below average and dry years. Spring and summer flows in the mainstem Klamath River (i.e., EWA volume) are proportionally representative of natural hydrologic conditions in the upper Klamath Basin defined by three primary hydrologic indicators, including UKL storage, UKL net inflow, and NRCS UKL inflow forecasts (Figure 13). The relationship between EWA volume and the three hydrologic indicators ensures that spring and summer flows in the mainstem Klamath River reflect water supply conditions and some key elements of the natural flow variability in the upper Klamath Basin, even though EWA volumes are reduced relative to the natural flow regime.

The proposed action employs a formulaic management approach that attempts to ensure appropriate water storage and sucker habitat in UKL while providing Klamath River flows that are intended to represent current hydrologic conditions in the upper Klamath Basin and meet coho salmon needs. However, due to Project deliveries reducing UKL elevations and increasing the amount of storage required to refill UKL on an annual basis, the proposed action will continue to contribute to diminished daily flow variability relative to the Klamath River natural flow regime, particularly in below average and dry years. Conversely, in average and wetter years (≤50 percent exceedance; see Table 13), IGD flows under the proposed action are expected to incrementally increase through the fall/winter period with more opportunities for flow

[14] These carcasses are likely concentrated in the upper Klamath River below IGD, increasing the potential for disease outbreaks to occur.

variability because in average and wetter years there is enough UKL inflow to provide additional storage in UKL and to support increased variable flows below IGD (Appendix A).

Under the proposed action, annual hydrographs at IGD include a greater percentage of daily flows at or near Reclamation's proposed biological minimum flows, with little to no variability, than the Klamath River hydrograph would include under a natural flow regime (Table 14). KBPM results for the April through June POR under the proposed action (when Reclamation's proposed action biological minimums are equal to Hardy et al. (2006) EBF flows for the Klamath River) indicate IGD releases would have occurred between 15 and 30 percent of the days (Table 14), whereas under a natural flow regime, biological minimum flows would likely only occur approximately 5 percent of the time in the Klamath River (95 percent exceedance flows). As mentioned above, Hardy et al. (2006) adopted EBF flows for the Klamath River that are equivalent to the monthly 95 percent exceedance level of their instream flow recommendations. Note that the key spring time period for coho fry and juveniles is expected to experience the greatest likelihood of flow variability. The months of March (8 percent), April (22 percent) and May (15 percent) have the lowest percentage of days at or near Reclamation's proposed minimum flows (Table 14).

Although NMFS expects the greatest likelihood of flow variability to occur below IGD during the critical spring period, the reduced flows in March through June provide less spring discharge volume for smolt outmigration and likely reduce available rearing and off-channel habitat for juvenile coho salmon relative to that provided under a natural flow regime. The increased percentage of days with low, stable base flows also reduces opportunities to inundate floodplains and side channels, which would create important rearing habitat (NMFS 2010a). While the proposed action enhances flow variability relative to some past Project operations, overall the proposed action will continue to contribute to diminished flow variability relative to a natural Klamath River flow regime, particularly in below average and dry water years.

The role of sediment maintenance and geomorphic flows in managed river systems to maintain the integrity and ecology of ecosystems and aquatic organisms and to facilitate sediment transport has been widely recognized (Petts 1996, USFWS and HVT 1999, Bunn and Arthington 2002, NMFS 2010a, Poff and Zimmermann 2010, USFWS 2016d). Sediment maintenance and geomorphic flows are critical for creating and maintaining in-channel and riparian habitat; as well as for disease mitigation, specifically to disrupt the *C. shasta* life cycle by adversely affecting the secondary host, an annelid polychaete worm, *Manayunkia speciosa*. For most years in the POR, immobile bed conditions occur for greater than 70 percent of each water year, and in all years (besides 1984), immobile bed conditions occur in greater than 50 percent of each water year under the proposed action (

Figure 14). These conditions are likely to continue during the five years of the proposed action. Consequently, the proposed action is likely to continue to contribute to extended periods of immobile bed conditions which can cause fine sediment to settle on spawning gravels and provide habitat conditions conducive to the establishment of aquatic vegetation, two conditions that are favorable to the spread of *C. shasta* in the Klamath River Basin (Stocking and Bartholomew 2007).

Under the proposed action, based on the POR, a surface flushing flow would occur in 34 out of 36 years. NMFS expects that a surface flushing flow will occur in all 5 years under the proposed action, unless consecutive critically dry years occur as in 1991-1992 and 2004-2005. 1992 and 2005 were the only two years for which modeling results indicated that a surface flushing event was attempted, but could not be achieved due to insufficient head in UKL. Surface flushing flow events have been shown to be effective at reducing risks to coho salmon associated with *C. shasta* infection in recent years (2016, 2017, and 2018). Therefore, as discussed below, NMFS believes that this element of the proposed action will provide an adequate magnitude and frequency of surface flushing flows that will likely help reduce disease risks to coho salmon associated with *C. shasta*. Implementation of the proposed action results in achieving a deep flushing flow in 4 out of 36 years with no deep flushing flows for 19 consecutive years from 1998 through 2016. Additionally, the 5-yr flood (8,688 cfs) and the 10-yr flood (10,727 cfs) under the proposed action are both of a lesser magnitude than the magnitude of a deep flushing flow (11,250 cfs). KBPM does not incorporate “forced” deep flushing flows in the model logic. This model logic, annual diversions for Project irrigation, and the inter-annual effect of increasing the amount of storage needed to refill UKL each year, reduces opportunities for deep flushing flows. NMFS concludes it is unlikely that a deep flushing flow will be implemented under the period of the effects of the proposed action (unless a wet year occurs), and that the frequency, magnitude and duration of deep flushing flows is reduced under the proposed action relative to the Klamath River natural flow regime. Lastly, the proposed action is likely to result in minimal reductions to the magnitude, frequency and duration of large, less frequent geomorphic flows (i.e., flows >15,000 cfs) relative to the natural flow regime primarily due to limited storage capacities in both UKL, and the network of Klamath River reservoirs above IGD.

During the period of effects of the proposed action, the Klamath River downstream of IGD is more likely to experience drier conditions than it would without Project operations. In large part as a result of the proposed action storing and delivering Project water, the Klamath River hydrograph will have reduced annual flow volumes, reduced daily average flows, reduced flow variability, reduced magnitude and frequency of deep flushing flows, and more immobile bed conditions relative to the natural hydrograph. However, under the first year of implementation of the proposed action, the upper Klamath Basin is likely to experience average to above average water supply conditions. UKL elevations are approaching flood curve thresholds, the March 1 NRCS March through September UKL inflow 50 percent exceedance forecast is 735,000 AF (112 percent of average), Klamath Basin snowpack is above average (120 percent), and the EWA is estimated to be approximately 600,000 AF as of April 1, 2019 Reclamation (2019d). As a result, NMFS expects that a surface flushing flow will be implemented in 2019, and IGD flows in April, May and June will be representative of an average to above average water year as indicated in the probability of exceedance table (Table 13). Under these hydrologic conditions, NMFS expects that available habitat will be adequate for outmigrating coho salmon fry and juveniles, and that disease infection rates will be relatively low compared to the historical disease infection data set.

2.2.4.1.3 Ramp Rates

Here, NMFS considers the hydrologic effects of ramp rates separately from the other hydrologic effects of the proposed action because the proposed ramp rates are temporary changes in river and stream hydrology[15]. Rapid ramp-down of flows can strand coho salmon fry and juveniles if mainstem flow reductions accelerate the dewatering of lateral habitats. Stranded coho salmon fry disconnected from the main channel are more likely to experience fitness risks, becoming more susceptible to predators and poor water quality. Death from desiccation may also occur as a result of excessive ramp-down rates that dry up disconnected habitats. While stranding of coho salmon fry and juveniles can occur under a natural flow regime, artificially excessive ramp-down rates exacerbate stranding risks. Salmonid fry and juveniles are generally at the most risk from stranding than any salmonid life stage due to their swimming limitations and their propensity to use margins of the channel.

NMFS expects the proposed ramp-down, and ramp-up rates, when flows at IGD are greater than 3,000 cfs, will generally reflect natural hydrologic conditions in the Klamath River at flows of this magnitude. NMFS expects any stranding that may occur at these higher flows to be consistent with rates that would be observed under natural conditions. NMFS concluded in the 2010 and 2013 Opinions (NMFS 2010a, NMFS and USFWS 2013) that the proposed ramp-down rates below 3,000 cfs adequately reduce the risk of stranding coho salmon fry and coho salmon redds. Therefore, NMFS continues to conclude that Reclamation's proposed ramp-down and ramp-up rates are not likely to adversely affect coho salmon redds, fry and juveniles.

2.2.4.1.4 Effects to Physical or Biological Features

The proposed action's hydrologic effects have the potential to affect the following three physical or biological features that are found within designated coho salmon critical habitat in the action area: Spawning areas, rearing areas, and migration corridors. Critical habitat within the mainstem action area is not designated downstream of the confluence with the Trinity River (tribal land). Therefore, the analysis of water management effects of the proposed action on critical habitat will be restricted to the Upper and Middle Klamath River reaches (i.e., between IGD and Trinity River). The analysis of Reclamation's coho restoration program and resultant restoration activities includes the Upper Klamath, Middle Klamath, Shasta, Scott, and Salmon River (i.e., the Interior Klamath Diversity Stratum).

The proposed action has the most hydrologic and water quality effects on the mainstem Klamath River near IGD, and such effects generally diminish in the Seiad to Orleans reach because the proportion of flow contributed by the proposed action diminishes with distance downstream of IGD.

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[15] The long term hydrologic impacts of water storage and release, including ramping operations, are discussed above.

In the *Hydrologic Effects* section (Section 2.2.4.1.2), NMFS recognizes Reclamation's strides to incorporate elements of the natural flow regime into the proposed action. While the frequency of surface flushing flows will be increased relative to the POR, and EWA release strategies incorporate key considerations for coho salmon, the Project consumes water and thus, reduces annual flow volumes, flow variability, deep flushing flows and spring discharge in the mainstem Klamath River.

2.2.4.1.4.1 Spawning Areas

Coho salmon are predominately tributary spawners and limited coho salmon spawning occurs in the mainstem Klamath River between Indian Creek (RM 107) and IGD (RM 190), primarily in side-channels and margins of the mainstem Klamath River (Magneson and Gough 2006). Where spawning habitat exists, gravel quality and fluvial characteristics are likely suitable for successful spawning and egg incubation. Because of storage limitations, the proposed action will likely have minimal reductions to the magnitude, frequency and duration of large, less frequent geomorphic flows (i.e., >15,000 cfs) relative to the natural hydrograph. However, the proposed action increases the frequency of surface flushing flows, decreases the frequency of deep flushing flows, and increases the duration of immobile bed conditions occurring relative to the natural hydrograph. The Project will periodically reduce fine sediments through surface flushing flow events, and the benefits of the flushing will likely be sustained for an extended period of the spring. However, in other portions of the year, the Project's effects of increasing the duration of immobile bed conditions likely increases the infiltration of fine sediments into spawning gravel. During a protracted period of dry years, similar to 2013 through 2015, the proposed action could contribute to conditions of large concentrations of fines, which could impact the quality of coho salmon spawning gravel.

Model results in the Phase II report (Hardy et al. 2006) for Chinook salmon spawning habitat indicate that the IGD to Shasta River reach has at least 80 percent of maximum available spawning habitat when flows are between 950 and approximately 2,600 cfs. While Chinook and coho salmon spawning habitat preferences (e.g., velocity depth, substrate) vary, coho salmon spawning habitat preferences fall within the range of conditions selected by Chinook salmon. Given the abundance of salmon spawning habitat when flows at IGD are 950 cfs or above and the low numbers of adult coho salmon spawning in the mainstem, NMFS expects that the quantity of coho salmon spawning habitat will be suitable under the proposed action.

In average and wetter years (≤50 percent exceedance; see Table 13 in the *Hydrologic Effects* section), flows under the proposed action are expected to incrementally increase through the fall/winter period with increased opportunities for flow variability. Though spawning habitat for coho salmon is not limited in the mainstem Klamath River, an increase in flows and flow variability during fall and winter will increase spawning habitat. As flows increase, suitable spawning habitat becomes more available close to the river margins such as side channels. Spawning habitat closer to the margins has a lower risk of scouring during peak runoff events than locations closer to the middle of the river. In addition, variable flows result in different and additional areas of the channel bed having high quality spawning habitat for coho salmon, which increases spawning habitat throughout the fall/winter period. Therefore, the proposed action is likely to increase the quantity of spawning habitat in the mainstem Klamath River in relatively wet years when IGD flows are variable and incrementally increase during the late fall and winter. Coho salmon spawning in the mainstem has been documented between 900 and 1,600 cfs (Magneson and Gough 2006). Spawning habitat is expected to be adequate during drier years due to the proposed minimum flows during this period.

2.2.4.1.4.2 Adult and Juvenile Migration Corridor

The proposed action would affect water depth and velocity in the mainstem Klamath River, which may affect fish passage. The proposed action will lower flows in the mainstem Klamath River during much of September, October, November and December. However, the November and December flows of at least 950 cfs under the proposed action will provide the depth and velocity necessary for adult coho salmon migration in the mainstem Klamath River, and thus are not expected to impede migration. In addition, the proposed action does retain some aspects of a natural flow regime with variable flows (albeit reduced from a natural flow regime), which will provide adult coho salmon migration cues commensurate with natural hydrologic conditions.

The juvenile migration corridor within the mainstem Klamath River is expected to be suitable at flows of at least 900 cfs. Navigating shallow channel sections is easier for juvenile coho salmon than adult salmon due to their smaller size. Juvenile coho salmon have also been observed migrating from the mainstem Klamath River into tributaries at times when IGD flows have been less than 1,300 cfs and tributary base flows are at summer low levels (Soto et al. 2008). The proposed action's effects on the migration corridors of juveniles looking to enter tributaries are dependent on both the alluvial features at those sites and mainstem and tributary flows.

Sutton and Soto (2012) documented several Klamath River tributaries (i.e., Cade [RM 110] and Sandy Bar [RM 76.8] creeks) where fish access into the creeks was challenging, if not impossible, when IGD flows were 1000 cfs in the summer. Because of their alluvial steepness, NMFS acknowledges that some tributaries (e.g., Sandy Bar Creek) may not be conducive to access until flows are very high, which may not be possible in the summer even without the proposed action. Stage height-flow relationship data at mainstem Klamath River gage sites (e.g., Seiad or Orleans) indicate that during low summer flow conditions, 100 cfs influences the Klamath River stage height by 0.1 to 0.13 feet. Given the minimal effect on stage height, combined with overriding factors influencing passage from the mainstem into tributaries (e.g., tributary gradient and flow), NMFS does not anticipate the proposed action will have an adverse effect on coho salmon juvenile migration corridors into tributaries. In addition, bi-annual flow increases in the late summer for the Tribal boat dance will likely serve as an environmental cue for early returning coho salmon adults and parr coho salmon, while enhancing passage opportunities.

2.2.4.1.4.3 Rearing Areas

Rearing areas provide essential features such as cover, shelter, water quantity, and space. The following discussion on the effects of the proposed action on rearing habitat is best categorized by the affected essential features of critical habitat, which include cover, shelter, space, and water quality. Cover, shelter, and space are analyzed together as habitat availability. Specific areas of rearing habitat most influenced by flow include side channels and floodplain access, which have greater opportunity to become inundated under a natural hydrology. NMFS also evaluates the efficacy of sediment maintenance flows on coho salmon critical habitat.

NMFS used the relationships of flow and habitat formulated by Hardy (2012) and Hardy et al. (2006) to quantify how coho salmon fry and juvenile habitats vary with water discharge in the mainstem Klamath River below IGD. The flow-habitat relationships provided by Hardy et al. (2006) and Hardy (2012) represent the best available data on flow-habitat relationship in the Klamath River. NMFS has not found any other studies that quantify the relationship between discharge and habitat in the Klamath River mainstem.

Hardy et al. (2006) developed habitat suitability criteria for life history stages of anadromous salmonids in the regulated mainstem Klamath River based on the fundamental concepts of the ecological niche theory. The 2006 report defines an ecological niche as “the set of environmental conditions (e.g., temperature, depth, velocity) and resources (things that are consumed such as food) that are required by a species to exist and persist in a given location.” Species and life stage specific habitat suitability criteria used in instream flow determinations are an attempt to measure the important niche dimensions of a particular species and life stage (Gore and Nestler 1988). These criteria are then used to measure niche changes relative to changes in flow.

Empirical data on juvenile coho salmon in the mainstem Klamath River are limited. While juvenile outmigration monitoring (e.g., downstream migrant traps) provides information on distribution and emigration timing on the mainstem Klamath River, there are few observations of juvenile coho salmon utilizing micro-habitat. Consequently, Hardy et al. (2006) developed literature-based habitat suitability criteria to quantify habitat availability for juvenile coho salmon within the mainstem Klamath River. Habitat suitability criteria were validated using the limited empirical observations of coho salmon fry and parr in the mainstem Klamath River (Hardy et al. 2006).

Using simulated hydrodynamic variables at intensive study sites, Hardy developed composite suitability indices for each site from the habitat suitability criteria data, which incorporated species and life-stage specific preferences with regard to specific microhabitat features, such as flow, depth, velocity, substrate, and cover characteristics. The composite suitability indices were later converted into a combined measure known as the weighted usable area (WUA) to characterize the quality and quantity of habitat in terms of usable area per 1,000 linear feet of stream (NRC 2008). USBR (2019a) then scaled up WUA results from the individual sites to the larger reach-level scale (see Hardy et al. (2006) or NRC (2008) for further discussion) as seen in Figure 15. WUA is a measure of habitat suitability, predicting how likely a habitat patch is to be occupied or avoided by a species life stage at a given time, place, and discharge (i.e., the suitability of the habitat for a specific species and life-stage of fish) (NRC 2008).

NMFS uses reach-level WUA curves to gauge the general change in instream habitat availability (incorporating both quantity and quality) within the mainstem Klamath River resulting from the proposed action, and characterizes the change as a difference in suitable habitat volume. WUA curves from reach-level study sites for the Upper Klamath and Middle Klamath River reach were used in this effects analyses (Table 16).

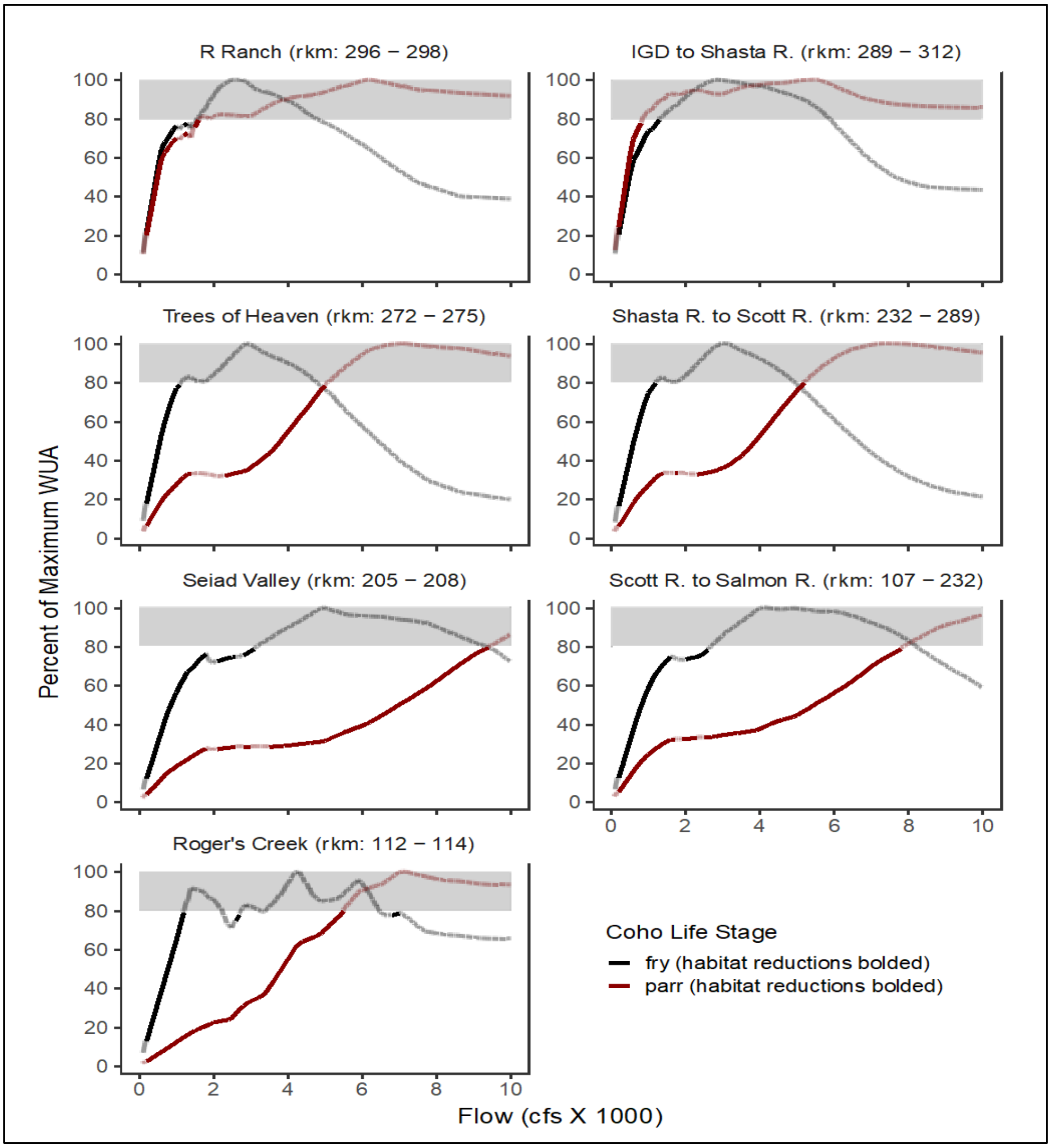

Figure 15. Coho salmon fry and parr habitat availability relative to IGD flows and four sites downstream of IGD and three reaches (from USBR 2019a). Flows account for tributary accretions estimated for each habitat unit when calculating WUA.

Table 16. Hardy et al. (2006) and Hardy (2012) reach level study sites used by NMFS for analysis.

Klamath River Reach	**Coho Salmon Fry**	**Coho Salmon Juvenile***
Upper Klamath River Reach	IGD to Shasta River reach	Trees of Heaven
	Shasta to Scott River reach	
		Seiad Valley
Middle Klamath River Reach	Scott to Salmon River reach	Rogers Creek

*While Hardy et al. (2006) developed WUA curves for coho salmon juveniles at seven reaches in the Klamath River, NMFS uses only the Trees of Heaven, Seiad Valley, and Rogers Creek reaches because these reaches have relatively high habitat availability and are most influenced by the proposed action (i.e., closest to IGD).

2.2.4.1.4.3.1 Coho Salmon Fry

The proposed action generally reduces flow volume in the mainstem Klamath River throughout most of the year. Therefore, NMFS assumes that in locations where there are positive relationships between flow and habitat, the proposed action generally reduces habitat availability because it generally reduces flow volume. As discussed in the *Environmental Baseline* section, coho salmon fry are present in the mainstem Klamath River from March to approximately mid-June (Justice 2007). Therefore, effects to coho salmon fry habitat are only considered for the March through mid-June period. While NMFS' ability to quantify proposed action effects are limited, NMFS expects the range of proposed action effects on mainstem Klamath River coho salmon fry habitat variability resulting from flow reductions will vary considerably, from having no effect to levels that NMFS considers adverse.

Between IGD and the Shasta River, habitat for coho salmon fry increases as flows increase to 4,100 cfs. However as explained in the *Analytical Approach* section (2.1), for the purpose of analyzing effects of the proposed action on coho salmon and their critical habitat, NMFS focused its analysis on those conditions when habitat availability is less than 80 percent of maximum available. The proposed action generally lowers flows, and coho salmon fry habitat is reduced to below 80 percent of maximum available from IGD to the Shasta River when flows are below approximately 1,400 cfs. Using the same logic for the further downstream reaches, NMFS assumes that when the proposed action contributes to mainstem flows below approximately 1,200 cfs, coho salmon fry habitat decreases to below 80 percent between the Shasta and Scott Rivers. Between the Scott and Salmon Rivers, coho salmon fry habitat availability decreases below 80 percent when the proposed action contributes to mainstem flows of approximately

1,000 to 2,500 cfs. The steeper the relationship between flow and percent of maximum habitat, the extent of habitat reduction becomes greater.

To summarize the proposed action's effects on coho salmon fry habitat availability, Reclamation (2018a) developed an exceedance table for the proposed action from March to June for three mainstem reaches. The exceedance table enables NMFS to assess the frequency and timing of coho salmon fry habitat reductions caused by the proposed action. The proposed action will minimally reduce coho fry habitat availability in the mainstem Klamath River between IGD (RM 190) to the Salmon River (RM 65.5) in below average years (> 50 percent exceedance) in June (Table 17). However, the magnitude of fry habitat availability is expected to be sufficient, as 80 percent of maximum available habitat will be provided in most areas and this is not considered limiting.

While there will be reductions in habitat availability to coho salmon fry, we do expect some flow variability under the proposed action, and generally, habitat quality and quantity will increase. Flow variability will occur during precipitation and snowmelt events, reflecting qualities of a natural flow regime. When hydrologic conditions in the upper Klamath Basin are wet, flow variability under the proposed action will result in higher flows in the mainstem Klamath River downstream of IGD. Temporary increases in mainstem flows are expected to result in short-term increases in the amount and quality of habitat in the mainstem for fry coho salmon. Therefore, the adverse effects to coho salmon fry habitat in the mainstem Klamath River between IGD and the Salmon River during below average to normal years are likely to be somewhat moderated by the flow variability under the proposed action when hydrological conditions in the upper Klamath Basin are wet. When the upper Klamath Basin is experiencing relatively wet hydrologic conditions, flows in the mainstem Klamath River will be relatively high.

Table 17. Daily average mainstem flows (cfs) where the proposed action will likely reduce coho salmon fry habitat availability to below 80 percent of maximum (orange highlight) (from USBR 2018a).

	Iron Gate Dam to Shasta River				Shasta to Scott River				Scott to Salmon River			
Exceedance	**March**	**April**	**May**	**June**	**March**	**April**	**May**	**June**	**March**	**April**	**May**	**June**
95%	1113	1429	1244	1056	1433	1641	1404	1126	2560	2494	1931	1341
90%	1302	1463	1280	1073	1731	1711	1467	1175	2932	2711	2197	1481
85%	1606	1518	1362	1099	1954	1848	1608	1229	3240	3027	2477	1603
80%	1782	1559	1483	1124	2165	1938	1742	1292	3620	3397	2684	1728
75%	1912	1695	1550	1159	2329	2097	1858	1345	3971	3849	2964	1816
70%	2122	1858	1611	1190	2589	2291	1978	1397	4340	4134	3334	1936
65%	2352	2004	1672	1227	2864	2446	2088	1441	4699	4473	3666	2065
60%	2582	2195	1766	1266	3174	2734	2221	1487	5231	4884	4003	2214
55%	2848	2430	1894	1312	3519	2983	2389	1539	6170	5395	4312	2392
50%	3140	2689	2072	1348	3884	3306	2537	1604	6716	5859	4609	2599
45%	3372	3013	2315	1400	4164	3675	2824	1690	7238	6476	5098	2855
40%	3735	3289	2590	1489	4613	3962	3230	1820	7643	6981	5804	3126
35%	4237	3640	2796	1626	5181	4467	3504	2012	8362	7733	6444	3434
30%	4668	3986	2999	1783	5818	4899	3729	2202	9173	8339	6923	3829
25%	5228	4631	3274	1917	6449	5544	4029	2381	10115	8937	7326	4410
20%	6082	5080	3555	2089	6897	6099	4402	2682	11237	9603	7889	4962
15%	6467	5611	3974	2416	7669	6537	4934	3026	12429	10198	8822	5556
10%	7148	6103	4403	2818	8693	7083	5474	3589	14272	11235	9797	6469
5%	8582	6669	5062	3464	10588	7806	6320	4271	17531	12322	10744	7755

2.2.4.1.4.3.2 Coho Salmon Juveniles

As shown in the *Environmental Baseline* section, coho salmon juveniles are present in the mainstem Klamath River throughout the year (see Figure 10). However, the period from March to June represents the peak of coho salmon juvenile presence (Justice 2007). While coho salmon juveniles are present in the mainstem Klamath River in the summer, their habitat is limited to areas that provide suitable cooler water temperatures during this period (i.e., thermal refugia). Therefore, NMFS will analyze the proposed action's effects on coho salmon juvenile rearing habitat during spring using the habitat modeling results provided by Reclamation (USBR 2019a). However, NMFS will also analyze the effects of the proposed action on the integrity of thermal refugia in the summer period.

As discussed earlier, the proposed action generally reduces flow volume in the mainstem Klamath River throughout the year, and juvenile coho salmon habitat is below 80 percent of maximum available at less than approximately 5,000 cfs at three study reaches. While the WUA relative to IGD flow curves (see Figure 15) generally show a positive relationship between flow and habitat, there are portions of the curves where more flow does not correspond to more available habitat (or corresponds to less habitat). The effects of flow reduction on juvenile coho salmon habitat availability in the mainstem Klamath River vary spatially and temporally downstream of IGD. The proposed action reduces juvenile coho salmon habitat availability across a broad range of flow exceedance values at the Trees of Heaven, Seiad Valley, and Rogers Creek sites during the spring (Figure 15 and Table 18 to Table 20).

In summary, the proposed action will reduce coho salmon juvenile habitat availability in the mainstem Klamath River from the Trees of Heaven (RM 172) to Rogers Creek (RM 72) reaches at various times of the year and at various flow exceedances. Of the three reaches, the proposed action reduces coho salmon juvenile habitat availability in the Seiad Valley reach the most: in most water years and in all months between October and June.

Table 18. Daily average mainstem flows (cfs) where the proposed action will likely reduce coho salmon juvenile habitat availability (blue highlight) in the Trees of Heaven reach (from USBR 2018a).

Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
95%	1114	1184	1146	1187	1229	1331	1547	1333	1095
90%	1135	1198	1163	1213	1267	1564	1591	1375	1129
85%	1162	1211	1188	1253	1305	1837	1699	1490	1171
80%	1184	1227	1199	1280	1348	2013	1766	1630	1214
75%	1202	1241	1218	1320	1407	2156	1912	1710	1258
70%	1226	1262	1241	1357	1481	2423	2057	1788	1307
65%	1246	1286	1263	1396	1568	2641	2257	1876	1345
60%	1260	1320	1293	1456	1710	2908	2466	1997	1377
55%	1286	1356	1328	1559	1905	3216	2704	2124	1415
50%	1315	1394	1392	1703	2182	3547	3005	2303	1466
45%	1343	1419	1454	1887	2442	3813	3349	2569	1540
40%	1364	1451	1576	2106	2750	4274	3636	2894	1660
35%	1389	1471	1766	2417	3120	4757	4039	3155	1832
30%	1408	1534	2027	2776	3471	5233	4447	3339	1975
25%	1440	1595	2293	3186	4032	5946	5127	3611	2156
20%	1466	1661	2676	3770	4749	6465	5576	3970	2373
15%	1511	1774	3188	4378	5561	7146	6155	4417	2683
10%	1573	1955	4047	5740	6937	7974	6547	4847	3222
5%	1712	3812	6112	7861	10689	9817	7216	5689	3858

Table 19. Daily average mainstem flows (cfs) where the proposed action will likely reduce coho salmon juvenile habitat availability (blue highlight) in the Seiad Valley reach (from USBR 2018a).

Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
95%	1154	1265	1290	1390	1578	1980	2065	1685	1210
90%	1180	1330	1340	1474	1710	2269	2228	1894	1315
85%	1212	1360	1390	1640	1848	2600	2485	2148	1433
80%	1253	1380	1437	1750	1970	2835	2734	2315	1536
75%	1280	1417	1490	1852	2112	3108	2952	2535	1598
70%	1305	1454	1576	1949	2221	3382	3194	2832	1694
65%	1330	1499	1650	2068	2437	3708	3486	3139	1806
60%	1357	1538	1730	2202	2744	4163	3891	3332	1925
55%	1387	1560	1850	2376	3083	4824	4343	3551	2052
50%	1425	1611	2006	2622	3419	5230	4657	3869	2247
45%	1457	1643	2178	2944	3770	5643	5138	4233	2467
40%	1498	1712	2374	3280	4191	6083	5624	4737	2667
35%	1535	1780	2653	3593	4608	6851	6320	5247	2944
30%	1575	1866	2951	4358	5213	7559	6863	5591	3244
25%	1611	1959	3465	5251	6089	8239	7390	6002	3730
20%	1668	2073	4324	5949	7257	9025	7961	6580	4189
15%	1739	2255	5171	7369	8463	10233	8555	7110	4749
10%	1845	2765	7126	9201	10357	11443	9167	8164	5507
5%	2008	5691	10546	12605	16578	14180	10192	9111	6528

Table 20. Daily average mainstem flows (cfs) where the proposed action will likely reduce coho salmon juvenile habitat availability (blue highlight) in the Rogers Creek reach (from USBR 2018a).

Exceedance	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
95%	1257	1509	1686	1926	2749	3741	3222	2500	1643
90%	1324	1601	1858	2369	3184	4284	3799	2873	1796
85%	1361	1737	2013	3011	3674	4889	4407	3128	1992
80%	1417	1810	2254	3369	4081	5437	4843	3405	2190
75%	1507	1876	2511	3661	4506	6018	5649	3965	2339
70%	1564	1932	2790	4021	5001	6562	6223	4460	2522
65%	1609	1975	3111	4493	5549	7087	6729	4850	2692
60%	1649	2041	3508	4947	6106	8036	7414	5470	2906
55%	1671	2102	3948	5397	6680	9226	8001	5922	3137
50%	1713	2182	4360	6079	7145	10159	8601	6458	3421
45%	1776	2296	4865	6970	7791	10793	9392	7293	3810
40%	1807	2472	5504	7692	8749	11549	10396	8216	4198
35%	1862	2662	6214	8522	9693	12674	11084	9125	4611
30%	1933	2999	7282	9961	11397	14058	11988	9722	5147
25%	2092	3319	8641	11865	12890	15490	12888	10418	5834
20%	2185	3933	9958	14586	15268	16844	13494	11617	6476
15%	2424	4808	12895	17418	18376	18150	14741	12531	7523
10%	2657	7402	18207	20915	22986	20701	16245	13656	8707
5%	3553	12371	27044	26670	31399	25082	18268	14706	10792

As with coho salmon fry, the adverse effects to coho salmon juvenile habitat in the Trees of Heaven, Seiad Valley, and Rogers Creek reaches are likely to be somewhat moderated by the flow variability incorporated into the proposed action (and from downstream additions) when hydrological conditions in the upper Klamath Basin are wet.

2.2.4.1.4.4 Water Quality

Water quality impairments in the Klamath River are most common in the late spring through summer. Therefore, NMFS narrows the water quality analysis to the spring and summer. As with most rivers, the water quality in the Klamath River is influenced by variations in climate and flow regime (Garvey et al. 2007, Nilsson and Malm-Renöfält 2008). NMFS will focus in this section on the water quality effects resulting from controlled flows, which are influenced by the proposed action. NMFS addresses climate effects in other sections of this opinion. Water quality analysis conducted by Asarian and Kann (2013) indicates that flow significantly affects water temperature, dissolved oxygen, and pH in the Klamath River. Multiple, complex, and interacting pathways link flow to water quality effects (Figure 16). In fact, of all the independent variables evaluated, Asarian and Kann (2013) found that flow had the strongest effect on water quality. The most relevant of these water quality parameters, water temperature, dissolved oxygen, and pH, are discussed further below.

2.2.4.1.4.5 Water Temperature

Project operation and IGD water releases have a relatively low ability to affect water temperatures in the mainstem Klamath River below IGD, as there is not a cold water storage source within the Project. As discussed previously, the proposed action will reduce the volume of water released from IGD during the spring. Water released from IGD influences water temperature in the mainstem Klamath River, and the magnitude and extent of the influence depends on the temperature of the water being released from the dam, the volume of the release, and meteorological conditions (NRC 2004). As the volume of water decreases out of IGD, water temperature becomes more responsive to local meteorological conditions such as solar radiation and air temperature due to reduced thermal mass and increased transit time (Basdekas and Deas 2007). The proposed action's effect of reducing mainstem flows in the spring will result in longer flow transit times, which will increase daily maximum water temperatures and, to a lesser extent, mean water temperatures in the mainstem Klamath River downstream of IGD during the spring (NRC 2004).

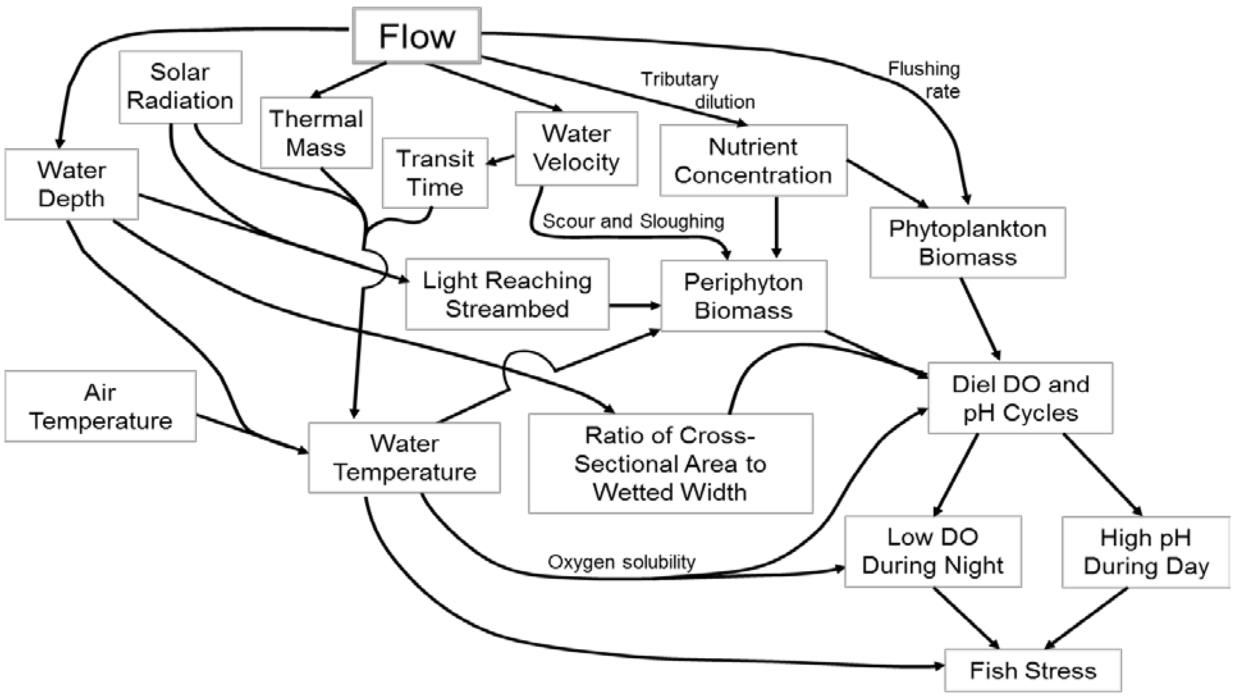

Figure 16. Conceptual model for the effect of flow on water quality in the mainstem Klamath River. The model only shows the most relevant factors that affect water quality (Asarian and Kann 2013).

Temperature modeling of the mainstem Klamath River by Perry et al. (2011) shows that increasing flows out of IGD by as much as 1,000 cfs in the spring decreases water temperatures on the mainstem Klamath River by only up to 0.5 °C at either the Shasta River or the Scott River confluence. Since the total net Project reductions (i.e., the total Project diversions) to mainstem Klamath River flows in the spring is approximately 1,000 cfs, the proposed action is likely to increase water temperature in the mainstem Klamath River between IGD and the Scott River by up to approximately 0.5 °C during the spring. Below the Scott River mouth, the proposed action's effects on water temperature in the spring are likely insignificant because cold water accretions and meteorological conditions have a pronounced effect on water temperatures in this portion of the mainstem Klamath River. In the late summer and early fall, any decreases in IGD flows are likely to minimally reduce water temperature in the mainstem Klamath River because reservoir water behind IGD is warmer than mainstem Klamath River water.

2.2.4.1.4.6 Nutrients and Dissolved Oxygen

Temperature is a primary influence on the ability of water to hold oxygen, with cool water able to hold more dissolved oxygen than warm water. The proposed action's spring warming effect on water temperatures and longer transit times increases the probability that dissolved oxygen concentrations will decrease in the mainstem Klamath River downstream of IGD. In addition, the proposed action also indirectly affects pH and dissolved oxygen through its interactions with periphyton, algae that grow attached to the riverbed.

The seasonal (summer/fall) release of nutrients out of Iron Gate Reservoir stimulates periphyton growth in the mainstem Klamath River (USDOI and CDFW 2012). The NRC (2004) stated that stimulation of any kind of plant growth can affect dissolved oxygen concentration. However, because nutrient concentration is only one factor influencing periphyton growth, the small increase in nutrients may not necessarily increase periphyton growth. Other factors influencing periphyton growth include light, water depth, and flow velocity. In addition, many reaches of the Klamath River currently have high nutrient concentrations that suggest neither phosphorus nor nitrogen is likely limiting periphyton growth. Thus, an increase in nutrient concentration would not necessarily result in worse dissolved oxygen and pH conditions.

While the proposed action's increase in nutrients in the mainstem Klamath River between IGD (RM 190) and Seiad Valley (RM 129) is not likely to have a direct influence on periphyton growth, the proposed action's reduction of mainstem flows has a larger effect on periphyton and its influence on dissolved oxygen concentration. Several mechanisms are responsible for flow effects on periphyton biomass. Some of these include the relationship between flow and water temperature, water depth, and water velocity. When low flows lead to warmer water temperature, periphyton growth likely increases (Biggs 2000). High flows increase water depth, which likely reduce light penetration in the river. Conversely, low flows generally decrease water depth, which increases periphyton photosynthesis. Low water depth also disproportionally amplifies the relative water quality effects of periphyton (i.e., diel cycles of dissolved oxygen would be magnified) because the ratio between the cross-sectional area and channel width decreases (i.e., mean depth decreases). In other words, the inundated periphyton biomass[16] would have greater water quality effect on the reduced water column.

High levels of photosynthesis cause dissolved oxygen concentration to rise during the day and lower at night during plant respiration. Low dissolved oxygen concentration at night reduces rearing habitat suitability at night. Daily fluctuations of up to 2 mg/L of dissolved oxygen in the mainstem Klamath River downstream from IGD have been attributed to daytime algal photosynthesis and nocturnal algal/bacterial respiration (Karuk 2002, Karuk 2003, Hiner 2006, NCRWQCB 2010).

In addition, the overall effect of the conceptual linkages between flow and dissolved oxygen is supported by an analysis of 11 years of mainstem Klamath River water quality data that found that higher flows were strongly correlated with higher dissolved oxygen minimums and narrower daily dissolved oxygen range. Therefore, when the proposed action reduces mainstem flows in

[16] Periphyton are attached to the riverbed and exert their influence on the water column chemistry by impacting diel cycles of photosynthesis and respiration in the overlying water column. Although periphyton would also decrease as the wetted channel area declines, they would decrease at a lower rate relative to water volume changes because the ratio of area:volume increases with decreased flow.

the summer, NMFS expects there will likely be a reduction to dissolved oxygen concentrations in the mainstem Klamath River between IGD and Orleans (RM 59). The proposed action's contribution to dissolved oxygen reduction likely diminishes around Orleans (RM 59) as tributary accretions offset the dissolved oxygen reductions near this site.

While the exact amount and extent of the proposed action's water quality effects are unknown, the proposed action's contribution to impaired water quality conditions adversely affects the rearing habitat element of coho salmon critical habitat. As discussed in the *Environmental Baseline*, dissolved oxygen concentrations regularly fall below 8 mg/L in the mainstem Klamath River during the summer (Karuk 2002, Karuk 2003, Karuk 2007, Karuk 2009, Karuk 2010, Karuk 2011), which is the minimum concentration for suitable salmonid rearing (USEPA 1986). Therefore, the proposed action will likely contribute to adverse effects to the rearing habitat element of coho salmon critical habitat when dissolved oxygen concentrations fall below 8 mg/L in the mainstem Klamath River during the summer.

2.2.4.1.4.7 Disease

The likelihood of juvenile coho salmon to succumb to ceratomyxosis is a function of a number of variables, such as temperature, flow, and density of actinospores (True et al. 2013). In turn the density of actinospores is dependent on the density and prevalence of infection of the polychaete intermediate *C. shasta* host. The proposed action generally reduces spring flows in the mainstem Klamath River downstream of IGD. By reducing spring flows, the proposed action will result in drier hydrologic conditions in the mainstem Klamath River relative to the natural hydrologic regime. Conditions representative of droughts can cause spawning gravels to become filled with fine sediment and provide habitat conditions conducive to the establishment of aquatic vegetation, two conditions that are favorable to the spread of *C. shasta* in the Klamath River Basin (Stocking and Bartholomew 2007).

Management of UKL also affects mid-winter peak flows, which in turn affects sediment movement and size distribution. Sediment movement and high flows are known to reduce the density and populations of the polychaete worm intermediate host for *C. shasta* (USFWS 2016b). Project operations affect the magnitude and frequency of these high flow events, which in turn has contributed to a higher risk of disease in juvenile coho salmon. These effects will be, in part, minimized by proposed near-annual surface flushing events, as they disrupt the life cycle of *C. shasta*. Actinospore density is likely to be influenced by spring flows and sediment maintenance flows, both of which provide important ecological function in potentially minimizing disease prevalence of *C. shasta* (see *Disease* section (Section 2.2.3.2.3) for more details on disease risk).

2.2.4.1.5 Summary of Effects to SONCC Coho Salmon ESU Critical Habitat

In average and wetter years (≤50 percent exceedance), flows under the proposed action are expected to incrementally increase through the fall/winter period. Though spawning habitat for coho salmon is not limited in the mainstem Klamath River, the proposed action is likely to increase the quantity of spawning habitat in the mainstem Klamath River in relatively wet years when IGD flows are variable and incrementally increase during the late fall and winter. The proposed action effects on spawning habitat quality from fine sediment deposition are expected to be minimal.

The proposed action is expected to affect water depth and velocity in the mainstem Klamath River, which may affect fish passage. The proposed action will generally lower flows in the mainstem Klamath River during much of September, October, November and December. However, the November and December flows of at least 950 cfs under the proposed action will provide the depth and velocity necessary for adult coho salmon spawning migration, and thus the proposed minimum flows are not expected to impede migration.

The juvenile coho salmon migration corridor within the mainstem Klamath River is expected to be suitable in terms of water depth and velocity at IGD flows of at least 900 cfs (minimum proposed in July). The proposed action's effects on the migration corridors of juveniles entering tributaries are dependent on both the alluvial features at those sites and tributary flows. Occasionally individual tributaries may not be accessible to juveniles in the mainstem Klamath River due to low tributary flow in dry years.

Using habitat modeling results, NMFS has determined that the amount of suitable coho salmon fry habitat will generally decrease due to Project operation. Although the amount of available habitat between IGD and the Salmon River is expected to be sufficient, in some areas during below average water years coho salmon fry habitat will be minimally below 80 percent maximum available in June. NMFS expects that at least 80 percent of maximum available habitat provides for the conservation needs of coho salmon.

The proposed action will generally decrease available juvenile coho salmon habitat from IGD through the Middle Klamath River reach. Based on habitat modeling results, available habitat is reduced below 80 percent of maximum available in most months of the year and in most water year types. NMFS expects that at least 80 percent of maximum available habitat provides for the conservation needs of coho salmon.

The proposed action will affect water quality in the Klamath River. In the spring, less water will be released from IGD under the proposed action. Water temperature modeling indicates that temperatures may increase in the IGD to Scott River reach by up 0.5 °C. Below the Scott River the proposed action's effects on water temperature is likely insignificant because cold water tributary flow and meteorological conditions have a pronounced effect on water temperatures in this portion of the Klamath River. Water temperature is a primary influence on the ability of water to hold oxygen, and the expectation of spring warming as a result of the proposed action is expected to result in decreased dissolved oxygen. The magnitude and frequency of the rise of water temperature in the spring, and the decrease of dissolved oxygen, is dependent on meteorological conditions and flow in any given year. When water temperatures rise above 16.5 °C in a given year, as they do every year at some time in the late spring/early summer, it can stress juvenile coho salmon. However, Project operations have little effect on water temperatures at this time of the year.

The proposed action is likely to decrease deep flushing flows and increase river bed immobility. Surface flushing flow frequency will increase under the proposed action, and they will occur almost every year, as detailed in the *Hydrologic Effects* section (Section 2.2.4.1.2.4). Surface flushing flows are known to disrupt polychaete populations and lower their prevalence of *C. shasta* infection.

2.2.4.2 Effects to Individuals

The proposed action is expected to affect SONCC coho salmon through the project operations and habitat restoration activities that will be funded by the Coho Restoration Grant Program, which will provide annual restoration funding of approximately $700,000 in fiscal years 2019 and 2020, and at least $500,000 per year in 2021 through 2023. Project Operations affect coho salmon through hydrologic and habitat modifications in the mainstem Klamath River.

2.2.4.2.1 Project Operations

As stated in the *Effects to SONCC Coho Salmon ESU Critical Habitat* section, under *Project Operations*, the coho salmon effects analysis is based on the results of the formulaic approach described in the proposed action and on adaptive management where details are sufficient for analysis. Except for the proposed in season flow management (e.g., for minimizing disease risks), the precise frequency and magnitude of deviations from the formulaic approach using the adaptive flow management process cannot be predicted at this time; however, the likely effects of the adaptive management approaches to IGD releases are described below in a qualitative manner in our analysis of effects to coho salmon individuals. Under the proposed action, the median Project delivery from all surface sources by water year is 408,000 AF with a minimum of 26,000 AF and a maximum of 480,000 AF for the POR (USBR 2018a). The proposed action's effects to coho salmon include reductions to flows at IGD.

2.2.4.2.1.1 Exposure

As previously discussed in the *Hydrologic Effects* section (Section 2.2.4.1.2), the proposed action reduces flows in the mainstem Klamath River throughout most of the year. Therefore, all life stages of coho salmon are expected to be exposed to proposed action effects in the next five years (Table 21). However, different populations of coho salmon will be exposed to varying levels of flow effects under the proposed action. Populations closest to IGD (e.g., Upper Klamath River) will experience the most pronounced exposure, while populations farthest away, such as the Lower Klamath River population, are not likely to be exposed.

Adult coho salmon are present in the mainstem Klamath River only during the upstream migration and spawning period. Upstream migration of adult coho salmon in the Klamath River spans the period from September to January, with peak movement occurring between late-

October and mid-November. In most years, all observations of adults in tributaries occur prior to December 15, while in some years (e.g., Scott River in 2009) most adults are observed in tributaries between December 15 and January 1. Therefore, adults that spawn in tributaries are expected to be exposed to hydrologic effects in the mainstem Klamath River primarily in the late fall to early winter, prior to them entering tributaries to spawn.

A small number of coho salmon (e.g., fewer than approximately 50 each year) spawn in the mainstem Klamath River, and thus a relatively small number of embryos and fry are expected to be present in the mainstem each winter and spring. In addition, coho salmon fry from tributaries emigrate into the mainstem Klamath River as a result of ecological conditions (e.g., high flow displacement or deleterious tributary conditions (Chesney 2007) or behavioral tendencies. However, most coho salmon fry from the tributaries (i.e., ≥ 50 percent) are assumed to rear in the tributaries.

Some juveniles likely rear in the mainstem throughout the year, and consist of parr and smolts. Juvenile coho salmon have been observed residing within the mainstem Klamath River downstream of Shasta River throughout the summer and early fall in thermal refugia during periods of high water temperatures (>22 °C). Some coho salmon parr may be present in the mainstem from the time they leave the tributaries to the following winter. However, as described above for fry, most parr from the tributaries (i.e., ≥ 50 percent) are assumed to rear in the tributaries.

Coho salmon smolts are expected to migrate to the mainstem Klamath River beginning in late February, with most natural origin smolts outmigrating to the mainstem during March, April and May (Wallace 2004). Courter (2008), using USFWS and CDFW migrant trapping data from 1997 to 2006 in tributaries upstream of and including Seiad Creek (e.g., Horse Creek, Shasta River, and Scott River), reported that 56 percent of coho smolts were trapped from April 1 through the end of June.

Once in the mainstem, smolts move downstream fairly quickly, with estimated median migration rates of 13.5 miles/day (range -0.09 to 114 miles/day) for wild coho salmon and 14.6 miles/day (range -2.3 to 27.8 miles/day) for hatchery coho salmon (Stutzer et al. 2006). Beeman et al. (2012) found that wild coho salmon smolts released near IGD had a median travel time of 10.4 and 28.7 days in 2006 and 2009, respectively, to the estuary. The maximum recorded time of wild coho salmon smolts traveling on the mainstem from IGD to the estuary was 63.8 days (Beeman et al. 2012).

Table 21. A summary of the coho salmon life stage exposure period to project-related flow effects.

<table>
<tr><th>Life Stage</th><th>Coho Salmon Population(s)</th><th>General Period of exposure when individuals are in the mainstem</th></tr>
<tr><td>Adults</td><td>Upper Klamath, Shasta River, Scott, and Middle Klamath rivers</td><td>September to mid-January</td></tr>
<tr><td>Embryos to pre-emergent fry</td><td>Upper Klamath River</td><td>November to mid-March</td></tr>
<tr><td>Fry</td><td>Upper Klamath, Shasta River, Scott, and Middle Klamath rivers</td><td>March to mid-June</td></tr>
<tr><td>Parr</td><td rowspan="2">Upper Klamath, Shasta River, Scott, and Middle Klamath rivers</td><td>May to February</td></tr>
<tr><td>Smolts</td><td>March to June</td></tr>
</table>

2.2.4.2.1.2 Response

2.2.4.2.1.2.1 Adults

Minimum daily average flows under the proposed action are at least 950 cfs during the period of upstream migration. NMFS concludes that the proposed action is not likely to adversely affect adult coho salmon migration in the mainstem Klamath River. Coho salmon escapement monitoring have confirmed successful adult passage in the mainstem Klamath River when IGD releases were at least 950 cfs in the fall (e.g., USFWS mainstem redd/carcass surveys, CDFW Shasta and Bogus Creek video weir studies, IGH returns). In addition, water temperatures in the mainstem Klamath River are cool or cold in the late fall and winter, and are not expected to impede coho salmon adult migration. In addition, flow variability incorporated into the proposed action may provide an environmental cue to stimulate adult coho salmon upstream migration when flows in the mainstem Klamath River mimics natural fall and winter freshets.

2.2.4.2.1.2.2 Eggs

As discussed in the *Effects to Physical or Biological Features* section and assuming coho salmon spawning habitat is similar to Chinook salmon, NMFS expects that the proposed action will provide suitable quantity of coho salmon spawning habitat for successful spawning and egg incubation. While the proposed action may contribute to sedimentation of spawning habitat, spawning habitat data collected by USFWS indicates adult salmonids successfully construct redds in the mainstem Klamath River annually. Based on the information we have, NMFS does not expect eggs in the mainstem Klamath River will be adversely affected by the proposed action.

Also, while the proposed action will likely reduce mainstem flows from October to January in average and less than average water years (> 50 percent exceedance; Table 13), coho salmon eggs in the mainstem are not expected to be dewatered. The naturally increasing flows during the winter from storm events downstream of IGD will also reduce the potential for dewatering of coho salmon eggs in the mainstem or side channels. In addition, redd dewatering is not expected to occur because of the conservative ramp-down rates proposed by Reclamation.

2.2.4.2.1.2.3 Fry

The proposed action is likely to adversely affect coho salmon fry in late spring during below average years by reducing habitat availability and increasing susceptibility to diseases (see *Effects to Physical or Biological Features*, section 2.2.4.1.4). The amount and extent of these potential adverse effects are expected to vary spatially and temporally, and result primarily from proposed action effects on flow. These effects are discussed separately below for simplicity, but note that they can affect coho salmon fry simultaneously, sequentially, or synergistically. Also, note that the proposed action incorporates elements of flow variability, in season flow management e.g., for disease management), and restoration activities, which can help to offset some of the adverse effects from flow reductions.

2.2.4.2.1.3 Water Quality

As discussed in the *Effects to Physical or Biological Features* section (Section 2.2.4.1.4), the proposed action's reduction of spring flows in the mainstem Klamath River is likely to increase water temperatures in the spring by up to approximately 0.5 °C in the mainstem between IGD and the Scott River. Increases to water temperature in the spring may have both beneficial and adverse effects to coho salmon fry. Increasing water temperature in the spring may stimulate faster growth. However, when water temperature chronically exceeds 16.5 °C, coho salmon fry may become stressed and more susceptible to disease-related mortality (Foott et al. 1999, Sullivan et al. 2000, Ray et al. 2012). Foott et al. (1999) found that when water temperatures are under 17 °C, Klamath River salmonids appear to be more resistant to ceratomyxosis. Therefore, the proposed action is likely to have minimal adverse effects to coho salmon fry when water temperatures are below 16.5 °C. Conversely, when daily maximum water temperatures are chronically above 16.5 °C in May to mid-June, the proposed action will contribute to water temperature conditions that will be stressful to coho salmon fry in the mainstem Klamath River between IGD and the Scott River.

2.2.4.2.1.4 Habitat Availability

As discussed in the *Effects to SONCC Coho Salmon ESU Critical Habitat* section (Section 2.2.4.1), the proposed action will generally reduce coho salmon fry habitat availability in the mainstem Klamath River between IGD (RM 190) to Shasta River (RM 144) reach and in the Scott (RM 144) to Salmon River (RM 65) reach in drier years (i.e., ≥60 percent exceedance) during June (Table 17).

Flow influences the width of the river channel and flow reductions likely reduce essential edge habitat, which decreases carrying capacities for coho salmon fry in the mainstem Klamath River. During the spring, coho salmon fry compete with other species (e.g., Chinook salmon) for available habitat. While habitat preferences between coho salmon fry are not the same as Chinook salmon, steelhead, and coho salmon juveniles, some overlap in habitat use is expected.

Based on literature, increased competition for space increases emigration rates or mortality (Chapman 1966, Mason 1976, Keeley 2001), and reduces growth rates (Mason 1976). Delayed growth results in a greater risk of individuals being killed by predators (Taylor and McPhail 1985). Coho salmon fry habitat in the mainstem Klamath River becomes increasingly important as the number of coho salmon fry in the mainstem increases in dry spring conditions because coho salmon fry move from low and warm water tributaries to the Klamath River. Generally, as the spring progresses from April through May, the number of coho salmon fry increases in the mainstem Klamath River downstream of the Shasta River (Chesney 2007). Therefore, the proposed action may reduce growth and survival of coho salmon fry in portions of the mainstem Klamath River between IGD and Salmon River (RM 65) during mid-June in below average water years (when IGH salmonids are also in the mainstem).

Conversely, when conditions are favorable (e.g., good water quality, low juvenile abundance, low disease), the proposed action is likely to have minimal adverse effects to coho salmon fry. By mid-June, coho salmon fry are likely to have transformed from fry to parr, and coho fry abundance in the mainstem Klamath River in late June is likely at a level that habitat reductions resulting from the proposed action are minimal.

Given that the abundance of coho salmon fry is likely to be greatest in the mainstem Klamath River from April through June, Reclamation has proposed managing flows during the driest of conditions and has proposed to implement Hardy et al.'s (2006) recommended ecological base flows as minimums during the April through June period. During dry hydrologic conditions in the Klamath Basin, the proposed action will reduce adverse effects to coho salmon fry in April to June by not reducing flows in the mainstem Klamath River below what Hardy et al. (2006) considers to be an occasional acceptable levels of risk to the health of aquatic resources. Note that Hardy et al. (2006) did not quantitatively assess disease risks in the ecological base flow recommendation.

2.2.4.2.1.5 Disease Effects to Coho Fry

Ceratomyxosis, which is caused by the *C. shasta* parasite, is the focus for NMFS in the coho salmon disease analysis because researchers believe that this parasite is a key factor limiting salmon recovery in the Klamath River (Bartholomew et al. 2007). Coho salmon in the Klamath River have coevolved with *C. shasta* and are relatively resistant to infection from this parasite (Hallett et al. 2012, Ray et al. 2012). Thus, the recent high mortality of Klamath River salmonids from *C. shasta* is atypical (Hallett et al. 2012). Modifications to water flow, sedimentation, and temperature have likely upset the host-parasite balance in the Klamath River (Hallett et al. 2012).

NMFS believes the high incidence of disease in certain years within the mainstem Klamath River results largely from the reduction in magnitude, frequency, and duration of sediment maintenance flows from the natural flow regime under which coho salmon evolved. The proposed action's effects on spring flows and sediment maintenance flows and their relationship to disease are discussed below. Research on the effects of *C. shasta* on coho salmon juveniles is applicable to coho salmon fry because the parasite targets species not life stages (Hallett et al. 2012).

2.2.4.2.1.5.1 Spring Flows

The likelihood of coho salmon fry to succumb to ceratomyxosis is a function of a number of variables, such as temperature, flow, and density of actinospores (True et al. 2013). Ray et al. (2012) found that actinospore density, and then temperature, was the hierarchy of relative importance in affecting ceratomyxosis for juvenile salmonids in the Klamath River. When actinospore densities are high, thermal influences on disease dampen (Ray et al. 2012). Studies have further supporting the observation of a threshold for high infectivity and mortality of juvenile salmonids when the Klamath River actinospore density exceeds about 10 actinospores/L (Hallett and Bartholomew 2006, Ray et al. 2012). For coho salmon juveniles, actinospore genotype II density of 5 spores/L was the threshold where 40 percent of exposed coho salmon died (Hallett et al. 2012). When actinospore genotype II densities exceeded 5 spores/L, the percent of disease-related mortality significantly increased for juvenile coho salmon (Hallett et al. 2012). In addition, ceratomyxosis progressed more quickly in coho salmon when parasite levels in the water (i.e., genotype II actinospore density) increased (Hallett et al. 2012).

Actinospore density is likely to be influenced by spring flows and sediment maintenance flows, both of which provide important ecological function in potentially minimizing disease prevalence of *C. shasta*. High spring flows likely dilute actinospores, and reduce transmission efficiency (Hallett et al. 2012). At a given actinospore abundance, higher flows will dilute spore concentrations. Fujiwara et al. (2011) found that the survival rate of IGH Chinook salmon was (1) significantly correlated with May 15 to June 15 stream flow in the mainstem Klamath River at Seiad Valley (RM 128), which is in the *C. shasta* infectious zone and (2) significantly lower than Trinity River Hatchery fish, which do not migrate through the infectious zone. These results support the Fujiwara et al. (2011) hypothesis that ceratomyxosis has an impact on the subset of the salmon population that migrates through the infection zone.

In 2007 and 2008 when flows at IGD in May to June were below 1,880 and 3,060 cfs, respectively, up to 86 percent of the coho salmon juveniles died from *C. shasta* after being placed in a sentinel trap in the Klamath River upstream of the Beaver Creek confluence (RM 162) for 72 hours and then reared in a laboratory between 16 to 20 °C (Hallett et al. 2012, Ray et al. 2012). In a similar sentinel study, True et al. (2013) found coho salmon mortality from *C. shasta* to be 98.5 percent within 27 days after exposure to 72 hours of the Klamath River in

2008. NMFS is not confident sentinel study results are an exact representation of mortality rates for free swimming individuals. Nevertheless, disease risks were likely moderate or high for those juvenile coho salmon inhabiting areas of the mainstem Klamath River near Beaver Creek while the sentinel study was ongoing in 2007 and 2008.

As discussed in our 2013 opinion, Chinook salmon in the Klamath River have been monitored for *C. shasta* prevalence of infection (POI) every year (e.g., via quantitative polymerase chain reaction [QPCR]) as Chinook juveniles are readily available. In addition to POI, it is important to consider the quantity of parasite DNA within fish tissue (DNA copy number) as this is an indicator of infection severity. For natural fish, early *C. Shasta* infections in the range of 2-4 logs (mean DNA copy number) correlated with clinical disease and mortality in a 2008 sentinel study (True et al. 2012). The researchers believe there is a high probability that the 2-4 log mean DNA range results in mortality of juvenile Chinook salmon (True et al. 2017, Voss et al. 2018). In annual monitoring since the NMFS (2013) opinion, end of March/first week of April though end of May POI varied within and between years as did disease severity (Figure 17). Infection rates and severity were relatively high in 2014 and 2015. In contrast, in 2016, infection rates were relatively high at times, but severity of infections was low. In 2017, both infection rates and severity of infections were low. This information highlights that *C. shasta* POI is not the only important metric to consider when assessing the effects of disease on salmonids.

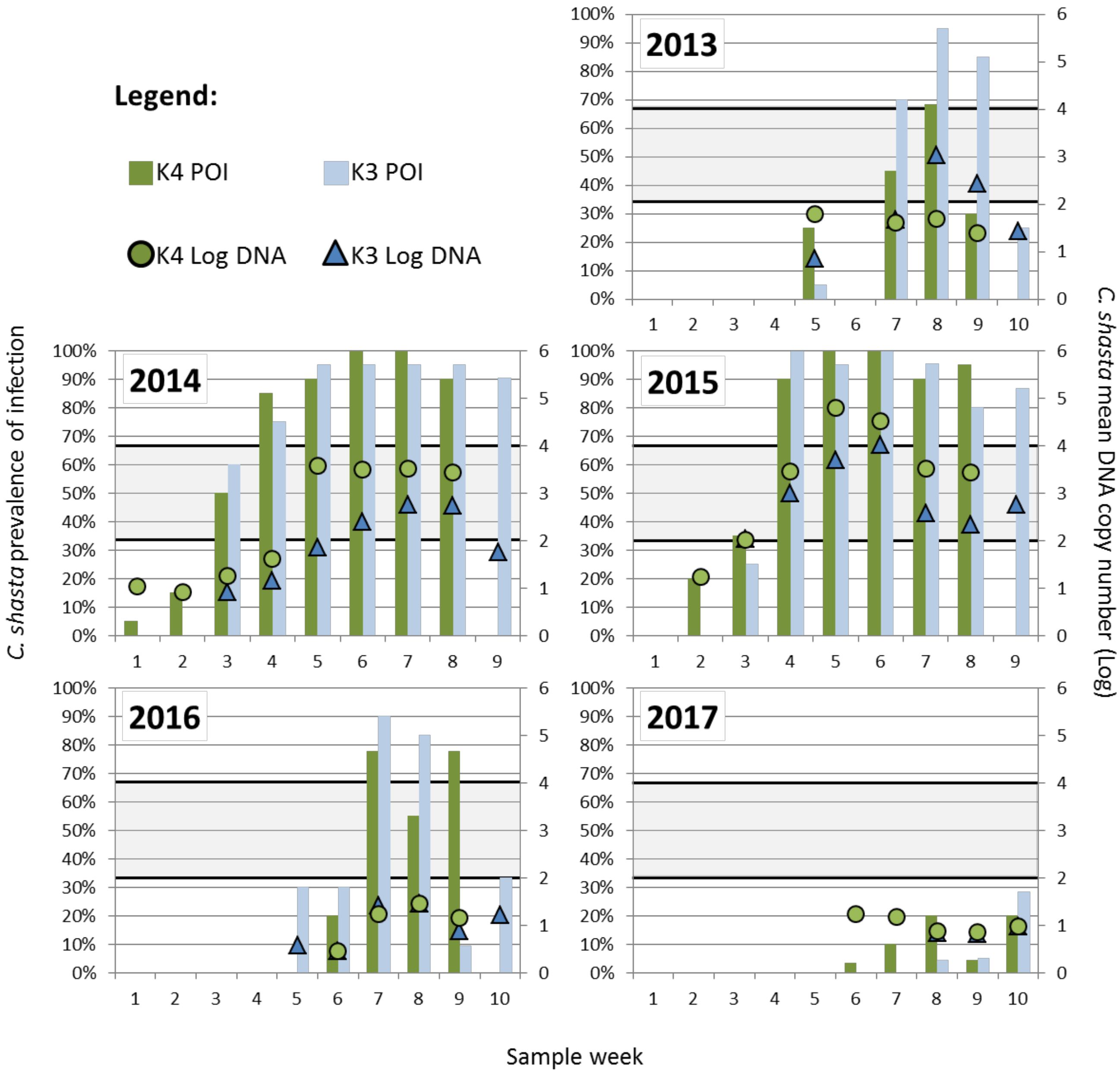

Figure 17. Ceratonova shasta prevalence of infection (POI) and mean DNA copy number (log) in natural juvenile Chinook salmon, captured in upper reaches: Shasta to Scott (K4) reach and Scott to Salmon (K3). Prevalence of infection is shown in columns (Y axis) and *C. shasta* mean DNA copy number (log) shown in circles and triangles (secondary Y axis). Sample week date is shown on the X axis. *Ceratonova shasta* mean DNA range of 2-4 logs correlates with clinical infection levels by histology, considered irreversible and likely to result in mortality (from True et al. 2017).

As previously discussed in the *Hydrologic Effects* section (section 2.2.4.1.2), the proposed action generally reduces spring flows in the mainstem Klamath River downstream of IGD. By reducing spring flows, the proposed action will result in drier hydrologic conditions in the mainstem Klamath River relative to the natural hydrologic regime. Summer base flow conditions occur earlier than historically, with spring flows now receding precipitously in May and June, whereas the spring snow-melt pulse and the vast amount of upper Klamath Basin wetland historically attenuated flows in the Klamath River much more slowly into August or September. Therefore, when environmental conditions are conducive to actinospore release in the spring (e.g., elevated water temperature), the proposed action will likely result in hydrologic conditions in the mainstem Klamath River that contribute to high *C. shasta* actinospore concentrations (e.g., ≥5 spores/L actinospore genotype II), which will likely increase the percentage of disease-related mortality to coho salmon fry in the mainstem Klamath River between Trees of Heaven (RM 172) and Seiad Valley (RM 129) in May to mid-June (Foot et al. 2008, Hallett et al. 2012, Ray et al. 2012). The proposed action will also likely increase the percentage of coho salmon fry in the mainstem Klamath River between Klamathon Bridge (RM 184) and Orleans (RM 59) that will experience sublethal effects of *C. shasta* infections during April to mid-June. Sublethal effects include impaired growth, swimming performance, body condition, and increased stress and susceptibility to secondary infections (Hallett et al. 2012).

NMFS notes that Reclamation included an adaptive flow management process to the proposed action for deviating from the formulaic approach when there may be specific ecologic objectives or disease risks that need to be addressed that can only be achieved by deviating from the formulaic approach to EWA distribution. Specifically, Reclamation's proposed action provides flexibility to deliver approximately 50,000 AF of EWA in a manner that best meets coho salmon needs (e.g., disease mitigation, habitat) in below average or dry years, opportunistic surface flushing flows in average to wet years, and an additional 20,000 AF for enhanced May/June flows in years of concern to NMFS. NMFS has flexibility to direct the 20,000 AF in manner to best meet coho salmon needs and we expect to be able to provide improvements to habitat quality, quantity, and water quality that will enhance the survival and fitness of fry and juvenile coho salmon. In-season flow management would be coordinated through the FASTA process (detailed in the *Proposed Action* section, Section 1.3 above). Real-time flow management in the spring to avert potential risks of disease will occur through close coordination between the Services and Reclamation with consideration to potential effects to listed suckers. While NMFS cannot specifically predict the full range of hydrologic conditions when flow increases above the formulaic approach will occur, NMFS expects that sufficient EWA volume will be available in nearly all water years (i.e., surface flushing flows occurred in 34 of 36 years in the POR). Because *C. shasta* actinospore densities are likely low during above average and wet years, deviations from the formulaic approach (or 50,000 AF of EWA) can be made to help dilute actinospore densities in the mainstem Klamath River downstream of IGD during below average and dry water years. Therefore, the in-season flow management element of the proposed action may further minimize disease risks to coho salmon during below average and dry water years. Note that if EWA volumes are overspent in the spring, summer flows in the mainstem may be lower than modeled, depending on the volume of EWA used for adaptively minimizing disease risks. However, minimum daily flows in the summer will be met at all times.

During dry water years, the proposed daily minimum flows for April, May and June will provide at least 1325 cfs, 1175 cfs, and 1025 cfs, respectively, at IGD for diluting actinospores. While these proposed minimum daily flows are not likely sufficient to dilute actinospore concentrations to below 5 genotype II spores/L when actinospore concentrations are high, these minimum daily flows provide a limit to the increase in disease risks posed to coho salmon under the proposed action, which may reduce disease-related mortality to coho salmon.

2.2.4.2.1.5.2 Sediment Maintenance Flows

Sediment maintenance flows provide important ecological function. Sediment maintenance flows flush fine sediment and provide restorative function and channel maintenance through scouring, which will likely reduce polychaete abundance and disturb their fine sediment habitat in the mainstem Klamath River. Fish health researchers (e.g., Stocking and Bartholomew 2007) have hypothesized high flow pulses in the fall and winter could have the added benefit of re-distributing salmonid carcasses concentrated in the mainstem downstream of IGD, since infected adult salmon spread the myxospore life history stage of *C. shasta*. In addition, sediment maintenance flows likely disrupt the ability of polychaetes to extract *C. shasta* spores (Jordan 2012). Bjork and Bartholomew (2009) found that higher water velocity resulted in lower *C. shasta* infections to the polychaete, and decreased infection severity in fish. Furthermore, sediment maintenance flows that occur in the spring are likely to also dilute actinospores and reduce transmission efficiency (Hallett et al. 2012).

Malakauskas et al. (2013) studied polychaete responses to short-term (i.e., 45 minutes) flow velocities in a flume, and concluded that polychaete populations likely exhibit high resiliency to flow-mediated disturbance events. Polychaetes employ a variety of behaviors for avoiding increases in flow, including extrusion of mucus, burrowing into sediments, and movement to lower flow microhabitats (Malakauskas et al. 2013). Results from the Malakauskas et al. (2013) study showed that few worms were dislodged at shear velocities below 3 cm/s on any substrate and above this level of shear, probability of dislodgement was strongly affected by both substrate type and velocity. Probability of dislodgement was greatest from fine sediments, intermediate from rock faces, and negligible for *Cladophora*. The short-term exposure of the polychaetes to flow velocities and the lack of multiple high flow exposures makes these results difficult to apply to the Klamath River. Therefore, NMFS relies on fish infection and disease data from the Klamath River to assess the proposed action's effects on disease prevalence.

In mid-March 2016, IGD released approximately 11,000 cfs for several days. Polychaete densities were found to be lower following the flow event (Bartholomew et al. 2017). By June, polychaete densities increased further downstream at Seiad and Orleans, suggesting polychaetes displaced by the March flow event settled out further downstream (Bartholomew et al. 2017). In 2017, several high flow events occurred during the February through March period, the largest exceeding 10,000 cfs in late March. Later in 2017 a surface flushing flow also occurred in mid-April 2017. Polychaete densities were generally low at all index sites, but increased in late-May and June (Bartholomew et al. 2018). Total actinospore densities at all index sites were also relatively low in spring 2017, but increased at the Beaver Creek site in late May (Bartholomew et al. 2018).

As discussed in the *Hydrologic Effects* section (Section 2.2.4.1.2), the proposed action will increase the frequency of surface flushing flows. This will likely decrease the abundance of polychaetes in the spring and summer following a sediment maintenance flow event. In addition, the increase in surface flushing flows under the proposed action will likely decrease the actinospore concentrations relative to the observed POR when the sediment maintenance flow event occurs in the spring, particularly in May and June.

However, the proposed action will reduce spring flows and result in increased duration of immobile bed conditions following surface flushing flow events, which will reduce the actinospore dilution effect since the surface flushing flows generally occur in the spring between March 1 and April 15. Reduced spring flows means less actinospore dilution, which will likely increase the density of actinospores in the May through June weeks following the surface flushing flow event.

The proposed action's net disease effect to coho salmon from implementation of surface flushing flows is somewhat unclear, but is likely to be improved over the observed POR because the increased frequency of surface flushing flow events will provide more intense and frequent disturbance to polychaetes and sediment. Holmquist-Johnson and Milhous (2010) identified needing high flows to flush fine sediments in the Klamath River. USFWS (2016d) synthesized the relevant sediment transport thresholds identified by the three studies in their Sediment Mobilization technical memorandum. Subsequently, the Disease Management Guidance document (Hillemeier et al. 2017) used the information provided in these three studies, and the Sediment Mobilization technical memorandum (USFWS 2016d), to develop criteria for describing sediment maintenance flows (i.e., surface and deep flushing flows) below IGD. Identified surface flushing flows will be implemented in most years under the proposed action. However, the benefits of surface flushing flows will be somewhat reduced as a result of reduced spring flows and increased immobile bed conditions that are expected to follow surface flushing flow events.

Nevertheless, the proposed action will continue to contribute to hydrologic conditions (e.g., reduced magnitude, frequency and duration of deep flushing flows relative to the natural flow regime) that allow *C. shasta* to continue to affect coho salmon fry fitness and survival. The proposed action will decrease the probability of achieving deep flushing flows in the mainstem Klamath River relative to the natural flow regime. Therefore, the proposed action will likely have an overall effect of contributing to fine sediment deposition and establishment of aquatic vegetation downstream from IGD primarily in the summer and fall, while also contributing to scouring in the spring.

2.2.4.2.1.5.3 Summary of Disease Effects to Coho Fry

NMFS believes the high incidence of disease for rearing coho salmon in certain years that feature low flows and relatively high water temperatures within the mainstem Klamath River results largely from the reduction in magnitude, frequency, and duration of mainstem flows from the natural flow regime under which the fish evolved. The proposed action will generally reduce spring flows in the mainstem Klamath River downstream of IGD relative to the natural flow regime. The increase in frequency of surface flushing flows (i.e., at least 6,030 cfs for 72 hours) is expected to somewhat disrupt the life cycle of *C. shasta* in the mainstem Klamath River between Trees of Heaven (RM 172) and Seiad Valley (RM 129) in May to mid-June (Foott et al. 2006, Hallett et al. 2012, Ray et al. 2012). Decreased spring flows at other times in the spring under the proposed action will also likely increase the percentage of coho salmon fry in the mainstem Klamath River between Klamathon Bridge (RM 184) and Orleans (RM 59) that will experience sublethal effects of *C. shasta* infections during April to mid-June. In addition, the proposed action will continue to contribute to reduced duration, magnitude, and frequency of peak flows above 10,000 cfs relative to the natural flow regime, which will likely allow *C. shasta* to proliferate in the mainstem Klamath River under certain environmental conditions (e.g., high water temperatures in the Klamath River and below average water years) and increase infection and disease-related mortality to coho salmon fry in the mainstem Klamath River, especially during consecutive dry years.

However, the real-time disease management element of the proposed action is likely to partially offset the increased disease risks to coho salmon during average and below average water years, and the minimum daily flows provide a limit to the increase in disease risks posed to coho salmon under the proposed action. While NMFS cannot quantify the magnitude of the increased disease risk to coho salmon under the proposed action, based on the reasons discussed above, NMFS concludes that the proposed action will result in disease risks to coho salmon that are lower than under observed POR conditions yet higher than under natural flow conditions.

2.2.4.2.1.6 Flow Variability

As discussed in the *Hydrologic Effects* section (Section 2.2.4.1.2), the proposed action will result in a mainstem Klamath River hydrograph that approximates the natural flow variability of the upper Klamath Basin. However, due to Project deliveries reducing UKL elevations and increasing the amount of storage required to refill UKL on an annual basis, the proposed action will continue to contribute to diminished daily flow variability (e.g., reduction of incremental increases of fall and winter base flows) relative to a natural Klamath River flow regime, particularly in below average and dry water years. Under the proposed action, the extent of the daily flow variability in the mainstem Klamath River will reflect, in part, the natural hydrologic conditions in the upper Klamath Basin (e.g., mainstem flows will increase when snow melt, precipitation, or both increases in the upper Klamath Basin), calculated using the daily net inflow to UKL. For example, when the upper Klamath Basin is experiencing relatively wet hydrologic conditions, flows in the mainstem Klamath River will be relatively high three days later. Conversely, when the upper Klamath Basin is experiencing relatively dry hydrologic conditions, flows in the mainstem Klamath River will be relatively low three days later. The effects of the proposed action on flow variability downstream of IGD will be greatest close to the dam and diminish longitudinally, as tributary accretions contribute to the volume of water and impart additional flow variability.

Variable flows, including small variations, provide dynamic fluvial environments in the mainstem Klamath River that may impair polychaete fitness, reproductive success, or infection with *C. shasta*. Since polychaetes appear to prefer stable hydrographs (Jordan 2012), flow variability will likely decrease polychaete habitat. In addition, polychaetes must extract *C. shasta* myxospores from the water to become infected (Strange 2010a, Jordan 2012). Increased flow variability may increase water velocity where polychaetes may have increased difficulty extracting myxospores or colonizing habitat. If sufficiently large, increased flow variability under the proposed action (e.g., a surface flushing flow event) will likely help disrupt the fine sediment habitat of *M. speciosa* and increase the redistribution of adult salmon carcasses in the mainstem Klamath River, which will likely reduce polychaetes in the mainstem Klamath River. In addition, when the upper Klamath Basin is experiencing relatively wet hydrologic conditions in the spring, flow variability under the proposed action will result in a relatively smaller reduction to mainstem flows during the spring, which will likely result in a relatively smaller increase in *C. shasta* actinospore concentrations, a smaller reduction to habitat availability for coho salmon fry, a smaller reduction to migration rate and survival of smolts, and a smaller reduction to water quality impairment than when the upper Klamath Basin is experiencing relatively drier hydrologic conditions in the spring. Therefore, the flow variability under the proposed action is likely to reduce the proposed action's adverse effects from reductions to mainstem Klamath River flows when wet hydrological conditions occur in the upper Klamath Basin (e.g., precipitation and snow melt).

2.2.4.2.1.7 Juveniles

Hydrologic and habitat changes can strongly affect juvenile fish survival in riverine systems (Schlosser 1985, Nehring and Anderson 1993, Freeman et al. 2001, Nislow et al. 2004). Of all the coho salmon life stages, juveniles are the most exposed to the hydrologic effects of the proposed action. Up to 50 percent of the total parr (i.e., from mainstem redds or tributaries) population will be affected in the mainstem Klamath River, while all smolts will use the mainstem Klamath River to outmigrate to the ocean.

The proposed action will likely adversely affect coho salmon juveniles by decreasing water quality (e.g., increasing water temperature, decreasing dissolved oxygen concentration), increasing susceptibility to diseases, delaying outmigration times, and reducing habitat availability. The amount and extent of these potential adverse effects are expected to vary spatially and temporally, and result primarily from proposed action effects on flow. These effects are discussed separately below for simplicity. However, note that they can affect coho salmon juveniles simultaneously, sequentially, or synergistically. Also, note that the proposed action incorporates elements of flow variability, in season flow management (e.g., for disease management), and restoration activities, which can help to offset some of the adverse effects from flow reductions.

2.2.4.2.2 Water Quality

Increases to water temperature in the spring may have both adverse and beneficial effects to coho salmon juveniles. When water temperatures chronically exceed 16.5 °C, coho salmon juveniles may become stressed (Sullivan et al. 2000). However, increasing water temperature in the spring may also stimulate faster growth (Dunne et al. 2011) and smolt outmigration (Hoar 1951, Holtby 1988, Moser et al. 1991), which may reduce exposure to actinospores and other pathogens in the mainstem Klamath River. For reasons similar to those discussed for water temperature effects on coho salmon fry, when daily maximum water temperatures become chronically above 16.5 °C in May to June, the proposed action will contribute to water temperature conditions that will be stressful to coho salmon juveniles in the mainstem Klamath River between IGD and the Scott River (RM 144).

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. At 8 mg/L, the maximum sustained swimming performance of coho salmon decreased (Davis et al. 1963, Dahlberg et al. 1968). Low dissolved oxygen can affect fitness and survival by increasing the likelihood of predation and decreasing feeding activity (Carter 2005). Sublethal effects include increased stress, reduced growth, or no growth, and are expected for coho salmon parr that are in the mainstem Klamath River below IGD during the summer and fall.

As discussed in the *Effects to Physical or Biological Features* section (Section 2.2.4.1.4), when the proposed action reduces mainstem flows in the summer, NMFS expects there will likely be a reduction to dissolved oxygen concentrations in the mainstem Klamath River between IGD (RM 190) and Orleans (RM 59). Coho salmon juveniles in the mainstem Klamath River between IGD and Orleans will be exposed to the reduced dissolved oxygen concentrations at night and early morning when they are not confined to thermal refugia at tributary confluences. Therefore, the proposed actions' contributions to low dissolved oxygen concentrations in the summer will adversely affect swimming performance (at ≤ 8.0 mg/L) and increase stress (at ≤ 6.0 mg/L) to coho salmon juveniles in the mainstem between IGD (RM 190) and Orleans (RM 59) during this period.

2.2.4.2.3 Disease Effects to Individuals

Similar to the discussion on disease effects on coho salmon fry section (Section 2.2.4.2.1.2.3), when environmental conditions are conducive to actinospore release in the spring (e.g., elevated water temperature), the proposed action will result in hydrologic conditions in the mainstem Klamath River that likely support high *C. shasta* actinospore concentrations that lead to mortality of coho salmon juveniles in the mainstem Klamath River between Trees of Heaven (RM 172) and Seiad Valley (RM 129) in May and June (Foott et al. 2006, Hallett et al. 2012, Ray et al.

2012). In addition, the proposed action will also likely increase the percentage of coho salmon juveniles in the mainstem Klamath River between Klamathon Bridge (RM 184) and Orleans (RM 59) that will experience sublethal effects of *C. shasta* infections during April to August (Foott et al. 2006, Hallett et al. 2012). However, the increase in frequency of surface flushing flows (i.e., at least 6,030 cfs for 72 hours) is expected to somewhat disrupt the life cycle of *C. shasta.*

The Arcata office of the USFWS (Arcata Fish and Wildlife Office (AFWO)) provided NMFS with a preliminary assessment of estimated proportions of mortality due to *C. shasta* of young-of year and juvenile coho salmon (Som et al. 2019). Som et al. (2019) applied the methods of (Ray et al. 2014) to a more contemporary, extended-sentinel trial dataset to estimate the weekly proportion of coho salmon emigrating from the Shasta and Scott rivers through the infectious zone in the mainstem Klamath River that succumb to disease. The infectious zone is defined as the mainstem Klamath River between the Shasta River confluence to Seiad for Shasta River coho salmon, and between the Scott River confluence to Seiad for Scott River coho salmon. Weekly-stratified abundance estimates of coho salmon passing through the monitoring stations on the Shasta and Scott rivers used in this analysis were provided by CDFW. Exposure times were based on the work of Beeman et al. (2012). Experimental sentinel cage studies of juvenile coho salmon conducted by Ray et al. (2014) informed AFWO's assessment on multiple variables including influence of temperature and spore concentrations on mortality. The assessment included both age 0+ young-of-the-year and 1+ smolts, and carries the assumption that the effects of these variables on mortality risk do not differ between the two age classes of juvenile coho salmon.

Implementation of the proposed action is expected to decrease actinospore density. Based on preliminary results of before and after polychaete density sampling around a surface flushing flow release in early April 2018, a conservative 25 percent reduction in actinospore densities was identified as being a reasonable assumption associated with the surface flushing flow feature of the proposed action. A 75 percent actinospore reduction was also used to represent a range of potential outcomes (Som et al. 2019). Estimates of proportions of mortality of outmigrating populations are summarized in

Table 22.

Table 22. Estimated prevalence of mortality (POM) of age 0+ and age 1+ (combined) coho salmon in the mainstem Klamath River between the Shasta River and Seiad (top) and the Scott River and Seiad (bottom), and under an assumed 25 and 75 percent actinospore reduction under the proposed action (Som et al. 2019).

Shasta River to Seiad	**2.42 day exposure**		
Year	POM	POM with 25% reduction in spores/l	POM with 75% reduction in spores/l
2005	0	0.04	0
2006	0.028	0.019	0.015
2007	0.447	0.379	0.234
2008	0.454	0.376	0.246
2009	0.546	0.488	0.175
2010	0.017	0	0
2011	0	0	0
2012	0	0	0
2013	0	0	0
2014	0.314	0.251	0.14
2015	0.696	0.362	0.151
2016	0.073	0	0

Scott River to Seiad	**1 day exposure**		
Year	POM	POM with 25% reduction in sp/l	POM with 75% reduction in sp/l
2005	0	0.099	0
2006	0.145	0.15	0.089
2007	0.331	0.265	0.101
2008	0.142	0.114	0.083
2009	0.16	0.139	0.053
2010	0.001	0	0
2011	0	0	0
2012	0	0	0
2013	0	0	0
2014	0.269	0.068	0.031
2015	0.282	0.223	0.133
2016	0.003	0	0

These preliminary results highlight that population-level effects can differ, even between years of high POI rates (e.g., 2015 and 2016). Also, when surface flushing flows are implemented (most years under the proposed action), POM of coho salmon is expected to be reduced relative to the POR.

2.2.4.2.4 Thermal Refugia

Thermal refugia along the mainstem provide salmon essential locations where coho salmon juveniles can seek refuge when water temperatures in the mainstem become excessive (Tanaka 2007). Without thermal refugia, mainstem flows alone could not support salmonid populations in the summer because of the high water temperatures in the mainstem Klamath River (Sutton 2007). Coho salmon juveniles use refugial habitat in both the mainstem Klamath River and non-natal tributaries as refuge from critically high mainstem Klamath River water temperatures in the summer (Sutton 2007, Sutton and Soto 2012, Soto et al. 2016). Sutton and Soto (2012) found that coho salmon juveniles began using thermal refugia when the mainstem Klamath River temperature approached approximately 19 °C. Similarly, Hillemeier et al. (2009) found that coho salmon started entering Cade Creek, a cooler tributary, when mainstem Klamath River temperature exceeded about 19 °C.

When coho salmon juveniles in the mainstem cannot access cooler tributaries, they can face elevated stress from mainstem temperatures, degraded water quality, competition with other salmonids for mainstem thermal refugia, and higher susceptibility to pathogens such as *C. shasta*. Mainstem thermal refugia provide coho salmon relief from temperature and poor water quality (e.g., high pH and low dissolved oxygen concentrations). However, mainstem thermal refugia do not provide coho salmon relief from susceptibility to *C. shasta* if actinospore densities are high (Ray et al. 2012).

The primary factor affecting the integrity of thermal refugia is the tributary flows, which are not affected by the proposed action. The higher the tributary flows, the larger the thermal refugia will be in the mainstem Klamath River. Tributaries that historically provided cold water additions to the mainstem Klamath River produce appreciably less water to the mainstem Klamath River due to water diversions, provide less non-natal rearing habitat (e.g., Shasta and Scott River), and reduce the amount of available thermal refugia in the mainstem.

While the proposed action does not affect the amount or timing of tributary flows, the proposed action can influence both the size of refugial habitat in the mainstem Klamath River as well as the connectivity between tributaries and the mainstem. When the proposed action decreases mainstem flows in the summer, water temperature becomes more influenced by meteorological conditions, which will increase daily maximum and median (to a lesser extent) water temperatures. Elevated water temperatures in the summer may temporarily reduce the size of thermal refugia in the mainstem (Ring and Watson 1999, Ficke et al. 2007, Hamilton et al. 2011). On the other hand, the NRC (2002 and 2004) hypothesized that increasing mainstem flows in the Klamath River might reduce the size of thermal refugia because of the warm water temperatures out of IGD.

Sutton (2007) studied the effects of flow on thermal refugia in the mainstem Klamath River, and ultimately suggested that thermal refuge area could be modified under variable flows. With limited empirical data and inconclusive results (Sutton 2007), it is unclear whether mainstem flow increases or decreases will affect thermal refugial size. Therefore, NMFS is unable to reach a conclusion regarding the effects of the proposed action relative to thermal refugial size, except as described below for the mainstem downstream of Seiad Valley.

NMFS can reasonably conclude that the proposed minimum summer flow of approximately 900 cfs from IGD is likely to result in insignificant effects to mainstem thermal refugial size downstream of Seiad Valley for several reasons. First, the effects of IGD flows on thermal refugia diminishes with increasing distance downstream due to tributary accretion, larger channel size, and less stable alluvial channels (Sutton 2007). Second, flow volume at IGD can alter the diurnal pattern of water temperatures within the Klamath River. However, the effect is most pronounced upstream of the Shasta River and is significantly reduced by the time flows reach Seiad Valley (RM 129)(PacifiCorp 2006). Third, NMFS considers coho salmon parr use of mainstem thermal refugial habitat (i.e., tributary confluences or cold water plumes at tributary confluences) within the Middle and Lower Klamath River reaches to be uncommon, since no fish have been observed in these areas during past thermal refugial studies (Sutton et al. 2004, Sutton 2007, Strange 2010b, Strange 2011). For these reasons, NMFS anticipates the proposed July through September flow regime is not likely to adversely affect coho salmon parr located within the downstream half of the Middle Klamath River and the entire lower Klamath River reaches.

In addition, NMFS notes that access to tributaries is important for coho salmon juveniles in the summer to seek thermal refuge, and that the lower the mainstem flows, the less likely coho salmon juveniles can access tributaries. Sutton and Soto (2012) documented several Klamath River tributaries (i.e., Cade [RM 110] and Sandy Bar [RM 76.8] creeks) where fish access into the creeks was challenging, if not impossible, when IGD flows were 1000 cfs in the summer. Because of their alluvial steepness, NMFS acknowledges that some tributaries (e.g., Sandy Bar Creek) may not be conducive to access until flows are very high, which may not be possible in the summer even under natural conditions.

As described in the *Effects to Physical or Biological Features* section (Section 2.2.4.1.4), given the minimal effect of IGD flows on stage height, combined with overriding factors influencing passage from the mainstem into tributaries (e.g., tributary gradient and flow), NMFS does not anticipate the proposed action will have an adverse effect on coho salmon juvenile accessing tributaries.

2.2.4.2.5 Habitat Availability

NMFS concludes that habitat availability for juveniles in the mainstem Klamath River is most critical between March to June because of: (1) the spring redistribution of coho salmon parr; (2) the presence of most, if not all, coho salmon smolts from the Interior Klamath Diversity Stratum in the mainstem during this time; and (3) the presence of other stressors, such as the addition of IGH salmonids, the onset of elevated water temperatures, and disease prevalence. During the spring, natural origin coho salmon parr and, to a lesser extent, smolts compete for habitat with natural origin and hatchery-released salmon and steelhead in late March to June. Competition for habitat peaks during May and early June when natural origin smolts co-occur with approximately five million Chinook salmon smolts from IGH. Therefore, habitat availability during spring is the most essential for coho salmon juveniles.

During the fall (i.e., October and November), coho salmon parr migrate through mainstem habitat as they redistribute from thermally suitable, summer habitat into winter rearing habitat characterized by complex habitat structure and low water velocities in tributaries (Lestelle 2007). The presence of coho salmon juveniles in the mainstem Klamath River is likely low in the fall and winter, and habitat availability in the mainstem Klamath River during the fall and winter is not considered limited. During the summer, coho salmon juveniles in the mainstem are limited to thermal refugia during the day, and habitat availability in the mainstem Klamath River during the summer is not considered limited for the relatively fewer coho salmon parr rearing in the mainstem during this period.

The amount of rearing habitat available in the mainstem Klamath River is correlated with flows, especially at certain ranges where water velocity, depth, and cover provide suitable conditions for juvenile rearing (Figure 15). As discussed earlier in the *Effects to Physical or Biological Features* section (Section 2.2.4.1.4), the Trees of Heaven, Seiad Valley, and Rogers Creek reaches all show reduced habitat availability as a result of the proposed action. Further downstream at the Rogers Creek reach, the proposed action will reduce habitat availability in March and April in drier water years (≥ 80 percent exceedance; Table 20) and in above average water years for the latter spring months (≥ 60 percent exceedance in May and ≥ 30 percent in June).

Higher flows (i.e., spring, summer, or total annual) are likely to provide more suitable habitat for juvenile growth and survival through increased production of stream invertebrates and availability of cover (Chapman 1966, Giger 1973). Reductions in spring flows can disconnect floodplains from rivers and reduce habitat availability and quality from floodplains (Sommer et al. 2001, Sommer et al. 2004, Opperman et al. 2010). By decreasing mainstem Klamath River flows, the proposed action reduces the extent of value floodplains provide to coho salmon. Healthy floodplains provide a number of resources, such as cover, shelter, and food, for rearing juveniles (Jeffres et al. 2008). Floodplain connectivity provides velocity refuge for juveniles to avoid high flows, facilitates large wood accumulation into rivers that form complex habitat (e.g., cover and pool), and provides off-channel areas with high abundance of food and fewer predators (NMFS 2016d).

Habitat availability and quality are essential for coho salmon growth and survival. Habitat quality exerts a significant influence on local salmonid population densities (Bilby and Bisson 1987). In addition, as habitat decreases, coho salmon juveniles are forced to use less preferable habitat, emigrate, or crowd, especially if habitat capacity is reached. All of these options likely have negative consequences for coho salmon juveniles. The use of less preferable habitat decreases the fitness of coho salmon juveniles and increases their susceptibility to predation. Conversely, the success and fitness of individuals is the ultimate index of habitat quality (Winker et al. 1995). Emigration of coho salmon juveniles prior to their physiological readiness for saltwater likely diminishes their chance of survival (Chapman 1966, Koski 2009).

The probability of observing density-dependent response in juvenile salmonids (i.e., growth, mortality or emigration) increases with the percent of habitat saturation. Strong positive correlations have also been found between total stream area (i.e., a habitat index) and coho salmon biomass (Pearson et al. 1970, Burns 1971). Fraser (1969) found that coho salmon density is inversely correlated with juvenile coho salmon growth and survival. Weybright and Giannico (2018) found that coho salmon density was negatively associated with coho salmon growth in a southern Oregon coastal basin. These studies are consistent with the understanding that juvenile growth is affected by interactions between competition and habitat quality (Keeley 2001, Rosenfeld and Boss 2001, Harvey 2005, Rosenfeld et al. 2005).

Growth and body size are important for juvenile coho salmon, and likely have a strong influence on the individual fitness of subsequent life stages (Ebersole et al. 2006). Studies on juvenile salmonids indicate that larger body size and fitness increases the probability of survival (Hartman et al. 1987, Lonzarich and Quinn 1995, Quinn and Peterson 1996, Zabel and Achord 2004, Ebersole et al. 2006, Roni 2012). Increased growth confers higher over-wintering survival for larger individuals than for smaller individuals (Quinn and Peterson 1996). Larger smolts also have a greater likelihood of surviving in the ocean than smaller smolts (Bilton et al. 1982, Henderson and Cass 1991, Yamamoto et al. 1999, Zabel and Williams 2002, Lum 2003, Jokikokko et al. 2006, Muir et al. 2006, Soto et al. 2008). In addition, larger smolts tend to 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).

Based on literature, increased competition for space increases emigration rates or mortality rates (Chapman 1966, Mason 1976, Keeley 2001), and reduces growth rates (Mason 1976). Delayed growth results in a greater risk of individuals being killed by predators (Taylor and McPhail 1985). Coho salmon juvenile habitat in the mainstem Klamath River becomes increasingly important as exposure of individuals increases in dry spring conditions, and juveniles move from tributaries to the Klamath River. Generally, as the spring progresses from April through May, the number of coho salmon juveniles increases in the mainstem Klamath River downstream of the Shasta River (Chesney 2007). When the density of coho salmon juveniles in the mainstem Klamath River are anticipated to be near or greater than habitat capacity, the proposed action will adversely affect coho salmon juveniles by increasing density dependent effects. Under these conditions, the proposed action will likely reduce growth and survival of coho salmon juveniles in the mainstem Klamath River between the Trees of Heaven (RM 172) and Rogers Creek (RM 72) in March to June. Conversely, when conditions are favorable (e.g., good water quality, low juvenile abundance, low disease), the proposed action will have minimal adverse effects to coho salmon juveniles (early March and prior to IGH Chinook salmon releases in May or early June).

2.2.4.2.6 Migration and Survival

Coho salmon juveniles begin the smoltification process by less vigorously defending their territories and forming aggregations (Sandercock 1991) while moving downstream (Hoar 1951). Several other physiological and behavioral changes also accompany smoltification of Pacific salmonids, including negative rheotaxis (i.e., facing away from the current) and decreased swimming ability (McCormick and Saunders 1987). These physiological and behavioral changes support the expectation that coho salmon smolts outmigrate faster with higher flows and experience higher survival because of decreased exposure to predation (Rieman et al. 1991), and disease pathogens (Cada et al. 1997). Beeman et al. (2012) monitored migration and survival of hatchery and wild coho salmon from 2006 to 2009, and found that discharge had a positive effect on passage rate on the mainstem Klamath River from the release site near IGD to the Shasta River. In addition, the median travel time for wild coho salmon juveniles from the release site to the Klamath River estuary was 10.4 days in 2006 when IGD flows exceeded 10,000 cfs, whereas the median travel time for wild coho salmon in 2009 was 28.7 days when IGD flows were less than 2,000 cfs. More importantly, Beeman et al. (2012) found that increasing discharge at IGD had a positive effect on survival of coho salmon smolts in the mainstem reach upstream of the Shasta River, and the positive effect of discharge decreased as water temperature increased.

Beeman et al.'s (2012) findings are consistent with other studies or reviews that have shown that increased flow (either total annual, spring or summer) results in increased smolt migration (Berggren and Filardo 1993, McCormick et al. 1998) or survival (Burns 1971, Mathews and Olson 1980, Scarnecchia 1981, Giorgi 1993, Cada et al. 1994, Lawson et al. 2004). Berggren and Filardo (1993) found a significant correlation between average flow and smolt migration time in the Columbia River. Scarnecchia (1981) found a highly significant positive relationship between total stream flows, and the rate of survival to the adult life stage for coho salmon in five Oregon rivers. Mathews and Olson (1980) documented a positive correlation between summer streamflow and survival of juvenile coho salmon. Lawson et al. (2004) found that spring flows correlated with higher natural smolt production on the Oregon Coast. Increases in summer flows, along with stabilizing winter flows, have led to increased production of coho salmon (Lister and Walker 1966, Mundie 1969), while Burns (1971) found that highest mortality of coho salmon in the summer occurred during periods of lowest flows.

By reducing spring flows in the mainstem Klamath River, the proposed action decreases survival and passage rates in the reach between IGD and the mouth of the Shasta River (RM 177) when flows at IGD are between 1,020 and 10,300 cfs, as supported by data from Beeman et al. (2012). The decrease in survival is likely a result of increased exposure to stressors in the mainstem Klamath River. Some of these adverse effects will be minimized by the flow variability incorporated into the proposed action when precipitation and snow melt occurs in the upper Klamath Basin.

2.2.4.2.7 Flow Variability

The proposed action employs a formulaic management approach to provide Klamath River flows that are intended to represent current hydrologic conditions in the upper Klamath Basin. However, due to Project deliveries reducing UKL elevations and increasing the amount of storage required to refill UKL on an annual basis, the proposed action will continue to contribute to diminished daily flow variability (e.g., reduction of incremental increases of fall and winter base flows) relative to a natural Klamath River flow regime, particularly in below average and dry water years.

The beneficial effects of flow variability described earlier for coho salmon fry (section 2.2.4.2.1.2.3) also apply to coho salmon juveniles. For example, surface flushing flows almost every year are expected to decrease *C. shasta* infection rates. In addition, juvenile coho salmon will be provided environmental cues with variable flows under the proposed action, and will likely redistribute downstream to abundant overwintering habitat in the lower Klamath River reach and downstream of non-natal tributaries during the fall.

2.2.4.2.8 Risk

The proposed action will likely result in increased risks to coho salmon individuals. Of all the different life stages, coho salmon fry and juveniles (parr and smolts) face the highest risks from the hydrologic effects of the proposed action, especially during the spring (Table 23). Risks to smolts apply to both IGH coho salmon and natural origin coho salmon from populations in the Upper Klamath, Middle Klamath, Shasta, Scott, and Salmon Rivers. Risks to coho salmon fry and juveniles from the Salmon River population are the least since most of the adverse effects of the proposed project diminish in the mainstem Klamath River at Orleans (RM 59).

Table 23. Summary of risks resulting from the proposed action to coho salmon life stages.

Potential Stressor	Project Effects	Life Stage	General Time	Mainstem Location
Reduced habitat quality	Increased likelihood of reduced growth or survival to some individuals	Fry	June	IGD (RM 190) to Shasta River (RM 177)
		Parr and Smolts	May to June	Trees of Heaven (RM 172) to Rogers Creek(RM 72)
Disease (*C. shasta*)	Increased likelihood of impaired growth, swimming performance, body condition, and increased stress and susceptibility to secondary infections	Fry	May to mid-June	Klamathon Bridge (RM 187.6) to Orleans (RM 59)
		Parr	May to August	
		Smolts	May to June	
	Increased likelihood of disease-related mortality	Fry	May to mid-June	Trees of Heaven (RM 172) to Seiad Valley (RM 129)
		Parr, and Smolts	May to June	
Elevated water temperature	Increased stress	Fry	May to mid-June	IGD to Scott River (RM 144)
		Parr and Smolts	May to June	
DO reduction	Decreased swimming performance and increased stress	Parr	June to August	IGD (RM 190) to Orleans (RM 59)
Decreased outmigration rates	Increased likelihood of mortality from other stressors in the mainstem Klamath River (e.g., disease, predation, impaired water quality)	Smolts	April to June	IGD (RM 190) to Shasta River (RM 177)

2.2.4.3 Summary of Effects to Individuals

All life stages of Klamath River coho salmon are expected to be exposed to proposed action effects during the period of effects of the proposed action, and populations closest to IGD (e.g., Upper Klamath, Middle Klamath, Shasta, and Scott populations) will experience the most pronounced exposure, while populations farthest away, such as the Lower Klamath River population, are not likely to be exposed. Adult coho salmon are present in the mainstem Klamath River only during the upstream migration and spawning period (September through January). Coho salmon eggs and fry associated with a relative small number of mainstem Klamath River spawners, as well as coho salmon fry that emigrate from tributaries for various reasons, are expected to be present in the mainstem each winter and spring. Some juvenile coho salmon rear in the mainstem throughout the year. Most natural origin coho salmon smolts outmigrate to the mainstem during March, April and May. Smolt migration to the estuary occurs at varying rates.

Minimum daily average flows under the proposed action are at least 950 cfs during upstream migration, and NMFS concludes that flows during this period are not likely to adversely affect adult coho salmon migration in the mainstem Klamath River. Also, water temperatures in the mainstem Klamath River are within the suitable range for adult coho salmon in the late fall and winter, and are not expected to impede coho salmon adult migration. Similarly, flow and temperature conditions are expected to be suitable for juvenile migration, including smolt outmigration. NMFS expects that the proposed action will provide suitable quantity of coho salmon mainstem spawning habitat for successful spawning and egg incubation, and does not expect eggs in the mainstem Klamath River will be adversely affected by the proposed action.

The proposed action's reduction of spring flows in the mainstem Klamath River is likely to increase water temperatures in the spring by up to approximately 0.5 °C in the mainstem between IGD and the Scott River. When water temperature chronically exceeds 16.5 °C, coho salmon fry and juveniles may become stressed and more susceptible to disease-related mortality. High water temperatures are linked to lower dissolved oxygen. Low dissolved oxygen can affect fitness and survival of coho salmon by increasing the likelihood of predation and decreasing feeding activity. Temperatures (and dissolved oxygen) are linked to meteorological conditions within years and between years.

Ceratomyxosis, which is caused by the *C. shasta* parasite, is the focus for NMFS in the coho salmon disease analysis because researchers believe that this parasite is a key factor limiting salmon recovery in the Klamath River. NMFS believes the high incidence of disease in certain years within the mainstem Klamath River results largely from the reduction in magnitude, frequency, and duration of sediment maintenance flows. Under the proposed action, NMFS expects surface flushing flows will occur in all years, and NMFS believes this will help disrupt the life cycle of *C. shasta.* Nevertheless, the proposed action will decrease the probability of achieving deep flushing flows in the mainstem Klamath River relative to the natural flow regime, increase immobile river bed conditions, and exacerbate disease conditions.

Thermal refugia along the mainstem Klamath River provide salmon essential locations where coho salmon juveniles can seek refuge when water temperatures in the mainstem become excessive. The primary factor affecting the integrity of thermal refugia is the cooler tributary flows, which are not affected by the proposed action. The higher the tributary flows, the larger the thermal refugia will be in the mainstem Klamath River. While the proposed action does not affect the amount or timing of tributary flows, when the proposed action decreases mainstem flows in the summer, water temperature becomes more influenced by meteorological conditions, which will increase daily maximum and median (to a lesser extent) water temperatures upstream of Seiad Valley.

The amount of rearing habitat available in the mainstem Klamath River is correlated with flows, especially at certain ranges where water velocity, depth, and cover provide suitable conditions for juvenile rearing. Upper and Middle Klamath, Shasta and Scott River coho salmon populations will all experience reduced habitat availability in the mainstem Klamath River as a result of the proposed action in most months of the year and in all water year types. The greatest adverse effects will be experienced by parr and smolts, while coho fry will experience limited habitat availability primarily in June.

2.2.4.4 Restoration Activities

2.2.4.4.1 Restoration Activities Effects to Critical Habitat

With its coho restoration grant program, Reclamation has proposed to fund conservation measures to improve conditions for coho salmon. Restoration activities that require instream activities will be implemented during low flow periods between June 15 and November 1 to minimize effects of construction activities. The specific timing and duration of construction for each project will vary depending on the project type, specific project methods, and site conditions. However, the duration and magnitude of short-term effects to coho salmon critical habitat associated with implementation of individual restoration projects will be minimized due to the multiple proposed avoidance and minimization measures.

The total number and location of restoration projects funded annually will vary from year to year depending on various factors, including project costs, funding and scheduling. Based on implementation information from the past three years (2016-2018) of the Reclamation coho restoration grant program (as detailed in USBR 2018a) and PacifiCorp's $500,000 coho enhancement fund (PacifiCorp 2018a), and Reclamation's proposal to fund $700,000 in 2019 and 2020, and $500,000 in 2021-2023, NMFS expects for purposes of this analysis that about 40 projects will be implemented (average of eight per year) over the course of the proposed action. Most proposed restoration project types may result in short-term adverse and long-term beneficial effects to coho salmon critical habitat. Some project types are wholly beneficial with no short-term adverse effects. These project types are more fully described below.

2.2.4.4.1.1 Riparian Habitat Restoration

All vegetation planting or removal (in the case of exotic species) in the action area will likely occur on stream banks and floodplains adjacent to the wetted channel and not in flowing water. Since the majority of work will occur during the summer growing season (a few container plants require winter planting), riparian plantings should be sufficiently established prior to the following winter storm season. Thus, project-related erosion following the initial planting season is unlikely since established plants will help anchor the restoration worksite. The long-term benefit from riparian restoration will be the establishment of a vibrant, functional riparian corridor providing juvenile and adult fish with abundant food and cover.

Riparian restoration projects will increase stream shading and instream cover habitat for rearing juveniles, moderate stream temperatures, and improve water quality through pollutant filtering. Beneficial effects of constructing livestock exclusionary fencing in or near streams include the rapid regrowth of grasses, shrubs, and other vegetation released from overgrazing, and reduced nitrogen, phosphorous, and sediment loading into the stream environment (Brenner and Brenner 1998, Line et al. 2000). Further, Owens et al. (1996) found that stream fencing has proven to be an effective means of maintaining appropriate levels of sediment in the streambed. Another documented, beneficial, long-term effect is the reduction in bankfull width of the active channel and the subsequent increase in pool area in streams (Magilligan and McDowell 1997). Riparian restoration projects will likely occur in association with other construction projects, such as native plantings along a reconstructed channel or newly implemented off channel pond. These projects will most likely occur in smaller tributaries where juvenile salmonids rear and riparian vegetation can more completely shade and cover the waterway. Over the next five years, NMFS expects to see a few riparian restoration projects in each sub-watershed that will contribute to a more properly functioning ecosystem for listed species by providing additional spawning and cover habitat relative to their current condition. Adverse effects of riparian planting projects may come in the form of sedimentation to the channel; however, these effects are expected to be miniscule and of short duration immediately following project implementation. As the riparian vegetation is established over the long term, channel stability is expected to be improved from baseline conditions with little to no sedimentation.

2.2.4.4.1.2 Water Conservation

Implementing water conservation measures will benefit coho salmon by returning some flow to the stream at a time when coho salmon require adequate habitat to rear and migrate. Increasing instream flow levels by diminishing water diversions will provide juvenile coho salmon with better access to suitable rearing and spawning habitat, especially during the summer and early fall when flows are lowest. Water quality is expected to be improved as a result of some projects such as construction of tail water ponds that will minimize the return of warm, nutrient rich water into the river. Water conservation projects are most likely to occur in the tributaries, such as the Shasta and Scott rivers. Therefore, short-term restoration of flows are expected to affect only the tributaries because the next priority water right user or riparian water right user is likely to divert those flows and water conserved at the restoration site is likely to increase instream flows in a relatively small reach of these tributaries.

Some construction type activities may occur for certain types of water conservation projects like development of alternative stockwater supply, tailwater collection ponds, water storage tanks, and piping open ditches. These activities typically occur in diversion ditches or locations away from natural stream channels designated as critical habitat. Therefore, increased mobilization of sediment, chemical contamination, or dewatering effects are unlikely to reach the stream channel and cause adverse effects to coho salmon critical habitat.

2.2.4.4.1.3 Instream Habitat Improvements

Instream habitat structures and improvement projects will provide cover for juveniles to escape predators and rest, increase spawning habitat, improve upstream and downstream migration corridors, improve pool to riffle ratios, and add habitat complexity and diversity. Some structures will be designed to reduce sedimentation, protect unstable banks, stabilize existing slides, provide shade, and create scour pools. Stream enhancement techniques aimed at reducing juvenile displacement downstream during winter floods and providing deep pools during summer low flows could substantially increase stream rearing capacity for coho salmon (Narver 1978).

Placement of LWD into streams can result in the creation of pools that influence the distribution and abundance of juvenile salmonids (Spalding et al. 1995, Beechie and Sibley 1997). LWD influences the channel form, retention of organic matter and biological community composition. In small (<10 m bankfull width) and intermediate (10-20 m bankfull width) streams, LWD contributes channel stabilization, energy dissipation and sediment storage (Cederholm et al. 1997). Presence and abundance of LWD is correlated with growth, abundance and survival of juvenile salmonids (Fausch and Northcote 1992, Spalding et al. 1995). The size of LWD is important for habitat creation (Fausch and Northcote 1992).

For placement of root wads, digger logs, beaver dam analogues, upsurge weirs, boulder weirs, vortex boulder weirs, boulder clusters, and boulder wing-deflectors (single and opposing), long-term beneficial effects are expected to result from the creation of scour pools that will provide rearing habitat for juvenile coho salmon. Improper use of weir and wing-deflector structures can cause accelerated erosion on the opposing bank; however, this can be avoided with proper design considerations. Proper placement of single and opposing log wing-deflectors and divide logs will provide long-term beneficial effects from the creation or enhancement of pools for summer rearing habitat and cover for adult salmonids during spawning. Proper placement of digger logs will likely create scour pools that will provide complex rearing habitat, with overhead cover, for juvenile salmonids and low velocity resting areas for migrating adult salmonids. Spawning gravel augmentation will provide long-term beneficial effects by increasing spawning gravel availability while reducing inter-gravel fine sediment concentrations.

In addition, where there is stream bank erosion, the installation of various weir structures and wing-deflector structures will direct flow away from unstable banks and provide armor (a hard point) to protect the toe of the slope from further erosion. Boulder faces in the deflector structures have the added benefit of providing invertebrate habitat, and space between boulders provides juvenile salmonid escape cover.

Instream restoration projects are one of the most commonly funded types of restoration projects and NMFS expects that several of these projects will occur in each sub watershed over the next five years. Most of these projects will likely occur in smaller tributaries where they will have the greatest benefit to rearing juvenile coho salmon like Sugar and French creeks (tributary to Scott River), Little Shasta and Parks creeks (tributaries to Shasta River), and Seiad and Horse creeks (tributaries to Klamath River). These projects are typically implemented on smaller, cold-water tributaries where juvenile coho salmon find velocity refuge in the winter or cold-water rearing habitat in the summer. Gravel augmentation, however, may occur in the mainstem Klamath River downstream of IGD or in the Shasta River downstream of Dwinnell Dam. NMFS expects that construction related activities associated with project implementation might result in introduction of toxic chemicals, localized stream dewatering, minor removal of riparian vegetation, and limited sedimentation. However, all fisheries restoration projects will include minimization measures outlined in CDFW's Restoration Manual (Flosi et al. 2010). Therefore, NMFS expects that adverse effects to critical habitat will be minor and of short duration, while long term beneficial effects to critical habitat are expected to occur from the projects.

2.2.4.4.1.4 Instream Barrier Modification for Fish Passage Improvement

Instream barrier modification for fish passage improvement projects will improve salmonid fish passage and increase access to suitable salmonid habitat. Long-term beneficial effects are expected to result from these projects by improving passage at sites that are partial barriers, and by providing passage at sites that are total barriers. Manual modifications to tributary mouths may restore access for juvenile coho salmon between the mainstem and the tributaries. This type of work is done by hand and by using hand tools. Typically, these projects occur annually at small, cold-water tributary mouths in the Mid-Klamath River reach such as Cade Creek, China Creek, Stanshaw Creek, Sandy Bar Creek, etc. NMFS expects that these projects will be small in scale and temporary in nature (summer low flow period) with minimal disturbance to the habitat since all work is done by hand. All of these restoration projects will provide improved passage so fish can access cold-water tributaries. No adverse effects are expected to occur to critical habitat as a result of instream barrier modification due to the temporary and small scale nature. Impacts will be wholly beneficial, as the migratory corridor will be improved for seasonal juvenile passage.

2.2.4.4.1.5 Fish Passage Improvement at Stream Crossings

Thousands of dilapidated stream crossings exist on roadways throughout the coastal drainages of northern and central California, many preventing listed salmonids from accessing vast expanses of historic spawning and rearing habitat located upstream of the structure. The proposed action includes funding of restoration projects, with stream-crossing barriers described as a priority restoration action to increase coho salmon access to cold water tributary habitat. Under the scope and scale of the restoration funds provided through the proposed action, NMFS expects that only minor stream-crossing barriers such as culverts and fjord type stream crossings will be addressed in the next five years. Many high priority stream-crossing barriers have already been improved through past restoration efforts. Therefore, projects implemented under this proposed action are likely to be located high in the watersheds of tributaries such as Scott, Shasta, and Salmon rivers, as well as crossings at smaller tributaries to the Klamath River. Based on the frequency of previously funded project types, NMFS expects approximately 1-2 stream crossing projects to be implemented Klamath Basin wide per year over the five year period of the proposed action. These projects will increase habitat availability by allowing fish to access additional spawning and rearing habitat, previously blocked by barriers.

NMFS expects that construction related activities associated with project implementation might result in introduction of toxic chemicals, localized stream dewatering, minor removal of riparian vegetation, and small amounts of sedimentation. However, all fish passage improvement projects will include minimization measures outlined in CDFW's Restoration Manual (Flosi et al. 2010). Therefore, NMFS expects that adverse effects to critical habitat will be minor and of short duration, while long term beneficial effects to critical habitat are expected to occur from the projects.

2.2.4.4.1.6 Fish Screens

Water diversions can greatly affect aquatic life when organisms are entrained into intake canals or pipes -- an estimated 10 million juvenile salmonids were lost annually through unscreened diversions in the Sacramento River alone (Upper Sacramento River Fisheries and Riparian Habitat Advisory Council 1989). Once entrained, juvenile fish can be transported to less favorable habitat (e.g., a reservoir, lake or drainage ditch) or killed instantly by turbines. Fish screens are commonly used to prevent entrainment of juvenile fish in water diverted for agriculture, power generation, or domestic use.

Reclamation may fund fish screen projects as part of their restoration program. All screening projects have similar goals, most notably preventing fish entrainment into intake canals and impingement against the mesh screen. To accomplish this, all screening projects in the action area will meet NMFS fish screen criteria (NMFS 1997), which outline screen design, construction and placement, as well as designing and implementing successful juvenile bypass systems that return screened fish back to the stream channel.

Based on the frequency of previously funded project types, NMFS expects only one to three fish screens will be installed over the next five years under the proposed action. These screens are likely to be installed on private property and associated with an agriculture operation, most likely in the Scott or Shasta watersheds. Typically, the screens will be located off channel and away from critical habitat with a minimal amount of indirect effects occurring during installation. Because fish screen installation will follow CDFW and NMFS guidelines, which include minimization measures for installation, we expect only short term and minor effects to critical habitat including a minor amount of vegetation removal and small amount of sedimentation that may be flushed downstream through a bypass channel during construction. Ultimately, the migratory corridor will be improved by reducing risk of entrainment.

2.2.4.4.1.7 Summary of Restoration Activities Effects to Critical Habitat

Although Reclamation's funding for restoration activities will likely result in minor and short-term adverse effects during implementation, NMFS expects that the suite of restoration activities will result in longer term improvements to the function and role of critical habitat in the action area. With the additional funding secured by Reclamation for fiscal years 2019 and 2020, NMFS expects about 40 projects to be implemented over the next five years.

Implementation of these projects will help to ameliorate some of the adverse effects that result from components of Reclamation's proposed action. Water quality is expected to be degraded as a result of project operations over the next five years. Rearing and migratory habitat will be reduced in quantity and quality during some years as a result of flow management under project operations. The restoration projects described in this section will provide better access to summer and winter rearing habitat, increase the abundance of rearing habitats, and improve the quality of rearing habitats. Additionally, migratory habitat will be improved through fish screening and water conservation measures, while spawning habitat is expected to be improved through gravel augmentation. Improvements to critical habitat though restoration projects will primarily occur in the larger tributaries downstream of IGD (e.g., Shasta River, Scott River, Seiad Creek, Horse Creek) where most coho salmon in the action area typically spawn and rear. In this way, the restoration projects will target coho salmon habitat most frequently utilized. Impacts from Project operations are expected primarily in the mainstem Klamath downstream of IGD to the confluence of the Salmon River. NMFS expects that the restoration projects funded under the proposed action will provide improvements to coho salmon critical habitat; however, they will not be able on their own to completely offset the adverse effects of proposed project operations.

2.2.4.4.2 Restoration Activities Effects to Individuals

Restoration activities that require instream activities will be implemented during low flow periods between June 15 and November 1. The specific timing and duration of each individual restoration project will vary depending on the project type, specific project methods, and site conditions. However, the duration and magnitude of effects to coho salmon associated with implementation of individual restoration projects will be significantly minimized due to the multiple proposed avoidance and minimization measures.

Implementing individual restoration projects with instream activities during the summer low-flow period will significantly minimize exposure to emigrating coho salmon smolts and coho salmon adults at all habitat restoration project sites. The total number and location of restoration projects funded annually will vary from year to year depending on various factors, including project costs, funding and scheduling. As described in the *Restoration Activities Effects to Critical Habitat* section (Section 2.2.4.4.1), NMFS expects about 40 projects to be completed over the course of the five year proposed action.

Most restoration projects have the potential to result in short-term adverse effects to coho salmon. Despite the different scope, size, intensity, and location of these proposed restoration actions, the potential adverse effects to coho salmon all result from dewatering, fish relocation, structural placement, and increased sediment. Dewatering, fish relocation, and structural placement may result in direct effects to listed salmonids, where a small percentage of individuals may be injured or killed. The effects from increased sediment mobilization into streams are usually indirect effects, where the effects to individuals from increased sediment (during the first winter rains after project completion for example) are reasonably certain to occur but are later in time.

2.2.4.4.2.1 Dewatering

Although many project types include the possibility of dewatering, not all individual project sites will need to be dewatered. When dewatering is necessary, only a small reach of stream at each project site will be dewatered for instream construction activities. Dewatering encompasses placing temporary barriers, such as a cofferdam, to hydrologically isolate the work area, re-routing stream flow around the dewatered area, pumping water out of the isolated work area, relocating fish from the work area (discussed separately), and restoring the project site upon project completion. The length of contiguous stream reach that will be dewatered for most projects is expected to be less than 500 feet and no greater than 1000 feet for any one project site.

2.2.4.4.2.1.1 Exposure

Because the proposed dewatering would occur during the low flow period, the life stage most likely to be exposed to potential effects of dewatering is juvenile coho salmon. Dewatering is expected to occur mostly during the first half of the instream construction window (e.g., to accommodate for the necessary construction time needed), and therefore should avoid exposure to adult coho salmon. Dewatering that occurs in the latter half of the instream construction window may expose early incoming coho salmon to displacement. However, adult coho salmon are not likely to be affected because adults will avoid the construction area and dewatering is very rarely done so late in the low flow season.

2.2.4.4.2.1.2 Response

If coho salmon juveniles are present, the adverse effects of dewatering result from the placement of the temporary barriers, the trapping of individuals in the isolated area, and the diversion of streamflow. Fish relocation and ground disturbance effects are discussed further below. Rearing juvenile coho salmon could be killed or injured if crushed during placement of the temporary barriers, such as cofferdams, though crushing is expected to be minimal due to evasiveness of most juveniles. Stream flow diversions could harm salmonids by concentrating or stranding them in residual wetted areas (Cushman 1985) before they are relocated, or causing them to move to adjacent areas of poor habitat (Clothier 1953, Clothier 1954, Kraft 1972, Campbell and

Scott 1984). Juvenile coho salmon that are not caught during the relocation efforts would be killed from either construction activities or desiccation.

Changes in flow are anticipated to occur within and downstream of restoration sites during dewatering activities. These fluctuations in flow, outside of dewatered areas, are anticipated to be small, gradual, and short-term, which should not result in any harm to salmonids.

Effects associated with dewatering activities will be minimized due to the multiple minimization measures that will be used as described in the section entitled, *Measures to Minimize Impacts to Aquatic Habitat and Species during Dewatering of Projects* within Part IX of the Restoration Manual (Flosi et al. 2010). However, it is feasible that some juvenile coho salmon will avoid capture and remain in the dewatered stream reach and die.

2.2.4.4.2.1.3 Risk

Juvenile coho salmon that avoid capture in the project work area will die during dewatering activities. NMFS expects that the number of coho salmon that will be killed as a result of barrier placement and stranding during site dewatering activities is very low, likely less than one percent of the total number of salmonids in the project area. The low number of juveniles expected to be injured or killed as a result of dewatering is based on the low percentage of projects that require dewatering (i.e., generally only up to 12 percent; NMFS 2012b), the avoidance behavior of juveniles to disturbance, the small area affected during dewatering at each site, the low number of juveniles in the typically degraded habitat conditions common to proposed restoration sites, and the low numbers of juvenile salmonids expected to be present within each project site after relocation activities.

2.2.4.4.2.2 Fish Relocation Activities

All restoration sites that require dewatering will include fish relocation if coho salmon are determined to be potentially present. CDFW personnel (or designated agents) capture and relocate fish away from the restoration project work site to minimize adverse effects of dewatering to listed salmonids. Fish in the immediate project area will be captured by seine, dip net and/or by electrofishing, and will then be transported and released to a suitable instream location.

2.2.4.4.2.2.1 Exposure

Because fish relocation occurs immediately prior to or during dewatering, the life stage most likely to be exposed to fish relocation are juvenile coho salmon.

2.2.4.4.2.2.2 Response

Fish relocation activities may injure or kill rearing juvenile coho salmon because these individuals are most likely to be present in the restoration sites. Any fish collecting gear, whether passive or active (Hayes 1983) has some associated risk to fish, including stress, disease transmission, injury, or death. The amount of injury and mortality attributable to fish capture varies widely depending on the method used, the ambient conditions, and the expertise and experience of the field crew. The effects of seining and dip-netting on juvenile salmonids include stress, scale loss, physical damage, suffocation, and desiccation. Electrofishing can kill juvenile salmonids, and researchers have found serious sublethal effects including spinal injuries (Habera et al. 1996, Nielsen 1998, Habera et al. 1999, Nordwall 1999). The long-term effects of electrofishing on salmonids are not well understood. Although chronic effects may occur, most effects from electrofishing occur at the time of capture and handling.

Most of the stress and death from handling result from differences in water temperature between the stream and the temporary holding containers, dissolved oxygen levels, the amount of time that fish are held out of the water, and physical injury. Handling-related stress increases rapidly if water temperature exceeds 18 °C or dissolved oxygen is below saturation. A qualified fisheries biologist will relocate fish, following both CDFW and NMFS electrofishing guidelines. Because of these measures, direct effects to, and mortality of, juvenile coho salmon during capture will be greatly minimized.

Although sites selected for relocating fish will likely have similar water temperature as the capture site and should have ample habitat, in some instances relocated fish may endure short-term stress from crowding at the relocation sites. Relocated fish may also have to compete with other salmonids, which can increase competition for available resources such as food and habitat. Some of the fish at the relocation sites may choose not to remain in these areas and may move either upstream or downstream to areas that have more habitat and lower fish densities. As each fish moves, competition remains either localized to a small area or quickly diminishes as fish disperse.

Fish relocation activities are expected to minimize individual project impacts to juvenile coho salmon by removing them from restoration project sites where they would have experienced high rates of injury and mortality. Fish relocation activities are anticipated to only affect a small number of rearing juvenile coho salmon within a small stream reach at and near the restoration project site and relocation release site(s). Rearing juvenile coho salmon present in the immediate project work area will be subject to disturbance, capture, relocation, and related short-term effects. Most of the effects associated with fish relocation are anticipated to be non-lethal. However, a very low number of rearing juvenile coho salmon captured may be injured or killed. In addition, the number of fish affected by increased competition is not expected to be significant at most fish relocation sites, based upon the suspected low number of relocated fish inhabiting the small project areas.

Effects associated with fish relocation activities will be significantly minimized due to the multiple minimization measures that will be utilized, as described in the section entitled, *Measures to Minimize Injury and Mortality of Fish and Amphibian Species during Dewatering* within Part IX of the Restoration Manual (Flosi et al. 2010).

2.2.4.4.2.2.3 Risk

NMFS considered several pieces of information when estimating number of coho salmon that may be captured, injured, and killed each year from the dewatering and relocation activities. The NOAA RC monitoring reports from the Arcata Office Programmatic Biological Opinion show that the program dewaters approximately 36 percent (14 out of 39 projects) of the projects that occur under the programmatic biological opinion. When estimating the maximum number of coho salmon that may be captured each year, NMFS used the NOAA RC monitoring reports to assess the actual number of coho salmon captured, injured, and killed in the SONCC coho salmon ESU (Table 24). NMFS used the highest percentage (1 percent) recorded under the NOAA RC program to estimate the percent of coho salmon that would be injured or killed each year. Based on implementation information from the past three years (2016-2018) of the Reclamation coho restoration grant program (as detailed in USBR 2018a) and PacifiCorp's $500,000 coho enhancement fund (PacifiCorp 2018a), and Reclamation's proposal to fund $700,000 in 2019 and 2020, and $500,000 in 2021-2023, NMFS expects about eight projects will be implemented in a single year. The data from NOAA RC varies greatly. However, it shows on average that 40 coho salmon are captured and relocated per project, although as many as 300 were captured during a single project. NMFS reviewed Reclamation's tracking spreadsheet for 2016 and 2017, which describes projects funded under Reclamation's restoration program. This spreadsheet shows most projects funded for the immediate future will take place in tributaries with some of the densest juvenile rearing populations in the Klamath Basin, including Scott River, Shasta River, French Creek, Mill Creek and Horse Creek (Bob Pagliuco, NOAA, pers. comm.[17]). Therefore, NMFS estimates that the number of juveniles relocated per project will be higher than the average (40) described in Table 24, but significantly less than the maximum (300) that was described. NMFS estimates an average of 100 juvenile coho salmon will be relocated per project and that up to eight projects per year will be implemented. Therefore, 800

[17] February 2019 personal communication from Bob Pagliuco, NOAA Fisheries Restoration Center, to Shari Witmore (NOAA Fisheries West Coast Region).

juvenile SONCC coho salmon could potentially be captured annually during the implementation of eight projects, of which up to eight may be injured or killed annually.

Table 24. Dewatering and fish relocation associated with the NOAA Restoration Center's Arcata Office Programmatic Biological Opinion. Data showing that on average 40 fish are relocated in each project and a maximum of 300 fish were relocated for a single project.

Year	Number of Dewatering Events	Number Coho Salmon Captured	Number Coho Salmon Injured	Number Coho Salmon Killed
2012	2	1	0	0
2013	1	35	0	0
2014	3	0	0	0
2015	4	197	0	1
2016	2	300*	0	0
2017	2	13	0	0
Average/ year	2.3	91	0	<1

*Although two dewatering projects occurred in 2016, only one of those, located in Mill Creek (tributary to Scott River) resulted in coho salmon capture. Therefore, 300 coho salmon were captured during a single project, representing the maximum number of fish relocated for one project in this data set.

2.2.4.4.2.3 Structural Placement

Most of the proposed restoration project types include the potential for placement of structures in the stream channel. These structural placements can vary in their size and extent, depending on their restoration objective. Most structural placements are discrete where only a localized area will be affected. The salmonids exposed to such structural placements are the same juvenile species that would be exposed to dewatering effects. Where structural placements are small and discrete, salmonids are expected to avoid the active construction area and thus will not be crushed. When structural placements are large or cover a large area, such as gravel augmentation, some juvenile salmonids may be injured or killed. However, the number of juveniles injured or killed is expected to be no more than the number of individuals that will be killed by desiccation after the reach is dewatered without such structural placement. Fish relocation is expected to remove most salmonids. In essence, juvenile fish that are not relocated will be killed by either dewatering or structural placement.

2.2.4.4.2.4 Increased Mobilization of Sediment

The proposed restoration project types involve various degrees of earth disturbance. Inherent with earth disturbance is the potential to increase background suspended sediment loads for a short period during and following project completion.

Restoration activities may cause temporary increases in turbidity and deposition of excess sediment may alter channel dynamics and stability (Habersack and Nachtnebel 1995, Hilderbrand et al. 1997, Hilderbrand et al. 1998). Erosion and runoff during precipitation and snowmelt will increase the supply of sediment to streams. Heavy equipment operation in upland and riparian areas increases soil compaction, which can increase runoff during precipitation. High runoff can then, in turn, increase the frequency and duration of high stream flows in construction areas. Higher stream flows increase stream energy that can scour stream bottoms and transport greater sediment loads farther downstream than would otherwise occur

All project types involving ground disturbance in or adjacent to streams are expected to increase turbidity and suspended sediment levels within the project work site and downstream areas. Therefore, instream habitat improvement, instream barrier modification for fish passage improvement, stream bank stabilization, fish passage improvements at stream crossings, small dam removal[18], creation of off channel/side channel habitat, and fish screen construction may result in increased mobilization of sediment into streams. Although riparian restoration may involve ground disturbance adjacent to streams, the magnitude and intensity of this ground disturbance is expected to be small and isolated to the riparian area. Fish screen projects are not expected to release appreciable sediment into the aquatic environment.

2.2.4.4.2.4.1 Exposure

In general, sediment-related effects are expected during the summer construction season (June 15 to November 1), as well as during peak-flow winter storm events when remaining loose sediment is mobilized. During summer construction, the species and life stages most likely to be exposed to potential effects of increased sediment mobilization are juvenile coho salmon. As loose sediment is mobilized by higher winter flows, adult coho salmon may also be exposed to increased turbidity. Removal of small dams and road crossing projects will have the greatest potential for releasing excess sediment. However, minimization measures, such as removing excess sediment from the dewatered channel prior to returning flow will limit the amount of sediment released. The increased mobilization of sediment is not likely to degrade spawning gravel because project related sediment mobilization should be minimal due to the use of sideboards and minimization measures. This small amount of sediment is expected to affect only a short distance downstream, and should be easily displaced by either higher fall/winter flows or redd building. In the winter, the high flows will carry excess fine sediment downstream to point bars and areas with slower water velocities. Some redds may experience miniscule amounts of fine sediment accumulation resulting in very small reduction in water flow through their redds.

[18] Because of the sideboards and engineering requirements described in the proposed action, small dam removal is expected to have similar sediment mobilization effects as culvert replacement or removal

Because redds are built where water velocities are higher, the minimally increased sediment mobilization is not expected to significantly impact existing redds. Since most restoration activities will focus on improving areas of poor instream habitat, NMFS expects the number of fish inhabiting individual project areas during these periods of increased sediment input, and thus directly affected by construction activities, to be relatively small.

2.2.4.4.2.4.2 Response

Short-term increases in turbidity are anticipated to occur during dewatering activities and/or during construction of coffer dams. Research with salmonids has shown that high turbidity concentrations can: reduce feeding efficiency, decrease food availability, reduce dissolved oxygen in the water column, result in reduced respiratory functions, reduce tolerance to diseases, and can also cause fish mortality (Berg and Northcote 1985, Gregory and Northcote 1993, Velagic 1995, Waters 1995). Mortality of coho salmon fry can result from increased turbidity (Sigler et al. 1984). Even small pulses of turbid water will cause salmonids to disperse from established territories (Waters 1995), which can displace fish into less suitable habitat and/or increase competition and predation, decreasing chances of survival. Nevertheless, much of the research mentioned above focused on turbidity levels significantly higher than those likely to result from the proposed restoration activities, especially with implementation of the proposed avoidance and minimization measures.

Research investigating the effects of sediment concentration on fish density has routinely focused on high sediment levels. For example, Alexander and Hansen (1986) measured a 50 percent reduction in brook trout (*Salvelinus fontinalis*) density in a Michigan stream after manually increasing the sand sediment load by a factor of four. In a similar study, Bjornn et al. (1977) observed that salmonid density in an Idaho stream declined faster than available pool volume after the addition of 34.5 m^3 of fine sediment into a 165 m study section. Both studies attributed reduced fish densities to a loss of rearing habitat caused by increased sediment deposition. However, streams subject to infrequent episodes adding small volumes of sediment to the channel may not experience dramatic morphological changes (Rogers 2000). Similarly, research investigating severe physiological stress or death resulting from suspended sediment exposure has also focused on concentrations much higher than those typically found in streams subjected to minor/moderate sediment input (Newcombe and MacDonald 1991, Bozek and Young 1994).

In contrast, the lower concentrations of sediment and turbidity expected from the proposed restoration activities are unlikely to be severe enough to cause injury or death of juvenile coho salmon. Instead, the anticipated low levels of turbidity and suspended sediment resulting from instream restoration projects will likely result in only temporary behavioral effects. Monitoring of newly replaced culverts[19] in Humboldt County detailed a range in turbidity changes

[19] When compared to other instream restoration projects (*e.g.*, bank stabilization, instream structure placement), culvert replacement/upgrade projects typically entail a higher degree of instream construction and excavation, and by extension greater sediment effects. Thus, NMFS focused on culvert projects as a “worst case” scenario when analyzing potential sediment effects from instream projects.

downstream of newly replaced culverts following winter storm events (Humboldt County 2002). During the first winter following construction, turbidity rates (NTU) downstream of newly replaced culverts increased an average of 19 percent when compared to measurements directly above the culvert. However, the range of increases within the 11 monitored culverts was large (range of 123 percent to -21 percent) (Humboldt County 2002, 2003, 2004). Monitoring results from one- and two-year-old culverts showed much less increases in NTUs downstream of the culverts (n=11; range of 12 percent to -9 percent), with an average increase in downstream turbidity of one percent. Although the culvert monitoring results show decreasing sediment effects as projects age from year one to year three, a more important consideration is that most measurements fell within levels that were likely to only cause slight behavioral changes [e.g., increased gill flaring (Berg and Northcote 1985), elevated cough frequency (Servizi and Martens 1992), and avoidance behavior (Sigler et al. 1984)]. Turbidity levels necessary to impair feeding are likely in the 100 to 150 NTU range (Gregory and Northcote 1993, Harvey and White 2008)). However, only one of the Humboldt County measurements exceeded 100 NTU (i.e., North Fork Anker Creek, year one), whereas the majority (81 percent) of downstream readings were less than 20 NTU. Importantly, the proposed action's minimization measures, some of which were not included in the culvert work analyzed above, will likely ensure that future sediment effects from fish passage projects will be less than those discussed above.

2.2.4.4.2.4.3 Risk

Small pulses of moderately turbid water expected from the proposed instream restoration projects will likely cause only minor physiological and behavioral effects, such as dispersing salmonids from established territories, potentially increasing interspecific and intraspecific competition, as well as increasing predation risk for the small number of affected fish.

NMFS does not expect sediment effects to accumulate downstream from restoration sites within a given watershed. Sediment effects generated by each individual project will likely impact only the immediate footprint of the project site and up to approximately 1500 feet of channel downstream of the site. Studies of sediment effects from culvert construction determined that the level of sediment accumulation within the streambed returned to control levels between 358 to 1,442 meters downstream of the culvert (Lachance et al. 2008). Because of the multiple measures to minimize sediment mobilization, described in the Restoration Manual (Flosi et al. 2010) under *Measures to Minimize Degradation of Water Quality,* on pages IX-50 and IX-51, downstream sediment effects from the proposed restoration projects are expected to extend downstream for a distance consistent with the range presented by Lachance et al. (2008). The proposed 800-foot buffer between instream projects is likely large enough to preclude sediment effects from accumulating at downstream project sites. Furthermore, the temporal and spatial scale at which project activities are expected to occur will also likely preclude significant additive sediment related effects. Assuming projects will be funded and implemented similar to Reclamation's coho salmon restoration program and PacifiCorp's coho enhancement fund in the past few years, NMFS expects that individual restoration projects sites will occur over a broad spatial scale each year. In other words, restoration projects occurring in close proximity to other projects during a given restoration season is unlikely, thus diminishing the chance that project effects would combine. Finally, effects to fish are expected to be short-term, since most project-related sediment will likely mobilize during the initial high-flow event the following winter season. Subsequent sediment mobilization is likely to occur following the next two winter seasons. However, suspended sediment generally should subside to baseline conditions by the third year (Humboldt County 2004, Klein 2006).

2.2.4.4.2.5 Noise, Motion, and Vibration Disturbance from Heavy Equipment Operation

Noise, motion, and vibration produced by heavy equipment operation are expected at most instream restoration sites. However, the use of equipment, which will occur primarily outside the active channel, and the infrequent, short-term use of heavy equipment in the wetted channel to construct cofferdams, is expected to result in insignificant adverse effects to listed fishes. Listed salmonids will be able to avoid interaction with instream machinery by temporarily relocating either upstream or downstream into suitable habitat adjacent to the worksite. In addition, the minimum distance between instream project sites and the maximum number of instream projects under the proposed Program would further reduce the potential aggregated effects of heavy equipment disturbance on listed salmonids

2.2.4.4.2.6 Beneficial Effects to Coho Salmon

Reclamation proposes to fund restoration actions to benefit coho salmon and its habitat. Fisheries habitat restoration projects that are funded by Reclamation will be designed and implemented consistent with the techniques and minimization measures presented in the CDFW's Restoration Manual (Flosi et al. 2010) to maximize the benefits of each project while minimizing effects to salmonids. Most restoration projects are for the purpose of restoring degraded salmonid habitat and are intended to improve instream cover, pool habitat, spawning gravels, and flow levels; remove barriers to fish passage; and reduce or eliminate erosion and sedimentation impacts. Others prevent fish injury or death, such as diversion screening projects. Although some habitat restoration projects may fail or cause small losses to the juvenile life history stage of listed salmonids in the project areas during construction, most of these projects are anticipated to restore coho salmon habitat over the long-term.

a. Instream Habitat Improvements

In addition to the habitat benefits discussed earlier in the *Restoration Activities Effects to Critical Habitat* section (Section 2.2.4.4.1), stream enhancement techniques aimed at reducing juvenile displacement downstream during winter floods and at providing deep pools during summer low flows could substantially increase rearing success and survival for coho salmon. Presence and abundance of LWD is correlated with growth, abundance and survival of juvenile salmonids (Fausch and Northcote 1992, Spalding et al. 1995). Weir structures can also be used to replace the need to annually build gravel push up dams. Once these weir structures are installed and working properly, construction equipment entering and modifying the channel would no longer be needed prior to the irrigation season. The benefits of reducing or eliminating equipment operation during the early spring reduces the possibility of crushing salmon redds and young salmonids.

b. Instream Barrier Modification for Fish Passage Improvement

Fish passage improvements will increase access for coho salmon adults and juveniles to previously unavailable habitat. These restoration activities will likely increase the current spatial structure of coho salmon populations. Reintroducing listed salmonids into previously unavailable upstream habitat will also likely increase reproductive success and ultimately fish population size in watersheds where the amount of quality freshwater habitat is a limiting factor.

c. Fish Screens

Fish screen projects will reduce the risk of fish being impinged or entrained into irrigation systems. Well-designed fish screens and associated diversions ensure that coho salmon injury or stranding is avoided, and that coho salmon are able to migrate through the stream.

2.2.4.4.2.7 Summary of Restoration Activities Effects to Individuals

Although Reclamation's funding for restoration activities will likely result in minor and short-term adverse effects during implementation, NMFS expects the suite of restoration activities will likely result in benefits to coho salmon in the action area. Based on implementation information from the past three years (2016-2018) of the Reclamation coho salmon restoration program (as detailed in USBR 2018a) and PacifiCorp's $500,000 coho enhancement fund (PacifiCorp 2018a), and Reclamation's proposal to fund $700,000 in 2019 and 2020, and $500,000 in 2021-2023, NMFS anticipates about 40 projects will be implemented throughout the Klamath Basin over the course of the 5-year proposed action.

Based on historic project implementation data, NMFS expects most of these projects to occur in the tributaries where most of the coho salmon typically spawn and rear in the action area. A small number of coho salmon may be killed each year as a result of relocation activities associated with project implementation. However, a large number of rearing juvenile coho salmon are expected to benefit from restored habitats. These fish will likely see increased growth and survival rates and be less likely to migrate downstream prematurely in search of alternative habitat, risking exposure to mainstem conditions. For this reason, smolts will be larger in size at outmigration and spend a shorter period of time in the mainstem where they will be exposed to Project operation effects. Therefore, NMFS expects that fish utilizing the restored habitats will have greater fitness and survival. Although a large number of coho salmon are expected to benefit from the restored habitats, NMFS does not expect the restoration actions on their own to offset all adverse effects of the proposed action since a portion of coho salmon rear and redistribute in the mainstem Klamath. Some fry and juvenile coho salmon rearing in the mainstem Klamath River may not directly benefit from the restoration actions and will still be subject to increased competition for space and reduced fitness from disease

2.2.5 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). 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 in the *Environmental Baseline Section* (section 2.2.3). Many activities described in the *Environmental Baseline Section* (Section 2.2.3) are reasonably certain to continue in the future. Although NMFS lacks definitive information on the extent or location of many of these categories of actions, the effects on SONCC coho salmon and their critical habitat of these future non-Federal actions are likely to be similar in the future.

2.2.5.1 Klamath Basin Agreements and Planned Dam Removals

In 2010, representatives of 45 organizations, including federal agencies, the states of California and Oregon, Indian tribes, counties, irrigators, and conservation and fishing groups of the Klamath Basin negotiated the Klamath Basin Restoration Agreement (KBRA) to address the long-term needs of the Klamath Basin (KBRA 2010). The agreement intended to: 1) restore and sustain natural production and provide for full participation in harvest opportunities of fish species throughout the Klamath Basin, 2) establish reliable water and power supplies which sustain agricultural uses and communities and NWRs, and 3) contribute to the public welfare and the sustainability of all Klamath Basin communities. The agreement included a provision to support the Hydroelectric Settlement, which established a process for potential removal of four major dams on the Klamath River, namely: IGD, Copco No. 1 Dam, Copco No. 2 Dam, and J.C. Boyle Dam (KBRA 2010).

However, the KBRA required Congressional approval to provide legal authority and funding for many activities. Because congressional approval was never obtained, the KBRA subsequently expired in 2015. An Upper Klamath Basin Comprehensive Agreement was signed in April of 2014 to address KBRA commitments, but this agreement was terminated in 2017 following the expiration of the KBRA.

Separately, many of the same organizations negotiated with PacifiCorp (not a party to the KBRA) to arrive at the Klamath Hydroelectric Settlement Agreement (KHSA) in 2010. The KHSA established a framework for potential removal of four PacifiCorp-owned developments (J.C. Boyle, Copco I, Copco II, and Iron Gate) on the Klamath River downstream of Reclamation's Klamath Project and interim operations of the KHP. The KHSA was amended in 2016 (KHSA 2016). An integral component of the amended KHSA provided that PacifiCorp and the KRRC would jointly file an application with FERC or transfer of the license for the four developments from PacifiCorp to the KRRC, and the KRRC would file an application to surrender and remove the four developments.

As described in the *Background Section* (Section 1.1), on September 23, 2016, PacifiCorp and the KRRC submitted an application to the FERC to amend the existing license for the Klamath Hydroelectric Project, establish an original license for the Lower Klamath Project consisting of four developments, and transfer the original license for the Lower Klamath Project to the KRRC. At that time, the KRRC also applied to surrender the license for the Lower Klamath Project, including removal of the four developments. On October 5, 2017, FERC issued notice of the application for amendment and transfer of the license and soliciting comments, motions to intervene, and protests. However, FERC still has not issued such a notice on the surrender application yet. According to a Definite Plan that the KRRC submitted to FERC on June 28, 2018, decommissioning of the four developments is expected to commence on January 1, 2021. However, FERC has not yet submitted a biological assessment or requested initiation of formal consultation under Endangered Species Act section 7 with the Services on any federal action that it would take to decide whether to approve decommissioning of the four developments. As described above at the beginning of this *Cumulative Effects Section*, "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." Therefore, the effects of FERC's future action of deciding whether to decommission the four developments are not included in the cumulative effects for this Opinion. However, this information about the proposed dam removal and related settlement efforts is relevant as part of the overall context of this consultation, including the five-year period of the proposed action (see USBR 2018a, Section 3.7.1 for details about dam removal and associated implications for this proposed action).

2.2.5.2 Klamath Agreements – Keno Dam Acquisition

Along with the KHSA, a Klamath Power and Facilities Agreement (KPFA) was signed in 2016 to mitigate impacts to irrigated agriculture due to increased power rates and potential impacts due to return of anadromous fish to the Upper Klamath Basin (KPFA 2016). Collectively, the two agreements commit the Department of the Interior to acquire Keno Dam from PacifiCorp, operate it consistent with historic practices, and based on NMFS' evaluation, may include the following activities: screening of diversions, management of livestock access, irrigation practices that prevent stream dewatering, protection and enhancement of riparian vegetation, fish passage improvement, culvert replacement, and reduction of erosion and sedimentation from streambanks and roads. The Department of the Interior has not acquired Keno Dam at this time. As described above at the beginning of this *Cumulative Effects Section*, "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." Therefore, the effects of Department of the Interior's future acquisition of Keno Dam and any related activities are not included in the cumulative effects for this Opinion.

2.2.5.3 Klamath Basin General Stream Adjudication

Since 1975, the State of Oregon has been in the process of adjudicating all pre-1909 and federally-reserved water rights to water from the Klamath River and its tributaries in the State of Oregon, including the rights associated with the Project. This process, generally known as the Klamath Basin General Stream Adjudication, will eventually result in a final determination of the nature and relative priority of water rights for the Project to water from the Klamath River and its tributaries, including UKL.

In 2013, the State of Oregon issued ACFFOD. Under Oregon law, the ACFFOD is subject to judicial review, but is enforceable unless stayed by the court. These proceedings are ongoing in Klamath County Circuit Court and are likely to result in changes to the ACFFOD and the nature of the water rights determined therein.

Enforcement of water rights in the ACFFOD since 2013, particularly The Klamath Tribes instream flow water rights to tributaries to UKL, has resulted in significant changes in hydrology in the Upper Klamath Basin. At times, all irrigation diversions in certain stream reaches have been completely curtailed by calls on the water rights held by the BIA on behalf of The Klamath Tribes. The *Water Rights Regulation in the Upper Klamath Basin* section (Section 1.3.2.10) in the *Proposed Federal Action* section (Section 1.3) describes how and to what extent Reclamation will determine and make additional water available to the Project due to water rights regulation, consistent with the ESA However, any potential changes to ACFFOD through the judicial review process, and their effects on hydrology in the Upper Klamath Basin, are not reasonably foreseeable, and are therefore not included in cumulative effects for this Opinion (USBR 2018a).

2.2.6 <u>Integration and Synthesis for SONCC coho Salmon</u>

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.2.3) to the environmental baseline (Section 2.2.3) and the cumulative effects (Section 2.2.5), taking into account the status of the species and critical habitat (Section 2.2.1), 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 diminishes the value of designated or proposed critical habitat for the conservation of the species.

2.2.6.1 Critical Habitat

2.2.6.1.1 Condition of Critical Habitat at the ESU Scale

The SONCC coho salmon *Status of Critical Habitat section* (Section 2.2.1.2.2) describes the condition of critical habitat at the ESU scale as mostly 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 essential features due to ongoing and past human activities. For example, large dams, such as the IGD, stop the recruitment of spawning gravels and large wood, which impacts both PBFs (spawning and rearing areas) as well as an essential feature of spawning areas (substrate). Water use in many regions throughout the ESU reduces summer base flows, which limits the establishment of several essential features such as water quality and water quantity. As mentioned in the *Status of Critical Habitat section* (Section 2.2.1.2.2) above, habitat generally remains degraded across the ESU but restorative actions have effectively improved the conservation value of critical habitat throughout the range of the SONCC coho salmon, including portions of the Interior Klamath Diversity Stratum. 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 growth and survival (Cooperman et al. 2006, Ebersole et al. 2006, Witmore 2014, Yokel et al. 2018).

2.2.6.1.2 Condition of Critical Habitat in the Interior Klamath Diversity Stratum

The current condition of critical habitat in the Interior-Klamath Diversity Stratum, which includes the Upper and Middle Klamath River reaches, is degraded. Sedimentation, low summer flows, poor water quality (including a high prevalence of fish diseases in the Klamath mainstem in some years), stream habitat simplification, and habitat loss from poorly designed road crossings and diversion structures continue to impair coho salmon streams in this stratum. Past and ongoing human activities often preclude sufficient recovery of critical habitat in the Interior Klamath Diversity Stratum to establish essential features. Water use in many regions throughout the diversity stratum (e.g., Shasta and Scott rivers) reduces summer base flows, which, in turn, limit the re-establishment of the essential features of water quantity and water quality. There has been a decline in UKL outflows since the 1960s, which is likely due to increasing Project diversions, decreasing net inflows, or other factors (Mayer 2008). Flow reductions across the stratum become most critical in periods of elevated water temperature, forcing coho salmon to seek limited areas of thermal refugia. Since the early 1990s, habitat restoration efforts in much of the Interior-Klamath diversity stratum have been incrementally improving the conservation value of critical habitat in the action area. This is evidenced by significant strides in the implementation of livestock exclusion riparian fencing, riparian habitat restoration, thermal refugia protection/enhancement, wetland habitat enhancement, fish exclusion screening, fish passage improvements, construction of beaver dam analog structures, off-channel ponds, water use efficiency, and agricultural water leasing programs. Since 2016, surface and deep flushing flow events released from IGD have improved channel condition in the Upper Klamath reach through movement of fine and coarse sediments, scouring of aquatic vegetation, and reduction of disease causing organisms. High priority restoration projects that have been funded under programs described in this Opinion provide better access to summer and winter rearing habitat, increase the abundance of rearing habitats, and improve the quality of rearing habitats. PacifiCorp, via its HCP, committed to maintain and improve coho salmon spawning and rearing habitat in the Upper Klamath River tributaries by implementing: 1) turbine venting; 2) measures to provide instream flow, flow variability, and flow ramping rate measures; 3) retrieval of large wood; 4) habitat restoration; 5) research studies; and 6) the funding and participation in IGH measures to support an HGMP. As of January 2018, implementation of these measures has included channel restoration; creation of off channel ponds, fish screens, and riparian fencing; and removal of passage barriers. In addition, turbine venting at IGD is likely improving dissolved oxygen immediately downstream of IGD. Gravel augmentation immediately below IGD, which has taken place in 2014, 2016, and 2017, is expected to improve the functionality and conservation value of critical habitat for adult spawning below IGD. The aggregate benefits from these habitat restoration efforts will be integral to the recovery of SONCC coho salmon in the Interior-Klamath diversity stratum. NMFS believes that within the period of the effects of the proposed action, climate change will continue to have noticeable effects on coho salmon and its critical habitat in the action area and effects may increase through changes to runoff, decreased snow water equivalent, decreased snowpack, and warmer air and water temperatures. Anticipated temperature increases are predicted to be as high as 0.8° C, and an annual increase in precipitation of approximately 3 percent (USBR 2011a). Projections also suggest that an increase in evapotranspiration will likely offset the increase in precipitation due to warming temperatures. The Klamath River downstream of IGD is expected to experience an approximate 5 percent increase in annual flow volume, with increases of approximately 30 percent during December through March and decreases of approximately 7 percent during April through July. However, the range of change due to hydrological conditions is expected to fall within the range of the analyzed POR, which includes a wide range of both excessively dry and excessively wet years. The apparent contradiction between decreasing snow water equivalent and increasing runoff is resolved by projections suggesting a greater proportion of precipitation will fall as rain instead of snow, and the increase in overall precipitation will be greater in the winter than in the summer.

NMFS expects many of activities discussed in the *Environmental Baseline* section will continue (e.g., harvest, predation, restoration activities, and land use/management activities). In addition, future climate change effects on coho salmon in the Klamath Basin within the period of the effects of the proposed action, may have noticeable additional effects on coho salmon beyond what has been occurring. Specific projections during the period of the effects of the proposed action that are expected to affect coho salmon include changes in seasonality of runoff, decreased snow water equivalent, decreased snowpack, and warmer air and water temperatures.

2.2.6.1.3 Project Effects on PBFs

Critical habitat for SONCC coho salmon ESU is comprised of PBFs, including spawning habitat, rearing habitat, and migration corridors to support one or more life stages of SONCC coho salmon. As summarized below, the conservation value of critical habitat in certain reaches of the Klamath River between IGD and approximately Orleans is likely to be reduced by Project operations at certain times or under certain environmental conditions, shifting what would be a more natural flow regime towards generally a drier condition. However, annual surface flushing flow events, augmented May and June flows in dry and below average water years, and implementation of restoration activities funded under the proposed action are expected to reduce adverse effects, and in some cases enhance the conservation value of critical habitat in the action area. As described in our effects analysis, we determined ramping rates at IGD are not likely to adversely affect critical habitat or coho individuals.

2.2.6.1.3.1 Spawning Habitat

The proposed action includes annual spring time surface flushing flow events which are expected to mobilize fines from Upper Klamath River spawning habitat and improve spawning habitat quality. As Project effects contribute to reductions in flow through late spring, summer and fall, some fines will settle out in spawning areas reducing the benefits from the surface flushing flow events. Generally, NMFS expects the quality and quantity of spawning habitat in the mainstem to be sufficient for the low numbers of adult coho spawners that use the mainstem for spawning.

Restoration activities will likely include improvements to coho salmon spawning habitat quality and quantity in key tributaries (e.g., Shasta and Scott rivers). Short term effects from restoration activities to spawning habitat are expected to be negligible due to required minimization measures. In summary, spawning habitat quantity and quality in the mainstem Klamath River is likely to be sufficient and, in key tributaries, improve as a result of the proposed action during the period of effects of the proposed action.

2.2.6.1.3.2 Migratory Corridors

The proposed action is not expected to decrease the conservation value of the migratory corridor for coho salmon in the action area. During the adult coho migration of September through January, the proposed action reduces flows in the mainstem Klamath River and minimum flows are likely to be common (see Hydrologic Effects section 2.2.4.1.2) . However, minimum flows under the proposed action will provide the necessary depth and velocity for adult coho salmon migration, and thus, are not expected to impede adult migration. In addition, the proposed action retains some aspects of a natural flow regime, including some flow variability from releases at IGD, which is enhanced by tributary accretions across the action area.

The juvenile migration corridor within the mainstem Klamath River is also expected to be suitable at flows of at least 900 cfs. Navigating shallow channel sections is easier for juvenile coho salmon than adult salmon due to their smaller size. Given the minimal reduction to stage height, combined with overriding factors influencing passage from the mainstem into tributaries (e.g., tributary gradient and flow), NMFS does not anticipate the proposed action will have an adverse effect on coho salmon juvenile migration corridors into tributaries. Bi-annual tribal boat dance flow increases in late summer that will result in short-term increases at IGD of approximately 750 cfs will also likely serve as a short-term environmental cue for parr coho salmon, while also enhancing passage opportunities.

Restoration activities funded under the proposed action may result in short-term disturbance to migration corridors for coho salmon when stream channels need to be temporarily re-routed; however, based on minimization measures (Flosi et al. 2010), a migratory corridor will be maintained at all times. Activities adding complexity to habitat will increase the number of pools, providing resting areas for adults, and the removal of barriers will increase access to habitat. NMFS expects restoration projects funded through Reclamation's program will prioritize opportunities to restore access to rearing and spawning habitat in key tributaries (e.g., Shasta, Scott) and increase the conservation value of existing critical habitat in the action area. Increasing available spawning habitat will allow for recolonization of new habitats by returning adults, increasing spatial structure and productivity. Restoration projects that open up previously blocked habitat are expected to have minor, short-term adverse effects to critical habitat, but increase the range of available rearing and spawning habitat for the conservation of coho salmon. Therefore, NMFS expects restoration projects that restore complexity to migratory corridors and access to habitats will increase the conservation value of existing critical habitat.

In summary, the proposed action is expected to not decrease the conservation value of migratory corridors for coho salmon in the action area during the period of effects of the proposed action, and is likely to result in some long term beneficial effects to migratory corridors from the proposed restoration activities.

2.2.6.1.3.3 Rearing Habitat

2.2.6.1.3.3.1 Habitat Availability

The proposed action will reduce coho salmon fry habitat availability in the mainstem Klamath River between IGD (RM 190) to the Salmon River (RM 65.5) in below average years (≥ 60 percent exceedance) in June, as seen in Table 17. While NMFS' ability to quantify the actual extent of habitat reduction is limited, the habitat reduction potential is greatest in the IGD to Scott River because of closer proximity to IGD. In addition, the proposed action will reduce coho salmon juvenile habitat availability in the mainstem Klamath River between the Trees of Heaven (RM 172) to Rogers Creek (RM 72) reaches at various times of the year and at various water exceedances. As discussed earlier, the proposed action generally reduces flow volume in the mainstem Klamath River throughout the year, and juvenile coho salmon habitat is below 80 percent of maximum available at less than approximately 5,000 cfs at three study reaches. While the WUA relative to IGD flow curves (see Figure 15) generally show a positive relationship between flow and habitat, there are portions of the curves where more flow does not correspond to more available habitat (or corresponds to less habitat). The effects of flow reduction on juvenile coho salmon habitat availability in the mainstem Klamath River vary spatially and temporally downstream of IGD. The proposed action reduces juvenile coho salmon habitat availability across a broad range of flow exceedance values at the Trees of Heaven, Seiad Valley, and Rogers Creek sites during the spring (Figure 15 and Table 18 to Table 20).

In summary, the proposed action will reduce coho salmon juvenile habitat availability in the mainstem Klamath River from the Trees of Heaven (RM 172) to Rogers Creek (RM 72) reaches at various times of the year and at various flow exceedances. Of the three reaches, the proposed action reduces coho salmon juvenile habitat availability in the Seiad Valley reach the most: in most water years and in all months between October and June.

Most striking of the three reaches, in the Seiad Valley reach the proposed action reduces coho salmon juvenile habitat availability in most water years and in all months between October and June. Thus, the effects of flow reduction on juvenile coho salmon habitat availability in the mainstem Klamath River vary spatially and temporally downstream of IGD.

While NMFS' ability to quantify the actual extent of habitat reduction is limited; the habitat reduction potential is greatest in the IGD to Scott River reach because of closer proximity to IGD. In addition, the proposed action will reduce coho salmon juvenile habitat availability in the mainstem Klamath River between Trees of Heaven (RM 172) and Rogers Creek (RM 72) at various times of the year over a wide range of water year types (see the *Rearing Areas* section (Section 2.2.4.1.4.3)).

While there will be reductions in rearing habitat availability, the proposed action does have flexibility at critical periods, to increase flows and enhance habitat in the mainstem, primarily through the augmented release of 20,000 ac. ft. in May and June and through the formulaic approach that releases EWA during periods of increased UKL net inflow. Flow variability through EWA releases are expected to occur during precipitation and snowmelt events, reflecting qualities of a natural flow regime. When hydrologic conditions in the upper Klamath Basin are wet, flow variability under the proposed action will result in higher flows in the mainstem Klamath River downstream of IGD. Temporary increases in mainstem flows are expected to result in short-term increases in the amount and quality of habitat in the mainstem for fry and juvenile coho salmon. Therefore, the proposed action includes provisions to reduce some adverse effects to coho salmon fry and juvenile habitat in the mainstem Klamath River. Based on the recommendations of Hardy et al. (2006), including their work to develop ecological based flows, Reclamation ensures that in the driest hydrologic conditions in the Klamath Basin, minimum flows will be met, and thus during the period of effects of the proposed action the overall risk to coho salmon fry and juvenile habitat in the mainstem will be moderate to low, depending on water year type.

NMFS anticipates adverse effects to critical habitat from habitat restoration to be minor and short-term as most restoration projects are anticipated to occur as one time disturbance events within the summer period when flows are lowest. Short-term adverse effects to rearing habitat will primarily occur as a result of dewatering the channel and increasing sediment input during instream activities. Temporary reduction of rearing habitat can occur through dewatering habitat and the filling of pools with fine sediment.

Despite the minor and short-term adverse effects, NMFS expects the suite of restoration activities will result in some long term improvements to the function and role of rearing habitat in the action area. For example, instream habitat structures and improvement projects will provide cover for juveniles to escape predators and rest, improve pool to riffle ratios, and add habitat complexity and diversity.

In summary, the proposed action will likely reduce the quantity of coho salmon juvenile rearing habitat in the mainstem Klamath River between IGD and the Salmon River, especially in the spring and during below average water years. To a lesser extent, coho fry rearing habitat will be reduced; however, such reduction is likely to occur in below average water years in June when coho fry are less common. The adverse effects to coho salmon juvenile and fry habitat in the Klamath River are likely to be somewhat moderated by flow variability incorporated into the proposed action (and from downstream additions) when hydrological conditions in the upper Klamath Basin are wet. Restoration activities are likely to increase the quantity and quality of rearing habitat in key tributaries of the action area, although restoration activities will not completely offset the adverse effects of proposed project operations.

2.2.6.1.3.3.2 Water Quality

The proposed action is likely to increase water temperature in the mainstem Klamath River between IGD and the Scott River by up to approximately 0.5 °C during the spring (Perry et al. 2011). Downstream of the Scott River mouth, the proposed action's effects on water temperature in the spring are likely insignificant because cold water accretions and meteorological conditions have a pronounced effect on water temperatures in the mainstem Klamath River. In the summer and early fall, any decreases in IGD flows are likely to reduce water temperature in the mainstem Klamath River because reservoir water behind IGD is warmer than the mainstem Klamath River. In addition, the proposed action will likely contribute to adverse effects to coho salmon rearing habitat when dissolved oxygen concentrations fall below 8 mg/L in the mainstem Klamath River during the summer.

Restoration activities funded under the proposed action are expected to improve water quality in some portions of the tributaries by replacing small irrigation dams with irrigation pumps, which eliminates an impounded area where water temperature elevates and dissolved oxygen concentrations decrease. In addition, the creation of tailwater ponds is likely to improve water temperature, dissolved oxygen concentrations and nutrient concentrations in some areas of tributaries by keeping warm and nutrient rich tailwater from directly entering the tributaries. Additional opportunities for restoration actions include conserving cold water springs in key tributaries, which are expected to be high priorities for funding under Reclamation's coho restoration grant program. Projects that protect thermal refugia will help to offset future impacts from climate change.

In summary, the proposed action is likely to adversely affect water quality in the mainstem Klamath River during the period of effects of the action by slightly increasing water temperature during the spring and decreasing dissolved oxygen concentrations during the summer. However, the proposed action may improve water quality in some key areas of the tributaries through restoration activities that reduce elevated water temperatures, increase dissolved oxygen concentrations, and decrease nutrients in tributaries. Reductions in water temperatures would be particularly important given the projected climate changes.

2.2.6.1.4 Response and Risk to the SONCC Coho Salmon ESU Critical Habitat

Many of the PBFs of SONCC coho salmon are currently degraded. As a result of implementing the proposed action, some of those PBFs will likely remain degraded for the period of effects of the action, while NMFS also expects some improvements to occur.

Mainstem rearing habitat for juvenile coho salmon will generally be limited in quantity and quality as a result of the proposed action. However, in years of average or wetter conditions, as expected in 2019, juvenile rearing habitat is likely to be sufficient in quality and quantity through the early part of spring. Generally under all water year types, juvenile rearing habitat becomes limited by late spring. Coho fry rearing habitat is expected to be sufficient in quantity through most of the spring period. By June, fry rearing habitat becomes more limited.

As water quality and water quantity conditions degrade as a result of the proposed action, mainstem Klamath River instream habitat will become conducive to disease pathogens, and in particular *C shasta*. Reclamation's surface flushing flows and augmented May and June flows will reduce the overall effects of the proposed action on these degraded conditions in coho salmon critical habitat through scouring and disturbing the habitat of the polychaete worm, *M. speciosa*, and through improvements to water quality including reduced water temperature.

The conservation value of migratory corridors of the mainstem Klamath River for all life stages of coho salmon are expected to be sufficient under the proposed action.

Long-term improvements to the PBFs of critical habitat are likely in some portions of the Klamath River tributaries near IGD. The conservation value of many of the PBFs, including rearing habitat, spawning habitat water quality and migratory corridors, in key tributaries of the Klamath River (e.g., Shasta and Scott rivers) will likely be enhanced where restoration activities are expected to occur under the proposed action and other programs.

Factoring in the status of SONCC coho salmon ESU critical habitat, the environmental baseline, and cumulative effects, the effects (both adverse and beneficial) resulting from the proposed action to the quantity and quality of the PBFs are not likely to appreciably diminish the overall conservation value of critical habitat at the diversity stratum or ESU scale.

2.2.6.2 SONCC coho salmon ESU

In the *Status of the Species* section (Section 2.2.1.2), NMFS summarized the currently high extinction risk of the SONCC coho salmon ESU. The factors that led to the listing of the SONCC coho salmon ESU as a threatened species and the currently high extinction risks include past and ongoing human activities, climatological trends and ocean conditions. Beyond the continuation of the human activities affecting the species, NMFS also expects that ocean conditions and climatic shifts will continue to have both positive and negative effects on the species' ability to survive and recover.

The extinction risk criteria established for the SONCC coho salmon ESU are intended to represent a species, including its constituent populations, that 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 become conserved, 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 effects of the environmental baseline, other activities that are interdependent or interrelated with the proposed action, and cumulative effects.

All four VSP parameters for the SONCC coho salmon ESU are indicative of a species facing moderate to high risks of extinction from myriad threats. As noted previously, 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 the 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 action area, individual coho salmon in all five populations (Upper Klamath, Middle Klamath, Shasta, Scott, and Salmon) in the Interior Klamath Diversity Stratum may be adversely affected by the proposed action. The populations within the Interior Klamath River Diversity 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 achieve a low risk of extinction. The large proportion of hatchery coho salmon to wild coho salmon reduces diversity and productivity of the wild species. However, due to the low demographics of the Upper Klamath River and Shasta River populations, 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. Iron Gate and Trinity River Hatchery Chinook salmon smolts compete with wild coho salmon for available space and resources. Poor habitat and water quality conditions in the Shasta and Scott River basins disperse larger numbers of coho salmon fry and parr out of the Shasta and Scott basins and into the mainstem Klamath River each spring than would otherwise occur if these tributaries met the ecological needs of coho salmon (Chesney and Yokel 2003). While not restricted to the Shasta and Scott rivers, coho salmon fry and parr emigration in response to poor habitat conditions appears to affect these two populations to a greater degree than other tributary-based populations within the Klamath River Basin (NRC 2004).

In the *Environmental Baseline* section (Section 2.2.3), 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 and operation of PacifiCorp's Klamath Hydroelectric Project, although PacifiCorp's Klamath Hydroelectric Project is expected to continue operating under an incidental take permit and associated HCP during the proposed action until transfer of the license for four facilities and decommissioning of those facilities occurs. The HCP is expected to minimize and mitigate the impacts of taking as a result of covered activities to the maximum extent practicable.

There has been a decline in UKL outflows since the 1960s, which is likely due to increasing Project diversions, decreasing net inflows, or other factors (Mayer 2008). There have been declines in winter precipitation in the upper Klamath Basin in recent decades and declines in upper-Klamath Lake inflow and tributary inflow, particularly base flows (Mayer 2008). Declines in tributary base flow could be due to increased consumptive use, in particular, groundwater use, and/or climate change. Agricultural diversions from the UKL have increased over the 1961 to 2007 period, particularly during dry years (Mayer 2008). Declines in Link River flows and Klamath River at Keno flows have been most pronounced during the base flow season (Mayer 2008), the time when agricultural demands are the greatest.

While the operation of the PacifiCorp's KHP will continue to block coho salmon access upstream of IGD and degrade water quality, PacifiCorp's HCP includes measures to minimize and mitigate these effects to the maximum extent practicable. PacifiCorp, via the HCP, committed to maintain and improve coho salmon spawning and rearing habitat in the Upper Klamath River tributaries by, implementing: 1) turbine venting; 2) measures to provide instream flow, flow variability, and flow ramping rate measures; 3) retrieval of large wood; 4) habitat restoration; 5) research studies; and 6) the IGH HGMP. As of January 2018, advancement on these measures has included channel restoration; creation of off channel ponds, fish screens, riparian fencing; and removal of passage barriers. In addition, turbine venting at IGD is likely improving dissolved oxygen immediately downstream of IGD. Gravel augmentation immediately below IGD, which has taken place in 2014, 2016, and 2017, is expected to improve the functionality and conservation value of critical habitat for adult spawning below IGD. Additional details on the progress of these projects are included in the *PacifiCorp Habitat and Conservation Plan* section (Section 2.2.3.2.8.5). Overall, the PacifiCorp HCP is expected to decrease the extinction risk of coho salmon in the action area.

NMFS expects many of activities discussed in the *Environmental Baseline* section will continue (e.g., harvest, predation, restoration activities, and land use/management activities). In addition, future climate change effects on coho salmon in the Klamath Basin within the period of the effects of the proposed action may have noticeable additional effects on coho salmon beyond what has been occurring. Specific projections during the period of the effects of the proposed action that are expected to affect coho salmon include changes in seasonality of runoff, decreased snow water equivalent, decreased snowpack, and warmer air and water temperatures.

2.2.6.2.1 Effects of the proposed action to the Interior Klamath River Diversity Stratum populations

As described in the *Effects to Individuals* section (Section 2.2.4.2), the proposed action is expected to result in adverse effects to coho salmon. Some of these adverse effects are expected to be minimized by elements of Reclamation's proposed action, including surface flushing flows, enhanced May and June flows in select years described throughout this opinion, flow variability proposed under the KBPM model logic, and the annual funding of restoration actions to improve critical habitat in the action area. A summary of these adverse effects and minimization measures is presented below. The coho salmon populations closest to IGD are expected to be most adversely affected. The coho salmon populations adversely affected the most to the least are the Upper Klamath (RM 128 – RM 190), Shasta (RM 177), Scott River (RM 144), Middle Klamath (RM 43 – RM 144), whereas coho salmon from the Salmon River (RM 66) population are expected to experience negligible effects from the proposed action.

Since coho salmon generally rear in freshwater for a year, adverse effects of the proposed action to rearing coho salmon may extend into the spring of 2025. Adverse effects of the proposed action to coho salmon include:

- Decreased habitat for coho salmon fry in the mainstem Klamath River from IGD to the Salmon River confluence in June during below average years ($\geq$ 50 percent exceedance);

- Decreased habitat for coho salmon juveniles in the mainstem Klamath River from IGD to downstream of Rogers Creek in March to June;

- As habitat decreases and becomes limited, coho salmon fry and juveniles are forced to use less preferable habitat, emigrate, or crowd, especially if habitat capacity is reached. All of these options likely have negative consequences for individuals. The use of less preferable habitat decreases the fitness of coho salmon individuals and increases their susceptibility to predation;

- Decreased spring flows in the mainstem Klamath River downstream of IGD and increased likelihood of consecutive drier years experienced in the Klamath River, which will likely:

- increase the likelihood of sub-lethal disease-related effects to coho salmon fry and juveniles while they are in the mainstem Klamath River between Klamathon Bridge (RM 184) and Orleans (RM 59),
- increase the likelihood of disease-related mortality for coho salmon fry and juvenile in the mainstem Klamath River between Trees of Heaven (RM 172) and Seiad Valley (RM 129) in May through June when environmental conditions are conducive to disease proliferation,
- increase stress to coho salmon fry and juveniles when daily maximum water temperature become chronically above 16.5 °C in the mainstem Klamath River between IGD and Scott River (RM 144) in May through June;

- Decreased summer flows, which will also result from adaptively increasing spring flows to reduce disease risks, will likely decrease dissolved oxygen in the mainstem Klamath River below 6.0 mg/L during the summer, which will likely increase stress to coho salmon juveniles in the mainstem Klamath River between IGD (RM 190) and Orleans (RM 59) during the night and early morning;

- Using data from the NOAA Restoration Center monitoring reports and Reclamation's project tracking spreadsheet, NMFS estimates that up to 800 juvenile SONCC coho salmon may be captured annually, of which up to eight juvenile SONCC coho salmon may be injured or killed, from fish relocation, structural placement and dewatering activities associated with some restoration actions.

Similar to the adverse effects described above, the coho salmon populations closest to IGD are expected to benefit most from the flow-related minimization measures on the mainstem Klamath River. Therefore, the coho salmon populations receiving the most beneficial effect of the flow-related minimization measures on the mainstem Klamath River, in order of the greatest to the least, are the Upper Klamath, Shasta, Scott, Middle Klamath, and Salmon River populations. Similarly, populations that are most likely to be adversely affected by effects of Project operations are prioritized for restoration actions under the Coho Restoration Grant Program (i.e., Upper Klamath, Shasta, Scott, Middle Klamath). The Salmon River population is expected to have minimal adverse effects resulting from the proposed action due to low exposure to flow related effects of the proposed action.

The following measures or factors incorporated into the proposed action will minimize some of the adverse effects listed above:

- Reclamation proposes to implement annual surface flushing flow events during the next five years defined as IGD releases of 6,030 cfs for a 72-hour duration. NMFS anticipates surface flushing flow events will reduce disease risks to juvenile coho salmon that could occur as a result of Project operations;

- Unlike the POR, improved hydrologic conditions in the mainstem Klamath River (i.e., higher magnitude and frequency of sediment maintenance flows) will likely decrease the likelihood of *C. shasta* infections for coho salmon fry and juveniles in the mainstem Klamath River between Klamathon Bridge (RM 184) and Orleans (RM 59) during March to June;

- Reclamation proposes to implement a 20,000 acre-foot release of augmented flow in May and June in dry through average water years during the next five years with flexibility to utilize in a manner that optimizes the volume to enhance conditions for juvenile coho salmon;

- Elements of flow variability incorporated into the proposed action are likely to increase spring flows when precipitation and snow melt is occurring in the Upper Klamath Basin, resulting in water quality improvements, such as reduced water temperatures and short term increases to rearing habitat for coho salmon fry and juveniles, and resulting in environmental cues for juvenile or adult migration. Flow variability is expected to be enhanced in wetter water years during the period of effects of the proposed action, and NMFS anticipates extensive flow variability in 2019 due to the above average snowpack;

- The minimum daily flows provide a limit to the disease risks posed to coho salmon under the proposed action by ensuring ecological base flows are met in critical times for coho salmon, including the spring and summer months;

- Reclamation's proposed restoration program is likely to result in funding of eight restoration projects each year of the proposed action. NMFS expects the suite of restoration activities implemented during the next five years will result in some long term improvements to the function and role of spawning, rearing, and migration habitat in the action area.

The proposed action's adverse effects and the minimization measures of both the Project operations and habitat restoration components of the proposed action are integrated and summarized in the table below.

Table 25. Summary of the proposed action's adverse effects and minimization measures.

<table>
<tr><th>Potential Stressor</th><th>Project Effects</th><th>Life Stage</th><th>General Time</th><th>Mainstem Location</th><th>Minimization Measure(s)</th><th>Proposed Action Effects</th></tr>
<tr><td rowspan="2">Habitat Reduction</td><td rowspan="2">Increased likelihood of reduced growth or survival to some individuals</td><td>Fry</td><td>June</td><td>IGD (RM 190) to Salmon River (RM 66)</td><td rowspan="2">Riparian and instream habitat restoration in the mainstem will likely help offset some of the habitat reduction during the next five years. Riparian restoration would generally require several years to effectively provide off setting effects. Instream restoration would provide more immediate benefits to fry. Successful floodplain restoration and creation of off-channel ponds will provide some high quality rearing habitat for coho salmon fry, which will likely offset some of the habitat reduction.

Water conservation projects may offset some habitat reductions. However, water conservation projects are most likely to occur in the tributaries, such as the Shasta and Scott rivers, and are expected to result in minor improvements to mainstem Klamath River habitat availability.

Elements of the proposed action that result in increased flow releases during periods of precipitation and/or snowmelt will enhance flow variability and likely provide improved water quality and water quantity conditions for coho salmon in the mainstem Klamath River

Formulaic approach prioritizes EWA releases in the spring and minimum daily flow targets in April to June meet Hardy et al.'s (2006) recommended ecological base flows.</td><td rowspan="2">The proposed action will result in habitat reductions in the mainstem Klamath River. However, the minimization measures are likely to offset some of the habitat reductions, especially during above average and wetter water years when flow variability is more likely to occur increasing flows in the mainstem Klamath River.</td></tr>
<tr><td>Parr and Smolts</td><td>March to June</td><td>Trees of Heaven (RM 172) to Rogers Creek (RM 72)</td></tr>
</table>

Potential Stressor	**Project Effects**	**Life Stage**	**General Time**	**Mainstem Location**	**Minimization Measure(s)**	**Proposed Action Effects**
Disease	Increased likelihood of impaired growth, swimming performance, body condition, and increased stress and susceptibility to secondary infections	Fry	May to mid-June	Klamathon Bridge (RM 187.6) to Orleans (RM 59)	Elements of the proposed action that result in increased flow releases during periods of precipitation and/or snowmelt are expected to attain thresholds in above average and wetter years that will help to disturb polychaetes and their habitats and ultimately reduce transmission of *C. shasta* on coho salmon. Compared to observed POR conditions, the proposed action will increase the magnitude and frequency of surface flushing flows, which will likely decrease the abundance of polychaetes in the spring and summer following a sediment maintenance flow event. In turn, this will likely decrease actinospore concentrations in the mainstem Klamath River and decrease *C. shasta* prevalence of infection, relative to the observed POR. The adaptive management element of the proposed action which includes augmenting IGD releases by 20,000 acre feet to benefit juvenile coho salmon is likely to reduce disease risks to coho salmon during average to below average water. Lastly, the proposed minimum daily flows in April to June will limit the increase in disease risks posed to coho salmon under the proposed action.	The proposed action will result in disease risks to coho salmon that are lower than observed POR conditions yet higher than under natural flow conditions.
		Parr	May to August			
		Smolts	May to June			
	Increased likelihood of disease-related mortality	Fry	May to mid-June	Trees of Heaven (RM 172) to Seiad Valley (RM 129)		
		Parr, and Smolts	May to June			

Potential Stressor	Project Effects	Life Stage	General Time	Mainstem Location	Minimization Measure(s)	Proposed Action Effects
Elevated water temperature	Increased stress	Fry	May to mid-June	IGD to Scott River (RM 144)	Flow variability incorporated into the proposed action will likely provide increased spring flows when precipitation and snow melt is occurring in the Upper Klamath Basin, especially during wetter water years. Water conservation projects and habitat improvements to areas of thermal refugia are expected to improve water quality conditions in the mainstem Klamath River.	Coho salmon will continue to have increased stress from slightly elevated water temperatures when daily maximum water temperatures become chronically above 16.5 °C in May to June
		Parr and Smolts	May to June			
DO reduction	Decreased swimming performance and increased stress	Parr	June to August	IGD (RM 190) to Orleans (RM 59)	Water conservation projects and habitat improvements to areas of thermal refugia are expected to improve water quality conditions in the mainstem Klamath River.	Coho salmon parr will continue to have decreased swimming performance or increased stress from decreased dissolved oxygen concentration in the mainstem during the late night and early morning when dissolved oxygen concentrations are below 8.0 mg/L or 6.0 mg/L, respectively.

Potential Stressor	Project Effects	Life Stage	General Time	Mainstem Location	Minimization Measure(s)	Proposed Action Effects
Decreased outmigration rate	Increased likelihood of mortality from other stressors in the mainstem Klamath River (e.g., disease, predation, impaired water quality)	Smolts	April to June	IGD (RM 190) to Shasta River (RM 177)	The adaptive management element of the proposed action which includes augmenting IGD releases by 20,000 acre feet to benefit juvenile coho salmon is likely to enhance environmental cues for outmigration during average to below average water year types.	Coho salmon smolts are likely to continue to have decreased outmigration rate in this reach, which will likely increase likelihood of decreased growth or increased mortality when environmental conditions are conducive to having increased stressors, such as increased water temperatures and disease proliferation.
Fish relocation Dewatering Structural Placement	Injury or mortality	Parr and smolts	June 15 to November 1	IGD (RM 190) to Salmon River (RM 66) and tributaries in action area	Compliance with CDFW's Restoration Manual (Flosi et al. 2010), proposed construction windows, and NMFS's fish screen criteria (NMFS 1997).	Up to 800 coho salmon juveniles may be captured each year, of which up to 8 may be injured or killed each year.

2.2.6.2.2 Effects of fitness consequences on population viability parameters

2.2.6.2.2.1 Abundance

NMFS expects the proposed action will reduce spring rearing juvenile habitat availability, decrease outmigration rates, and contribute to continued water quality impairments in the mainstem Klamath River in the spring and summer. However, the aggregate effect of the proposed minimization measures such as annual surface flushing flows, enhanced flexibility to release 20,000 ac. ft. of water in the May and June period, maintaining elements of flow variability in the proposed action, and funding at least 2.9 million dollars total for the restoration program, will help to reduce these effects of the proposed action. Through the coho restoration grant program, Reclamation, with assistance from NMFS, will prioritize restoration projects that conserve water at critical periods and enhance instream and off-channel habitats that improve rearing habitat for coho salmon fry and juveniles in key coho tributary rearing habitats, such as the Shasta and Scott rivers, which is expected to decrease the number of coho salmon fry and parr that prematurely migrate out of the tributaries. By reducing the number of coho salmon fry and parr that prematurely enter the mainstem Klamath River, the exposure duration of these coho salmon life stages to the adverse effects in the mainstem Klamath River will be minimized somewhat through the proposed action.

Of all the adverse effects of the proposed action, NMFS concludes that the disease risk from *C. shasta* is the most significant to coho salmon because *C. shasta* is a key factor limiting salmon recovery in the Klamath River (Bartholomew et al. 2007). While the proposed action will reduce disease prevalence relative to the POR, NMFS does not expect the minimization measures proposed by Reclamation to completely offset effects of the proposed action contributing to *C. shasta* infection in coho salmon. However, implementation of court ordered flows in 2017 and 2018 illustrate benefits of surface flushing flows, including disturbed polychaete habitat and low prevalence of infection in juvenile salmonids. While NMFS cannot quantify the magnitude of the increased disease risk to coho salmon as a result of the proposed action, NMFS concludes that the proposed action will result in disease risks to coho salmon that are lower than under observed POR. Populations closest in proximity to IGD and exposed to the infectious zone from I-5 through Seiad (i.e., Upper and Middle Klamath, Shasta, and Scott river populations) are expected to experience improvement in survival, and abundance of these populations is expected to improve.

2.2.6.2.2.2 Productivity

As discussed above, NMFS expects the proposed action will result in disease risks to coho salmon that are lower than under observed POR conditions yet higher than under natural flow conditions. Populations of coho salmon that are likely to experience improved survival are the Upper and Middle Klamath, Shasta and Scott rivers. By lowering disease risks, NMFS believes that coho salmon fry and juveniles will have a greater chance of returning as adults, which is expected to result in higher productivity to Upper and Middle Klamath, Shasta and Scott rivers populations over the period of effects of the proposed action.

2.2.6.2.2.3 Diversity

As described in the *Environmental Baseline* section (Section 2.2.3), coho salmon exhibit unique life history strategies including non-natal rearing that depend on the mainstem Klamath River for survival. Life history diversity of coho salmon substantially contributes to their persistence, and environmental variability is a key component for a species to exhibit a diversity of life history strategies. As described in the *Hydrological Effects* section (Section 2.2.4.1.2), the proposed action contributes in part to an impaired hydrology in the mainstem Klamath River, which is expected to reduce flow variability and magnitude during spring periods when coho salmon fry and juveniles are expected to be most abundant in the mainstem Klamath River. As analyzed in our *Effects of the Action* section (Section 2.2.4), Reclamation proposes measures to reduce flow-related effects of the proposed action, including more frequent surface flushing flows, augmented May and June flows during average and below average water years, and habitat restoration. Efforts to reduce *C. shasta* infection in particular will help improve the diversity of coho salmon by increasing survival rates of individuals while present in the mainstem Klamath River. In addition, water conservation and other habitat restoration activities in the tributaries will likely enhance key tributary rearing habitats, which is expected to decrease the number of coho salmon fry migrating out of the tributaries due to poor conditions. During summer months, when coho parr are most likely to utilize areas of the thermal refugia of mainstem Klamath River and lower portions of tributaries, the proposed action is expected to provide sufficient flows to allow fish access. Therefore, NMFS concludes the proposed action is not likely to result in a level of effects that will reduce diversity of affected populations.

2.2.6.2.2.4 Spatial Structure

As discussed in the *Effects to Individuals* section (Section 2.2.4.2) NMFS concludes that the proposed action is not likely to adversely affect adult coho salmon migration in the mainstem Klamath River, and NMFS does not expect the proposed action will have an adverse effect on coho salmon juvenile migration corridors into tributaries. In addition, the proposed habitat restoration is likely to increase coho salmon spatial structure in the action area when barriers or impediments to migration are removed. Therefore, NMFS does not expect the proposed action will reduce the spatial structure of coho salmon.

2.2.6.2.3 Summary

NMFS concludes that coho salmon individuals from Salmon River and Lower Klamath River populations are unlikely to experience more than negligible impacts from the proposed action. However, individuals from the Upper Klamath, Shasta, Scott and Middle Klamath populations are likely to experience adverse effects from the proposed action. Of all the adverse effects of the proposed action, NMFS believes that the disease risk from *C. shasta* is the most significant to coho salmon. NMFS concludes that the proposed action will result in disease risks to coho salmon that are lower than under observed POR conditions yet likely higher than under natural flow conditions. By lowering disease risks in a direction toward those under natural flow conditions, NMFS believes that coho salmon abundance and productivity will likely improve over the period of effects of the proposed action for the Upper Klamath, Middle Klamath, Shasta, and Scott populations, which will improve survival, and not appreciably reduce the likelihood of recovery for these populations. NMFS concludes the proposed action is not likely to result in a level of habitat reduction where coho salmon fry and juveniles in the coho salmon populations in the actions area will have reduced life history diversity. Finally, NMFS does not expect the proposed action will reduce the spatial structure of coho salmon populations in the action area.

Factoring in the status of the Klamath River coho salmon populations and the SONCC coho salmon ESU, the environmental baseline conditions of the action area, and the cumulative effects, NMFS concludes the proposed action is not likely to increase the extinction risk of the Upper Klamath, Shasta, Scott, Salmon, and Middle Klamath river populations. Therefore, the proposed action is not likely to increase the extinction risk of the Interior Klamath River Diversity Stratum or the SONCC coho salmon ESU. As a result, NMFS concludes the proposed action would not be expected to appreciably reduce the likelihood of both the survival and recovery of the SONCC coho salmon ESU.

2.3 Southern Resident Killer Whale DPS (Southern Residents)

2.3.1 Rangewide Status of the Species

As described above, this Opinion examines the status of each species that would 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' current "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The action area does not include the area designated as critical habitat for Southern Residents (see the Action Area for Southern Residents section below). Therefore, this Opinion does not examine the condition of critical habitat for Southern Residents or further address such critical habitat.

The Southern Resident Killer Whale DPS (Southern Residents), composed of J, K and L pods, was listed as endangered under the ESA in 2005 (70 FR 69903 (November 18, 2005)). A 5-year review under the ESA completed in 2016 concluded that Southern Residents should remain listed as endangered and includes recent information on the population, threats, and new research results and publications (NMFS 2016e).

The limiting factors described in the final recovery plan included reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS 2008a). This section summarizes the status of Southern Residents throughout their range, using information taken largely from the recovery plan (NMFS 2008a), recent 5-year review (NMFS 2016e), as well as new data that became available more recently.

2.3.1.1 Status of Southern Residents

2.3.1.1.1 Abundance, Productivity, and Trends

Southern Residents are a long-lived species, with late onset of sexual maturity (review in NMFS 2008a). Females produce a low number of surviving calves over the course of their reproductive life span (Bain 1990, Olesiuk et al. 1990). Compared to Northern Resident killer whales (a resident killer whale population with a sympatric geographic distribution ranging from coastal waters of Washington State and British Columbia north to Southeast Alaska) Southern Resident females appear to have reduced fecundity (Ward et al. 2013, Velez-Espino et al. 2014); the average inter-birth interval for reproductive Southern Resident females is 6.1 years, which is longer than the 4.88 years estimated for Northern Resident killer whales (Olesiuk et al. 2005). Recent evidence has indicated pregnancy hormones (progesterone and testosterone) can be detected in Southern Residents feces and have indicated several miscarriages, particularly in late pregnancy (Wasser et al. 2017). The authors suggest this reduced fecundity is largely due to nutritional limitation. Mothers and offspring maintain highly stable social bonds throughout their lives, which is the basis for the matrilineal social structure in the Southern Resident population (Bigg et al. 1990, Baird 2000, Ford et al. 2000). Groups of related matrilines form pods. Three pods – J, K, and L – make up the Southern Resident population.

At present, the Southern Resident population has declined to the lowest levels seen in over 30 years (Figure 18). Since censuses began in 1974, J and K pods have steadily increased their sizes. However, the population suffered an almost 20 percent decline from 1996-2001 (from 97 whales in 1996 to 81 whales in 2001), largely driven by lower survival rates in L pod. The overall population had increased slightly from 2002 to 2010 (from 83 whales to 86 whales). During an international science panel review of the effects of salmon fisheries (Hilborn et al. 2012), the panel stated that during 1974 to 2011, the population experienced a realized growth rate of 0.71 percent, from 67 individuals to 87 individuals. In 2014 and 2015, there was a "baby boom" in the Southern Residents population that was the result of multiple successful pregnancies that occurred in 2013 and 2014. However, as of December 2018, the population has decreased to only 74 whales, a historical low in the last 30 years with a current realized growth rate (from 1974 to 2017) at half of the previous estimate described in the science panel report; 0.29 percent.

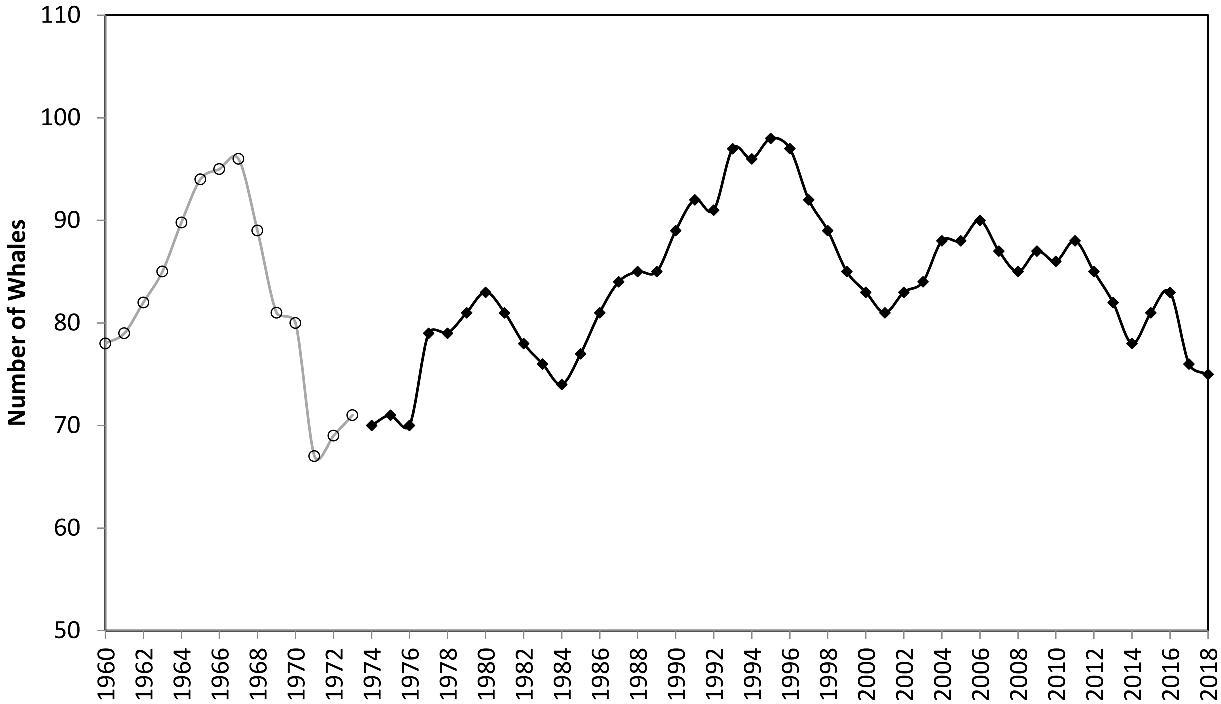

Figure 18**.** Population size and trend of Southern Residents, 1960-2018. Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of Olesiuk et al. (1990). Data from 1974-2018 (diamonds, black line) were obtained through photo-identification surveys of the three pods (J, K, and L) in this community and were provided by the Center for Whale Research (CWR; unpublished data) and NMFS (2008a).

There is representation in all three pods, with 22 whales in J pod, 18 whales in K pod and 34 whales in L pod. Although the age and sex distribution is generally similar to that of Northern Residents that are a stable and increasing population (Olesiuk et al. 2005), there are several demographic factors of the Southern Resident population that are cause for concern, namely reduced fecundity, sub-adult survivorship in L pod, and the total number of individuals in the population (review in 2008a)). Based on an updated pedigree from new genetic data, most of the offspring in recent years were sired by two fathers, meaning that less than 30 individuals make up the effective reproducing portion of the population. Because a small number of males were identified as the fathers of many offspring, a smaller number may be sufficient to support population growth than was previously thought (Ford et al. 2011, NWFSC unpublished data). Some offspring were the result of matings within the same pod raising questions and concerns about inbreeding effects. Research into the relationship between genetic diversity, effective breeding population size, and health is currently underway to determine how this metric can inform us about extinction risk and inform recovery (NWFSC unpublished data).

Seasonal mortality rates among Southern and Northern Resident whales may be highest during the winter and early spring, based on the numbers of animals missing from pods returning to inland waters each spring. Olesiuk et al. (2005) identified high newborn mortality that occurred outside of the summer season. At least 12 newborn calves (nine Southern Residents and three

Northern Residents) were seen outside the summer field season and disappeared by the next field season. Additionally, stranding rates are higher in winter and spring for all killer whale forms in Washington and Oregon (Norman et al. 2004). Data collected from three Southern Resident strandings in the last five years have contributed to our knowledge of the health of the population and the impact of the threats to which they are exposed. Transboundary partnerships have supported thorough necropsies of L112 in 2012, J32 in 2014, and L95 in 2016, which included testing for contaminant load, disease and pathogens, organ condition, and diet composition. A final necropsy report for J34, who was found dead near Sechelt, British Columbia on December 20, 2016, is still pending.[20]

The NWFSC continues to evaluate changes in fecundity and mortality rates, and has updated the work on population viability analyses conducted for the 2004 Status Review for Southern Residents and the 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, the data now suggests a downward trend in population growth projected over the next 50 years. As the model projects out over a longer time frame (50 years) there is increased uncertainty around the estimates; however, if all of the parameters in the model remain the same the overall trend shows a decline in later years. This downward trend is in part due to the changing age and sex structure of the population, but also related to the relatively low fecundity rate observed over the period from 2011 to 2016 (Figure 19)(NMFS 2016e)). To explore potential demographic projections, Lacy et al. (2017) constructed a population viability assessment that considered sublethal effects and the cumulative impacts of threats (contaminants, acoustic disturbance, and prey abundance). They found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate. Furthermore, they suggested in order for the population to reach the recovery target of 2.3 percent growth rate, the acoustic disturbance would need to be reduced in half and the Chinook salmon abundance would need to be increased by 15 percent (Lacy et al. 2017).

Ford and Ellis (2006), Ford et al. (2010) evaluated 25 years of demographic data from Southern and Northern Resident killer whales and found that changes in survival largely drive their population, and the populations' survival rates were strongly correlated with coast-wide availability of Chinook salmon. Ward et al. (2009) found that Northern and Southern Resident killer whale fecundity was highly correlated with Chinook salmon abundance indices, and reported the probability of calving increased by 50 percent between low and high Chinook salmon abundance years. More recently, Ward et al. (2013) considered new stock-specific Chinook salmon indices and found strong correlations between the indices of Chinook salmon abundance, such as the West Coast Vancouver Island (WCVI) used by the Pacific Salmon Commission, and killer whale demographic rates. However, no single stock or group of stocks was identified as being most correlated with the whales' demographic rates. Further, they stress that the relative importance of specific stocks to the whales likely changes over time (Ward et al. 2013).

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[20] The initial findings can be found at: http://www.pac.dfo-mpo.gc.ca/fm-gp/species-especes/mammalsmammiferes/srkw-eprs-j34-eng.html

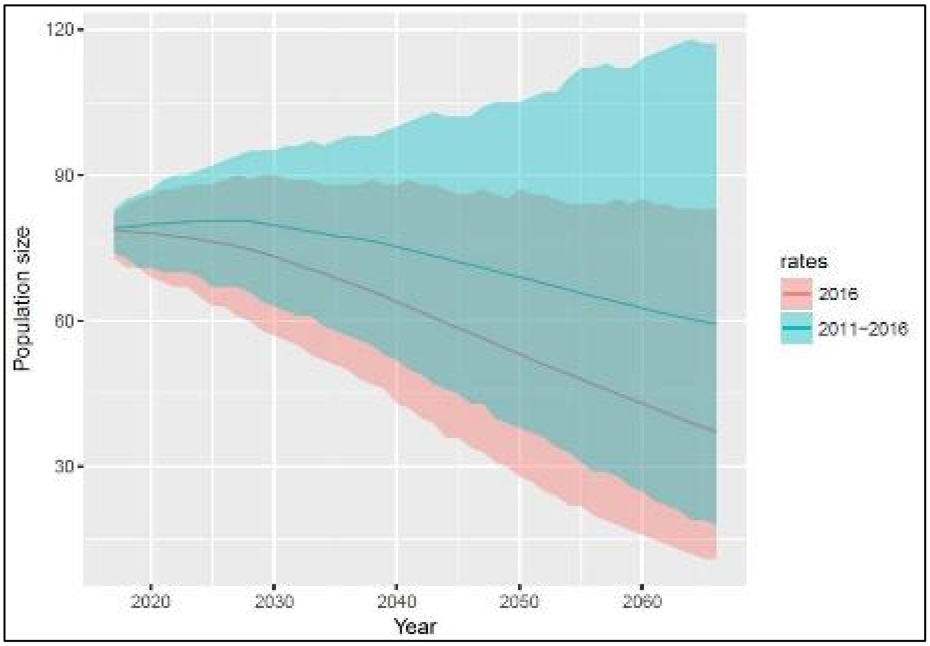

Figure 19. Southern Residents population size projections from 2016 to 2066 using 2 scenarios: (1) projections using demographic rates held at 2016 levels, and (2) projections using demographic rates from 2011 to 2016. The pink line represents the projection assuming future rates are similar to those in 2016, whereas the blue represents the scenario with future rates being similar to 2011 to 2016 (NMFS 2016e).

Because of this population's small abundance, it is also susceptible to demographic stochasticity – randomness in the pattern of births and deaths among individuals in a population. Several other sources of stochasticity can affect small populations and contribute to variance in a population's growth and extinction risk. Other sources include environmental stochasticity, or fluctuations in the environment that drive fluctuations 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, known as the extinction vortex (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. A delisting criterion for the Southern Residents DPS is an average growth rate of 2.3 percent for 28 years (NMFS 2008a). In light of the current average growth rate of 0.29 percent (from 1974 to present), this recovery criterion reinforces the need to allow the population to grow quickly.

2.3.1.1.2 Geographic Range and Distribution

Southern Residents 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 (NMFS 2008a, Hanson et al. 2013, Carretta et al. 2017) (Figure 20). Southern Residents 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 spend a 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). In general, the three pods are increasingly more present in May and June and spend a considerable amount of time in inland waters through September. Late summer and early fall movements of Southern Residents in the Georgia Basin are consistent, with strong site fidelity shown to the region as a whole and high occurrence in the San Juan Island area (Hauser et al. 2007, Hanson and Emmons 2010). All three pods generally remain in the Georgia Basin through October and make frequent trips to the outer coasts of Washington and southern Vancouver Island and are occasionally sighted as far west as Tofino and Barkley Sound (Ford et al. 2000, Hanson and Emmons 2010; Whale Museum unpublished data). Sightings in late fall decline as the whales shift to the outer coasts of Vancouver Island and Washington.

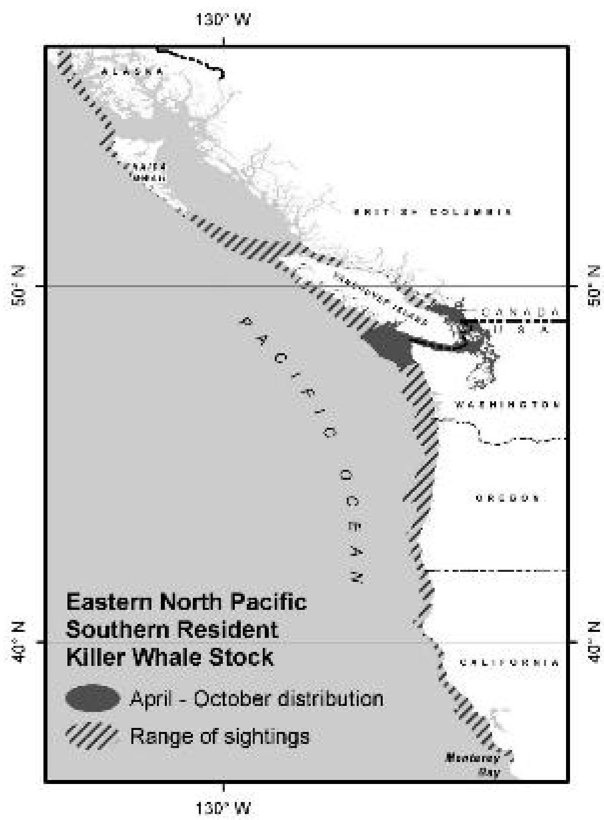

Figure 20. Geographic range of Southern Residents (Reprinted from Carretta et al. (2017)).

Although seasonal movements are generally 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; Whale Museum unpublished data). For example, K pod has had variable occurrence in June ranging from 0 days of occurrence in inland waters to over 25 days (Figure 21). Fewer observed days in inland waters likely indicate changes in their prey availability (i.e., abundance, distribution and accessibility). During fall and early winter, Southern Resident pods, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum and Chinook salmon runs (Osborne 1999, Hanson et al. 2010).

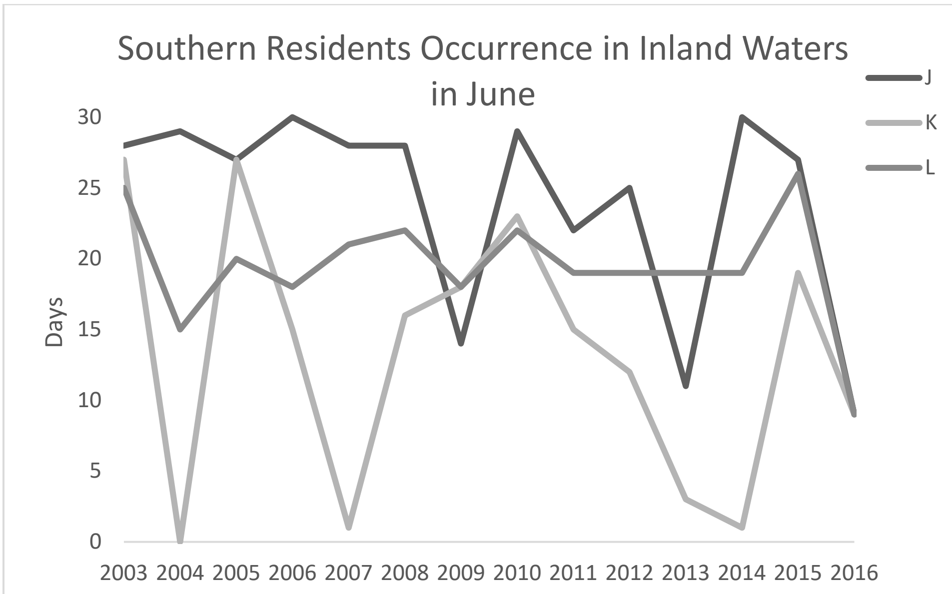

Figure 21. Number of days of Southern Residents occurrence in inland waters number in June for each year from 2003 to 2016 (data from The Whale Museum).

In recent years, several sightings and acoustic detections of Southern Residents have been obtained off the Washington and Oregon coasts in the winter and spring (Hanson et al. 2010, Hanson et al. 2013; NWFSC unpublished data). Satellite-linked tag deployments have also provided more data on the Southern Residents movements in the winter indicating that K and L pods use the coastal waters along Washington, Oregon, and California during non-summer months (NWFSC unpubl. Data). Detection rates of K and L pods on the passive acoustic recorders occur with greater frequency off the Columbia River and Westport and are most common in March (Hanson et al. 2013). J pod has also only been detected on one of seven passive acoustic recorders positioned along the outer coast (Hanson et al. 2013). The limited range of the sightings/ acoustic detections of J pod in coastal waters, the lack of coincident occurrence during the K and L pod sightings, and the results from satellite tagging in 2012–2016 (NWFSC unpubl. data) indicate J pod has limited occurrence along the outer coast and extensive occurrence in inland waters, particularly in the northern Georgia Strait.

2.3.1.2 Limiting Factors and Threats

Several factors identified in the final recovery plan for Southern Residents may be limiting recovery. These are quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Oil spills are also a risk factor. 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 (Lacy et al. 2017) and available data suggests that all of the threats are potential limiting factors (NMFS 2008a).

2.3.1.2.1 Quantity and Quality of Prey

Southern Residents 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. Southern Residents are the subject of ongoing research, including direct observation, scale and tissue sampling of prey remains, and fecal sampling. The diet data indicate that the whales are consuming mostly larger (i.e., older) Chinook salmon. Chinook salmon is their primary prey despite the much lower abundance in some areas and during certain time periods in comparison to other salmonids, for reasons that remain unknown, but factors of potential importance include the Chinook salmon species' 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 (kilocalories/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 approximately 2.7 coho, 3.1 chum, 3.1 sockeye, or 6.4 pink salmon (O'Neill et al. 2014). Caloric content and size at maturity are likely similar in wild and hatchery fish; however, size at return is dependent on age class and differences in wild and hatchery age classes are known to occur. Recent research suggests that Resident killer whales are capable of detecting, localizing and recognizing Chinook salmon through their ability to distinguish Chinook salmon echo structure as different from other salmon (Au et al. 2010).

Scale and tissue sampling from May to September in inland waters of WA and BC indicate that their diet consists of a high percentage of Chinook salmon (monthly proportions as high as >90 percent) (Hanson et al. 2010, Ford et al. 2016). Genetic analysis of the Hanson et al. (2010) samples indicate that when Southern Residents are in inland waters from May to September, they consume Chinook salmon stocks that originate from regions including the Fraser River (including Upper Fraser, Mid Fraser, Lower Fraser, North Thompson, South Thompson and Lower Thompson), Puget Sound (North and South Puget Sound), the Central British Columbia Coast and West and East Vancouver Island.

DNA (deoxyribonucleic acid) quantification methods are used to estimate the proportion of different prey species in the diet from fecal samples (Deagle et al. 2005). Recently, Ford et al. (2016) confirmed the importance of Chinook salmon to the Southern Residents in the summer months using DNA sequencing from whale feces. Salmon and steelhead made up to 98 percent of the inferred diet, of which almost 80 percent were Chinook salmon. Coho salmon and steelhead are also found in the diet in spring and fall months when Chinook salmon are less abundant. Specifically, coho salmon contribute to over 40 percent of the diet in late summer, which is evidence of prey shifting at the end of summer towards coho salmon (Ford et al. 1998, Ford and Ellis 2006, Hanson et al. 2010, Ford et al. 2016). Less than 3 percent each of chum salmon, sockeye salmon, and steelhead were observed in fecal DNA samples collected in the summer months (May through September). Prey remains and fecal samples collected in inland waters during October through December indicate Chinook and chum salmon are primary contributors of Southern Resident's diet (NWFSC unpubl. data).

Observations of whales overlapping with salmon runs (Wiles 2004, Zamon et al. 2007, Krahn et al. 2009) and collection of prey and fecal samples have also occurred in coastal waters in the winter months. Preliminary analysis of prey remains and fecal samples sampled during the winter and spring in coastal waters indicated the majority of prey samples were Chinook salmon, with a smaller number of steelhead, chum salmon, and halibut (NWFSC unpubl. data). 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 included 12 U.S. west coast stocks, and over half the Chinook salmon consumed originated in the Columbia River (NWFSC unpubl. data). Columbia River, Central Valley, Puget Sound, and Fraser River Chinook salmon comprise over 90 percent of the whales' coastal Chinook salmon diet (NWFSC unpubl. data).

There are many factors that affect the abundance, productivity, spatial structure, and diversity, of Chinook salmon and thus affect prey availability for the whales. For example, Lower Columbia River Chinook salmon populations began to decline by the early 1900s because of habitat alterations and harvest rates that were unsustainable, particularly given changing habitat conditions. Human impacts and limiting factors come from multiple sources, including hydropower development, habitat degradation, hatchery effects, fishery management and harvest decisions, and ecological factors that include environmental variability and predation of salmonids by a number of marine mammals and other marine species. Following along these lines, in 2011 NMFS convened an independent science panel to critically evaluate the effects of salmon fisheries on the abundance of Chinook salmon available to Southern Residents. Overall, the panel concluded that at a broad scale, salmon abundance will likely influence the recovery of the whales, but the impact of reduced Chinook salmon harvest on future availability of Chinook salmon to Southern Residents is not clear, and the panel cautioned against overreliance on correlative studies or implicating any particular fishery (Hilborn et al. 2012). Following the independent science panel approach on the effects of salmon fisheries on Southern Residents (Hilborn et al. 2012), NMFS and partners have actively engaged in research and analyses to fill gaps and reduce uncertainties raised by the panel in their report.

In general, over the past decade, some Chinook salmon stocks within the range of the whales have had relatively high abundance (e.g. WA/OR coastal stocks, some Columbia River stocks) compared to the previous decade, whereas other stocks originating in the more northern and southern ends of the whales' range (e.g. most Fraser stocks, Northern and Central B.C. stocks, Georgia Strait, Puget Sound, and Central Valley) have declined. Changing ocean conditions driven by climate change may influence ocean survival of Chinook and other Pacific salmon, further affecting the prey available to Southern Residents.

In an effort to identify Chinook salmon stocks that are important to Southern Residents and prioritize recovery efforts to increase the whales' prey base, NMFS and Washington Department of Fish and Wildlife (WDFW) released a priority stock report identifying the Chinook salmon stocks of most importance to the health of the Southern Resident populations along the West Coast (NOAA and WDFW 2018) [21]. The priority stock report was created by analyzing scat and prey scale/tissue samples to identify Chinook salmon stocks in the whales' diet, observing 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 Southern Residents 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 26 is a summary of those stock descriptions.

[21]https://www.westcoast.fisheries.noaa.gov/publications/protected_species/marine_mammals/killer_whales/recovery/srkw_priority_chinook_stocks_conceptual_model_report___list_22june2018.pdf

Table 26. Summary of the priority Chinook salmon stocks (adapted from NOAA and WDFW 2018)

Priority	ESU/Stock Group	Run Type	Rivers or Stocks in Group
1	North Puget Sound South Puget Sound	Fall	Nooksack, Elwha, Dungeness, Skagit, Stillaguamish, Snohomish, Nisqually, Puyallup, Green, Duwamish, Deschutes, Hood Canal Systems
2	Lower Columbia Strait of Georgia	Fall	Fall Tules and Fall Brights (Cowlitz, Kalama, Clackamas, Lewis, others), Lower Strait (Cowichan, Nanaimo), Upper Strait (Klinaklini, Wakeman, others), Fraser (Harrison)
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
14	North/Central Oregon Coast	Fall	Northern (Siuslaw, Nehalem, Siletz) and Central (Coos, Elk, Coquille, Umpqua)
15	West Vancouver Island	Fall	Robertson Creek, WCVI Wild
16	Southern OR & Northern CA Coastal	Fall and Spring	Rogue, Chetco, Smith, Lower Klamath, Mad, Eel, Russian
	California Coastal	Fall and Spring	

Currently, hatchery production is a significant component of the salmon prey base returning to watersheds within the range of Southern Residents (Barnett-Johnson et al. 2007, NMFS 2008a). Although hatchery production has contributed some offset 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). Healthy natural-origin salmon populations are important to the long-term maintenance of prey populations available to Southern Residents because it is uncertain whether a hatchery dominated mix of stocks is sustainable indefinitely and because hatchery fish can differ, relative to natural-origin Chinook salmon, for example, in size and hence caloric value and in availability/migration location and timing. However, the release of hatchery fish has not been identified as a threat to the survival or persistence of Southern Residents. It is possible that hatchery produced fish may benefit this endangered population of whales by enhancing prey availability as scarcity of prey is a primary threat to Southern Residents survival and hatchery fish often contribute to the salmon stocks consumed (Hanson et al. 2010).

2.3.1.2.2 Nutritional Limitation and Body Condition

When prey is scarce, Southern Residents likely spend more time foraging than when prey is plentiful. 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 of 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 Southern Residents were observed from boats to have a pronounced "peanut-head"; and all but two subsequently died (Durban et al. 2009; Center for Whale Research 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, NMFS's Southwest Fisheries Science Center (SWFSC) has used aerial photogrammetry to assess the body condition and health of Southern Residents, initially in collaboration with the CWR and, more recently, with the Vancouver Aquarium and SR^3 (Sealife Response, Rehabilitation, and Research). 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 Southern Residents (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 Southern Residents body condition since 2008, and documented members of J pod being in poorer body condition in May compared to September (at least in 2016 and 2017) (Trites and Rosen 2018).

Although body condition in whales can be influenced by a number of factors, including prey availability, disease, physiological or life history status, and may vary by season and across years, prey limitation is the most likely cause of observed changes in body condition in wild mammalian populations (Matkin et al. 2017). It is possible that poor nutrition could contribute to mortality through a variety of mechanisms. To demonstrate how this is possible, we reference studies that have demonstrated the effects of energetic stress (caused by incremental increases in energy expenditures or incremental reductions in available energy) on adult females and juveniles from many different taxa, including marine mammals (e.g., adult females: Gamel et al. (2005), Schaefer (1996), Daan et al. (1996), juveniles: Noren et al. (2009), Trites and Donnelly (2003)). Small, incremental increases in energy demands should have the same effect on an animal's energy budget as small, incremental reductions in available energy, such as one would expect from reductions in prey. Ford and Ellis (2006) report that resident killer whales engage in prey sharing about 76 percent of the time. Prey sharing presumably would distribute more evenly the 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). Therefore, although cause of death for most individuals that disappear from the population is unknown, poor nutrition could contribute to additional mortality in this population.

2.3.1.2.3 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). Southern Residents are exposed to a mixture of pollutants, some of which may interact synergistically and enhance toxicity, influencing their health. Contaminants of various types, including persistent organic pollutants that are believed to pose significant risks for Southern Residents and other marine life, enter marine waters from numerous sources throughout the action area but are typically concentrated near populated areas of high human activity and industrialization (Mongillo et al. 2016). High levels of these pollutants have been measured in blubber biopsy samples from Southern Residents (Ross et al. 2000, Krahn et al. 2007, Krahn et al. 2009), and more recently, these pollutants were measured in fecal samples collected from Southern Residents providing another potential opportunity to evaluate exposure to these pollutants (Lundin et al. 2016a, Lundin et al. 2016b).

Killer whales are exposed to persistent pollutants primarily through their diet. For example, Chinook salmon contain higher levels of some persistent pollutants than other salmon species, but only limited information is available for pollutant levels in Chinook salmon (Krahn et al. 2007, O'Neill and West 2009, Veldhoen et al. 2010, Mongillo et al. 2016). The majority of growth in salmon occurs while feeding in saltwater (Quinn 2005). Therefore, the majority (> 96 percent) of persistent pollutants in adult salmon are accumulated while feeding in the marine environment (Cullon et al. 2009, O'Neill and West 2009). The marine distribution of salmon is an important factor affecting pollutant accumulation as is evident across the different salmon populations. For example, Chinook salmon populations feeding in close proximity to land-based sources of contaminants have higher concentrations (O'Neill et al. 2006).

Upon consumption of prey species that contain these pollutants, these harmful pollutants are stored in the killer whale’s blubber and can later be released. When the whales metabolize the blubber in response to food shortages or reduced acquisition of food energy that could occur for a variety of other reasons, the pollutants are redistributed to other tissues. The release of pollutants can also occur during gestation or lactation. Once the pollutants mobilize into circulation, they have the potential to cause a toxic response. Therefore, nutritional stress from reduced Chinook salmon populations may act synergistically with high pollutant levels in Southern Residents and result in adverse health effects.

2.3.1.2.4 Disturbance from Vessels and Sound

Vessels have the potential to affect killer whales through the physical presence and activity of the vessel, increased underwater sound levels generated by boat engines, or a combination of these factors. Vessel strikes are rare, but do occur and can result in injury or mortality (Gaydos and Raverty 2007). 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).

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, Southern Residents are the 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 2008a). There is a growing body of evidence documenting effects from vessels on small cetaceans and other marine mammals (NMFS 2010b, 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 motoring vessels up to 400 meters away has the potential to affect the echolocation abilities of foraging whales (Holt 2008, Lusseau et al. 2009, Noren et al. 2009, Williams et al. 2010). 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).

At the time of the whales' listing under the ESA, NMFS reviewed existing protections for the whales and developed recovery actions, including vessel regulations, to address the threat of vessels to killer whales. NMFS concluded it was necessary and advisable to adopt regulations to protect killer whales from disturbance and sound associated with vessels, to support recovery of Southern Residents. Federal vessel regulations were established in 2011 to prohibit vessels from approaching killer whales within 200 yards (182.9 meters (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 the final rule, NMFS committed to reviewing the vessel regulations to evaluate effectiveness, and also to study the impact of the regulations on the viability of the local whale watch industry. In March 2013, NMFS held a killer whale protection workshop[22] to review the current vessel regulations, guidelines, and associated analyses; review monitoring, boater education, and enforcement efforts; review available industry and economic information and identify data gaps; and provide a forum for stakeholder input to explore next steps for addressing vessel effects on killer whales.

In December 2017, NMFS completed a technical memorandum evaluating the effectiveness of regulations adopted in 2011 to help protect endangered Southern Residents from the impacts of vessel traffic and noise (Ferrara et al. 2017). In the assessment, Ferrara et al. (2017) used five measures: education and outreach efforts, enforcement, vessel compliance, biological effectiveness, and economic impacts. For each measure, the trends and observations in the 5 years leading up to the regulations (2006-2010) were compared to the trends and observations in the 5 years following the regulations (2011-2015). The memo finds that the regulations have benefited the whales by reducing impacts without causing economic harm to the commercial whale-watching industry or local communities. The authors also find room for improvement in terms of increasing awareness and enforcement of the regulations, which would help improve compliance and further reduce biological impacts to the whales.

2.3.1.2.5 Oil Spills

In the Northwest, Southern Residents are the most vulnerable marine mammal population to the risks imposed by an oil spill due to their small population size, strong site fidelity to areas with high oil spill risk, large group size, 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 Southern Residents 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 Southern

[22] The presentations and supporting documents (including workshop notes) can be found at: http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/killer_whale/vessel_regulations.html.

Residents remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers in inland waters.

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, 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), and potentially death and long-term effects on population viability (Matkin et al. 2008, Ziccardi et al. 2015). For example, 122 cetaceans stranded or were reported dead within 5 months following the Deepwater Horizon spill in the Gulf of Mexico (Ziccardi et al. 2015). An additional 785 cetaceans were found stranded from November 2010 to June 2013, which was declared an Unusual Mortality Event (Ziccardi et al. 2015). In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may also adversely affect Southern Residents by reducing food availability.

2.3.2 Action Area for Southern Residents

"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 action area for Southern Residents is different than the action area for SONCC coho salmon described above as there are no effects of flow management that directly affect Southern Residents. Rather there is an indirect link to Southern Residents from effects on Chinook salmon and Chinook salmon spawning and rearing habitat in the Klamath River because Chinook salmon are a primary prey for Southern Residents in the Pacific Ocean. This indirect link results in effects in the Pacific Ocean where Southern Residents feed on concentrations of adult Chinook salmon (see USBR 2018a, Section 9.1.2 for more detail). This action area for Southern Residents is the section of the ocean where there is species overlap between Klamath River Chinook salmon and Southern Residents. The exact boundaries of this area cannot be precisely defined based upon current information; however, as described in more detail in the *Link between Southern Resident and Klamath River Chinook as Prey* section (Section 2.3.3.1.2), the action area where Southern Residents and Chinook salmon from the Klamath River (particularly fall-run) overlap includes coastal waters ranging from Northern California through Central Oregon, up to the Columbia River. Given that the range of Klamath River Chinook salmon does not include the designated critical habitat for Southern Residents within the inland waters of WA, including Puget Sound and the Strait of Juan de Fuca, the action area does not include critical habitat for Southern Residents.

2.3.3 Environmental Baseline

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 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process (50 CFR 402.02).

2.3.3.1 Factors Affecting the Prey of Southern Residents 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 Southern Residents. 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 Southern Residents does not include the Klamath River Basin, this section focuses on important factors for Chinook salmon and for Southern Residents in the marine environment.

2.3.3.1.1 Significance of Prey and Prey reductions

As described in the *Rangewide Status of Southern Resident Killer Whale* section (Section 2.3.1), statistical correlations between various Chinook salmon abundance indices and the vital rates (fecundity and survival) of Southern Resident killer whales have been outlined in several papers. In addition to examining whether any fundamental linkages between vital rates and prey abundance are evident, another primary purpose of many of these analyses has 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 Southern Residents. Largely, attempts to compare the relative importance of any specific Chinook salmon stocks or stock groups using the strengths of these statistical relationships have not produced clear distinctions as to which are most influential, as 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 Southern Resident vital rates than any specific or smaller aggregations of Chinook salmon stocks, including those that originate from the Fraser River that have been positively identified as key sources of prey for Southern Residents during certain times of the year in specific areas (see Hilborn et al. 2012, Ward et al. 2013). However, there are still questions about the diet preferences of Southern Residents throughout the entire year, as well as the relative exposure of Southern Residents to various Chinook salmon or other salmon stocks outside of inland waters during the summer and fall.

As referenced above, the independent science panel found good evidence that Chinook salmon are a very important part of the Southern Resident diet and that some Southern Residents 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 Southern Resident survival and reproduction. They identified "reasonably strong" evidence that vital rates of Southern Residents 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 Southern Resident survival may not be realistic or may diminish at Chinook salmon abundance levels beyond the historical average (Hilborn et al. 2012). 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 Southern Resident killer whales throughout their range may be as influential on their vital rates as any other relationships with any specific Chinook salmon stocks.

2.3.3.1.2 Link between Southern Residents and Klamath River Chinook Salmon as Prey

As described in the Rangewide Status of Southern Resident Killer Whale section (Section 2.3.1), Southern Residents (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 Southern Residents. 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 Southern Residents 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), although 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 Southern Residents 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 stocks from California during the winter and spring compared to the summer and fall, 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 during the winter or spring, 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, and that data collected from hatchery fish (usually where CWTs are applied) are representative of the distribution of both wild and hatchery populations.

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, and 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 (USBR 2011b). 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.[23]

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 Southern Residents 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. 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[24] 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 salmon are an important part of the diet for most Southern Residents during portions of the year when Southern Residents occur in coastal waters off the North American coast, especially south of the Columbia River, which includes the times of potential reduced body condition and increased diet diversity that received additional weight during a recent prey prioritization process described above.

2.3.3.1.3 Relationship of Klamath River Chinook to Overall Ocean Abundance

Given that the best information available links Southern Resident population dynamics to the abundance of Chinook salmon available to Southern Residents at a coastwide level, 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 the range of Southern Residents. Currently, there is no capability 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 Southern Residents during the winter and spring. There are many different management and

[23] 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.

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

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. A commonly used approach involves use of relative indexes as opposed to absolute measures of abundance, such as the WCVI index that has been previously related to Southern Resident population dynamics. In addition, many of the estimates or forecasts of Chinook salmon abundance used for management are related to escapements that are not inclusive of adult Chinook salmon that remain in the ocean to mature, or succumb to predation or other forms of mortality. In combination, use of catch and escapement data from Chinook salmon populations that occur in the range of Southern Residents could provide some minimum measure of the absolute abundance of Chinook salmon that are available, although all of these Chinook salmon individuals would not necessarily always overlap with Southern Residents during any specific time period given the uncertain and variable migratory nature of Chinook salmon and Southern Residents. Without any comprehensive and consistent monitoring and assessment methodology across Chinook salmon populations throughout the range of Southern Residents, we will combine the data and information that is available for use in generally characterizing the abundance of coastwide Chinook salmon potentially available to Southern Residents, as well as the relative importance of Klamath River Chinook salmon to that total.

In general, ocean abundance estimates for Chinook salmon that originate from U.S. systems are provided by the Pacific Fisheries Management Council (PFMC 2019). The estimated 2019 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 274,200 fish, which is generally consistent with the average ocean abundance of Klamath Chinook over the last 10 years, although significantly lower than ocean abundances approaching/exceeding 1 million fish that have occurred at times in the past (PFMC 2019). In 2019, the Sacramento Index (SI) is estimated to have an ocean abundance of 379,600 fish (PFMC 2019)[25]. 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 300,000 only 3 times in the last 12 years (PFMC 2019). Including escapement forecasts for Columbia River Chinook salmon stocks (514,400 fish) with other stocks south of the Strait of Juan de Fuca (48,800 fish); along with Puget Sound, Hood Canal, and the Strait of Juan de Fuca combined (243,800 fish); the total Chinook salmon abundance from these sources equals 1,460,800 fish in 2019 (PFMC 2019), of which 274,200/1,460,800=19 percent originate from the Klamath River. As mentioned, 2019 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.

While the estimated proportion of Chinook salmon originating from the Klamath River for 2019 does include accounting of most of the significant populations of Chinook salmon along the U.S.

[25] 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 2019).

coast, this does not include any totals from significant Canadian Chinook salmon populations that are likely encountered by Southern Residents to some degree, in particular Fraser River and West Coast Vancouver Island stocks. Although abundance estimates or escapement forecasts for 2018 are not readily available for these Chinook salmon stocks (largely managed through relative abundance indices), it is possible to look at historical catch and escapement numbers to get a sense of at least the minimum number of these fish that are in the ocean in the range of Southern Residents at some point each year. During the independent science panel, historical estimates of catch and escapement for most all major Chinook salmon stocks from British Columbia to California were produced (Kope and Parken 2011). Across all major Chinook salmon populations, Kope and Parken (2011) reported that the total number of Chinook salmon that were either captured or escaped annually from 1979-2010 ranged from about 2-6 million; commonly between 3 and 4 million fish. Although these totals are certainly an underestimate of all the Chinook salmon that could be present in coastal waters along the west coast associated with these populations, and the precise overlap of Southern Residents with all these populations at all times during the year is not well established, we conclude based on the historical catch and escapement data presented above that the relative magnitude of Chinook salmon in the range of Southern Residents each year is likely at least several million fish. Based on the tabulations of catch and escapement conducted by Kope and Parken (2011), we can get a sense of the relative contribution of Klamath River Chinook salmon (as represented by the Klamath Fall-run) to the total abundance of Chinook salmon in the range of Southern Residents. On average since the early 1980s, it appears that Klamath River Chinook salmon constitute about 4 percent of the total catch and escapement of all these Chinook salmon populations that are likely encountered by Southern Residents to some degree, although this proportion varies from about 1-9 percent each year depending on varying strengths in run size (Kope and Parken 2011). This generally agrees with information provided in the BA, where Reclamation concluded the Klamath produces 1 to 10 percent of Chinook salmon found in coastal water from California through British Columbia (USBR 2018a). 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 Southern Residents throughout their range in some years; likely at least several hundred thousand individual fish other than during years of exceptionally low abundance for Klamath River Chinook salmon. In addition, the known distributions of Chinook salmon along the coast suggest that Klamath River Chinook salmon are an increasingly significant prey source (as Southern Residents move south along the U.S. West Coast) during any southerly movements of Southern Residents 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).

2.3.3.1.4 Climate Change and Environmental Factors in the Ocean

The availability of Chinook salmon to Southern Residents is affected by a number of environmental factors and climate change. 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 Southern Residents). 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 Southern Residents maybe 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 Southern Resident 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, as well as the recent northeast Pacific marine warming phenomenon (aka “the blob”) (Peterson et al. 2006, Wells et al. 2008). Evidence exists that suggests early marine survival for juvenile salmon is a critical phase in their survival and development into adults. The correlation between various environmental indices that track ocean conditions and salmon productivity in the Pacific Ocean, both on a broad and a local scale, provides an indication of the role they play in salmon survival in the ocean. Moreover, 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.

2.3.3.1.5 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 Southern Residents, including the Pacific Coast Salmon Plan fisheries (NMFS 2009), the 10 year terms of the Pacific Salmon Treaty (term of biological opinion from 2018-2027; NMFS 2008b) and the *United States v. Oregon* 2008 Management Agreement (term of opinion from 2018-2027; NMFS 2018c). In these past harvest opinions, NMFS has considered the short-term effects to Southern Residents 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 fish that escape to spawn. These past 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 Southern Residents 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 Southern Residents.

2.3.3.1.6 Scientific Research

Research activities on Southern Residents are typically conducted between May and October in inland waters, 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 Southern Residents, especially during the winter and spring when Southern Residents 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 Southern Resident (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. 2018).

2.3.3.1.7 Other Factors Affecting Southern Residents in the Action Area

As described above in the *Rangewide Status of the Species* section (Section 2.3.1), Southern Residents are affected by a number of activities and stresses in 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 Southern Residents throughout their range, including when they occur in coastal waters within the action area.

2.3.3.1.8 Summary of Environmental Baseline

Southern Residents are exposed to a wide variety of human activities and environmental factors in the action area. All the activities discussed above in the *Rangewide Status of the Species* section (section 2.3.1) are likely to have some level of impact on Southern Residents 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 Southern Resident 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). There is limited information on how these factors or additional unknown factors may be affecting Southern Residents 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 2008a).

2.3.4 Effects of the Action

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR 402.02). Indirect effects are those that are caused by the proposed action and are later in time, but still are reasonably certain to occur.

The primary potential impact of the proposed action on Southern Residents that has been identified in the BA (USBR 2018a) and in this Opinion is through potential reductions in availability of preferred prey, Chinook salmon, in the coastal waters where Chinook salmon from the Klamath River may be encountered by Southern Residents.

The *Quantity and Quality of Prey section* (Section 2.3.1.2.1) of the *Factors Affecting the Prey of Southern Residents in the Action Area* section (Section 2.3.3.1) describes the evaluation by the Science Panel (Hilborn et al. 2012) of the state of the science of the effects of salmon fisheries on Southern Residents. While there is uncertainty in the extension of the statistical correlations to precise predictions of the effect of Chinook salmon abundance on the Southern Resident population, to date there are no data or alternative explanations that contradict fundamental principles of ecology that wildlife populations respond to prey availability in a manner generally consistent with the analyses that link Chinook salmon abundance and Southern Residents. As a result, and based on evidence discussed in the *Rangewide Status of the Species* section (Section 2.3.1) and the *Factors Affecting the Prey of Southern Residents in the Action Area* section (Section 2.3.3.1), NMFS concludes that the best available science suggests that relative changes in Chinook salmon abundances are likely to influence the Southern Resident population.

2.3.4.1 Impacts to the Abundance of Chinook as a Result of the Proposed Action

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 Southern Residents and Klamath River Chinook salmon are potential prey for Southern Residents along the coast. Effects of the proposed action that reduce Chinook salmon production could lead to adverse effects to Southern Residents. 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, largely, we 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. Here we summarize both Chinook salmon specific information as well as relevant coho salmon information to help analyze the effects the proposed action on Chinook salmon production.

2.3.4.1.1 Klamath River Chinook Salmon

2.3.4.1.1.1 Klamath River Chinook Salmon Life History

Chinook salmon display two types of life history strategies in the Klamath River, spring-run and fall-run, 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 Upper Klamath Trinity River (UKTR) ESU 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 typically mature and return to freshwater between three and six years of age (Snyder 1931).

2.3.4.1.1.2 Chinook Salmon Spatial Structure/Distribution

Chinook salmon distribution has been greatly reduced in the Klamath Basin, first by the construction of Copco 1 Dam starting in 1912 (Hamilton et al. 2016). Currently, IGD, which was constructed in 1962, represents the upstream limit of anadromy in the Klamath River. Additionally, construction of Dwinnell Dam in the Shasta River blocked portions of habitat starting in 1928, while the Lewiston Dam built in 1963 on the Trinity River prevented access to many tributary habitats including East Fork, Stuart Fork, Upper Trinity River, and Coffee Creek (Campbell and Moyle 1991). The significant loss of habitat because of dams has resulted in two mitigation hatcheries, Iron Gate and Trinity River Hatcheries.

Although both spring-run and fall-run Chinook salmon are present in the Klamath basin, no spring-run Chinook salmon have been observed as spawning in the mainstem Klamath River (Shaw et al. 1997). Instead, adult spring-run Chinook salmon will only use the mainstem as a migratory corridor to reach their spawning grounds in the tributaries. Currently, known distribution of spring-run Chinook salmon are limited to the Salmon River and Trinity River sub-basins. As described in our analysis of effects of the proposed action on coho salmon, the effects of the proposed action are ameliorated substantially downstream as tributary accretions influence water quality, water quantity and other physical and ecological factors. Because the Salmon River is approximately 125 River Miles downstream of IGD with several large tributary influences upstream, we do not anticipate more than negligible effects from the proposed action on spring-run Chinook salmon. Conversely, a large portion of the fall-run Chinook salmon population in the Klamath basin are exposed to portions of the mainstem Klamath River that are impacted by the proposed action.

2.3.4.1.1.3 Chinook Salmon Abundance and Productivity

Natural-spawned Chinook salmon abundance has declined dramatically since dams were constructed in the 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. Hatchery production in the Basin increases the overall abundance of Chinook salmon in the Klamath. The IGH releases nearly six million fall-run Chinook salmon juveniles each year, while Trinity River Hatchery releases 4.3 million juvenile spring-run and fall-run Chinook salmon combined. Figure 22 shows the natural spawner abundance of fall-run Chinook salmon in the Klamath Basin from 1978 to 2018, and Figure 23 shows the entire escapement of fall-run Chinook salmon during the same period but with hatchery fish included (CDFW 2018). Spring-run Chinook salmon have a much lower abundance in the Klamath River. Figure 24 summarizes the escapement of hatchery and wild spawning adult spring-run Chinook salmon.

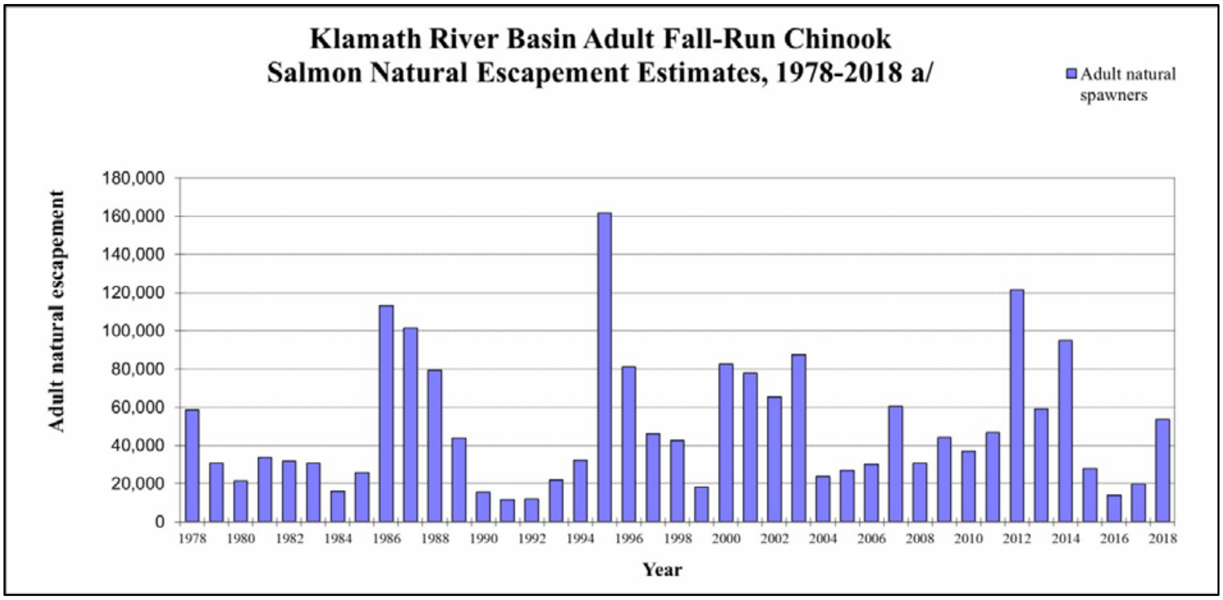

Figure 22. Adult natural escapement of fall-run Chinook in the Klamath Basin, including Trinity River fish (CDFW 2018). 2018 a/ is preliminary.

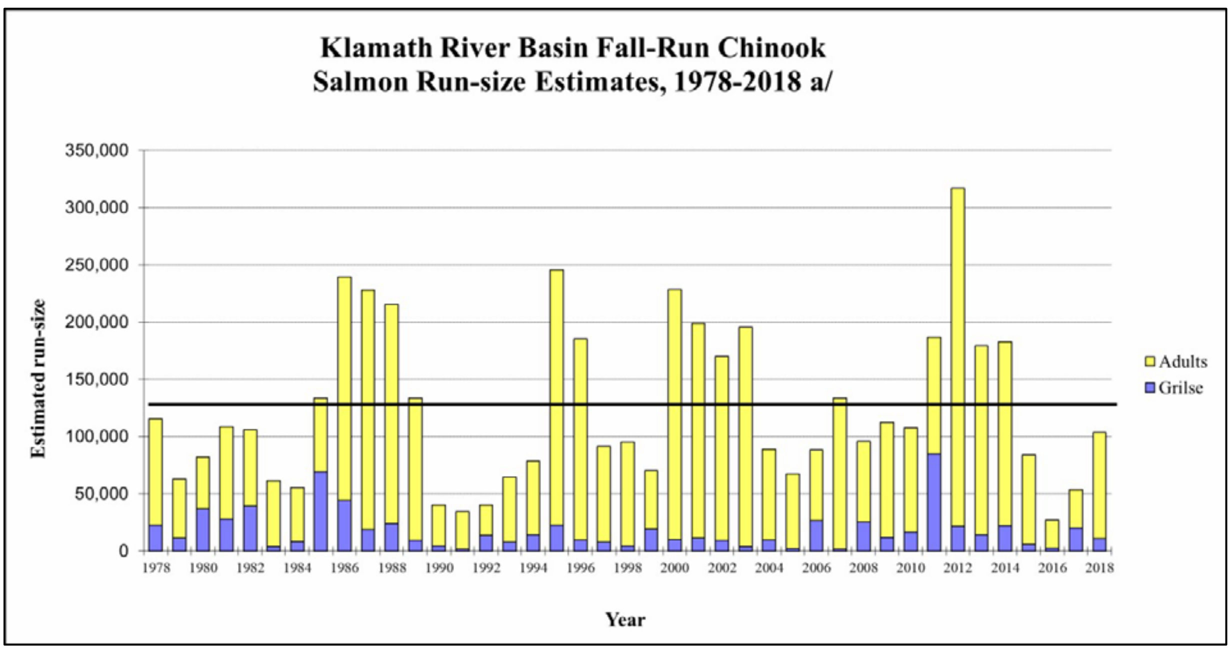

Figure 23. Adult escapement of fall-run Chinook in the Klamath Basin, including hatchery fish, in the Trinity and Klamath Rivers (CDFW 2018). 2018 a/ is preliminary.

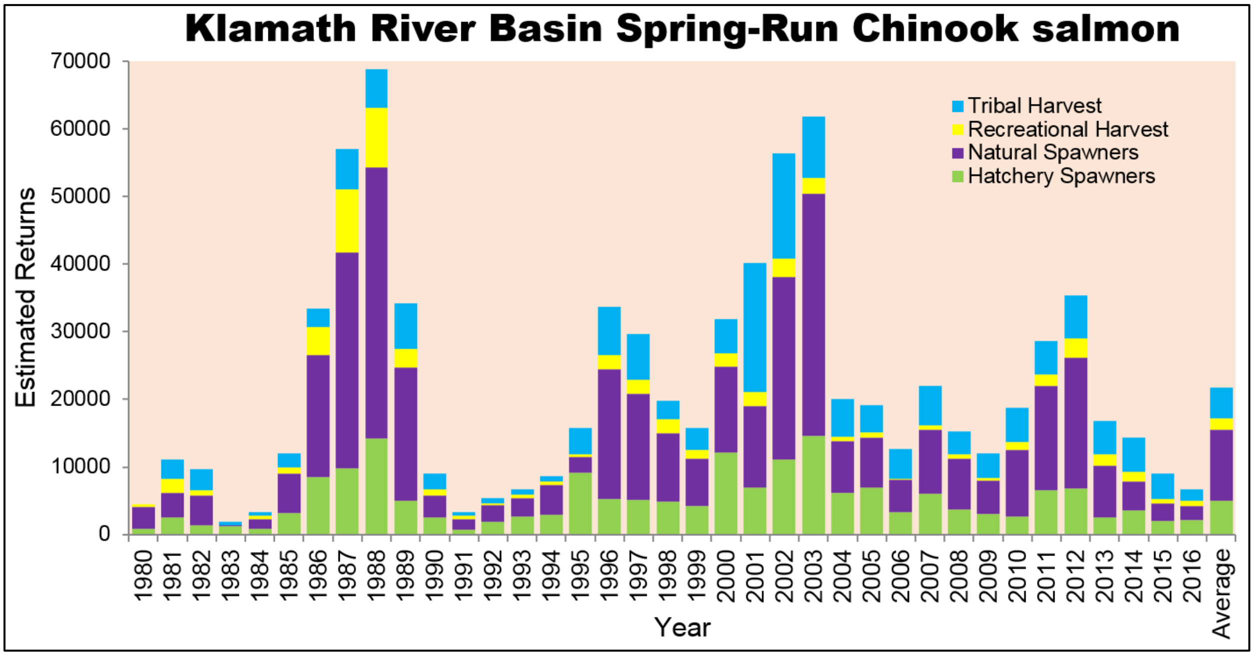

Figure 24. Klamath Basin adult spring-run Chinook salmon abundance estimates (CDFW 2018).

2.3.4.1.1.4 Chinook Salmon Diversity

Diversity within the Chinook salmon population is represented by the differing life history strategies described above. These include spring and fall-run adult migration timing, different timing for freshwater rearing and smolt emigration, and different periods for adult maturation ranging from less than one-year-old precocious males to six-year-old adults.

Hatcheries can also play a role in shifting genetic diversity within populations. Releasing hatchery-origin fish can result in lower productivity of natural-origin salmonids. Between 1998 and 2016, Iron Gate and Trinity River Hatcheries released roughly 9.8 million hatchery Chinook salmon annually (CDFW, unpublished data). Hatchery-origin Chinook salmon found in the wild are typically spawned adjacent to the two hatcheries and gene flow from hatchery-origin fish is mostly limited to those areas (Kinziger et al. 2013).

2.3.4.1.2 Effects of the Proposed Action on Chinook Salmon Individuals

As described earlier in the SONCC coho salmon *Effects of the Action* section (Section 2.2.3), the proposed action affects salmonid habitat in the action area through the Project Operations and annual restoration fund. The proposed action's greatest effects to Chinook salmon production are associated with the effects to the Klamath River hydrology. As a result of operating the Project, the Klamath River annual flow volume, spring peak magnitude and duration, deep flushing flows, and flow variability are reduced relative to the natural hydrograph. Similar to our conclusion regarding effects of the proposed action on coho salmon, populations proximal to IGD (i.e., Klamath River mainstem, Iron Gate Hatchery, Bogus, Shasta, Scott) will experience the greatest effects of Project Operations, whereas populations in the lower Klamath River (i.e., Salmon) will be less likely to be affected.

2.3.4.1.2.1 Exposure and Response

2.3.4.1.2.1.1 Adults

Fall-run Chinook salmon adults enter the Klamath River from July through September and may remain in the mainstem until spawning in late October and early November (Snyder 1931). Adult Chinook salmon can be susceptible to disease such as Ich (*Ichthyophthirius multifiliis*) and columnaris (caused by *flabobacterium columnare*) 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, killing more than 33,000 adult salmon and steelhead (Guillen 2003). In low flow years, and under elevated water temperatures, Reclamation's proposed minimum flows at IGD may contribute to conditions that increase risks of disease to adult Chinook salmon that enter the Klamath River in late summer and early fall.

2.3.4.1.2.1.2 Eggs

In our enclosed EFH analysis below, we describe model results in Hardy et al. (2006) for Chinook salmon spawning that indicate there is an abundance of spawning habitat between IGD and the Shasta River reach. The proposed action will provide at least 950 cfs during the spawning and incubation period (October - February). These flows combined with cooler fall and winter water temperatures should be sufficient to provide suitable conditions for egg incubation. Therefore, fall-run Chinook salmon eggs in the mainstem Klamath River are not expected to be adversely affected by the proposed action.

2.3.4.1.2.1.3 Juveniles

Fall-run Chinook salmon fry, parr, and smolt will be exposed to an altered flow regime resulting from the proposed action. When fry emerge from their redds (December – February) they seek slow water habitat located on the channel fringes and in off-channel habitat features. The majority of juvenile Chinook salmon rear as parr for a short period prior to outmigration in March to mid-June. During this spring freshwater rearing period, habitat availability will be reduced under some hydrological conditions (see the *Hydrologic Effects to SONCC coho salmon* section (Section 2.2.4.1.2) above), with a decreased amount of essential edge habitat. Reclamation's EFH analysis (2019a) uses a hydrodynamic model developed for the mainstem Klamath River (Hardy et al. 2006) and weighted usable area (WUA) curves to simulate habitat availability for Chinook salmon under the proposed action (Figure 25). Reclamation (2019a) developed reach-level habitat estimates, and their analysis shows that Chinook salmon fry and parr will see a reduction in habitat during the spring (March – June) under a wide range of flows (Table 27). The effects of the proposed action would likely be most influential during dry years with the greatest impacts occurring in June for all stream reaches. To offset some of the potential risks to juvenile salmonids in the May/June time period, Reclamation has proposed to adaptively manage 20,000 ac. ft. of water in below average through average water years, and NMFS will assist Reclamation to utilize this water in a fashion to provide short term increases to habitat availability when fish are likely to gain the most benefit. This habitat reduction increases competition with other salmonids and may force fish to relocate to less suitable habitat. These effects will likely result in reduced growth and survival of juvenile fall-run Chinook salmon in the mainstem between IGD and the Salmon River. In addition, the reduction in magnitude, frequency and duration of sediment maintenance flows contributes to increased exposure to disease in the mainstem Klamath River.

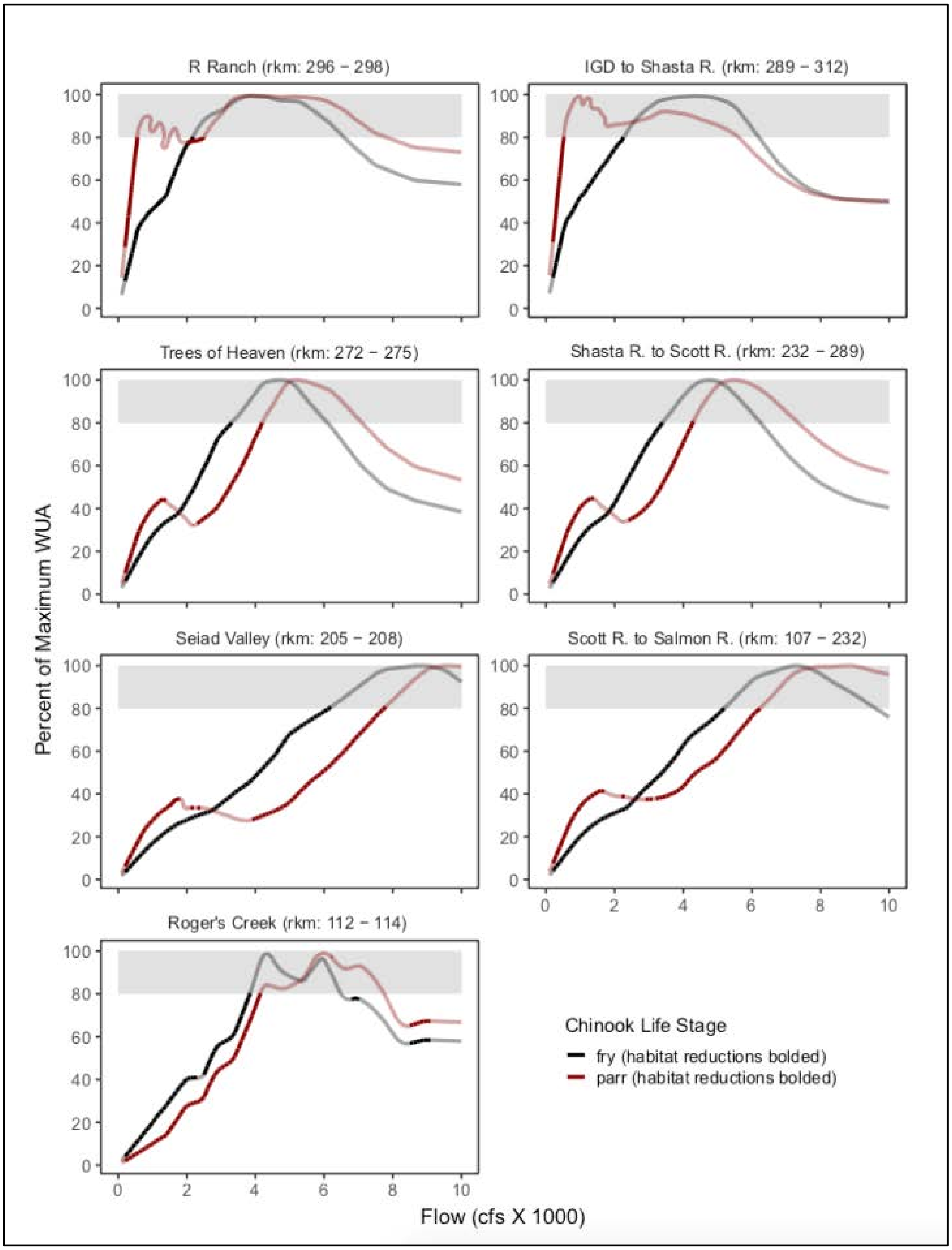

Figure 25. Chinook salmon fry and parr habitat availability relative to mainstem flows for three reaches and four sites downstream of IGD. Flows account for tributary accretions and were estimated for each habitat unit when calculating WUA. Gray horizontal bands indicate WUA values ≥ 80 percent of maximum. Potential habitat reductions due to the Proposed Action are bolded (USBR 2018a).

Table 27. Daily average mainstem flows (cfs) within nearest 5 percent exceedance where the Proposed Action will likely reduce Chinook salmon fry habitat availability to below 80 percent of maximum (orange highlight). Flows estimated for the midpoint of each reach. (from USBR 2018a).

	Iron Gate Dam to Shasta River rkm 289-312				Shasta to Scott Rivers rkm 232-289				Scott to Salmon Rivers rkm 107-232			
Exceedance	**March**	**April**	**May**	**June**	**March**	**April**	**May**	**June**	**March**	**April**	**May**	**June**
95%	1113	1429	1244	1056	1433	1641	1404	1126	2560	2494	1931	1341
90%	1302	1463	1280	1073	1731	1711	1467	1175	2932	2711	2197	1481
85%	1606	1518	1362	1099	1954	1848	1608	1229	3240	3027	2477	1603
80%	1782	1559	1483	1124	2165	1938	1742	1292	3620	3397	2684	1728
75%	1912	1695	1550	1159	2329	2097	1858	1345	3971	3849	2964	1816
70%	2122	1858	1611	1190	2589	2291	1978	1397	4340	4134	3334	1936
65%	2352	2004	1672	1227	2864	2446	2088	1441	4699	4473	3666	2065
60%	2582	2195	1766	1266	3174	2734	2221	1487	5231	4884	4003	2214
55%	2848	2430	1894	1312	3519	2983	2389	1539	6170	5395	4312	2392
50%	3140	2689	2072	1348	3884	3306	2537	1604	6716	5859	4609	2599
45%	3372	3013	2315	1400	4164	3675	2824	1690	7238	6476	5098	2855
40%	3735	3289	2590	1489	4613	3962	3230	1820	7643	6981	5804	3126
35%	4237	3640	2796	1626	5181	4467	3504	2012	8362	7733	6444	3434
30%	4668	3986	2999	1783	5818	4899	3729	2202	9173	8339	6923	3829
25%	5228	4631	3274	1917	6449	5544	4029	2381	10115	8937	7326	4410
20%	6082	5080	3555	2089	6897	6099	4402	2682	11237	9603	7889	4962
15%	6467	5611	3974	2416	7669	6537	4934	3026	12429	10198	8822	5556
10%	7148	6103	4403	2818	8693	7083	5474	3589	14272	11235	9797	6469
5%	8582	6669	5062	3464	10588	7806	6320	4271	17531	12322	10744	7755

To help NMFS evaluate the effects of Reclamation's proposed action on Chinook salmon production, USGS modeled survival of Chinook salmon from the time they spawn in the Upper Klamath River until they reach the ocean as smolts (USGS 2019). USGS's Stream Salmonid Simulator (S3) model represents an integrated set of sub models that predict the effects of water management alternatives on the production of juvenile Chinook salmon. This synchronized series of sub models reflects the array of physical and biological processes that interact to affect the growth, movement, and survival of fish at a given life stage. Using the S3 model, USGS was able to evaluate the amount of available habitat and resulting growth and survival of juvenile Chinook salmon associated with Reclamation's proposed annual 72 hour surface flushing flow event as a measure to reduce *C. shasta* infection among Chinook salmon. The S3 model also specifically evaluated the anticipated effects of disease exposure and resultant mortality associated with the proposed flushing flows. USGS reviewed environmental conditions from 2005-2017 (hereafter in the Southern Resident analysis defined as S3 POR) when a wide range of water year types were present and robust data sets were available on water quality and disease parameters such as spore concentrations and infection rates of juvenile Chinook salmon, all necessary components to run the model. This approach allows us to look back at different years to see what would have occurred under the proposed action's conditions versus what actually did occur under baseline conditions. Using this approach, we can forecast various rates of survival under different water year types that may occur in the future when the habitat conditions are influenced by the proposed action. By looking at the historical data, USGS estimated that under the proposed action, populations of Chinook salmon that benefit from the surface flushing flow events (Bogus, Iron Gate Hatchery, Klamath River, Shasta, Scott) would generally have experienced higher survival rates than what occurred under the S3 POR (Figure 26).

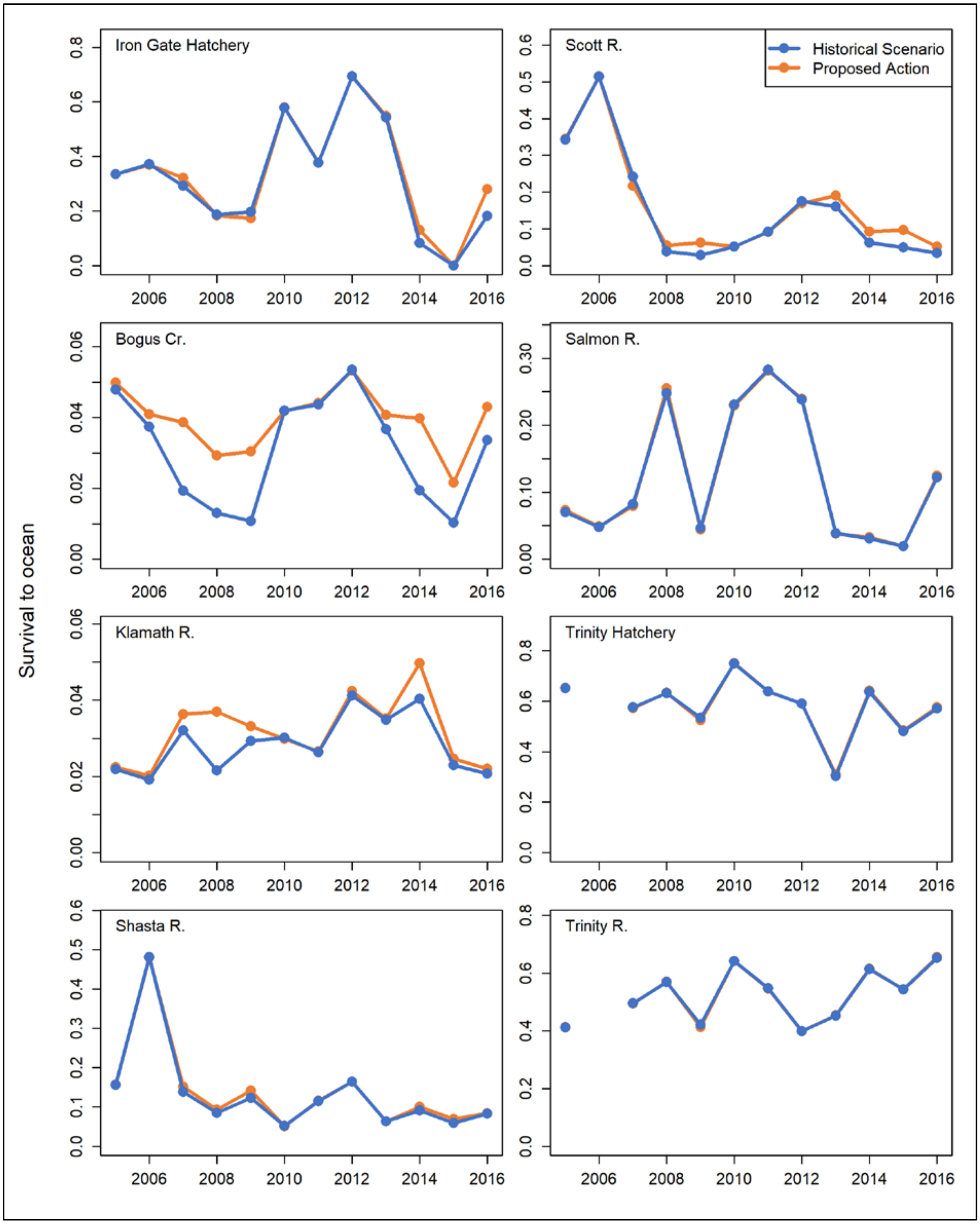

Figure 26. Survival to the ocean from the time of entering the Klamath River for each source population modeled by S3 (USGS 2019).

Using this information, it is possible to quantify changes in survival rates as a result of the proposed action compared to the S3 POR. Table 28 illustrates the changes in the overall combined juvenile survival to ocean entry for all the Chinook salmon populations in the Klamath River Basin as described in Figure 26. Overall, relative rates of juvenile survival are expected to variably increase as a result of the proposed action compared to the S3 POR and previous operations, particularly in certain years where disease (especially) and suitable habitat may be more limiting factors (e.g., 2014 and 2016). USGS's S3 disease model defines prevalence of infection markedly different from field monitoring data in which histological analysis or qPCR is used to determine whether fish are clinically infected with *C. shasta*. In the S3 model, fish that are assigned to the infected groups are predicted to die at some future date from *C. shasta*, and this prediction is based on analysis of sentinel trial data where the proportion of fish that die and their time until death is known. However, POI has been previously reported in Klamath River monitoring, and defined as individuals testing positive for *C shasta* infection. This is how POI was used in terms of our incidental take statement with our 2013 opinion. As POI has been previously reported in Klamath River monitoring and used, the fate of infected fish that survive to the ocean is unknown, and some may eventually recover from disease and ultimately survive. It is important to recognize that infected fish, under USGS's definition of prevalence of infection for purposes of the S3 model, would have died based on sentinel trial data. Given this expectation, we can further relate the likely impacts of disease under the proposed action to the S3 POR by assuming that all infected juveniles that are still alive at ocean entry will subsequently die very soon. With limited exception in the analysis results, this conservative assumption indicates the overall juvenile survivability under the proposed action is improved - as much as 18 percent during years when disease may be a significant threat.

Table 28. Estimated juvenile survival to ocean entry under the Proposed Action relative to Historical Conditions for Klamath Basin, in terms of all juveniles and only juveniles that are uninfected at ocean entry.

Annual total of juveniles surviving to ocean entry				
Brood year	**Migration Year**	**Proposed Action**	**Historical Conditions**	**Percent change Proposed Action**
2004	2005	3557929	3546051	0.3%
2005	2006	2434296	2452653	-0.7%
2006	2007	3418534	3200557	6.8%
2007	2008	3218852	3048952	5.6%
2008	2009	2264309	2213432	2.3%
2009	2010	6588962	6594971	-0.1%
2010	2011	3924006	3918214	0.1%
2011	2012	6578966	6575273	0.1%
2012	2013	6080155	5997978	1.4%
2013	2014	3854922	3358030	14.8%
2014	2015	1910966	1748224	9.3%
2015	2016	2530979	2142436	18.1%

Annual total of uninfected juveniles surviving to ocean entry				
Brood year	**Migration year**	**Proposed Action**	**Historical Conditions**	**Percent change Proposed Action**
2004	2005	3540458	3522061	0.5%
2005	2006	1038575	919212	13.0%
2006	2007	1871931	1728381	8.3%
2007	2008	2293524	2166554	5.9%
2008	2009	2040751	2010064	1.5%
2009	2010	6497709	6377971	1.9%
2010	2011	3920083	3897332	0.6%
2011	2012	6578966	6575235	0.1%
2012	2013	6080155	5866874	3.6%
2013	2014	3391852	2882308	17.7%
2014	2015	1858014	1713852	8.4%
2015	2016	1690090	1539668	9.8%

Effects of the proposed action, both adverse and beneficial, are most pronounced in portions of the mainstem Klamath River downstream and closest to IGD. Naturally produced fall-run Chinook salmon that spawn in the mainstem, and utilize tributaries in close proximity to IGD (i.e., Klamath River, Bogus Creek, Shasta River, Scott River), as well as hatchery production from the Iron Gate Hatchery, have the highest likelihood of being affected by Reclamation's proposed measures to reduce disease infection. In our analysis of the S3 POR, and for naturally produced populations in the disease zone, juvenile survival rates generally are expected to increase in most years (Table 30 and Table 31). During the S3 POR, the proportion of the annual Klamath River Basin production associated with the naturally produced populations in the disease zone averages about 20 percent, although it ranged from ~ 6 percent to 60 percent. Additional results from S3 indicated that the combination of predicted prevalence of infection (defined as the percentage of the juveniles infected with *C. shasta* expected to die) for juveniles surviving to the Kinsman location from naturally produced Chinook salmon populations that spawn in the mainstem and utilize tributaries in close proximity to IGD would have been expected to be no higher than 53 percent during the POR under the proposed action (Table 29)(USGS 2019).

Table 29. Simulated prevalence of infection (POI) of juvenile Chinook salmon (Klamath River, Bogus Creek, Shasta River) at Kinsman trap location. Zero entries indicate estimates from trapping program were unavailable due to high river flows (USGS 2019).

	Historical			Proposed Action		
Migration year	**Infected Fish**	**Total Abundance**	**POI**	**Infected Fish**	**Total Abundance**	**POI**
2005	37781	731425	0.05	22135	727491	0.03
2006	44015	277381	0.16	9225	280479	0.03
2007	346040	768333	0.45	266226	771933	0.34
2008	1108104	1762775	0.63	926098	1753206	0.53
2009	500232	1011143	0.49	427725	1030037	0.42
2010	63941	1881132	0.03	16139	1858386	0.01
2011	2454	471075	0.01	4	486598	0.00
2012	81	1414429	0.00	0	1434261	0.00
2013	124634	3675663	0.03	0	3684969	0.00
2014	1490838	3666971	0.41	245143	3583101	0.07
2015	501374	3293923	0.15	630526	3873034	0.16
2016	264421	1309242	0.20	165673	1294682	0.13

Table 30. Estimated juvenile survival to ocean entry under the Proposed Action relative to Historical Conditions for naturally produced populations in the disease zone of the Klamath Basin, in terms of all juveniles and only juveniles that are uninfected at ocean entry.

Annual total of juveniles surviving to ocean entry from naturally produced population in disease zone				
Brood year	**Migration year**	**Proposed Action**	**Historical Conditions**	**Percent change Proposed Action**
2004	2005	328083	320652	2.3%
2005	2006	153351	147735	3.8%
2006	2007	483076	422901	14.2%
2007	2008	485410	305394	58.9%
2008	2009	455503	348943	30.5%
2009	2010	745509	750809	-0.7%
2010	2011	274816	272647	0.8%
2011	2012	666241	661259	0.8%
2012	2013	1482122	1433759	3.4%
2013	2014	1533558	1254875	22.2%
2014	2015	1121951	961120	16.7%
2015	2016	558381	528802	5.6%

Annual total of uninfected juveniles surviving to ocean entry from naturally produced population in disease zone				
Brood year	**Migration year**	**Proposed Action**	**Historical Conditions**	**Percent change Proposed Action**
2004	2005	317009	303100	4.6%
2005	2006	148175	129992	14.0%
2006	2007	386124	355578	8.6%
2007	2008	298401	242872	22.9%
2008	2009	340646	294112	15.8%
2009	2010	734269	711847	3.1%
2010	2011	274793	269950	1.8%
2011	2012	666241	661222	0.8%
2012	2013	1482122	1404596	5.5%
2013	2014	1420642	1022663	38.9%
2014	2015	1068999	926748	15.3%
2015	2016	481873	443950	8.5%

In order to gain perspective on how the changes in juvenile survival to ocean entry would affect available Chinook salmon prey for Southern Residents in the action area, we can forecast general expectations for survival of these juveniles at ocean entry to adult (age-4) using mean survival rates at age-4 that have been previously estimated and/or assumed for Klamath River fall-run Chinook salmon hatchery fish (USGS 2019). While these assumptions and resulting estimates are not precise, they do offer a general expectation for the relative magnitude of change in the number of adult Chinook salmon that would be expected to result from operational changes in the proposed action relative to the S3 POR using the S3 model. For all production in the Klamath Basin, the differences are expected to be variable, with hundreds or thousands of more adults available during some years, especially for broods that would be exposed to more stressful conditions (Table 31). On average, there will be ~1625 more age-4 Klamath Chinook salmon[26] in the ocean each year relative to the S3 POR as a result of improved juvenile survival. To put that in relative perspective, there will be an estimated 106,000 age-4 Klamath Chinook in the ocean in 2019 (PFMC 2019). Specifically with respect to the naturally produced population in the disease zone, the proposed action is expected to usually result in more age-4 Chinook salmon in the ocean each year; on average ~900 more fish per year relative to the S3 POR. Given these results, we expect that improved juvenile survival to ocean entry for fall-run Chinook salmon populations in the Klamath River will result in additional adult Chinook salmon in the ocean as prey for Southern Residents.

[26] Klamath River Chinook salmon mature and return to spawn at different ages (2-5 years old), although most individuals return by age 4. We generally accept that there would be more fish of all age types in the ocean each year, proportional to the general expectations for survival at age. For example, the anticipated survival rate of age-3 Klamath River Chinook salmon is 80% (USGS 2019).

Table 31. Estimated number of adult equivalents (age-4) resulting from juvenile survival to ocean entry under the Proposed Action relative to Historical Conditions for all production in the Klamath Basin, and for naturally produced populations in the disease zone of the Klamath Basin, using assumed mean survival rates at age-4 for individuals beyond ocean entry.

Adult Equivalents - assumed mean survival rates for all Klamath Basin Chinook				
Brood year	Migration Year	Proposed Action	Historical Conditions	Difference
2004	2005	44247	44099	148
2005	2006	30273	30502	-228
2006	2007	42514	39803	2711
2007	2008	40030	37917	2113
2008	2009	28159	27527	633
2009	2010	81942	82016	-75
2010	2011	48800	48728	72
2011	2012	81817	81771	46
2012	2013	75614	74592	1022
2013	2014	47941	41761	6179
2014	2015	23765	21741	2024
2015	2016	31476	26644	4832

Adult Equivalents - assumed mean survival rates for naturally produced populations in the disease zone				
Brood year	Migration Year	Proposed Action	Historical Conditions	Difference
2004	2005	4080	3988	92
2005	2006	1907	1837	70
2006	2007	6008	5259	748
2007	2008	6037	3798	2239
2008	2009	5665	4340	1325
2009	2010	9271	9337	-66
2010	2011	3418	3391	27
2011	2012	8286	8224	62
2012	2013	18432	17831	601
2013	2014	19072	15606	3466
2014	2015	13953	11953	2000
2015	2016	6944	6576	368

Although the model shows that survival of Chinook salmon would be higher under the proposed action compared to historical conditions, NMFS expects that the proposed action will still adversely affect the Chinook salmon population when conditions are favorable for disease proliferation, by reducing flow magnitude, duration and variability. Exposure to disease in the Klamath River will vary across populations with some having higher survival than others. For example, Figure 26 shows that juvenile Chinook salmon progeny from Bogus Creek and the mainstem Klamath River spawners will have low survival rates of 1 percent to 5 percent by the time they reach the ocean. Conversely, upon entering the Klamath River, progeny of fish spawned in the larger tributaries such as Scott, Shasta, and Trinity Rivers are expected to have much higher survival rates. This difference can be explained by length of time the fish are exposed to mainstem conditions. Fish reared in tributaries enter the Klamath at an older age, larger size, and remain there for only a short period of time while outmigrating. These graphs show a wide range of survival rates even within populations depending on the year. Dry water year types, such as 2015, will have the lowest survival rates (as low as 0 percent for fish released at IGH). During these times, NMFS expects Reclamation's proposed action to have a more significant impact on Chinook salmon survival, exacerbating poor water quality conditions during an already poor water year. While the proposed action is expected to contribute to disease infection, we expect that Reclamation's proposed annual surface flushing flows and augmented flows in May and June will help to reduce some of the effects of the proposed action in drier years and in periods of elevated water temperatures. During wetter years with low water temperatures through spring under the proposed action, we expect disease rates will likely be low.

2.3.4.1.2.2 Effects of the Coho Restoration Grant Program

Reclamation proposes to fund $700,000 in 2019 and 2020, and $500,000 in years 2021-2023, to improve habitat conditions for coho salmon. NMFS expects most of these restoration projects to also improve conditions for Chinook salmon, especially in key Chinook salmon-producing tributaries such as the Shasta and Scott rivers, because Chinook salmon occupy many of the same habitats at the same time as coho salmon. Based on implementation information from the past three years (2016, 2017, and 2018) of the Reclamation coho salmon restoration program (as detailed in USBR 2018a) and PacifiCorp's coho enhancement fund (PacifiCorp 2018a), NMFS estimates eight restoration projects will be implemented each year throughout the mainstem Klamath River and tributaries. Therefore, although Reclamation's funding for restoration activities will likely result in minor and short-term adverse effects during implementation, NMFS expects the suite of restoration activities will result in longer term improvements to the function and role of instream habitat in the action area and thus improve conditions for Chinook salmon. However, these improvements, on their own, will not completely offset effects of Project operations.

2.3.4.1.2.3 Summary of Effects on Chinook Salmon Individuals

The *Effects to Individuals* section (Section 2.2.4.2) for SONCC coho salmon describes the effects of the proposed action to ESA listed coho salmon. Because Chinook salmon occupy many of the same habitats at the same time as coho salmon, this analysis can inform effects to Chinook salmon as well. Below, Table 32 utilizes Chinook salmon specific information to summarize risks to each life stage under conditions provided by Reclamation's proposed action. This table relies on much of the analysis performed in the *Effects to Individuals* section for SONCC coho salmon above.

Table 32. Excerpted from the SONCC coho salmon *Effects to Individuals section* (Section 2.2.4.2) and modified to represent risks to fall-run Chinook salmon.

Potential Stressor	Project Effects	Life Stage	General Time	Mainstem Location
Habitat Reduction	Increased likelihood of reduced growth or survival to some individuals	Fry	Late March to mid-June	IGD (RM 190) to Salmon River (RM 66)
		Smolts	May to June	Trees of Heaven (RM 172) to Rogers Creek (RM 72)
Disease	Increased likelihood of impaired growth, swimming performance, body condition, and increased stress and susceptibility to secondary infections	Fry	May to mid-June	Klamathon Bridge (RM 187.6) to Orleans (RM 59)
		Smolts	May to June	
	Increased likelihood of disease-related mortality	Fry	May to mid-June	Trees of Heaven (RM 172) to Seiad Valley (RM 129)
		Smolts	May to June	
		Adults	August to September	Estuary (RM 0) to IGD (RM 190)
Elevated water temperature	Increased stress	Fry	May to mid-June	IGD to Scott River (RM 143)
		Smolts	May to June	
Decreased outmigration rates	Increased likelihood of mortality from other stressors in the mainstem Klamath River (e.g., disease, predation, impaired water quality)	Smolts	April to June	IGD (RM 190) to Shasta River (RM 176)

Considering the analysis provided in the SONCC coho salmon *Effects to Individuals* section (Section 2.2.4.2) and the overlap of exposure and response that will occur to Chinook salmon, combined with modeled results from the S3 model, NMFS expects the proposed action to result in adverse effects to fall-run Chinook salmon juveniles and adults. Adverse effects to juveniles will primarily occur in the form of disease exposure during their rearing and outmigration period in the mainstem Klamath River. Because reduced edge habitat will only occur in some years and only a portion of the Chinook salmon fry population rears in the mainstem, NMFS expects, to a lesser degree, reduced habitat availability and competition among other salmonids will result in reduced growth and survival of juvenile Chinook salmon. Adult Chinook salmon will be exposed to lower flows in the mainstem Klamath River and, when combined with elevated water temperatures in late summer and early fall, the proposed action is expected to have an adverse effect of delaying migration, which would reduce reproductive success. Adverse effects in the form of disease, migration delays, and limited habitat availability are expected to occur primarily during the drier water years when Reclamation's proposed action will exacerbate poor water quality conditions. While the proposed action is expected to contribute to disease infection over the period of effects of the proposed action, we expect that Reclamation's proposed annual surface flushing flows and augmented flows in May and June will help to reduce some of the effects of the proposed action in drier years and in periods of elevated water temperatures. During wetter years with low water temperatures through spring under the proposed action, we expect disease rates will likely be low. Although Reclamation's funding for restoration activities will likely result in minor and short-term adverse effects during implementation, NMFS expects the suite of restoration activities will result in longer term improvements to the function and role of instream habitat in the action area, and thus improve conditions for Chinook salmon. However, these improvements, on their own, will not completely offset effects of Project operations.

In terms of productivity and abundance, Klamath River Chinook salmon are largely comprised of the fall-run and, to a much lesser degree, spring-run Chinook salmon. This is reflected in annual spawning escapement estimates for the Klamath River and its associated tributaries; fall-run Chinook salmon escapement estimates are typically on the order of one to three hundred thousand adults, compared to typically on the order of less than twenty thousand for spring-run Chinook salmon combined (Table 32). As described above, NMFS does not anticipate more than negligible adverse effects to spring-run Chinook salmon given their limited exposure to effects from the proposed action.

In total, various stressors will reduce the fitness and survival of fall-run Chinook salmon as a result of the proposed action, primarily in drier water years when environmental stressors are heightened (Table 32). Drier years are likely to occur during the period of effects of the proposed action; however, it is important to note that, based on current hydrological data and forecasts, 2019 is anticipated to be an average or wetter hydrological year. Our analysis of effects of the proposed action to Chinook salmon generally describes and summarizes those effects in a qualitative manner based on the available information. We generally cannot quantify the effects of the underlying and ongoing impact of Project operations on juvenile survival under the proposed action, with the notable exception of explicit quantification of the relative improvements in overall juvenile survival and characterization of changes in survival of adult Chinook salmon in the ocean relative to historical conditions that are anticipated to result from the proposed action.

Because the available analytical methods are limited, the absolute magnitude of reduced prey that results from effects of the proposed action to Klamath River Chinook salmon cannot be further described at this time. This restricts our ability to provide more specific quantifiable expectations for the reductions in the abundance of fall-run Chinook salmon in the ocean available as prey for Southern Residents. Nevertheless, the analysis in this consultation indicates that a reduction in available prey is expected as a result of the effects of the proposed action.

In summary, the effects of the proposed action on fall-run Chinook salmon are expected to reduce the number of juvenile Chinook salmon migrating out of the Klamath River and adult Chinook salmon returning to spawning grounds. This will reduce the abundance of Chinook salmon in the ocean and consequently reduce prey for Southern Residents. However, NMFS expects that survival of juvenile Chinook salmon from the Klamath River will improve from what occurred during the POR as a result of the flow regime that will be implemented through the proposed action, and that the effects of Project operations on disease mortality of juvenile Chinook salmon will be reduced.

2.3.4.2 General Effects of Reduced Prey Base for Southern Residents

The information described above suggests that the population dynamics of Southern Residents are related to the abundance of Chinook salmon available as prey throughout the range of Southern Residents. As a result, reductions in availability of preferred prey (Chinook salmon) may affect the survival and reproductive success of Southern Residents. As described in the *Rangewide Status of Southern Residents* section (Section 2.3.1), and the *Factors Affecting the Prey of Southern Residents in the Action Area* section (Section 2.3.3.1), during the winter and spring, Southern Residents (particularly members of K and L pod) are likely to spend at least some time in coastal waters where they would be affected by reductions in Klamath River Chinook salmon abundance due to the proposed action. As described in the *Factors Affecting the Prey of Southern Residents in the Action Area* section (Section 2.3.3.1), Southern Residents (particularly members of K and L pod) are linked to consumption of Chinook salmon from California based on the contaminant signatures discussed above. As described in *Factors Affecting the Prey of Southern Residents in the Action Area* section (Section 2.3.3.1), 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 Southern Residents (~ 4 percent on average, but varying substantially between ~1 and 9 percent during any given year). As described in the *Factors Affecting the Prey of Southern Residents in the Action Area* section (Section 2.3.3.1), Klamath River Chinook salmon become an increasingly significant portion of prey source during any southerly movements of Southern Residents along the coast of Oregon and California that may occur during the winter and spring, and Klamath River Chinook salmon may constitute as much as 45 percent of local abundance of Chinook salmon in these areas when Southern Residents are in this area.

Southern Residents could abandon particular areas in search of more abundant prey or expend substantial effort to find prey resources in response to a decrease in the amount of available Chinook salmon due to the proposed action. 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). Southern Residents are known to consume other species of fish, including other salmon, 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 Southern Residents could lead to behavior changes and nutritional stress that could negatively affect the animal's growth, health, reproductive success, and/or ability to survive.

2.3.4.3 Project Operations Related Impacts of Reduced Prey Base for Southern Residents

Based on the analyses of expected effects of the proposed action to Chinook salmon populations in the Klamath River, reductions in the survival and productivity of Chinook salmon populations are expected to occur during the period of effects of the proposed action and the greatest effects will occur following drier water years when effects of the proposed action are most pronounced. These reductions would decrease the abundance of Chinook salmon populations in the ocean and the availability of these Chinook salmon populations as prey for Southern Residents 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, leading to increased expenditures of energy during foraging. 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 described in Section 2.3.3.1 *Factors Affecting the Prey of Southern Residents in the Action Area*, but available information suggest their exposure may be much more limited or nonexistent. The expected consequences of significant reductions in the abundance of preferred prey for these Southern Residents are reductions in the fitness of individuals because of impaired foraging behavior and increased energy expended to find sufficient prey and nutritional stress, which can diminish health, lower growth rates, lower reproductive rates and increase mortality rates. Based on the general relative analyses that have been described in Section 2.3.4.1.2 *Effects of the Proposed Action on Chinook Salmon Individuals section*, all members of K and L pod are expected to be adversely affected, or "harmed,"[27] through the increased risk of impaired foraging due to decreased Chinook salmon abundance in the ocean resulting from effects of the proposed action.

Based on the analyses of expected effects of the proposed action to Klamath River Chinook salmon, we generally cannot quantify the impacts due to the operational effects of the proposed action on Southern Residents. Based on modeling results described earlier, we anticipate that juvenile survival should be improved compared to the S3 POR as a result of changes in operations associated with the proposed action, especially during years when there are potential threats associated with disease and limited suitable habitat. As a result of improved juvenile survival, we anticipate that at times several hundreds or thousands more adult Chinook salmon

[27] 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 Southern Residents **"***by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering"*; specifically, in this case, feeding**.**

could be available as prey for Southern Residents in the action area especially after drier water years when potential stress on juvenile Chinook salmon broods and their survival on the way to the ocean would be highest. However, the general, overall qualitative assessment indicates that the conditions for Chinook salmon in the Klamath River as a result of Project operations will result in continued reductions and limitations in juvenile Chinook salmon survival and fitness that are expected to reduce the abundance of Klamath River Chinook salmon populations in the ocean. In particular, decreased and limited abundances resulting from the proposed action are expected for fall-run Chinook salmon from the Klamath River. Several effects of the proposed action are expected to consistently decrease Chinook salmon abundance, especially in drier water years throughout the period of effects of the proposed action. These impacts are expected to affect a number of key fall-run Chinook salmon spawning populations, including Bogus Creek, Iron Gate Hatchery, Shasta, Scott and mainstem Klamath, leading to both limitations in the overall survival and productivity of these populations of Chinook salmon and reductions in the number of Chinook salmon available in the southern portion of the range of Southern Residents. These reductions in available prey are most likely to be detected by all members of K and L pod, during foraging on a reduced prey field, leading to increased expenditures of energy during foraging. The expected consequences of reduced abundance of preferred prey for Southern Residents are reduced fitness of individual Southern Residents through increased energy expended to find sufficient prey and nutritional stress. Based on the general relative analyses that have been described above, all members of K and L pod are expected to be at risk of reduced fitness due to decreased Chinook salmon abundance in the ocean resulting from proposed action-related operations.

2.3.4.4 Overall Effects of Reduced Prey Base for Southern Residents as a Result of the Proposed Action

Based on the analysis above, NMFS expects that the proposed action will generally reduce the amount of Klamath River fall-run Chinook salmon available in the ocean for Southern Residents to forage. Reduced abundance, in a range of magnitudes dependent upon other environmental factors, will extend to the potential return of the 2023 cohort (up to 2027). The result of reduced ocean abundance of Klamath River Chinook salmon over this time period is that Southern Residents, especially for K and L pod whales, are expected to periodically face conditions where individuals present in the action area are required to spend more time foraging, which increases energy expenditures and the potential for nutritional stress, which can negatively affect the animal's growth, body condition, and health.

As described in Section 2.3.3.1 *Factors Affecting the Prey of Southern Residents in the Action Area*, Chinook salmon from the Klamath River are expected to constitute a sizeable component of the diet of Southern Residents in coastal waters within the action area where they overlap. Southern Residents are expected to detect and respond to reduced Klamath River Chinook salmon abundance and a reduced prey field during foraging, likely resulting in Southern Residents searching for other Chinook salmon and more abundant prey fields, either within the action area and/or other parts of their range. While Chinook salmon are expected to be the preferred prey with high nutritional value, Southern Residents are capable of taking advantage of other prey sources to supplement their nutritional needs and are assumed to do so in the immediate absence of sufficient Chinook salmon resources. Based on the distribution of

Klamath River Chinook salmon described in Section 2.3.3.1 *Factors Affecting the Prey of Southern Residents in the Action Area*, any nutritional and energetic stress impacts caused by the proposed action are most likely to occur in the more southerly range of Southern Residents. Based on research and the known distribution of Southern Residents described in Section 2.3.1 *Rangewide Status of Southern Residents*, and Section 2.3.3.1 *Factors Affecting the Prey of Southern Residents in the Action Area*, we conclude that while Southern Residents are known to occasionally use the southerly end of their range during some years, it is also likely that this population may limit or avoid use of this area altogether during some years.

Ford and Ellis (2006) report that Southern Residents engage in prey sharing about 76 percent of the time during foraging activities. Prey sharing presumably would 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). While the overall absolute impact of the proposed project on the survival and abundance of Klamath River Chinook salmon is not quantified, there are components of the proposed action that offer benefits in terms of reducing the potential impacts of disease and limitations on suitable habitat that are expected to improve survival, especially for the Chinook populations most impacted by Project operations. There are also restoration actions that are anticipated to occur that should improve Chinook salmon survival under the proposed action. Additionally, we anticipate that the benefits of reducing the potential impacts of disease and limitations on suitable habitat that lead to improved survival will be accrued during drier water years when the potential for the diminished survival of juvenile Chinook salmon in the Klamath River would be expected to occur as described above. Based on the S3 model results, we conclude that Chinook salmon productivity will likely increase for the Upper Klamath, Middle Klamath, Shasta, and Scott river population in relation to the S3 POR over the period of effects of the proposed action. Based on these improved conditions for Klamath River Chinook salmon, the ability of Southern Residents to take action to search out other areas with more abundant Chinook salmon prey fields or take advantage of other prey sources to supplement their nutritional needs in the immediate absence of sufficient Chinook salmon resources, the variable contribution of Klamath Chinook to the available prey within the action area and total abundance of Chinook available in the ocean for Southern Residents across their range on an annual basis, and the likelihood that Southern Residents may avoid the southern end of their range in some years (where Klamath Chinook can be an important food source), we conclude that the relative magnitude of adverse effects resulting from the behavioral changes and nutritional stress that may occur in response to reduced abundance of Klamath River Chinook salmon prey in the ocean available to Southern Residents in the ocean each year over the duration of the effects of the proposed action would likely be limited in extent and moderated to some degree by the factors discussed above. As a result, we do not anticipate more severe adverse effects such as immediate or delayed mortality or diminished reproductive rates for individuals as a result of the proposed action.

2.3.5 <u>Cumulative Effects</u>

"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). 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.

Pertinent cumulative effects that relate to the proposed action are described above in Section 2.2.5 *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.

With respect to cumulative effects related to Southern Residents and Chinook salmon in the marine waters of the Pacific Ocean within the action area, future tribal, state, and local government actions will likely be in the form of legislation, administrative rules, policy initiatives, or fishing permits. Activities are primarily those conducted under state and tribal management. These actions may include changes in ocean policy and increases and decreases in the types of activities that currently occur, including changes in the types of fishing activities, resource extraction, or designation of marine protected areas, any of which could impact Southern Residents, Chinook salmon, or their habitat. Government actions are subject to political, legislative and fiscal uncertainties. These realities, added to the geographic scope, which encompasses several government entities exercising various authorities, and the changing economies of the region, make analysis of cumulative effects in this regard highly speculative. A Final Recovery Plan for Southern Resident killer whales was published in 2008 (NMFS 2008a). Although state, tribal and local governments have developed plans and initiatives to benefit Southern Residents and Chinook salmon, they must be applied and sustained in a comprehensive way before NMFS can consider them “reasonably certain to occur” in its analysis of cumulative effects. Private activities in this portion of the action area are primarily associated with boating related activities and other potential sources of marine pollution.

In summary, these potential factors are ongoing and expected to continue in the future, and the level of their impact is uncertain. For these reasons, it is not possible to predict beyond what is included in the subsections pertaining to cumulative effects above, and whether future non-Federal actions will lead to an increase or decrease in prey available to Southern Resident, or have other effects on their survival and recovery. It is likely that the *Status of the Species* (Section 2.3.1) and *Environmental Baseline* (Section 2.3.3) characterize the type and magnitude of the effects these factors may be expected to have in the future during this proposed action.

2.3.6 Integration and Synthesis for Southern Residents

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the effects of the action (Section 2.2.3) to the environmental baseline (Section 2.2.3) and the cumulative effects (Section 2.2.5), taking into account the status of the species (Section 2.2.1), 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 diminishes the value of designated or proposed critical habitat for the conservation of the species.

The status of the species and environmental baseline for Southern Residents has been described in sections 2.3.1 and 2.3.3, respectively. As described above in section 2.3.4, our analysis of effects to Southern Residents relies upon on the expected impacts of the proposed action on the abundance and availability of Chinook salmon for them, and how any expected changes in prey availability will affect the fitness of Southern Residents and ultimately the survival and reproduction of Southern Residents. Considering that the Chinook salmon from the Klamath River that are expected to be impacted by the proposed action are fall-run Chinook salmon, our assessment of the expected impacts of the proposed action on the abundance and availability of Chinook salmon focuses on this component of Chinook salmon productivity in the Klamath Basin.

The Southern Resident 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. Over the last 5 decades, the Southern Resident 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 Southern Resident population, with 52 of the 74 members. Chinook salmon has been confirmed to be the preferred prey of Southern Residents, and both the survival and fecundity of Southern Residents have previously been linked to the abundance of Chinook salmon that may be available for them as prey. A recent population viability assessment found that over the range of scenarios tested, the effects of prey abundance on fecundity and survival had the largest impact on the population growth rate. There is some evidence of a decline in fecundity rates through time for reproductive females, which may be linked to fluctuations in abundance of Chinook salmon prey among other factors. Other signs of poor health (peanut head) have been observed in a number of individuals as well. 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 fresh water environment, including ongoing Project operations and climate change. The harvest of Chinook salmon in the ocean also reduces the abundance of prey for Southern Residents. It is also likely that the accumulation of pollutants in Southern Residents through consuming Chinook salmon 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 Southern Resident population over time, but the relative small Southern Resident population size and limited reproductive success in recent years remains the primary source of concern for this species.

Based on the analysis in Section 2.3.4 *Effects of the Action,* NMFS expects that the proposed action will reduce the amount of Klamath River fall-run Chinook salmon available in the ocean for Southern Residents to forage throughout the duration of the effects of the proposed action, extending as far as 2027 by the time all of the juvenile Chinook production 5 years from now have fully matured and returned to spawn or otherwise been removed from the ocean through mortality. Based on the analyses that have been performed and the limitations of the available tools, the expectations for the absolute magnitude of these reductions in total cannot be precisely estimated, although we note that significant improvements in juvenile Chinook salmon survival and resulting increases in adult Chinook salmon available for Southern Residents in the action area are anticipated to occur as a result of the proposed action relative to historical conditions over the period of effects of the proposed action (extending through 2027), which should help mitigate effects of the proposed action to some degree. While the absolute magnitude of the overall impact of the proposed action cannot be precisely determined, we expect that the proposed action will generally result in reduced abundance of Chinook salmon, and we expect that Southern Residents will at times be harmed through impaired foraging behavior and success, requiring additional time spent foraging, which increases energy expenditures and the potential for nutritional stress, especially for members of K and L pods.

When prey is scarce, Southern Residents likely spend more time foraging than when prey is plentiful. 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. Since 2008, aerial photogrammetry studies from SWFSC and partners have been used to assess the body condition and the health of Southern Resident killer whales. More recent annual aerial surveys of the population have provided evidence of a general decline in Southern Resident killer whale body condition since 2008, and documented members of J pod being in poorer body condition in May compared to September. Although body condition in whales can be influenced by a number of factors, including disease, physiological or life history status, prey limitation is the most likely cause of observed changes in body condition in wild mammalian populations.

As described in Section 2.3.4 *Effects of the Action Section*, the overlap in distribution of Southern Residents and Klamath fall-run Chinook salmon occurs when Southern Residents are occasionally in the southern part of their range along the coast of California and Oregon during the winter and spring. If prey fields are not sufficient in a portion of their foraging range, Southern Residents are known to engage commonly in prey sharing, and are also known to switch to other sources of prey during those times, which helps to distribute and minimize the extent of effects to individuals across the population. While the analysis of the effects of the proposed action indicate that Project operations will generally continue to contribute to reducing Chinook salmon productivity in the Klamath River, the proposed action includes measures that are expected to lower disease risk in a direction toward disease risk under natural flow conditions and ultimately improve overall juvenile fall-run Chinook salmon survival. As a result, we believe that Chinook salmon productivity in the Upper Klamath, Middle Klamath, Shasta, and Scott river populations for the period of effects of the proposed action will likely improve, ultimately increasing the amount of potential prey for Southern Residents in the ocean during this time, especially if the threats of disease and habitat stress are relatively high. Based on these factors and available information, NMFS concludes that the proposed action would likely not alter the fitness of individual Southern Residents enough to further reduce their survival and reproduction rates over the next five to nine years of effects of the proposed action. Based on this conclusion regarding individual Southern Residents, NMFS concludes that the proposed action would not be expected to reduce the reproduction, numbers, or distribution of the Southern Residents population.

Factoring in the status of the species, environmental baseline, and cumulative effects, NMFS concludes the proposed action would not be expected to appreciably reduce the likelihood of both the survival and recovery of the Southern Resident killer whale DPS.

2.4 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, any effects of interrelated and interdependent activities, and 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, or destroy or adversely modify their designated critical habitat.

After reviewing and analyzing the current status of the listed species, the environmental baseline within the action area, the effects of the proposed action, any effects of interrelated and interdependent activities, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the Southern Resident Killer Whale DPS.

2.5 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). "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 Incidental Take Statement (ITS).

Section 7(b)(4) of the ESA provides for an incidental take statement for threatened and endangered species of marine mammals only if authorized pursuant to section 101(a)(5) of the Marine Mammal Protection Act (MMPA). Until the proposed action receives authorization for the incidental taking of marine mammals under section 101(a)(5) of the MMPA, the incidental take of Southern Residents described below is not exempt from the ESA taking prohibitions pursuant to section 7(o) of the ESA.

2.5.1 Amount or Extent of Take

In the biological opinion, NMFS determined that incidental take is reasonably certain to occur as follows: NMFS anticipates the proposed action will result in incidental take in the form of harm to SONCC coho salmon ESU individuals through increased disease risks, habitat reductions, elevated water temperatures, reductions to dissolved oxygen concentrations, and decreased smolt outmigration rates. In addition, NMFS anticipates the proposed action will result in incidental take in the form of capturing, wounding, and killing SONCC coho salmon ESU individuals through fish relocation and dewatering during restoration activities. Finally, NMFS anticipates the proposed action will result in incidental take in the form of harm to Southern Resident individuals through reduction in prey availability and impairment of foraging behavior as described in the *Incidental Take Summary for Southern Residents* section (Section 2.5.1.3).

Quantifying the amount or extent of incidental take of coho salmon in the mainstem Klamath River is difficult since the Project's primary mechanism for affecting coho salmon is through hydrologic changes to the Klamath River discharge at IGD due to the proposed action storing and delivering Project water. NMFS cannot quantify the amount or extent of incidental take as a result of these hydrologic changes and resulting habitat-based effects in terms of numbers of individuals of coho salmon since finding dead or impaired specimens resulting from habitat-based effects is unlikely because of the dynamic nature of riverine systems, including variations in hydrologic conditions, variations in the population size of coho salmon, annual variations in the timing of spawning and migration, and variations in habitat use within the action area. In addition, the physical and biological mechanisms influencing growth, predation rates and competitive interactions of coho salmon in the Klamath River are myriad and complex. For instance, predation rates within the Klamath River are likely influenced by water quantity, water quality (e.g., turbidity), and available instream habitat, as well as the relationship between predator and prey abundance and the spatial overlap between the two. Due to the inherent biological characteristics of aquatic species, such as coho salmon, the large size and variability of the Klamath River, the operational complexities of managing Klamath River flows, and the difficulty in both locating deceased coho salmon in this environment and then determining cause of harm, quantifying individuals that may be taken incidental to the many components of the proposed action is generally not possible. In addition, incidental take of coho salmon from the increased disease risk is difficult to estimate because of the limited data on coho salmon-specific infection and mortality rates. When NMFS cannot quantify the amount or extent level of incidental take in terms of the numbers of individuals, NMFS uses surrogates to estimate the amount or extent of incidental take.

As discussed in the Opinion, NMFS identified that the proposed action will result in the incidental take of coho salmon in the mainstem Klamath River in the form of harm due to habitat reductions during March through June, elevated water temperatures during May through June, reductions to dissolved oxygen concentrations during June through August, decreased smolt outmigration during April through June, and increased disease risks during April through August. Since habitat reductions, elevated water temperatures, reductions to dissolved oxygen concentrations, decreased smolt outmigration rates, and increased disease risks are inextricably linked to flow, which is quantifiable and can be monitored, NMFS uses hydrologic-based surrogates, because water availability in the mainstem Klamath River in the spring and summer has a direct effect on these sources of incidental take. NMFS uses the minimum average daily flows at IGD (Table 33), the reductions to IGD flows due to UKL control logic (Table 34 and Table 35) and the EWA used (Table 36 and Table 37) at levels described more specifically below as surrogates for the amount or extent of incidental take to coho salmon as a result of the effects.

In our analysis of effects of the action, NMFS assumes that minimum daily average IGD flows, reductions to IGD flows due to UKL control logic, and EWA volume to be released at IGD (i.e., EWA used) as described in the proposed action for the next five years will be consistent with what was modeled in the KBPM for the POR. In NMFS' analysis of effects of the action, NMFS expects minimum daily average IGD flows in Table 33 will be met, and reductions to IGD flows due to UKL control logic will be consistent with those identified in Table 6 and Table 7. NMFS also anticipates the percent of EWA volume to be released at IGD (i.e., EWA used) by June 30 and September 30 of each water year to be consistent with those identified in Table 36 and Table 37. The minimum daily average IGD flows, the percent reductions to daily IGD flows, and the percentages of EWA used by June 30 and September 30 of each water year reflect the boundaries of the flow conditions NMFS analyzed in the biological opinion. Therefore, NMFS uses the following surrogates for the amount or extent of incidental take to coho salmon expected as a result of the flow-related effects of the proposed action described above: (1) the minimum daily average flows described in Table 33[28] shall be met; (2) the daily reduction to IGD flow due to UKL control logic shall not exceed the largest daily reduction to IGD flow modeled in the POR of 74 percent, (3) the percentage of the final EWA volume based on June 1 supply and used between March 1 and June 30 shall not be less than the lowest percentage of EWA spent and modeled in the POR of 61 percent, and (4) based on annual June 1 EWA supply, EWA released between March 1 and September 30 shall not be underspent by more 5 percent[29]. If any of these four thresholds are not met, the amount or extent of incidental take to coho salmon will be considered exceeded unless NMFS determines that extraordinary hydrologic conditions rather than effects of the proposed action were responsible for the IGD flow reductions or EWA underspend. For example, water year 1997 was an unusual hydrologic year in the POR with an extraordinarily wet spring in late April and May resulting in EWA being underspent by 14 percent. 1997 represents an outlier year in the modeled POR. In 35 out of 36 years in the POR, the proportion of EWA underspend did not exceed 5 percent. Our analysis leads us to believe we are unlikely to experience an extraordinary hydrologic condition in the next five years that would result in a significant EWA underspend as observed in the modeled 1997 water year. These thresholds are quantifiable, will be monitored, and will be reported at specific times during implementation of the proposed action, as described in more detail in the terms and conditions below, serving as clear, effective reinitiation triggers throughout the term of the proposed action.

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[28] Up to 5 percent reduction below the minimum daily average flows at IGD may occur for up to 72-hours because facility control limitations and stream gage measurement error may limit the ability to manage precise changes in releases from IGD. If such a flow reduction occurs, the resulting average flow for the month will meet or exceed the associated minimum daily average flow.

[29] NMFS does not expect greater than a 5 percent 'underspending' of EWA to occur during implementation of the proposed action to remain within the effects we analyzed in this Opinion, unless a water year with extraordinary hydrologic conditions occurs.

Table 33. Minimum daily average flows (cfs) for Iron Gate Dam.

Month	Iron Gate Dam Average Daily Minimum Target Flows (cfs)
March	1,000 cfs (28.3 m^3/sec)
April	1,325 cfs (37.5 m3/sec)
May	1,175 cfs (33.3 m3/sec)
June	1,025 cfs (29.0 m3/sec)
July	900 cfs (25.5 m^3/sec)
August	900 cfs (25.5 m^3/sec)
September	1,000 cfs (28.3 m^3/sec)

Table 34. Average, maximum, and number of daily reductions in Iron Gate Dam flow due to UKL Control Logic.

Daily Reduction in Iron Gate Dam Flow due to UKL Control Logic						
Month	**AVG (# of Days)**	**MAX (# of Days)**	**AVG (CFS)**	**MAX (CFS)**	**AVG (%)**	**MAX (%)**
October	6	31	16	170	1	15
November	3	19	10	382	1	19
December	0	0	0	0	0	0
January	0	0	0	0	0	0
February	0	0	0	0	0	0
March	7	31	170	4165	7	73
April	5	27	123	4227	3	74
May	3	30	44	2810	2	69
June	0	3	2	810	0	32
July	1	31	6	348	1	28
August	1	22	3	366	0	28
September	3	30	17	465	1	32

Table 35. Average and maximum monthly total reduction in Iron Gate Dam flow due to UKL Control Logic.

Monthly Total Reduction in Iron Gate Dam Flow due to UKL Control Logic				
Month	**AVG (AF)**	**MAX (AF)**	**AVG (% Volume)**	**MAX (% Volume)**
October	1,000	8,000	1	11
November	1,000	6,000	1	7
December	0	0	0	0
January	0	0	0	0
February	0	0	0	0
March	10,000	136,000	6	55
April	7,000	154,000	3	54
May	3,000	56,000	2	37
June	0	4,000	0	5
July	0	14,000	1	20
August	0	7,000	0	10
September	1,000	22,000	1	27

Table 36. Percent of final June 1 EWA used between March 1 and June 30 under the proposed action for the POR.

Water Year	Percent EWA Used (%)	Water Year	Percent EWA Used (%)
1981	76	1999	81
1982	84	2000	75
1983	82	2001	72
1984	83	2002	74
1985	75	2003	75
1986	85	2004	72
1987	77	2005	66
1988	74	2006	75
1989	81	2007	77
1990	74	2008	69
1991	77	2009	72
1992	61	2010	70
1993	82	2011	73
1994	61	2012	77
1995	75	2013	69
1996	78	2014	66
1997	64	2015	66
1998	79	2016	72

Table 37. Proposed action Final June 1 EWA allocations and EWA release volumes by September 30 for the POR.

Water Year	EWA VOLUME (TAF)	EWA USED (TAF)	EWA UNDERSPEND (TAF)	EWA UNDERSPEND (%)	EWA OVERSPEND (TAF)	EWA OVERSPEND (%)
1981	441	469	0	0	28	6
1982	911	940	0	0	29	3
1983	1073	1061	12	1	0	0
1984	940	956	0	0	16	2
1985	639	629	10	2	0	0
1986	766	806	0	0	40	5
1987	482	489	0	0	7	1
1988	456	484	0	0	28	6
1989	818	815	4	0	0	0
1990	435	447	0	0	12	3
1991	400	430	0	0	30	8
1992	407	385	22	5	0	0
1993	783	791	0	0	8	1
1994	407	404	3	1	0	0
1995	663	644	19	3	0	0
1996	734	734	0	0	0	0
1997	607	522	85	14	0	0
1998	911	891	19	2	0	0
1999	857	848	9	1	0	0
2000	651	650	1	0	0	0
2001	400	412	0	0	12	3
2002	481	490	0	0	9	2
2003	495	495	0	0	0	0
2004	470	478	0	0	8	2
2005	435	434	1	0	0	0
2006	871	842	30	3	0	0
2007	536	529	7	1	0	0
2008	599	577	22	4	0	0
2009	514	512	2	0	0	0
2010	427	430	0	0	3	1
2011	775	737	38	5	0	0
2012	577	582	0	0	5	1
2013	424	418	6	1	0	0
2014	407	411	0	0	4	1
2015	400	404	0	0	4	1
2016	517	519	0	0	1	0

In this Opinion, NMFS identified the proposed action's contribution to increasing risks to coho fry and juveniles from *C. shasta* infection. NMFS identified the proposed action's contribution to *C. shasta* risks will result in harm to coho salmon through increased likelihood of impaired growth, swimming performance, body condition, increased stress and susceptibility to secondary infections, and increased likelihood of disease related mortality. Limited data exist or are expected to be available on juvenile coho salmon fitness in relation to these disease risks and NMFS cannot specifically quantify the amount or extent of incidental take associated with disease related impediments to fitness. In our 2013 Opinion, NMFS used the prevalence of infection (POI) of Chinook salmon as a surrogate for disease related mortality of coho salmon (NMFS and USFWS 2013). Although POI remains an important monitoring characteristic for evaluating intra- and inter-annual infectious patterns in the Klamath River, measures of POI levels alone are not sufficient to infer the individuals will be negatively impacted by disease, as demonstrated by new information from 2017 (True et al. 2017). More specifically, recent work has suggested that mortality is more accurately predicted by the severity of infection and disease progression within individuals than by POI alone (USFWS 2016a). Severity of infection and disease progression are highly influenced by water temperature (USFWS 2016c).

For this Opinion, in addition to the surrogates described above for flow-related effects of the proposed action, NMFS has determined to use a coho salmon-specific incidental take surrogate for estimated risk to coho salmon fry and juveniles from *C. shasta* infection. AFWO has developed a preliminary draft model that estimates the prevalence of mortality (POM), defined as the predicted proportion of a spring/early summer outmigrating population of juvenile fish that suffer C. shasta induced mortality. As discussed in the SONCC coho salmon *Effects of the Action section*, NMFS concluded that the proposed action will likely result in disease risks to coho salmon fry and juveniles that are lower than those observed during POR conditions, and as such, we conclude that the incidental take of coho salmon fry and juveniles will be lower than the rates observed in the POR. NMFS does not have information to specifically estimate what the reduced *C. shasta* infection rates for salmon will be under the proposed action; however, for reasons described in the SONCC coho salmon *Effects of the Action section*, NMFS expects annual surface flushing flows will, at a minimum, reduce spores/l by approximately 25 percent.

In our *Integration and Synthesis* section, we determined that populations proximal to IGD and exposed to the infectious zone of mainstem Klamath River between IGD and Seiad are most likely to be infected. As one of those populations most likely to be exposed, the Shasta River population serves as a useful indicator of incidental take of coho salmon as a result of effects of the proposed action related to *C. shasta* infection due to the relative abundance and robustness of monitoring data collected, and the expected continuation of monitoring data collections throughout the proposed action.

In the 2005-2016 period of record analyzed by USFWS using the preliminary POM model, POM was predicted to be high in 2007-2009, with the highest POM affecting the Shasta population in 2009 (POM =0.55) (
Table 22). The predicted high POM occurring between 2007-2009 is corroborated by the work of USGS through their S3 modeling results, indicating low survival of juvenile Chinook salmon from populations proximal to IGD (see Figure 26, Southern Resident analysis) in those same years.

Results from the preliminary draft USFWS POM model indicate 2009 as the year of highest POM in their study period, and in that year a 25 percent reduction in spores expected as a result of the proposed action is simulated to have resulted in a reduction of POM from 0.55 to of 0.49.

Therefore, the amount or extent of incidental take of coho salmon as a result of the proposed action's contribution to C. shasta risks will be considered exceeded if annual Shasta River coho salmon POM exceeds 0.49 (49 percent, see Table 38). NMFS anticipates the POM model to be finalized including a peer-review process, at which time NMFS will determine if adjustments to this incidental take surrogate are necessary. This POM threshold is quantifiable, will be monitored, and will be reported at specific times during the proposed action, as described in more detail in the terms and conditions below, serving as a clear, effective reinitiation trigger throughout the term of the proposed action.

Table 38. Estimated prevalence of mortality (POM) of age 0+ and age 1+ (combined) coho salmon in the mainstem Klamath River between the Shasta River and Seiad, under an assumed 25 and 75 percent actinospore reduction under the proposed action.

Shasta River to Seiad	**2.42 day exposure**		
Year	POM	POM with 25% reduction in spores/l	POM with 75% reduction in spores/l
2005	0	0.04	0
2006	0.028	0.019	0.015
2007	0.447	0.379	0.234
2008	0.454	0.376	0.246
2009	0.546	0.488	0.175
2010	0.017	0	0
2011	0	0	0
2012	0	0	0
2013	0	0	0
2014	0.314	0.251	0.14
2015	0.696	0.362	0.151
2016	0.073	0	0

2.5.1.1 Restoration Activities

Over the 5-year term of the proposed action, NMFS expects the restoration activities funded under the proposed action will result in incidental take of SONCC ESU coho salmon juveniles. NMFS expects short-term increased sedimentation, noise, and vibration disturbance as a result of restoration activities; however, these effects are expected to be minor and will not rise to the level of incidental take of individuals. Juvenile coho salmon will be captured, wounded, or killed from the dewatering, structural placement, and fish relocating activities at the restoration project sites. Based on monitoring data of similar restoration activities described in this Opinion, we concluded 40 coho salmon may be captured and relocated per project, and 1 percent of those captured may be injured or killed. NMFS identified that, on average, Reclamation's program is likely to fund eight projects, annually. Juvenile coho salmon that avoid capture in the project work area will die during dewatering activities. NMFS expects that the number of coho salmon that will be killed as a result of barrier placement and stranding during site dewatering activities is very low, likely less than one percent of the total number of salmonids in the project area. Based on an information that 100 coho fry and juveniles are estimated to be captured and relocated per project, and of those captured and relocated, up to 1 percent are estimated to be injured or killed, and Reclamation is likely to fund 8 projects annually, NMFS expects no more than 800 juvenile and fry SONCC coho salmon are expected to be captured and relocated annually and up to eight may be injured or killed annually. These thresholds are quantifiable, will be monitored, and will be reported at specific times during the proposed action, as described in more detail in the terms and conditions below, serving as clear, effective reinitiation triggers throughout the term of the proposed action.

2.5.1.2 Incidental Take Summary for Coho Salmon

A summary of the amount or extent of incidental take of coho salmon by life history stage, stressor, and general location within the action area that is expected to occur as a result of the proposed action is presented below (Table 39).

Table 39. Summary of annual incidental take of SONCC coho salmon expected to occur as a result of the proposed action.

Cause of Incidental Take	**Life Stage**	**General Time**	**Location**	**Type of Incidental Take**	**Amount or Extent of Incidental Take**
Habitat Reduction	Fry	June	IGD to Shasta River, Scott River to Salmon River	Harm	Measured by flow surrogates described above as (1) the minimum daily average flows described in Table 33; (2) daily reduction to IGD flow due to UKL control logic shall not exceed 74%, (3) the percentage of the final June 1 EWA volume used between March 1 and June 30 shall not be less than 61 percent, and (4) based on annual June 1 EWA supply, EWA released between March 1 and September 30 shall not be underspent by more 5 percent.
	Parr and Smolts	May to June	Trees of Heaven to Rogers Creek		
Increased risk of disease (*C. shasta*)	Fry	May to mid-June	Klamathon Bridge to Orleans	Harm	In addition to the flow surrogates described above, measured by a surrogate of up to 49 percent (via AFWO evaluation of prevalence of mortality) of the total annual juvenile coho salmon outmigrating from the Shasta River.
	Parr	May to August			
	Smolts	May to June			
	Fry	May to mid-June	Trees of Heaven to Seiad Valley		
	Parr, and Smolts	May to June			

Cause of Incidental Take	Life Stage	General Time	Location	Type of Incidental Take	Amount or Extent of Incidental Take
Elevated water temperature	Fry	May to mid-June	IGD to Scott River	Harm	Measured by flow surrogates described above as (1) the minimum daily average flows described in Table 33; (2) daily reduction to IGD flow due to UKL control logic shall not exceed 74%, (3) the percentage of the final June 1 EWA volume used between March 1 and June 30 shall not be less than 61 percent, and (4) based on annual June 1 EWA supply, EWA released between March 1 and September 30 shall not be underspent by more 5 percent.
	Parr and Smolts	May to June			
DO reduction	Parr	June to August	IGD (RM 190) to Orleans (RM 59)	Harm	
Decreased outmigration rates	Smolts	April to June	IGD (RM 190) to Shasta River (RM 177)	Harm	
Fish Relocation and Structural Placement	Fry, Parr, Smolts	June 15 to November 1	IGD to Estuary and tributaries in action area	Capture, wound, or kill	Fish Relocation, Structural Placement, and Dewatering combined, up to 800 coho salmon fry and juveniles may be captured and relocated, of which up to 8 may be wounded or killed annually.
Dewatering	Fry, Parr, Smolts	June 15 to November 1	IGD to Estuary and tributaries in action area	Capture, wound, or kill	

2.5.1.3 Incidental Take Summary for Southern Residents

NMFS anticipates that the reduction in the abundance of Klamath River Chinook salmon that will occur as a result of the proposed action will result in some level of harm to Southern Residents, specifically members of K and L pod (currently 52 individuals), by reducing prey availability and causing impairment in foraging behavior, leading animals to forage for longer periods, travel to alternate locations, and experience nutritional stress and related health effects. Currently, we cannot readily observe or quantify impacts to foraging behavior or any changes to health of individual killer whales in the population from the general level of prey reduction that has been described in the proposed action because we do not have the data or metrics needed to monitor and establish relationships between the effects of the proposed action and individual Southern Resident health. As a result, we will rely on surrogates of the amount or extent of incidental take of Southern Residents as a result of the proposed action in the form of the extent of effects to Chinook salmon populations described in the effects analysis on Chinook salmon section (Sections 2.3.4 *Effects of the Action* and 2.3.6 *Integration and Synthesis for Southern Residents*), and the measures of flow surrogates used in Section 2.5.1.2 *Incidental Take Summary for Coho Salmon*. Exceedance of the extent of effects to Chinook salmon would be viewed as an exceedance of the anticipated harm to Southern Residents.

While we cannot quantify the total extent of Klamath River Chinook salmon productivity that is lost or the total extent that is limited by the proposed action, we can use the same measures of flow already used for surrogates of incidental take to coho salmon to describe the extent of impacts to Chinook salmon that have been analyzed in this Opinion, given that impacts from the proposed action as reflected by flows reflects the same general principles of how the proposed action affects both coho and Chinook salmon in the Klamath River. These flow thresholds also serve as boundaries of effects to Chinook salmon (and ultimately Southern Residents) that have been analyzed in the Opinion. Therefore, we will use these flow thresholds as surrogates for the amount or extent of anticipated incidental take of Southern Residents as a result of the proposed action. In addition, we can monitor and quantify the impact of infection rates and disease mortality on juvenile survival of Klamath River Chinook salmon to the ocean, consistent with the assumptions and analysis described in the *Effects of the Proposed Action on Chinook Salmon Individuals* section (Section 2.3.4.1.2), that relied upon results anticipated by the S3 models. The benefits of the proposed action flushing flows to reduce disease and improve suitable habitat are directly related to the anticipated improvement in juvenile survival that is an important part of the effects analysis and conclusion of this opinion.

Similar to our coho salmon incidental take criteria, we use an estimated prevalence of *C. shasta* infection rate at the Kinsman trapping location metric for juvenile Chinook salmon in the Klamath River as an indicator for monitoring the disease related effects of the proposed action on Chinook salmon, and ultimately on Southern Residents. We apply the conservative assumption described in USGS (2019) that defines all infected juveniles will subsequently die. In the *Effects of the Proposed Action on Chinook Salmon Individuals* section (Section 2.3.4.1.2), S3 model results indicated that the prevalence of infection for naturally produced juvenile Chinook salmon surviving to the Kinsman trap location that originate from spawning in the mainstem and utilize tributaries in close proximity to IGD (i.e., Klamath River, Bogus Creek, Shasta River) would not have exceeded 53 percent over the S3 POR if the proposed action had been implemented during that time. By extension from these results, we expect that the prevalence of infection for naturally produced juvenile Chinook salmon surviving to the Kinsman trap location that originate from spawning in the mainstem and utilize tributaries in close proximity to IGD will not exceed 53 percent during the proposed action. Therefore, we use this level, as measured by the S3 model, as an additional surrogate for the amount or extent of anticipated incidental take of Southern Residents as a result of the proposed action. This threshold is quantifiable, will be monitored at a similar location to our coho salmon disease threshold, and will be reported at specific times during the proposed action, as described in more detail in the terms and conditions below, serving as a clear, effective reinitiation trigger throughout the term of the proposed action (Table 40). As we describe in the *Effects of the Proposed Action on Chinook Salmon Individuals* section (Section 2.3.4.1.2), POI has been previously reported in Klamath River monitoring, and defined as individuals testing positive for *C shasta* infection. This is how POI was used in terms of our incidental take statement with our 2013 opinion. As POI has been previously reported in Klamath River monitoring and used, the fate of infected fish that survive to the ocean is unknown, and some may eventually recover from disease and ultimately survive. It is important to recognize that infected fish, under USGS's definition of prevalence of infection for purposes of the S3 model, would have died based on sentinel trial data. Therefore, POI for purposes of the S3 model is similar to POM as described above in this incidental take statement as it relates to SONCC coho salmon.

Table 40. Simulated prevalence of infection (POI) of juvenile Chinook salmon (Klamath River, Bogus Creek, Shasta River) at Kinsman trap location. Zero entries indicate estimates from trapping program were unavailable due to high river flows (USGS 2019).

	Historical			**Proposed Action**		
Migration year	**Infected Fish**	**Total Abundance**	**POI**	**Infected Fish**	**Total Abundance**	**POI**
2005	37781	731425	0.05	22135	727491	0.03
2006	44015	277381	0.16	9225	280479	0.03
2007	346040	768333	0.45	266226	771933	0.34
2008	1108104	1762775	0.63	926098	1753206	0.53
2009	500232	1011143	0.49	427725	1030037	0.42
2010	63941	1881132	0.03	16139	1858386	0.01
2011	2454	471075	0.01	4	486598	0.00
2012	81	1414429	0.00	0	1434261	0.00
2013	124634	3675663	0.03	0	3684969	0.00
2014	1490838	3666971	0.41	245143	3583101	0.07
2015	501374	3293923	0.15	630526	3873034	0.16
2016	264421	1309242	0.20	165673	1294682	0.13

2.5.2 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.

2.5.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" are nondiscretionary measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take (50 CFR 402.02).

RPM 1. Reclamation shall take all necessary and appropriate actions within its authorities to minimize take of coho salmon and Southern Residents as a result of implementing the proposed action.

RPM 2. Reclamation shall prepare and provide NMFS with plan(s) and report(s) describing how Reclamation is implementing the Project in accordance with the proposed action and how impacts of the incidental take on listed species in the action area will be monitored and documented.

2.5.4 Terms and Conditions

The terms and conditions described below are non-discretionary, and Reclamation or any applicant must comply with them in order to implement the RPMs (50 CFR 402.14). Reclamation 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). 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.

2.5.4.1 The following terms and conditions implement reasonable and prudent measure 1:

1A. Take Actions to Ensure EWA Distribution and IGD Flows Are Managed within the Scope of the Proposed Action

The bounds to the hydrological conditions expected under this Opinion are described in the *Effects of the Action* section. Since habitat reductions, elevated water temperatures, reductions to dissolved oxygen concentrations, decreased smolt outmigration rates, and increased disease risks are inextricably linked to flow, which is quantifiable and can be monitored, NMFS uses flow thresholds described above in the *Amount or Extent of Take* section as surrogates to measure the amount or extent of incidental take. Monitoring annual EWA volumes and distribution and IGD flows and whether they are within the scope of the proposed action will provide Reclamation and NMFS with the information needed to determine whether incidental take surrogates are met. Therefore, as the irrigation season progresses from March 1 – September 30, Reclamation shall manage EWA distribution and IGD flows to meet the following surrogates and monitor EWA distribution and IGD flows (including reductions to IGD flows due to UKL control logic) to determine whether the following surrogates are met:

- The minimum daily average flows described in Table 33 are met.

- The daily reduction to IGD flow due to UKL control logic shall not exceed the largest daily reduction to IGD flow modeled in the POR of 74 percent.

- The percentage of the final EWA volume based on June 1 supply and used between March 1 and June 30 shall not be less than 61 percent.

- Based on annual June 1 EWA supply, EWA released between March 1 and September 30 shall not be underspent by more 5 percent.

Based on monitoring, if Reclamation determines any of the thresholds listed above have not been met or EWA spending and/or IGD flows are expected to potentially fall outside the thresholds listed above, Reclamation shall immediately notify NMFS and consult with the Services to determine the causative factors. If EWA spending and/or IGD flows have not yet fallen outside the thresholds listed above and NMFS determines that causative factors are not due to extraordinary hydrologic conditions, Reclamation, in consultation with the Services, shall determine and take in-season corrective actions including adjustments to avoid falling outside the thresholds listed above.

In addition, to reduce the likelihood of underspending EWA by greater than five percent by September 30th, Reclamation shall complete an assessment, in coordination with the Services, of EWA used and EWA remaining on May 1 of each calendar year to ensure that the percentage of EWA used in March and April is consistent with EWA distribution modeled in the KBPM for the POR and is not expected to fall outside the thresholds listed above.

1B. Monitor Keno Impoundment and UKL Project-Related Diversions
Reclamation shall monitor Project-related diversions in the Keno Impoundment and around UKL to reduce uncertainty associated with the unknown volumes of water delivered to these lands under operation of the Klamath Project. Monitoring and annual reporting of these Project-related diversions helps ensure that the diversion volumes are consistent with what was modeled in the KBPM for the POR and will provide NMFS with more certainty regarding KBPM output, specifically IGD flows, Project deliveries and UKL elevations. More certainty in water allocations will help improve the KBPM and reduce error through time, and aid in in-season management to address disease issues and minimize incidental take. Reclamation shall also compile monitoring data for these diversions on an annual basis for the duration of the proposed action and assemble the data into a complete data set to be reported in the Annual Monitoring Report and incorporated into the next proposed action.

1C. Consultation with the Services on Release of Project Call Water
Reclamation has proposed to quantify an amount of inflow that may result from a Project call and deliver this amount to Project irrigators as that additional inflow manifests during the irrigation season. Ultimately, a scientifically robust, peer-reviewed methodology should be developed and used to quantify call water, but none is available at this time. A protracted period without an agreed-upon method for call water quantification may result in unforeseen consequences for listed species, including the potential for incidental take of listed species

beyond that contemplated in the Services' opinions. Therefore, Reclamation shall produce a robust water quantification tool or method by June 1, 2021. Reclamation shall have the tool or method peer-reviewed and make any necessary adjustments identified by this process by June 1, 2022. During the interim period, while development of this tool or method is ongoing (i.e., water years 2019 and 2020) and prior to a call being made, Reclamation shall coordinate with the Services to quantify any additional volume of water related to a Project call and determine potential impacts of its delivery to listed species before delivery quantity is announced or deliveries begin. This coordination will ensure that call water quantification methodology is sound and does not result in the potential for incidental take of listed species beyond that which was analyzed by the Services in their opinions.

Reclamation shall coordinate with the Services, and other appropriate agencies (e.g., USGS, Oregon Water Resources Department, irrigation districts), for review and technical support in the development of the quantification tool or method. Reclamation will also coordinate with the Services in planning and conducting peer review.

1D. Develop and Implement a Hydrological and Biological Data Management Plan
Reclamation's effective management of hydrological and biological data related to Project operations and effects is essential to ensure that incidental take of listed species as a result of effects of the proposed action can be evaluated and minimized and to maintain a period of record for future consultations. In addition, ready and structured access to data and model runs relevant to water allocation and management is essential to ensure that incidental take as a result of effects of the proposed action can be evaluated and minimized. Therefore, Reclamation shall develop a data management plan that will include the details of how hydrological and biological data related to Project operations and effects will be stored and shared with NMFS and other agencies. Reclamation shall develop the plan in coordination with USFWS and NMFS, provide the Services a draft plan for review and comment by October 1, 2019, provide the Services a final plan that addresses the Services' comments by December 1, 2019, and implement the final plan thereafter; these dates can be adjusted to ensure a high quality product if Reclamation, NMFS and USFWS agree that it is necessary.

The plan shall include standard operating procedures for collecting, reviewing, finalizing, storing, and presenting Project reservoir elevations (including UKL), Link, Keno and IGD flows, Project diversions, and pumping data as well as biological data collected during disease and outmigrant monitoring outlined above. The plan shall include annual updates to hydrological data sets, as well as plans for finalizing historical data sets such that official versions are available upon request or via web hosting. The plan shall also include an annual update of the KBPM, with output provided to the Services.

1E. Operations Spreadsheets
As of early February 2019, Reclamation was developing one or more operations spreadsheets to implement the proposed action. The spreadsheet(s) translate the code in the KBPM and the detailed written description of the proposed action provided in Appendix 4 of the addendum to the proposed action included in Reclamation's final biological assessment (USBR 2019a) into an operations spreadsheet(s). The operations spreadsheet(s) will bring together the input data (e.g., UKL net inflow, UKL elevations, NRCS forecasts), equations (e.g., seasonal water supply

allocations, daily EWA releases), and relationships (e.g., EWA is calculated before Project Supply, methods by which the Lower Klamath Lake Refuge may be delivered water) that Reclamation will use on a daily basis to implement the proposed action. The operations spreadsheet(s) will provide information to Reclamation to operate the Project as described in the proposed action and minimize incidental take of listed species, and provide information to Reclamation and the Services to monitor implementation of the proposed action as analyzed in the Services' opinions. Therefore, Reclamation shall provide the Services with the proposed action implementation and operation spreadsheet(s) by June 1, 2019, and at least annually thereafter. Reclamation shall provide updates to the Services within 2 weeks of Reclamation's acceptance and use of an updated operations spreadsheet(s). Reclamation shall provide the Services with a tutorial explaining how Reclamation uses the spreadsheet, which data may be updated, and which data should remain fixed and not be changed or updated. Subject to when Reclamation's operations staff are available, Reclamation shall offer this tutorial to new Service employees with relevant designations (e.g., hydrologist) and assignments related to the Project as they join Service staff throughout the duration of this Opinion.

1F. Development of a post-facilities removal Operations plan

As described in the opinion, removal of four facilities in PacifiCorp's KHP may begin as early as 2021. To minimize incidental take of listed coho salmon as a result of Project Operations and ensure that Project Operations are implemented as analyzed in the opinion, Reclamation shall, by October 2020 or at least four months prior to the scheduled commencement of facilities removal, develop and provide to the Services an Operations plan that incorporates a flow release strategy from Keno Dam. The Operations plan shall include at least the following elements (1) ramp down rates at Keno Dam that minimize risks to stranding coho fry; (2) EWA releases consistent with the proposed action analyzed in the opinion; and (3) development of minimum flow releases at Keno Dam that represent conditions below IGD currently met through IGD minimum flows.

1G. Abundance, prevalence of infection, and predicted mortality of emigrating juvenile salmon in the Klamath River

The AFWO and its Tribal partners operate rotary screw traps and frame nets each spring and summer during the juvenile Chinook Salmon emigration period to estimate the abundance of outmigrant juvenile salmon at three locations on the Klamath River, with the Kinsman site located just upstream of the Scott River confluence currently the most downstream location sampled. A fourth monitoring location near Orleans, California is currently being developed that is expected to be operational in 2020, which will extend monitoring, estimation, and prediction abilities to just above the confluence with the Trinity River. A mark-recapture experiment is used in conjunction with a Bayesian time-stratified spline-based method to estimate characteristics and abundance of outmigrant populations on a weekly-stratified basis, which are used to calibrate and validate the Stream Salmonid Simulator Population Dynamics Model. In addition, these data are key in informing managers in real-time on population levels and for assessing population-level effects of infectious diseases. Chinook salmon disease rates continue to be an important indicator of coho salmon disease risks.

Therefore, Reclamation shall fund monitoring and estimation of the abundance, prevalence of infection, and predicted mortality of emigrating juvenile Chinook and coho salmon disease in the lower Klamath River, with emphasis on determining the effects of flushing and dilution flow releases under the proposed action, updating data and recalibrating the 80 percent outmigration model. Continued operation of downstream migrant traps will support the further understanding of, among other things, population-level effects of disease on coho and Chinook salmon and the better estimation of associated mortality. This will support better in-season management of flows and minimization of incidental take of listed species.

1H. In the event of funding lapses, fund the monitoring and reporting requirements of DFW Shasta River Rotary Screw Trap

The Shasta Rotary Screw Trap is an essential monitoring component of the Incidental Take Statement (ITS). Maintaining data collection of juvenile coho salmon at the Shasta River Rotary Screw Trap will contribute to minimizing incidental take of coho salmon through informed flow management and monitoring the likelihood of exceeding incidental take of coho salmon as described in the incidental take statement for this opinion. California Department of Fish and Wildlife (CDFW) currently funds and operates the trap and funding is secured for 2019. Therefore, Reclamation shall coordinate with CDFW to determine whether CDFW will continue to fund and operate the trap after 2019. In the event that CDFW will not continue to fund and operate the trap from 2020 through 2023, Reclamation shall ensure the trap is operated or operation is fully funded and reports are generated to inform the necessary requirements of data collection to evaluate incidental take of coho salmon described in the ITS.

1I. Fund Development and Refinement of Klamath River Decision Support Tools

C. shasta spore concentrations are a key driver of infection and mortality of juvenile outmigrant salmon in the Klamath River. Currently, S3 relies on a time-series of historically observed spore concentrations and, consequently, is insensitive to simulation scenarios that might influence spore concentrations. Data are now available, however, that will allow calibration of a model to predict spore concentrations for a given set of river conditions. A spore concentration submodel currently under development by USFWS will be incorporated into S3 model architecture as a function of among- and within-year flow effects. The S3 and River Basin Model-10 (RBM10) will also be updated with contemporary data to improve the model's predictive capabilities in minimizing the effects of water management actions on infection and mortality of juvenile Chinook salmon and coho salmon due to *C. shasta.*

Reclamation's Project water management in the Klamath River has included augmented water releases from IGD intended to reduce the concentrations of *C. shasta* spores throughout the water column, thereby reducing the probability of infection and mortality of juvenile salmonids due to infectious disease. Because the S3 decision support model explicitly incorporates discharge, it can be used to assess hypotheses regarding potential volumetric reductions in spore concentrations in response to flow releases from IGD as well as the relative effect of environmental flow releases (i.e., deep and surface flushing events) on fish infection and mortality. Simulations of potential water management scenarios will include predicted spore concentrations and fish infection and disease-related mortality. This will support better in-season management of flows and minimization of incidental take of listed species.

Therefore, Reclamation shall fund the development of (1) a spore concentration submodel, (2) updates to S3 model parameters, and (3) scenario model runs to evaluate the effect of in-season disease triggers on simulated prevalence of infection and mortality.

1J. Fund Fish Modeling to evaluate the effects of *C. shasta* spore concentrations on the survival of out-migrating coho salmon in the Klamath River

Modeling to evaluate the effects of *C. shasta* spore concentrations on the survival of out-migrating coho salmon in the Klamath River will provide better survival information on migrating coho salmon, and increase the understanding of the level of disease-related mortality of coho salmon as a result of the proposed action. The Bayesian hierarchical Cormack-Jolley-Seber model is a particular statistical model that accounts for the impacts of physical variables on fish survival and migration rates, accounts for imperfect detection that is afforded via the multiple telemetry stations implemented in survival studies, and integrates the data that is missing for non-detected fish to provide population-levels estimates of disease risk. Therefore, Reclamation shall fund the application of a Bayesian hierarchical Cormack-Jolley-Seber model to assess the effects of *C. shasta* spore concentrations on the survival of actively migrating coho salmon in the Klamath River and provide results of that modeling to NMFS.

2.5.4.2 The following terms and conditions implement reasonable and prudent measure 2:

2A. Terms and Conditions Implementation Plan

Reclamation shall develop an "*Implementation Plan*" in consultation with the Services describing how Reclamation intends to implement the Terms and Conditions in this opinion. The *Implementation Plan* shall describe the process Reclamation will follow to ensure necessary resources are allocated to implement the Terms and Conditions and to complete required monitoring and reporting by the due dates. Having this agreement will ensure that terms and conditions are reliably and fully implemented and will aid in identifying any problems as early as possible and help avoid any additional incidental take of listed species beyond what was considered in this opinion.

We understand that this Opinion contains multiple requirements for deliverables and that it might be infeasible for Reclamation to have all of them prepared by the stated due dates because of staffing and funding limitations; therefore, we will work with Reclamation to develop an acceptable implementation schedule. Reclamation shall develop the draft *Implementation Plan* in consultation with the Services, provide the Services a draft *Implementation Plan* for review and comment by October 1, 2019, provide the Services a final *Implementation Plan* that addresses the Services' comments by December 15, 2019, and implement the final *Implementation Plan* thereafter; these dates can be adjusted to ensure a high quality product if Reclamation, NMFS and USFWS agree that it is necessary. The Implementation Plan may be amended by Reclamation in coordination with NMFS and USFWS.

2B. Reporting Requirements

Reclamation shall provide the Services with an Annual Monitoring Report by March 1st every year. Reclamation shall coordinate with the Services to develop a format for the Annual Monitoring Report that will be effective and efficient. Reclamation shall provide the Services with the draft reporting format for review and comment by October 1, 2019, provide the Services with the final reporting format addressing the Services' comments by December 1, 2019, and implement the final reporting format thereafter. The first Annual Monitoring Report shall be due

March 1, 2020. Development of an annual monitoring report will ensure collection and dissemination of Project operations information and the effect of incidental take on listed species. This will aid in identification and minimization of any incidental take of listed species.

The Annual Monitoring Report shall include a description of actions Reclamation has taken and is preparing to take to comply with the terms and conditions in this Opinion. The Annual Monitoring Reports shall include the following information, unless a different specific date or period is specifically described below, in which case Reclamation shall provide NMFS with the information as specifically described below:

1. Reclamation shall report all measured accretion data (Link River Dam to Keno Dam) and all measured and estimated accretion data (Keno Dam to IGD) in addition to all of the EWA, Project and Refuge information.
2. Reclamation shall complete an assessment in coordination with the Services of EWA used and EWA remaining on May 1 of each calendar year.
3. Reclamation shall provide a report of daily and monthly reductions of IGD releases due to UKL control logic on a monthly basis (particularly important in the March through June period).
4. Reclamation shall provide monthly update reports for the formulaic approach during the fall/winter operations including reductions to IGD flows due to UKL control logic, UKL net inflow, Link River Dam to IGD accretions, UKL levels, winter Project deliveries, Refuge deliveries, and any other relevant data NMFS identifies during implementation of the proposed action.
5. Reclamation shall provide rolling monthly and annual graphs of the observed, smoothed UKL net inflow and observed IGD flows versus the one and two week forecasted IGD flow schedules for the entire water year.
6. Reclamation will provide an annual report on the type and location of each restoration project implemented. The monitoring report shall include the total number of coho salmon captured, relocated, injured, or killed for each restoration project, and will be submitted annually by March 1 to the NMFS Northern California office:

   National Marine Fisheries Service
   Jim Simondet, Klamath Branch Supervisor
   1655 Heindon Road
   Arcata, California 95521

   All coho salmon mortalities encountered must be retained, placed in an appropriately sized whirl-pak or zip-lock bag, labeled with the date and time of collection, fork length, location of capture, and frozen as soon as possible. Frozen samples must be retained until specific instructions are provided by NMFS.

2C. Monitor and Maintain Water Level and Flow Management Gages Throughout the Project.

Reclamation shall maintain and monitor water level and flow measurement gages throughout the Project and the Klamath River. Locations where accurate hydrologic data are needed include those listed below. These locations are needed to calculate Project water use and effects on coho salmon, and ensure compliance with this Incidental Take Statement. Reclamation shall evaluate this list annually in coordination with the Services and include additional monitoring sites if Reclamation and the Services determine additional monitoring sites are needed.

1. A Canal
2. Lost River to Lost River Diversion Channel at Wilson Dam
3. Ady Canal (at the point of common diversion for agriculture and the Lower Klamath Lake NWR, and at the point of entry into the Refuge)
4. North Canal
5. Straits Drain at State Line and at pumps F and FF
6. West Side Power Canal
7. Station 48
8. Miller Hill Pumping Plant
9. Miller Hill spill
10. UKL
11. Link River Dam
12. Keno Dam
13. Iron Gate Dam

2.6 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).

Reclamation should maximize the benefits of opportunistic high flow releases to create habitat conditions conducive to salmonid fitness, and detrimental to the disease pathogen *Ceratanova shasta*. For example, to the extent practicable, Reclamation should implement deep flushing flow events described as Measure 2 in Hillemeier et al. (2017) Implementation of Guidance Measure 2.

Reclamation should comply with all terms and conditions related to Southern Residents until the proposed action receives authorization for the incidental taking of marine mammals under section 101(a)(5) of the MMPA.

2.7 Reinitiation of Consultation

This concludes formal consultation for Klamath Project Operations from April 1, 2019 through March 31, 2024.

As 50 CFR 402.16 states, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and if: (1) The amount or extent of incidental taking specified in the ITS is exceeded, (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion, (3) the agency action is subsequently modified in a manner that causes an effect on the listed species or critical habitat that was not considered in this opinion, or (4) a new species is listed or critical habitat designated that may be affected by the action.

2.8 "Not Likely to Adversely Affect"' Determinations

Under the ESA, "effects of the action" means the direct and indirect effects of an action on the listed species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action (50 CFR 402.02). The applicable standard to find that a proposed action is not likely to adversely affect listed species or critical habitat is that all of the effects of the action are expected to be discountable, insignificant, or completely beneficial. 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. Discountable effects are those extremely unlikely to occur.

2.8.1 Southern DPS North American Green Sturgeon

Reclamation has determined that the proposed action may affect, but is not likely to adversely affect, southern DPS green sturgeon (USBR 2018a). Reclamation determined that the action area is not within areas designated as critical habitat for the southern DPS of North American green sturgeon; thus, Reclamation essentially determined the proposed action is expected to have no effect on critical habitat for this DPS.

The southern DPS of North American green sturgeon (southern DPS green sturgeon) is listed as a threatened species, and includes all green sturgeon spawning populations south of the Eel River, with the only known spawning population being in the Sacramento River (71 FR 17757 (April 7, 2006)). In 2009, NMFS published a final rule designating critical habitat for southern DPS green sturgeon that does not include as critical habitat any portion of the Klamath Basin (74 FR 52300 (October 9, 2009)). Although the presence of southern DPS green sturgeon has not been documented in the Klamath River, sub-adult and adult southern DPS green sturgeon enter coastal bays and estuaries north of San Francisco Bay, California, during the summer months to forage (Moser and Lindley 2007), and the Klamath River estuary could potentially be utilized by southern DPS green sturgeon sub-adult and adult life stages (NMFS 2018d).

The proposed action, depending on hydrological conditions in a given year, may reduce the cumulative flow in the lower Klamath River during spring and summer when southern DPS green sturgeon may be present in Klamath River estuary. However, this variation in flows to the estuary resulting from the proposed action will not inhibit marine migration of southern DPS green sturgeon to the Klamath River estuary zone. Project operations are not expected to alter, reduce, or change the availability of food resources or meaningfully modify water temperature in the Klamath River estuary. Nor is the proposed action expected to adversely affect other physical, chemical, or biological resources in the Klamath River estuary. Therefore, the potential effects of the proposed action on southern DPS green sturgeon are considered insignificant or discountable. Based on this analysis, NMFS concurs with Reclamation that the proposed action is not likely to adversely affect southern DPS green sturgeon.

2.8.2 Southern DPS Pacific Eulachon

Reclamation has determined that the proposed action may affect, but is not likely to adversely affect, southern DPS Pacific eulachon and its designated critical habitat (USBR 2018a).

The southern DPS of Pacific eulachon (southern DPS eulachon) was listed as threatened species in 2010 (75 FR 13012 (March 18, 2010)). In 2011, NMFS published a final rule designating critical habitat for southern DPS eulachon that includes as critical habitat the lowest 10.7 RM of the Klamath River, from the Klamath River mouth to the Klamath River confluence with Omogar Creek; however, critical habitat does not include any tribal lands of the Yurok Tribe or the Resighini Rancheria (76 FR 65324 (October 20, 2011)). Eulachon are semelparous and anadromous, spending 3-5 years the ocean before returning to freshwater to spawn. Spawning grounds are typically in the lower reaches of larger snowmelt-fed rivers. Eulachon spawn when water temperatures range from 0 to 10°C, which typically occurs between December and June. Spawning occurs over sand or coarse gravel substrates. Eggs are fertilized in the water column, then sink and attach to gravel or sand and incubate for 20 to 40 days. The larvae are then carried downstream and are dispersed by estuarine and ocean currents shortly after hatching in the spring. Juvenile eulachon move from shallow nearshore areas to mid-depth areas. After three to five years, adults migrate back to natal basins to spawn (NMFS 2017d).

In the Klamath River, adults rarely migrate more than 8 miles inland (NRC 2004). With funding from NMFS, the Yurok Tribal fisheries biologists surveyed for eulachon in the lower Klamath River and found only two eulachon in early 2011 and 40 in 2012 (YTFP 2011, YTFP 2012). Yurok tribal fishermen also caught five eulachon in early 2011 (YTFP 2011).

The proposed action, depending on hydrological conditions in a given year, may reduce the cumulative flow in the lower Klamath River when southern DPS eulachon may be present in Klamath River. However, this variation in flows to the estuary resulting from the proposed action will not inhibit marine migration of southern DPS eulachon to the lower Klamath River. Project operations are not expected to alter, reduce, or change the availability of food resources or meaningfully modify water temperature in the portion of the Klamath River where eulachon may occur or where southern DPS critical habitat is designated. Nor is the proposed action expected to adversely affect other physical, chemical, or biological resources in this area of the Klamath River. Therefore, the potential effects of the proposed action on southern DPS eulachon and its critical habitat are considered insignificant or discountable. Based on this analysis, NMFS concurs with Reclamation that the proposed action is not likely to adversely affect southern DPS eulachon and southern DPS eulachon designated critical habitat.

3 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) directs Federal agencies to consult with the National Marine Fisheries Service (NMFS) on all actions or proposed actions that may adversely affect Essential Fish Habitat (EFH). The MSA (section 3) defines EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." 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) also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH.

This analysis is based, in part, on: 1) the EFH assessment provided by Reclamation and received by NMFS on March 18, 2019 (USBR 2019e); 2) Reclamation's 2019 amended BA; 3) descriptions of EFH for Pacific Coast Salmon in the Pacific Coast Salmon Fishery Management Plan (PFMC 2014) developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce; and 4) the NMFS (2017b) EFH response on Klamath Project Operations.

3.1 Proposed Action

The proposed action and the action area for this consultation are described above in NMFS' Biological Opinion. The proposed action is Reclamation's continued operation of the Klamath Project (Project) to store, divert, and convey water to meet authorized Project purposes and contractual obligations in compliance with applicable State and Federal law. Reclamation also proposes to carry out the activities necessary to maintain the Project and ensure its proper long-term function and operation. The period covered by this proposed action is April 1, 2019, through March 31, 2024.

Reclamation's proposed Project Operations consist of three major elements:

1. Store waters of the Klamath and Lost Rivers in Upper Klamath Lake, Clear Lake and Gerber reservoirs.

2. Operate the Project, or direct the operation of the Project, for the delivery of water for irrigation purposes, subject to water availability, while maintaining lake and river hydrologic conditions that avoid jeopardizing the continued existence of listed species and adverse modification of designated critical habitat.

3. Perform operation and maintenance (O&M) activities necessary to maintain Project facilities to ensure proper long-term function and operation.

In addition, Reclamation proposes to fund restoration projects through their coho restoration grant program. Reclamation proposes to annually fund 700,000 dollars in 2019 and 2020, and 500,000 dollars in 2021-2023, subject to the availability of future funding and annual appropriations, to support restoration activities for the Southern Oregon/Northern California Coast (SONCC) coho salmon Evolutionarily Significant Unit and its critical habitat. Projects given the highest priority under this program include access improvement and barrier removal, improved habitat and access to coldwater refugia, instream habitat enhancement and protections, and water conservation.

3.2 Essential Fish Habitat Affected by the Project

The action area includes the mainstem Klamath River from IGD at RM 190 to the Klamath River mouth. Tributaries accessible to anadromous salmonids between IGD and the Klamath River mouth may be affected by the proposed action through Reclamation's coho restoration grant program, and are also included as part of the action area (with the exception of the Trinity River).

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 2016). However, the action is not expected to adversely affect Pacific Coast groundfish or coastal pelagic EFH. Their EFH occurs in the Klamath River estuary and marine environments and the proposed action is not expected to adversely affect the physical, chemical, and biological resources in the Klamath River estuary or the marine environment (see section 2.8 above). Therefore, this EFH analysis will focus on Pacific salmon EFH. The PFMC described and identified EFH for Pacific salmon (PFMC 2014).

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. Habitat Areas of Particular Concern (HAPC) have been identified in Appendix A to the Pacific Coast Salmon FMP. 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 2019 Opinion.

3.2.1 Coho Salmon

Coho salmon generally follow a three year life cycle life-history that includes the incubation and hatching of embryos; emergence and initial rearing of juveniles in freshwater; estuarine migration and rearing, migration to oceanic habitats for extended periods of feeding and growth; and return to natal waters for completion of maturation, spawning, and death. Coho salmon adults typically migrate into the Klamath River during mid-September through mid-January. Upstream migrations are typically associated with pulse flows due to fall rain events. Although coho salmon primarily spawn in tributary streams from November through January, they have been observed spawning in side channels, at tributary confluences, and suitable shoreline habitats in the mainstem. Egg incubation lasts approximately seven weeks and typically occurs during November through March. Alevins remain in the gravel approximately two to three weeks and then emerge as free-swimming fry during February to mid-May with the peak in April and May. Coho salmon will typically rear in freshwater for one year before migrating to the ocean. Outmigration can begin as early as February and continue through mid-June, with peak numbers arriving in the estuary during April and May.

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.

Coho salmon EFH in the Klamath River estuary and marine environment is not considered further in this EFH consultation response, as the proposed action is not expected to adversely affect the physical, chemical, and biological resources in these areas (see section 2.8 above).

3.2.2 Chinook Salmon

Chinook salmon follow a life-history that includes the incubation and hatching of embryos; emergence and initial rearing of juveniles in freshwater; estuarine migration and rearing, migration to oceanic habitats for extended periods of feeding and growth; and return to natal waters for completion of maturation, spawning, and death. Fall-run Chinook salmon are distributed throughout the Klamath River downstream of IGD. Adult upstream migration through the estuary and lower Klamath River begins in July or August, peaks in early September, and continues through late October. Fall-run Chinook salmon spawning peaks in late October and early November. Spring-run Chinook salmon adult upstream migration begins in March or April and extends until mid-July. Spring-run Chinook salmon spawning generally occurs roughly one month earlier than the fall-run Chinook salmon spawn timing distribution. In general, spawning Chinook salmon require gravel and cobble areas, primarily at the head of riffles or in pool tailouts, featuring appropriate water depth and velocity. Chinook salmon fry in the Klamath River emerge from redds between December and late February, although timing may vary somewhat depending on run, and temperatures in different years and tributaries.

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.

Chinook salmon EFH in the Klamath River estuary and marine environment is not considered further in this EFH consultation response, as the proposed action is not expected to adversely affect the physical, chemical, and biological resources in these areas (see section 2.8 above).

3.3 Adverse Effects on Essential Fish Habitat

3.3.1 Hydrological Effects of the Proposed Action

The proposed action results in a hydrograph that resembles the shape of the natural flow regime. However, in large part as a result of operating the Project, the Klamath River annual flow volume, spring peak magnitude and duration, deep flushing flows, and flow variability are reduced relative to the natural hydrograph. Under the proposed action, the Klamath River will have lower base flows in the fall and winter, lower and earlier peak discharge, reduced spring and summer discharge, and an earlier return to base flow relative to the natural hydrograph. While spring flows will generally be reduced, Reclamation proposes to implement annual surface flushing flow events that will likely result in short duration (i.e., 3 days) events that occur at a greater frequency (and higher magnitude in critically dry years) than would be expected under a natural hydrograph.

For most years under the proposed action, immobile bed conditions (i.e., IGD flows <2,500 cfs) occur for greater than 70 percent, and in all years (besides 1984), immobile bed conditions occur in greater than 50 percent of each water year. Overall under the proposed action, the Klamath River below IGD is more likely to experience reduced daily average flows and flow variability, while experiencing less frequent deep flushing flows and longer duration of immobile bed conditions; all representative of years drier than expected to occur under the natural flow regime during the period of effects of the proposed action.

The proposed action's hydrologic effects have the potential to affect the following three components of EFH: spawning areas, rearing areas, and migration corridors. The magnitude of proposed action effects on EFH are greatest proximal to IGD and reduce downstream due to the ameliorating effects of key tributaries (e.g., Scott River, Salmon River).

As previously discussed, the proposed action will increase the frequency of surface flushing flows, increase the duration of immobile bed conditions, and decrease the frequency of deep flushing flows relative to the natural flow regime. Because of storage limitations, the proposed action will likely have minimal reductions to the magnitude and frequency of geomorphic flows (i.e., IGD flows >15,000 cfs) relative to the natural hydrograph. The increased duration of immobile bed conditions and reduced frequency of deep flushing flows, combined with the benefits of annual surface flushing flows will, as a whole, slightly increase the amount of fine sediments in mainstem spawning gravel. Therefore, the proposed action is likely to reduce the quality of spawning habitat when spawning gravel becomes filled by fine sediment over time.

3.3.1.1 Hydrological Effects on Ceratonova shasta

The likelihood of juvenile salmon to succumb to ceratomyxosis is a function of a number of variables, such as temperature, flow, and density of actinospores (True et al. 2013). The proposed action generally reduces spring flows in the mainstem Klamath River downstream of IGD. By reducing spring flows, the proposed action will result in drier hydrologic conditions in the mainstem Klamath River relative to the natural hydrologic regime. Conditions representative of droughts can cause fine sediments to settle in spawning gravels and provide habitat conditions conducive to the establishment of aquatic vegetation, two conditions that are favorable to the spread of C. shasta in the Klamath River Basin (Stocking and Bartholomew 2007). These effects of the proposed action will be, in part, minimized by proposed annual surface flushing events. Actinospore density is likely to be influenced by spring flows and sediment maintenance flows, both of which provide important ecological function in potentially minimizing disease prevalence of C. shasta.

Management of UKL also affects mid-winter peak flows, which in turn affects sediment movement and size distribution. Sediment movement and high flows are known to reduce the density and populations of the polychaete worm alternate host for *C. shasta* (USFWS 2016b). Operation of the Project does not affect the magnitude and frequency of geomorphic flows (>15,000 cfs). Operation of the Project does decrease the frequency of deep flushing flows (>10,000 cfs) which in turn has contributed to a higher risk of disease in juvenile Chinook and coho salmon.

3.3.2 Coho Salmon Habitat

The effects of the proposed action on coho salmon habitat are described at length in the *Effects to SONCC Coho Salmon ESU Critical Habitat* (section 2.2.4.1) of the attached 2019 Opinion.

Of note:

In average and wetter years (≤50 percent exceedance), flows under the proposed action are expected to incrementally increase through the fall/winter period. Though spawning habitat for coho salmon is not limited in the mainstem Klamath River, the proposed action is likely to increase the quantity of spawning habitat in the mainstem Klamath River in relatively wet years when IGD flows are variable and incrementally increase during the late fall and winter. The proposed action includes annual spring time surface flushing flow events which are expected to mobilize fines from Upper Klamath River spawning habitat and improve spawning habitat quality. As Project effects contribute to reductions in flow through late spring, summer and fall, some fines will settle out in spawning areas reducing the benefits from the surface flushing flow events. Generally, NMFS expects the quality and quantity of spawning habitat in the mainstem to be sufficient for the low numbers of adult coho salmon spawners that use the mainstem for spawning.

The proposed action would affect water depth and velocity in the mainstem Klamath River, which may affect fish passage. The proposed action will generally lower flows in the mainstem Klamath River during much of September, October, November and December. However, the November and December flows of at least 950 cfs under the proposed action will provide the depth and velocity necessary for adult coho salmon spawning migration, and thus the proposed minimum flows are not expected to impede migration.

The juvenile coho salmon migration corridor within the mainstem Klamath River is expected to be suitable in terms of water depth and velocity at IGD flows of at least 900 cfs (minimum proposed in July). The proposed action's effects on the migration corridors of juveniles entering tributaries are dependent on both the alluvial features at those sites and tributary flows. Occasionally individual tributaries may not be accessible to juveniles in the mainstem Klamath River due to low tributary flow in dry years.

Using habitat modeling results, NMFS has determined that the amount of suitable coho salmon fry habitat will generally decrease due to Project operation. Although the amount of available habitat between IGD and the Salmon River is expected to be sufficient for coho salmon fry, in some areas during below average water years coho salmon fry habitat will be below 80 percent maximum available in June.

The proposed action will generally decrease available juvenile coho salmon habitat from IGD through the Middle Klamath River reach. Based on habitat modeling results, available habitat is reduced below 80 percent of maximum available in most months of the year and in most water year types.

The proposed action will affect water quality in the Klamath River. In the spring, less water will be released from IGD under the proposed action. Water temperature modeling indicates that temperatures may increase in the IGD to Scott River reach by up 0.5 °C. Below the Scott River the proposed action's effects on water temperature is likely negligible because cold water tributary flow and meteorological conditions have a pronounced effect on water temperatures in this portion of the Klamath River. Water temperature is a primary influence on the ability of water to hold oxygen, and the spring warming expectation as a result of the proposed action is expected to result in decreased dissolved oxygen. The magnitude and frequency of the rise of water temperature in the spring, and decreasing dissolved oxygen, is dependent on meteorological conditions and flow in any given year.

Implementation of some restoration projects in the Klamath Subbasin could cause short-term adverse effects to coho salmon habitat due to disturbance of the stream bed and associated benthic organisms within the wetted channel in the mainstem Klamath River and some tributaries. In the long-term, these projects are expected to be beneficial to coho salmon habitat by re-establishing fish passage, re-establishing rearing habitat, increasing flows, and improving water management capabilities.

3.3.3 Chinook Salmon Habitat

Within the range of flows anticipated under the proposed action, there is generally a positive relationship between flow and habitat availability. Given the proposed action generally is expected to reduce flows, results indicate the proposed action has an adverse effect on Chinook salmon habitat availability over a wide range of flow conditions (Figure 27)

The proposed action reduces Chinook fry habitat availability in the mainstem Klamath River between IGD and the Salmon River in March-June with the highest frequency of negative effects occurring in June followed by May (Figure 27, Table 41). The effects of the proposed action would likely be most significant during dry years when average daily spring flows range from 1,000 – 5,000 cfs because negative effects on habitat availability March-May were predicted to occur most frequently at flows from 50-95 percent exceedance; however, in June, negative effects on habitat availability occur at flows from 15-95 percent exceedance.

The proposed action reduces parr habitat availability across a broad range of flow exceedance values at the R Ranch, Trees of Heaven, Seiad Valley, and Rogers Creek sites during the spring (Figure 27 and Table 42 to Table 45).

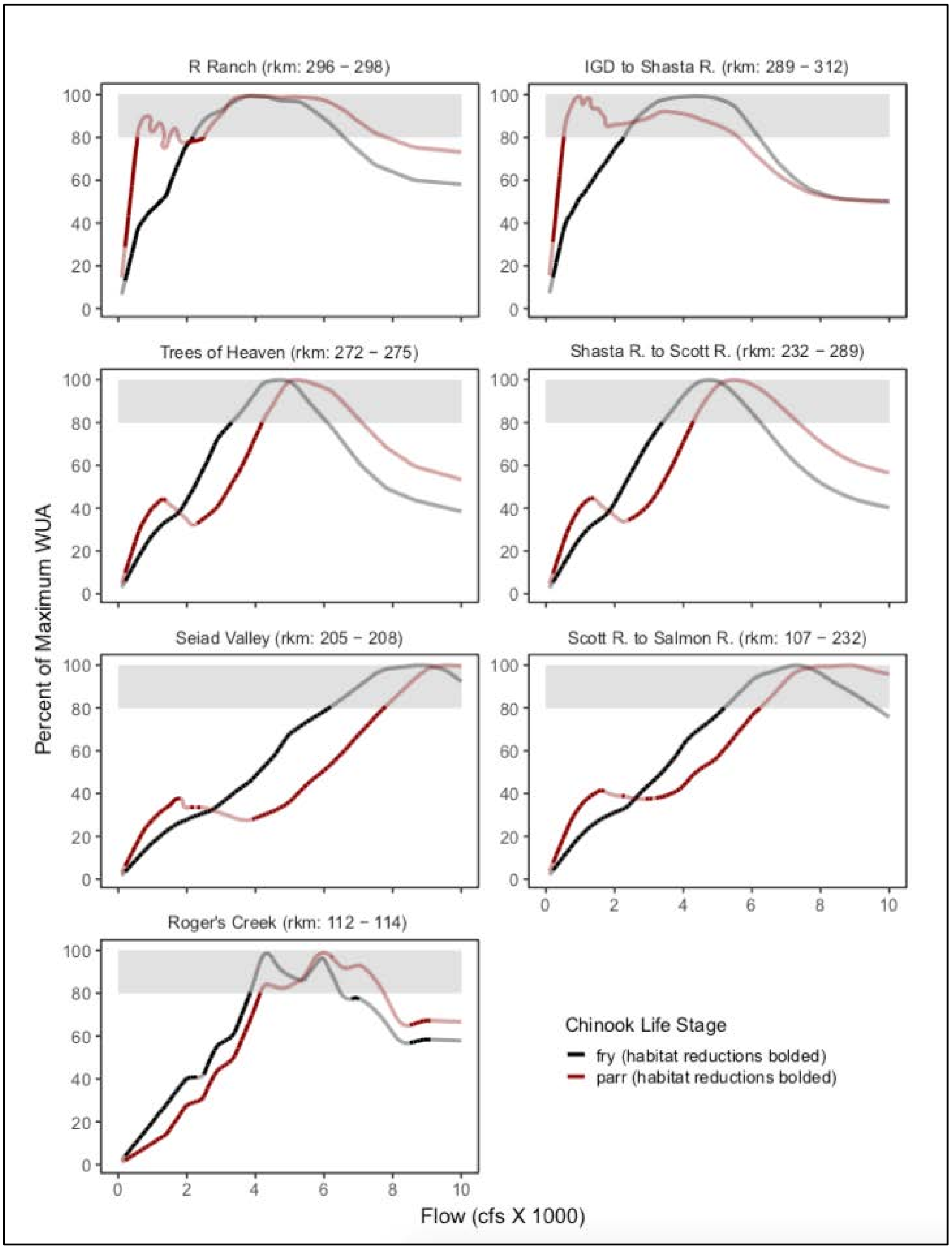

Figure 27. Chinook salmon fry and parr habitat availability relative to mainstem flows for three reaches and four sites downstream of IGD. Flows account for tributary accretions and were estimated for each habitat unit when calculating WUA. Gray horizontal bands indicate WUA values ≥ 80 percent of maximum. Potential habitat reductions due to the proposed action are bolded (USBR 2018a).

Table 41. Daily average mainstem flows (cfs) within nearest 5 percent exceedance where the proposed action will likely reduce Chinook salmon fry habitat availability to below 80 percent of maximum (orange highlight). Flows estimated for the midpoint of each reach (USBR 2018a).

Exceedance	Iron Gate Dam to Shasta River				Shasta to Scott River				Scott to Salmon River			
	March	April	May	June	March	April	May	June	March	April	May	June
95%	1113	1429	1244	1056	1433	1641	1404	1126	2560	2494	1931	1341
90%	1302	1463	1280	1073	1731	1711	1467	1175	2932	2711	2197	1481
85%	1606	1518	1362	1099	1954	1848	1608	1229	3240	3027	2477	1603
80%	1782	1559	1483	1124	2165	1938	1742	1292	3620	3397	2684	1728
75%	1912	1695	1550	1159	2329	2097	1858	1345	3971	3849	2964	1816
70%	2122	1858	1611	1190	2589	2291	1978	1397	4340	4134	3334	1936
65%	2352	2004	1672	1227	2864	2446	2088	1441	4699	4473	3666	2065
60%	2582	2195	1766	1266	3174	2734	2221	1487	5231	4884	4003	2214
55%	2848	2430	1894	1312	3519	2983	2389	1539	6170	5395	4312	2392
50%	3140	2689	2072	1348	3884	3306	2537	1604	6716	5859	4609	2599
45%	3372	3013	2315	1400	4164	3675	2824	1690	7238	6476	5098	2855
40%	3735	3289	2590	1489	4613	3962	3230	1820	7643	6981	5804	3126
35%	4237	3640	2796	1626	5181	4467	3504	2012	8362	7733	6444	3434
30%	4668	3986	2999	1783	5818	4899	3729	2202	9173	8339	6923	3829
25%	5228	4631	3274	1917	6449	5544	4029	2381	10115	8937	7326	4410
20%	6082	5080	3555	2089	6897	6099	4402	2682	11237	9603	7889	4962
15%	6467	5611	3974	2416	7669	6537	4934	3026	12429	10198	8822	5556
10%	7148	6103	4403	2818	8693	7083	5474	3589	14272	11235	9797	6469
5%	8582	6669	5062	3464	10588	7806	6320	4271	17531	12322	10744	7755

Table 42. Daily average mainstem flows (cfs) within nearest 5 percent exceedance where the Proposed Action will likely reduce Chinook salmon juvenile habitat availability (blue highlight) in the R Ranch reach (USBR 2018a).

R Ranch									
Exceedance	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
95%	1007	1023	983	1002	1027	1113	1325	1175	1025
90%	1013	1031	992	1017	1050	1302	1325	1175	1025
85%	1025	1038	1001	1038	1073	1606	1325	1175	1025
80%	1043	1044	1009	1062	1102	1782	1350	1175	1025
75%	1066	1051	1021	1084	1150	1912	1501	1175	1025
70%	1091	1062	1030	1104	1202	2122	1654	1175	1025
65%	1111	1090	1042	1131	1280	2352	1770	1241	1025
60%	1125	1112	1059	1187	1386	2582	1938	1392	1025
55%	1145	1149	1085	1264	1546	2848	2130	1562	1025
50%	1162	1199	1130	1395	1789	3140	2349	1722	1025
45%	1178	1226	1189	1563	2099	3372	2628	1959	1078
40%	1195	1257	1276	1753	2396	3735	2936	2156	1227
35%	1211	1273	1455	2010	2740	4237	3208	2369	1347
30%	1227	1309	1709	2407	3044	4668	3503	2589	1503
25%	1254	1369	1924	2728	3487	5228	4147	2834	1652
20%	1296	1433	2284	3212	4068	6082	4520	3095	1786
15%	1318	1521	2685	3731	4773	6467	5044	3418	2055
10%	1382	1691	3382	4894	5866	7148	5565	3844	2438
5%	1486	3177	5317	6563	8625	8582	6095	4501	3018

Table 43. Daily average mainstem flows (cfs) within nearest 5 percent exceedance where the proposed action will likely reduce Chinook salmon juvenile habitat availability (blue highlight) in the Trees of Heaven reach (USBR 2018a).

Trees of Heaven									
Exceedance	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
95%	1114	1184	1146	1187	1229	1331	1547	1333	1095
90%	1135	1198	1163	1213	1267	1564	1591	1375	1129
85%	1162	1211	1188	1253	1305	1837	1699	1490	1171
80%	1184	1227	1199	1280	1348	2013	1766	1630	1214
75%	1202	1241	1218	1320	1407	2156	1912	1710	1258
70%	1226	1262	1241	1357	1481	2423	2057	1788	1307
65%	1246	1286	1263	1396	1568	2641	2257	1876	1345
60%	1260	1320	1293	1456	1710	2908	2466	1997	1377
55%	1286	1356	1328	1559	1905	3216	2704	2124	1415
50%	1315	1394	1392	1703	2182	3547	3005	2303	1466
45%	1343	1419	1454	1887	2442	3813	3349	2569	1540
40%	1364	1451	1576	2106	2750	4274	3636	2894	1660
35%	1389	1471	1766	2417	3120	4757	4039	3155	1832
30%	1408	1534	2027	2776	3471	5233	4447	3339	1975
25%	1440	1595	2293	3186	4032	5946	5127	3611	2156
20%	1466	1661	2676	3770	4749	6465	5576	3970	2373
15%	1511	1774	3188	4378	5561	7146	6155	4417	2683
10%	1573	1955	4047	5740	6937	7974	6547	4847	3222
5%	1712	3812	6112	7861	10689	9817	7216	5689	3858

Table 44. Daily average mainstem flows (cfs) within nearest 5 percent exceedance where the proposed action will likely reduce Chinook salmon juvenile habitat availability (blue highlight) in the Seiad Valley reach (USBR 2018a).

Seiad Valley									
Exceedance	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
95%	1154	1265	1290	1390	1578	1980	2065	1685	1210
90%	1180	1330	1340	1474	1710	2269	2228	1894	1315
85%	1212	1360	1390	1640	1848	2600	2485	2148	1433
80%	1253	1380	1437	1750	1970	2835	2734	2315	1536
75%	1280	1417	1490	1852	2112	3108	2952	2535	1598
70%	1305	1454	1576	1949	2221	3382	3194	2832	1694
65%	1330	1499	1650	2068	2437	3708	3486	3139	1806
60%	1357	1538	1730	2202	2744	4163	3891	3332	1925
55%	1387	1560	1850	2376	3083	4824	4343	3551	2052
50%	1425	1611	2006	2622	3419	5230	4657	3869	2247
45%	1457	1643	2178	2944	3770	5643	5138	4233	2467
40%	1498	1712	2374	3280	4191	6083	5624	4737	2667
35%	1535	1780	2653	3593	4608	6851	6320	5247	2944
30%	1575	1866	2951	4358	5213	7559	6863	5591	3244
25%	1611	1959	3465	5251	6089	8239	7390	6002	3730
20%	1668	2073	4324	5949	7257	9025	7961	6580	4189
15%	1739	2255	5171	7369	8463	10233	8555	7110	4749
10%	1845	2765	7126	9201	10357	11443	9167	8164	5507
5%	2008	5691	10546	12605	16578	14180	10192	9111	6528

Table 45. Daily average mainstem flows (cfs) within nearest 5 percent exceedance where the proposed action will likely reduce Chinook salmon juvenile habitat availability (blue highlight) in the Rogers Creek reach (USBR 2018a).

Rogers Creek									
Exceedance	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
95%	1257	1509	1686	1926	2749	3741	3222	2500	1643
90%	1324	1601	1858	2369	3184	4284	3799	2873	1796
85%	1361	1737	2013	3011	3674	4889	4407	3128	1992
80%	1417	1810	2254	3369	4081	5437	4843	3405	2190
75%	1507	1876	2511	3661	4506	6018	5649	3965	2339
70%	1564	1932	2790	4021	5001	6562	6223	4460	2522
65%	1609	1975	3111	4493	5549	7087	6729	4850	2692
60%	1649	2041	3508	4947	6106	8036	7414	5470	2906
55%	1671	2102	3948	5397	6680	9226	8001	5922	3137
50%	1713	2182	4360	6079	7145	10159	8601	6458	3421
45%	1776	2296	4865	6970	7791	10793	9392	7293	3810
40%	1807	2472	5504	7692	8749	11549	10396	8216	4198
35%	1862	2662	6214	8522	9693	12674	11084	9125	4611
30%	1933	2999	7282	9961	11397	14058	11988	9722	5147
25%	2092	3319	8641	11865	12890	15490	12888	10418	5834
20%	2185	3933	9958	14586	15268	16844	13494	11617	6476
15%	2424	4808	12895	17418	18376	18150	14741	12531	7523
10%	2657	7402	18207	20915	22986	20701	16245	13656	8707
5%	3553	12371	27044	26670	31399	25082	18268	14706	10792

3.3.3.1 Chinook Spawning Habitat

Model results in the Phase II report for Chinook salmon spawning habitat indicate that the IGD to Shasta River reach of the Klamath River has at least 80 percent of maximum available spawning habitat when flows are between 950 and approximately 2,500 cfs. Given the abundance of Chinook spawning habitat when flows at IGD are 950 cfs or above, NMFS expects the proposed action will not have adverse effects on the quantity of Chinook salmon spawning habitat.

3.3.4 Water Quality

Water quality impairments in the Klamath River are most common in the late spring through summer. Therefore, NMFS narrows the water quality analysis to the spring and summer. As with most rivers, the water quality in the Klamath River is influenced by variations in flow regime. In this analysis, NMFS focuses on the water quality effects resulting from controlled flows, which are influenced by the proposed action. Water quality analysis conducted by Asarian and Kann (2013) indicates that flow significantly affects water temperature, dissolved oxygen, and pH in the Klamath River.

3.3.5 Water Temperature

As previously mentioned, the proposed action will generally reduce the volume of water released from IGD during the spring. Water released from IGD influences water temperature in the mainstem Klamath River, and the magnitude and extent of the influence depends on the temperature of the water being released from the dam, the volume of the release, and meteorological conditions. As the volume of water decreases out of IGD, water temperature becomes more responsive to local meteorological conditions such as solar radiation and air temperature due to reduced thermal mass and increased transit time (Basdekas and Deas 2007). The proposed action's effect of reducing mainstem flows in the spring will result in longer flow transit times, which will increase daily maximum water temperatures and, to a lesser extent, mean water temperatures in the mainstem Klamath River downstream of IGD during the spring (NRC 2004).

Temperature modeling of the mainstem Klamath River by Perry et al. (2011) shows that increasing flows out of IGD by as much as 1000 cfs in the spring decreases water temperatures on the mainstem Klamath River by up to 0.5 °C at either the Shasta River or the Scott River confluence. Since the total net Project reductions (i.e., the total Project diversions minus return flows) to mainstem Klamath River flows in the spring is 1,000 cfs, the proposed action is likely to increase water temperature in the mainstem Klamath River between IGD and the Scott River by up to approximately 0.5 °C during the spring. This increase in water temperature can negatively affect EFH in the late spring if temperatures are 16.5 °C. Below the Scott River mouth, the proposed action's effects on water temperature in the spring are likely insignificant because cold water accretions and meteorological conditions have a pronounced effect on water temperatures in the mainstem Klamath River. In the summer and early fall, any decreases in IGD flows are likely to reduce water temperature in the mainstem Klamath River because reservoir water behind IGD is warmer than mainstem Klamath River water.

3.3.6 Nutrients and Dissolved Oxygen

Temperature is a primary influence on the ability of water to hold oxygen, with cool water able to hold more dissolved oxygen than warm water. The proposed action's warming effect on water temperatures and longer transit times increases the probability that dissolved oxygen concentrations will decrease in the mainstem Klamath River downstream of IGD. In addition, the proposed action also indirectly affects pH and dissolved oxygen through its interactions with periphyton, algae that grow attached to the riverbed.

The proposed action results in agricultural tailwater discharges at the Lost River Diversion Canal and the Klamath Straits Drain. These discharges occur in the Link River upstream of Keno Dam, and contribute to impaired water quality conditions in the mainstem Klamath River downstream of IGD. These agricultural discharges generally increase the nutrient concentration of the Keno Impoundment reach in the summer and fall. Nutrient concentrations decline with distance downstream due to dilution by tributaries and interception and retention within Copco and Iron Gate Reservoirs; however, enough nutrients pass through the reservoirs to still support abundant affect growth of periphyton in the mainstem Klamath River below IGD. Total phosphorus will slightly increase downstream of IGD because of the increased nutrient concentrations released from the Klamath Straights Drain or the Lost River Diversion Channel in the summer and fall.

The seasonal (summer/fall) release of nutrients out of Iron Gate Reservoir stimulates periphyton growth in the mainstem Klamath River. The (NRC 2004) stated that stimulation of any kind of plant growth can affect dissolved oxygen concentration.

While the proposed action's increase in nutrients in the mainstem Klamath River between IGD (RM 190) and Seiad Valley (RM 129) is not likely to have a direct influence on periphyton growth, the proposed action's reduction of mainstem flows has a larger effect on periphyton and its influence on dissolved oxygen concentration. Several mechanisms are responsible for flow effects on periphyton biomass. Some of these include the relationships between flow and water temperature, water depth, and water velocity. When low flows lead to warmer water temperature, periphyton growth likely increases. High flows increase water depth, which likely reduce light penetration in the river. Conversely, low flows generally decrease water depth, which increases periphyton photosynthesis. Low water depth also disproportionally amplifies the relative water quality effects of periphyton (i.e., diel cycles of dissolved oxygen would be magnified) because the ratio between the cross-sectional area and channel width decreases (i.e., mean depth decreases). Some of these effects of the proposed action will be ameliorated as a result of annual surface flushing flows during the spring period.

High levels of photosynthesis cause dissolved oxygen concentration to rise during the day and lower at night during plant respiration. Low dissolved oxygen concentration at night reduces rearing habitat suitability at night. Daily fluctuations of up to 2 mg/L of dissolved oxygen in the mainstem Klamath River downstream from IGD have been attributed to daytime algal photosynthesis and nocturnal algal/bacterial respiration. In addition, the overall effect of the conceptual linkages between flow and dissolved oxygen is supported by an analysis of 11 years of mainstem Klamath River water quality data that found that higher flows were strongly correlated with higher dissolved oxygen minimums and narrower daily dissolved oxygen range (Asarian and Kann 2013). Therefore, when the proposed action reduces mainstem flows in the summer, NMFS expects there will likely be a reduction to dissolved oxygen concentrations in the mainstem Klamath River between IGD and Orleans (RM 59).

3.3.7 Restoration Activities

Reclamation proposes to fund conservation measures to improve conditions for coho salmon. These same restoration activities will also often benefit Chinook salmon, because Chinook salmon occupy many of the same habitats at the same time as coho salmon. Restoration activities that require instream activities will be implemented during low flow periods between June 15 and November 1. The specific timing and duration of each individual restoration project will vary depending on the project type, specific project implementation methods, and site conditions. However, the duration and magnitude of short-term effects to salmon habitat associated with implementation of individual restoration projects will be minimized due to the multiple proposed avoidance and minimization measures.

Except for riparian habitat restoration and streamflow augmentation, which are not expected to result in short-term adverse effects, all proposed restoration types may result in short-term adverse and long-term beneficial effects to coho salmon habitat. Despite the different scope, size, intensity, and location of these proposed restoration actions, the potential short-term adverse effects to Chinook salmon habitat all result from dewatering and increased sedimentation. The effects from increased sediment mobilization into streams are usually indirect effects to habitat because they are reasonably certain to occur and are later in time.

3.3.8 HAPC Adverse Effects

The proposed action is expected to adversely affect some HAPCs (listed above) at times during some water years.

1. Complex channel and floodplain habitat - As reflected in some of the physical habitat modeling, lower flows from IGD can contribute to less inundation of side channels and floodplain habitat at times in those areas of the Klamath River where such habitat is available at higher flows.

2. Thermal refugia - Some tributaries within the Klamath River support populations of juvenile salmon, and offer critical cool water refugia within their lower reaches when mainstem temperatures and water quality approach uninhabitable levels. 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. In general, mainstem habitat is not suitable for rearing large numbers of juvenile salmonids, making tributary habitats highly valuable for growth and survival of salmon. Generally, the conservation role of juvenile summer and winter rearing areas of the Middle Klamath River reach is impaired and functioning at a low level during summer months.

After reviewing the effects of Project operations, NMFS has determined that the proposed action would adversely affect coho salmon and Chinook salmon EFH as summarized in Table 46.

Table 46. Adverse effects to EFH with potential impacts on Chinook and coho salmon life stages.

Adverse Effect	Chinook Salmon Life Stages		
	0+ age	1+ age	Adult[30]
Hydrological Changes	Yes	Yes	Yes
Water Quality	Yes	Yes	At times
Available Habitat	At times	At times	No
Restoration Projects	Short-term	Short-term	Short-term
Adverse Effect	Coho Salmon Life Stages[31]		
	0+ age	1+ age	Adult
Hydrological Changes	Yes	Yes	Yes
Water Quality	Yes	Yes	No
Available Habitat	At times	At times	No
Restoration Projects	Short-term	Short-term	Short-term

3.4 Essential Fish Habitat Conservation Recommendations

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described above, the mainstem Klamath River and tributaries designated as EFH for Pacific Coast salmon.

1. Reclamation should maximize the benefits of opportunistic high flow releases to create habitat conditions conducive to salmonid fitness, and detrimental to the disease pathogen Ceratanova shasta. For example, to the extent practicable, Reclamation should implement deep flushing flow events described as Measure 2 in Hillemeier et al. (2017) Implementation of Guidance Measure 2 will also help reduce adverse effects of the proposed action to water quality.

2. Reclamation should ensure that habitat restoration projects funded through the coho restoration grant program are designed and implemented consistent with techniques and minimization measures presented in California Department of Fish and Wildlife's (CDFW) California Salmonid Stream Habitat Restoration Manual, Fourth Edition, Volume II (Part IX: Fish Passage Evaluation at Stream Crossings, Part XI: Riparian Habitat Restoration, and Part XII: Fish Passage Design and Implementation; referred to as the Restoration Manual) (Flosi et al. 2010). This will help ensure that any short-term adverse effects to the streambed and associated benthic organisms EFH are minimized.

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[30] Differences between Chinook salmon and coho salmon in the effects of water quality on the adult life stage are due to the difference in adult migration timing.

[31] Adverse effects to coho salmon habitat is summarized from the attached Opinion.

Fully implementing these EFH conservation recommendations would protect, by avoiding or minimizing the adverse effects described in Section 3.3 above, approximately 190 river miles of designated EFH for Pacific Coast salmon.

3.5 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, Reclamation must provide a detailed response in writing to NMFS within 30 days after receiving an EFH Conservation Recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH Conservation Recommendations unless NMFS and the Federal agency have agreed to use alternative time frames for the Federal agency response. The response must include a description of measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, NMFS established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

3.6 Supplemental Consultation

Reclamation 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 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 response is Reclamation. Other interested users could include Project water users, Klamath Basin tribes and other stakeholders. Individual copies of this opinion were provided to Reclamation. The format and naming adheres 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. It adheres 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 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 response contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses included or incorporated by reference 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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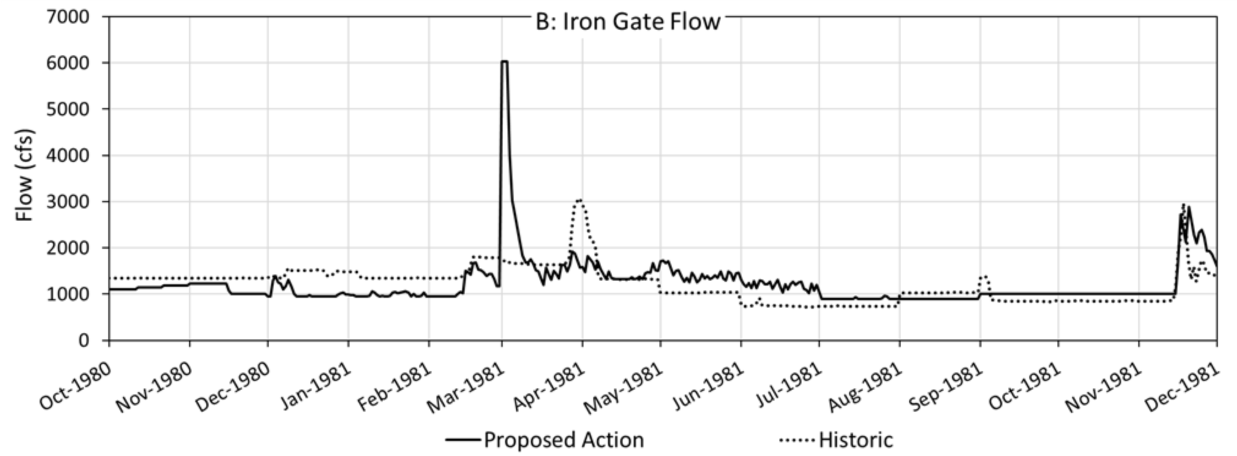
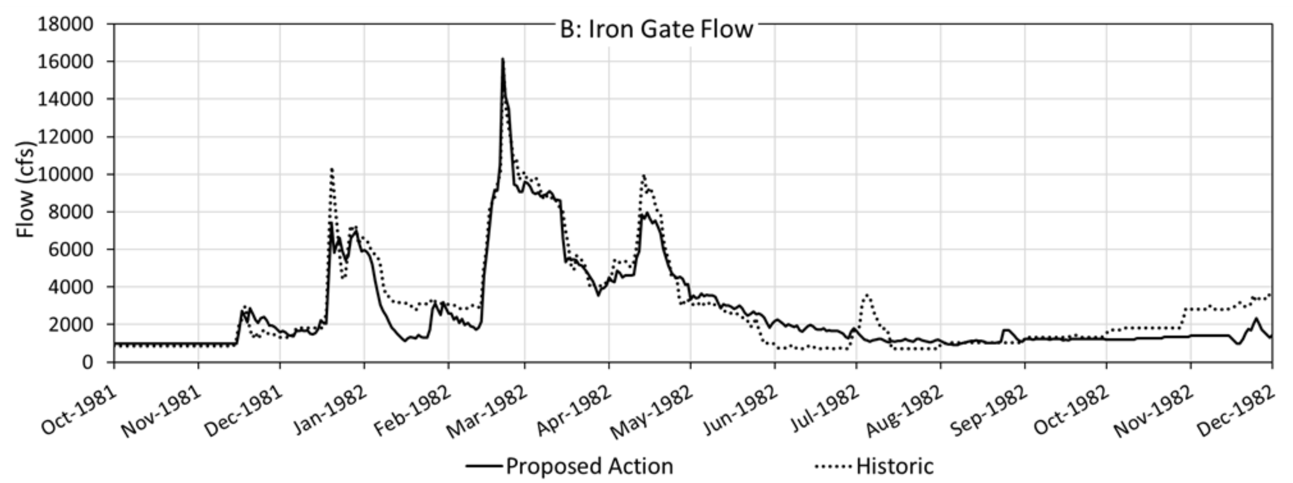
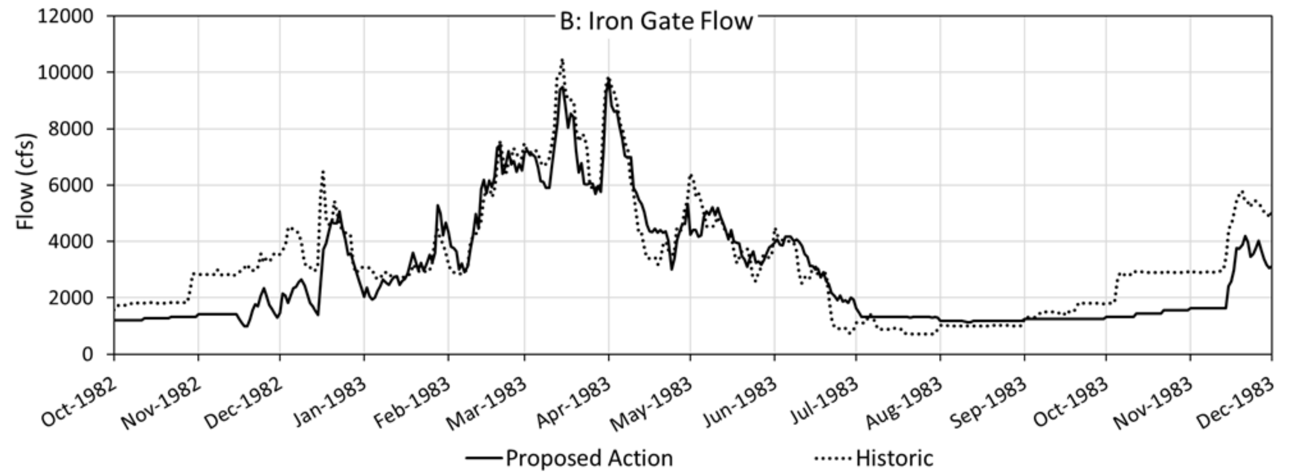
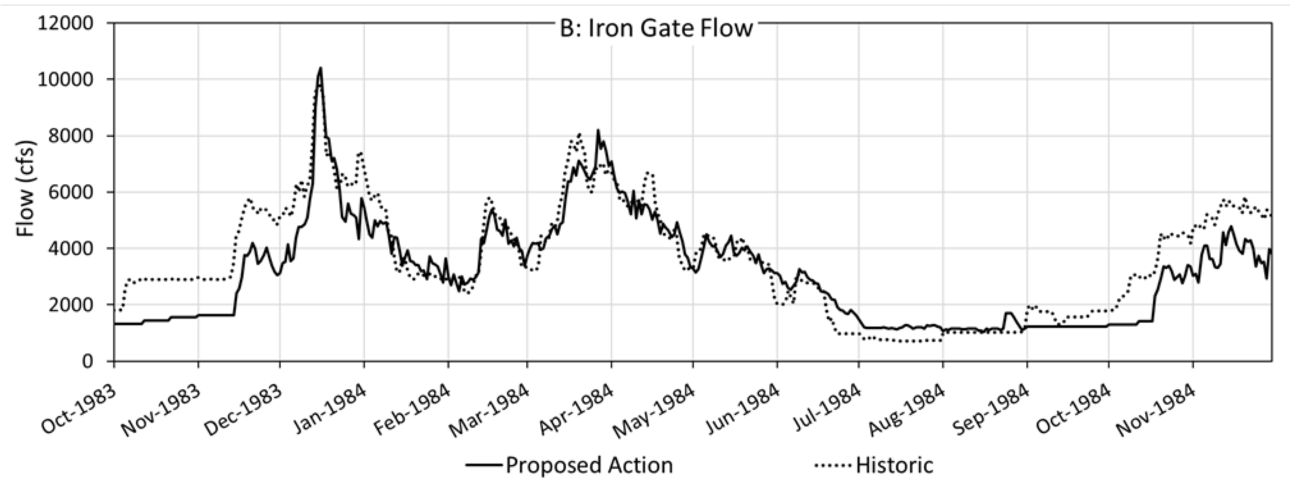
6 APPENDICES

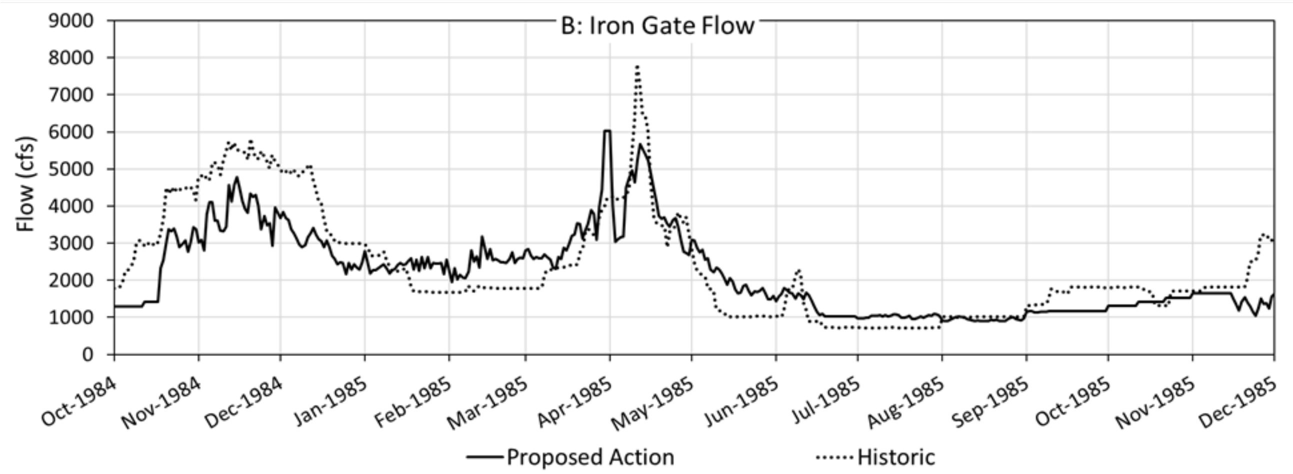
Appendix A - Historic and modeled proposed action daily average flows at Iron Gate Dam for the 1981-2016 period of record (from USBR 2019a).

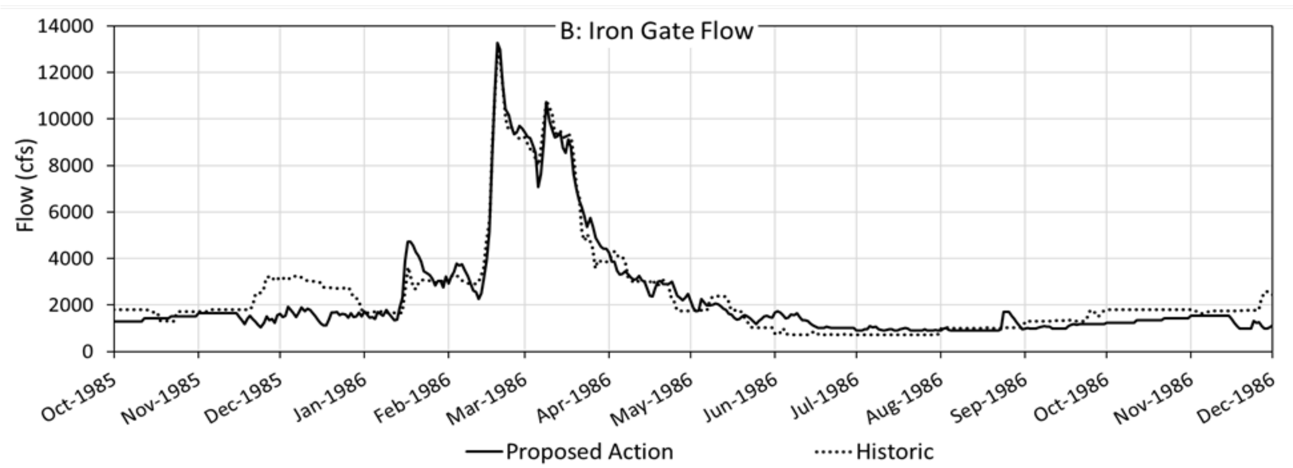


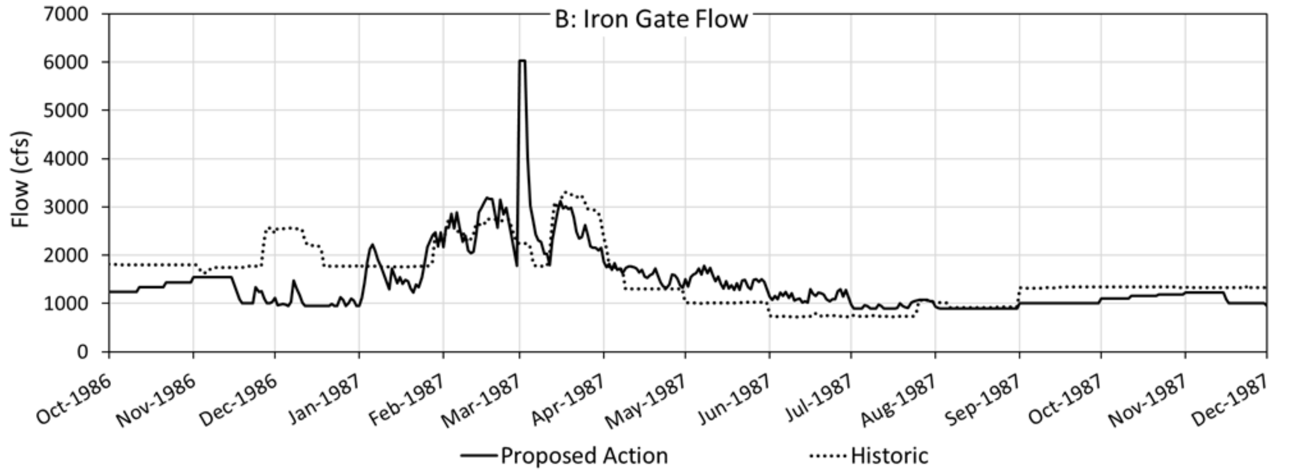


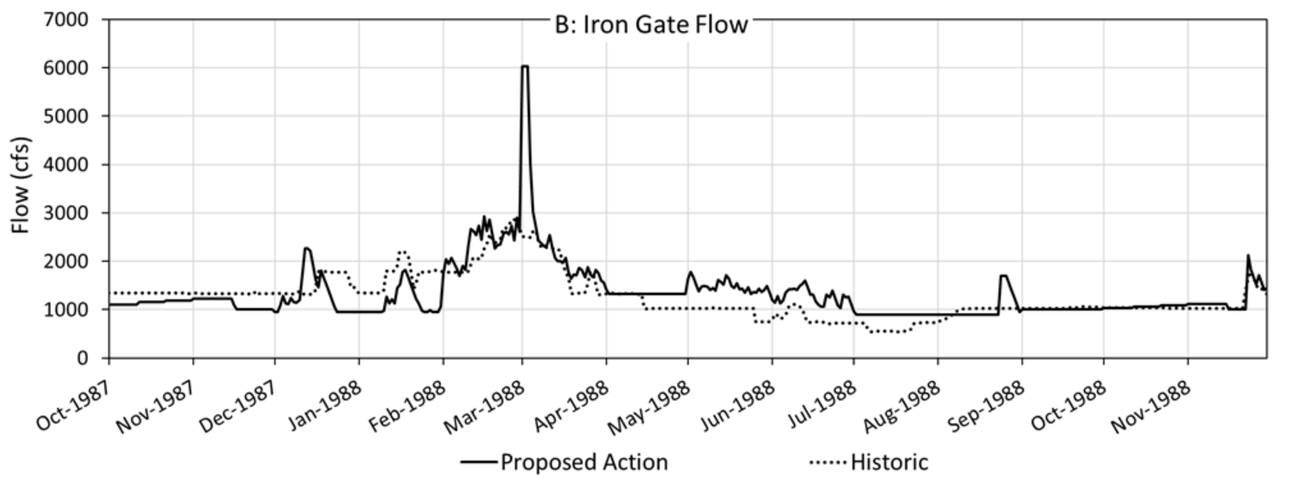

B: Iron Gate Flow
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
Oct-1982
Nov-1982
Dec-1982
Jan-1983
Feb-1983
Mar-1983
Apr-1983
May-1983
Jun-1983
Jul-1983
Aug-1983
Sep-1983
Oct-1983
Nov-1983
Dec-1983
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
Oct-1983
Nov-1983
Dec-1983
Jan-1984
Feb-1984
Mar-1984
Apr-1984
May-1984
Jun-1984
Jul-1984
Aug-1984
Sep-1984
Oct-1984
Nov-1984
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Oct-1984
Nov-1984
Dec-1984
Jan-1985
Feb-1985
Mar-1985
Apr-1985
May-1985
Jun-1985
Jul-1985
Aug-1985
Sep-1985
Oct-1985
Nov-1985
Dec-1985
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
14000
12000
10000
8000
6000
4000
2000
0
Oct-1985
Nov-1985
Dec-1985
Jan-1986
Feb-1986
Mar-1986
Apr-1986
May-1986
Jun-1986
Jul-1986
Aug-1986
Sep-1986
Oct-1986
Nov-1986
Dec-1986
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-1986
Nov-1986
Dec-1986
Jan-1987
Feb-1987
Mar-1987
Apr-1987
May-1987
Jun-1987
Jul-1987
Aug-1987
Sep-1987
Oct-1987
Nov-1987
Dec-1987
Proposed Action
Historic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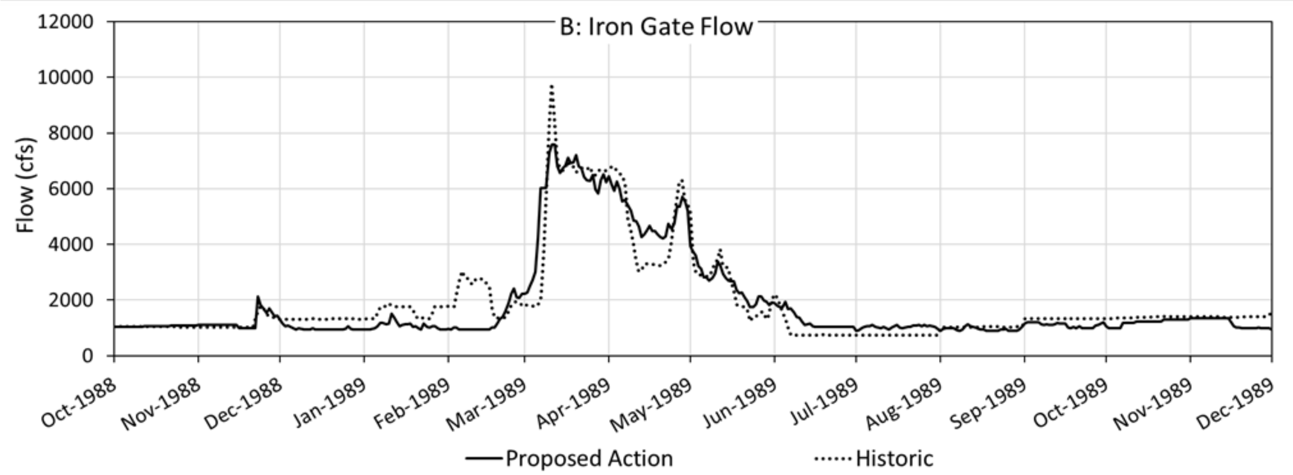
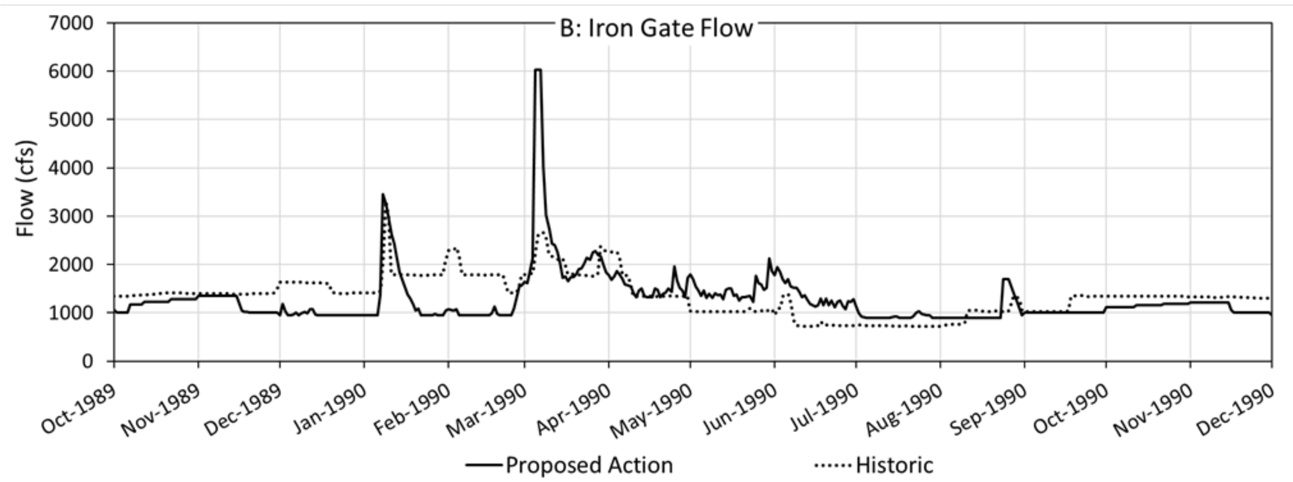
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-1987
Nov-1987
Dec-1987
Jan-1988
Feb-1988
Mar-1988
Apr-1988
May-1988
Jun-1988
Jul-1988
Aug-1988
Sep-1988
Oct-1988
Nov-1988
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
Oct-1988
Nov-1988
Dec-1988
Jan-1989
Feb-1989
Mar-1989
Apr-1989
May-1989
Jun-1989
Jul-1989
Aug-1989
Sep-1989
Oct-1989
Nov-1989
Dec-1989
Proposed Action
Historic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Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-1989
Nov-1989
Dec-1989
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Feb-1990
Mar-1990
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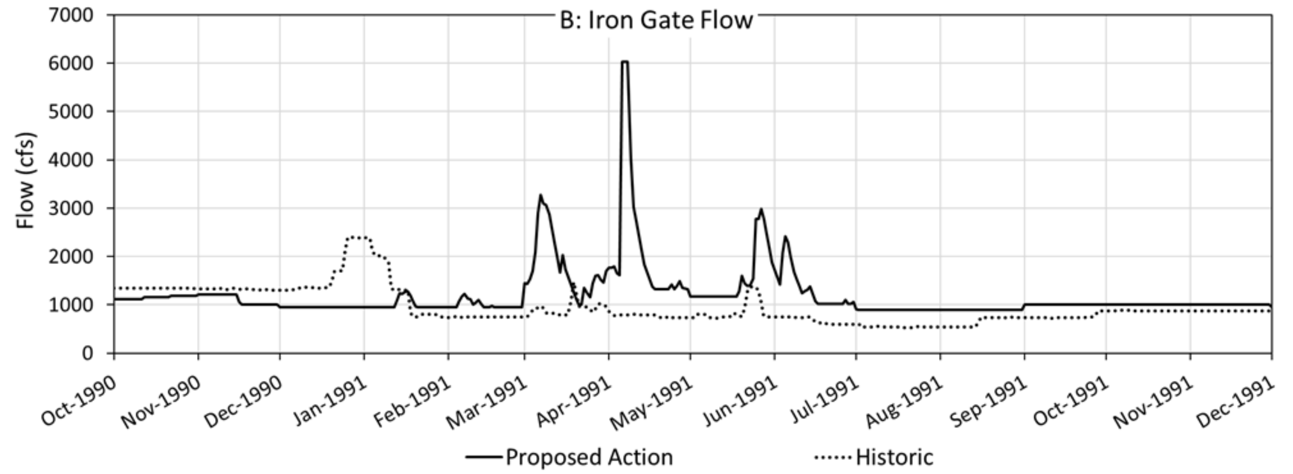
Oct-1990
Nov-1990
Dec-1990
Proposed Action
Historic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Flow (cfs)
7000
6000
5000
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3000
2000
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0
Oct-1990
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Feb-1991
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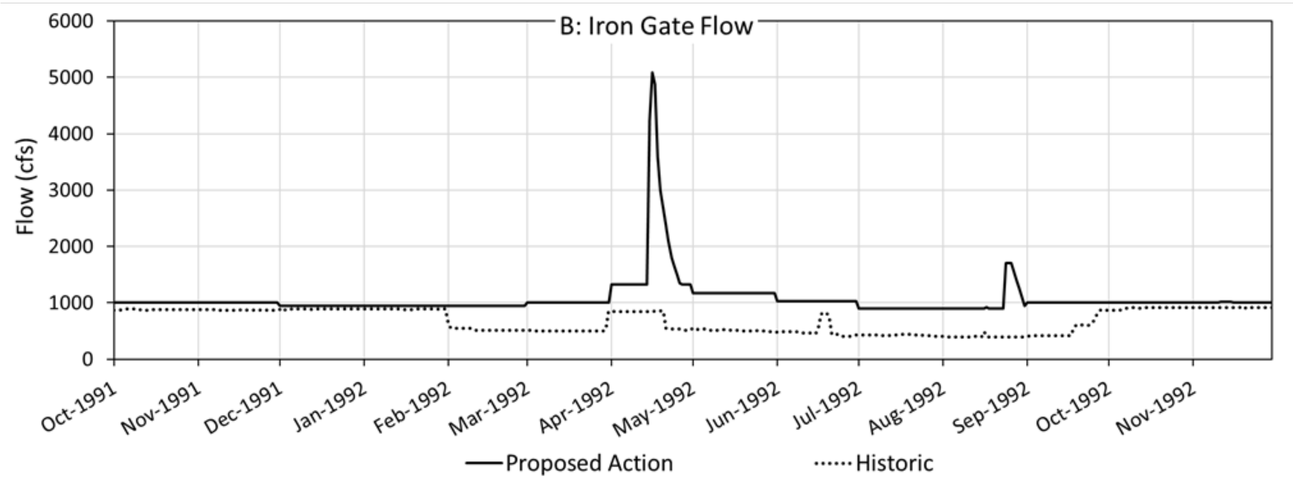
Dec-1991
Proposed Action
Historic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Flow (cfs)
6000
5000
4000
3000
2000
1000
0
Oct-1991
Nov-1991
Dec-1991
Jan-1992
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Nov-1992
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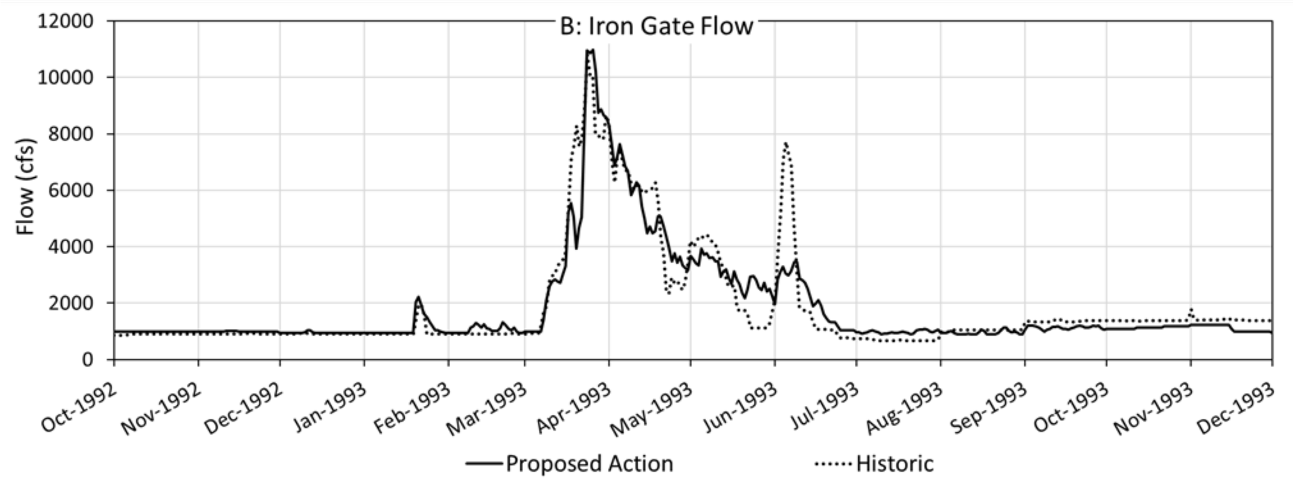
Historic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Flow (cfs)
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Oct-1992
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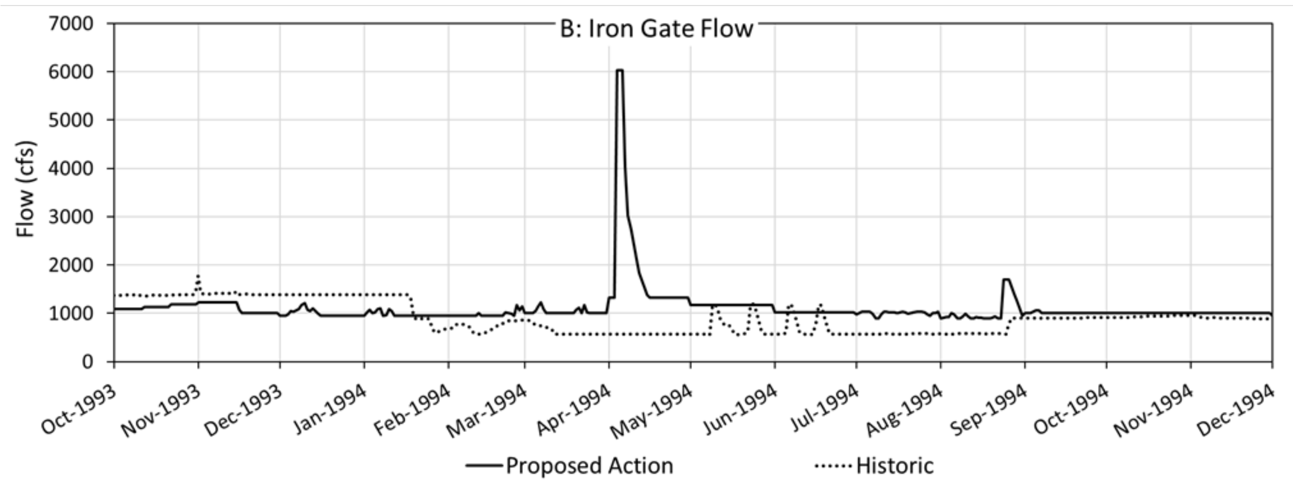
Historic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Flow (cfs)
7000
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Oct-1993
Nov-1993
Dec-1993
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Feb-1994
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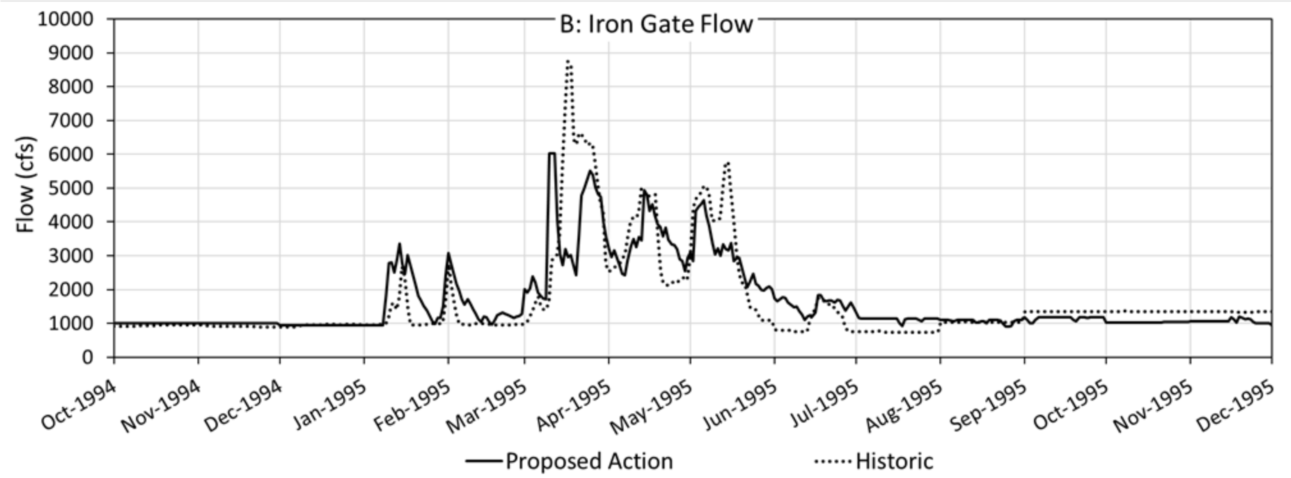
Oct-1994
Nov-1994
Dec-1994
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Oct-1994
Nov-1994
Dec-1994
Jan-1995
Feb-1995
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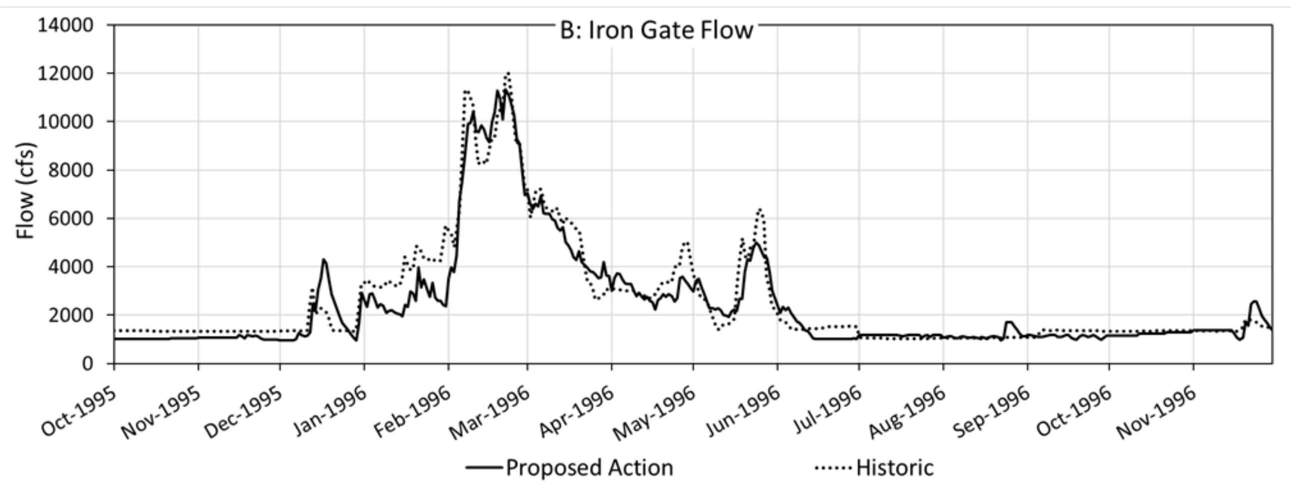
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
14000
12000
10000
8000
6000
4000
2000
0
Oct-1995
Nov-1995
Dec-1995
Jan-1996
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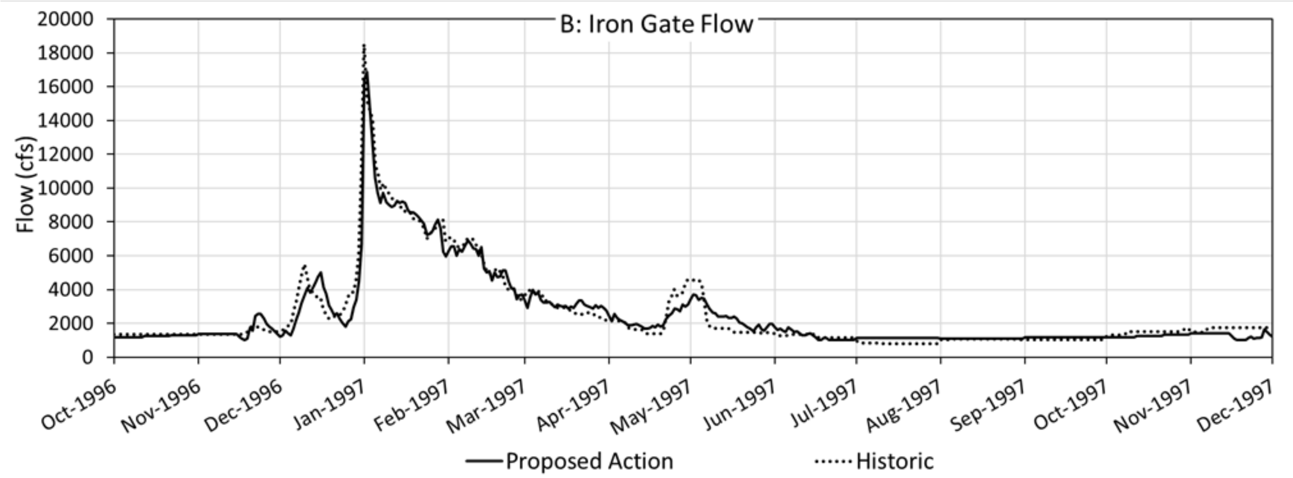
Proposed Action
Historic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Flow (cfs)
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18000
16000
14000
12000
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8000
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Jan-1997
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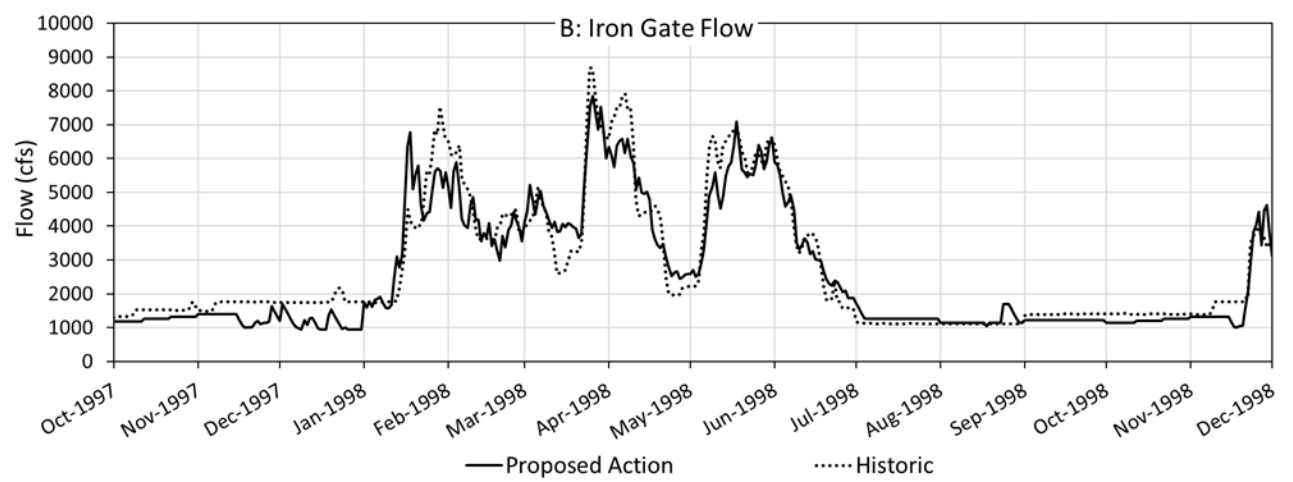
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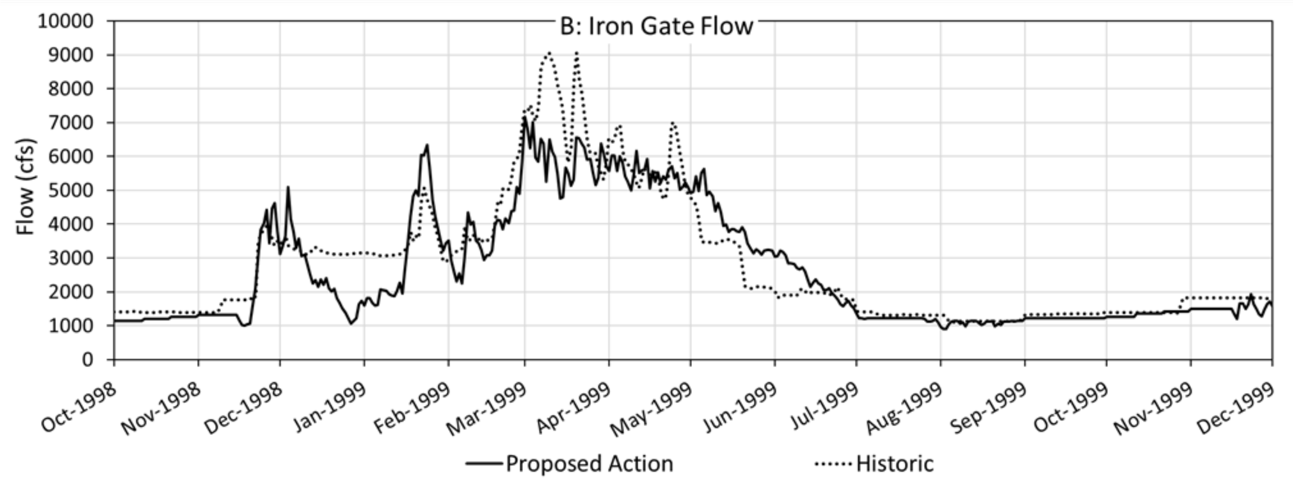
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Flow (cfs)
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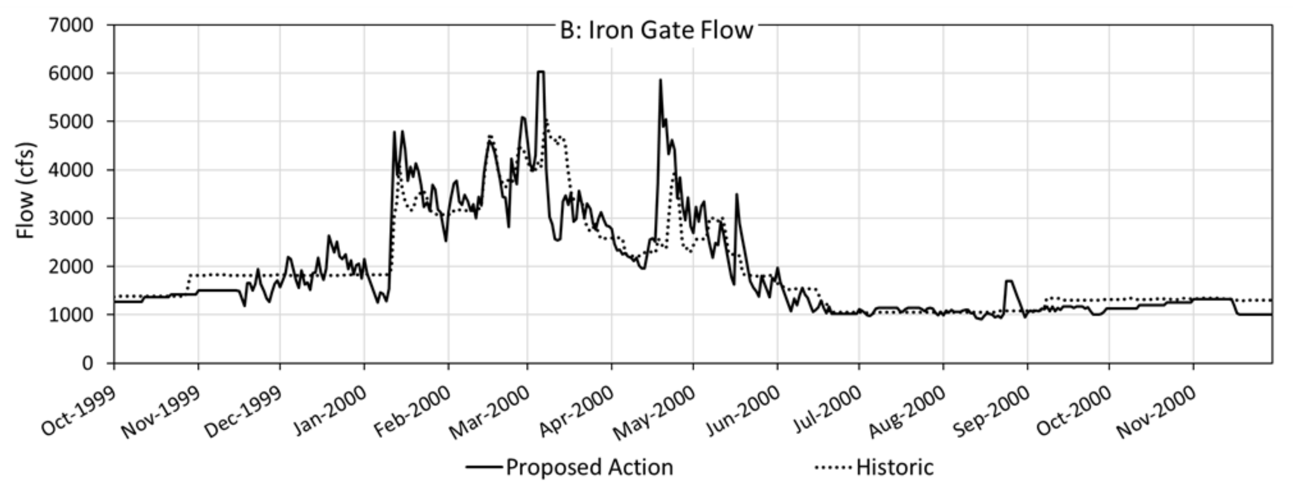
Historic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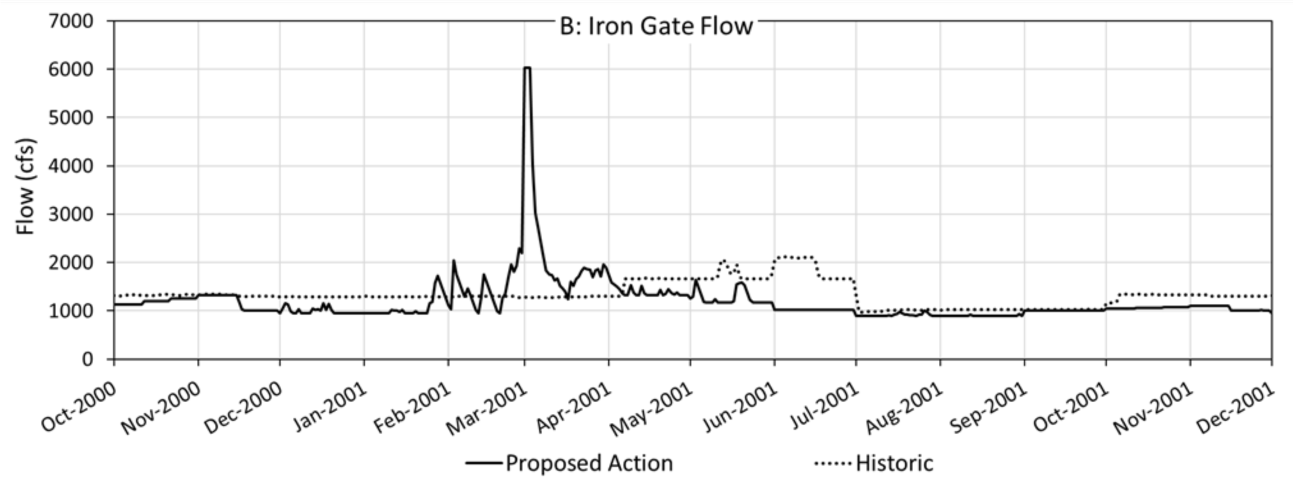
Sep-2000
Oct-2000
Nov-2000
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2000
Nov-2000
Dec-2000
Jan-2001
Feb-2001
Mar-2001
Apr-2001
May-2001
Jun-2001
Jul-2001
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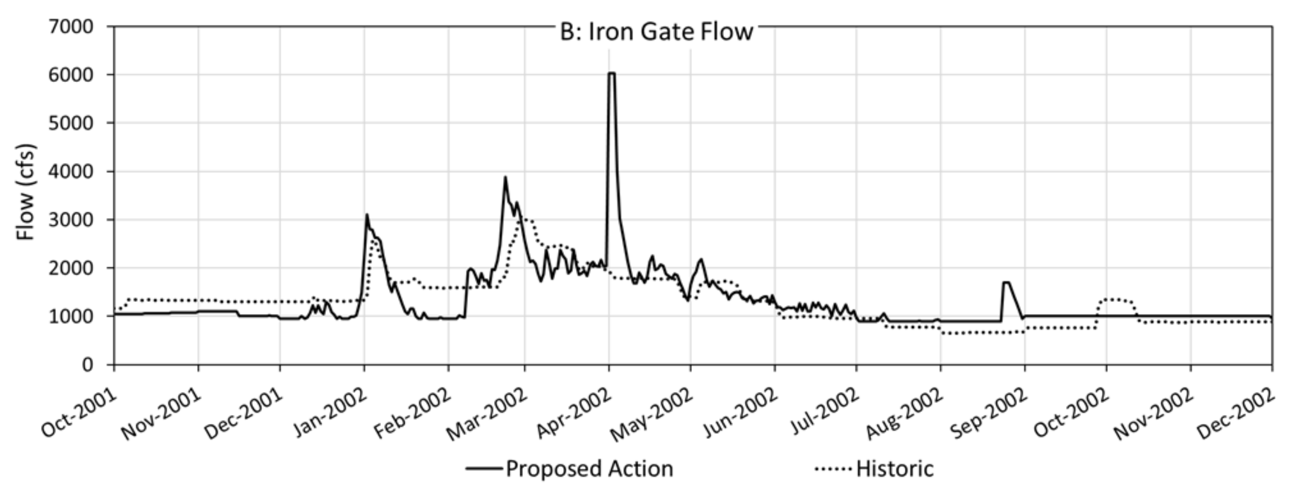
Oct-2001
Nov-2001
Dec-2001
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2001
Nov-2001
Dec-2001
Jan-2002
Feb-2002
Mar-2002
Apr-2002
May-2002
Jun-2002
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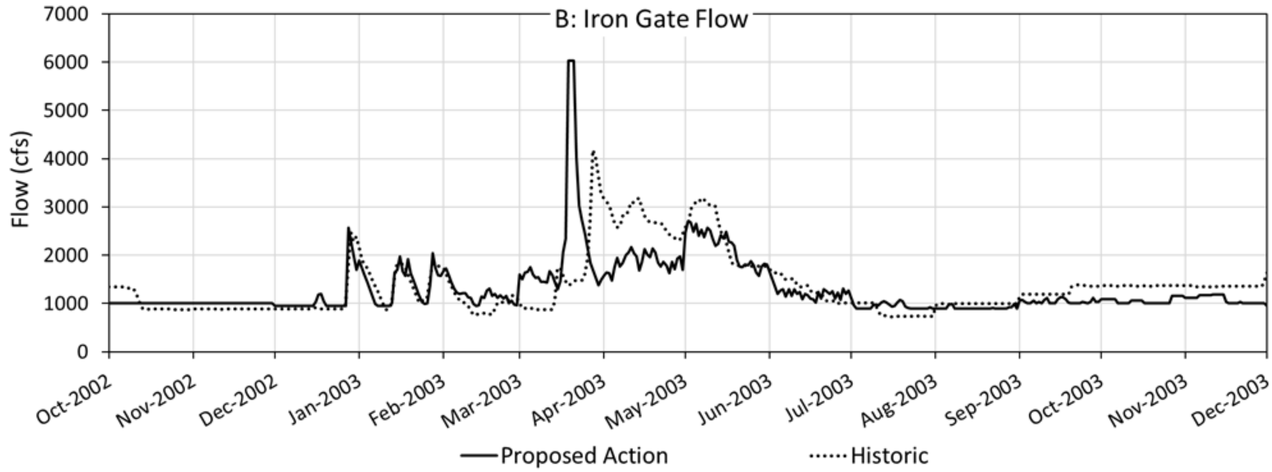
Oct-2002
Nov-2002
Dec-2002
Proposed Action
Historic



B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2002
Nov-2002
Dec-2002
Jan-2003
Feb-2003
Mar-2003
Apr-2003
May-2003
Jun-2003
Jul-2003
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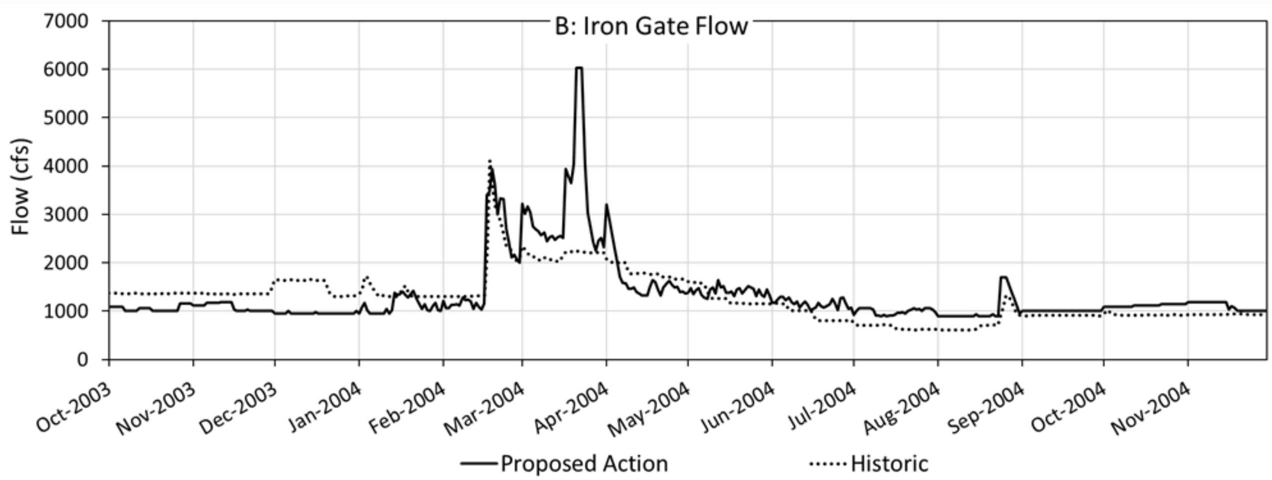
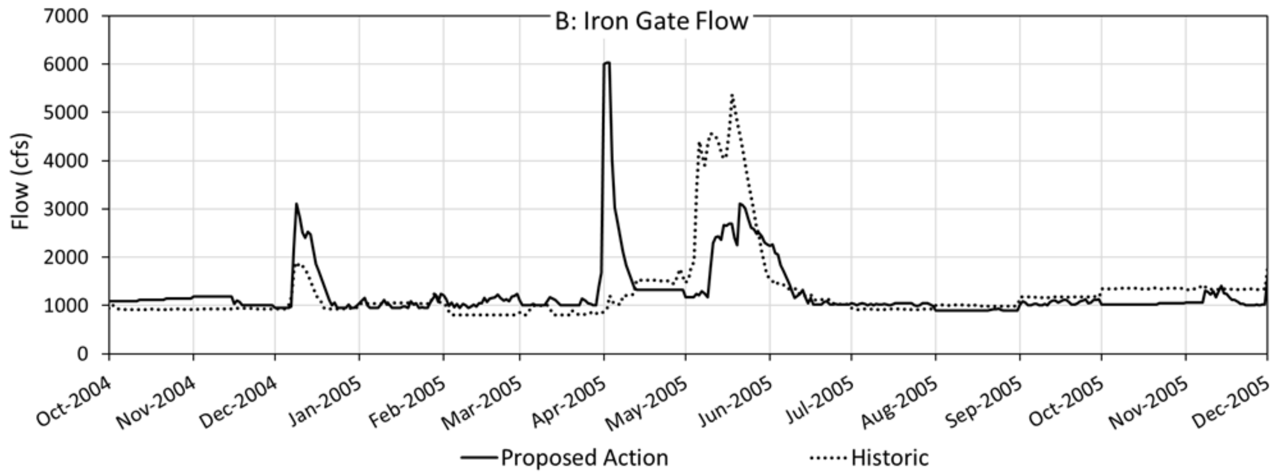
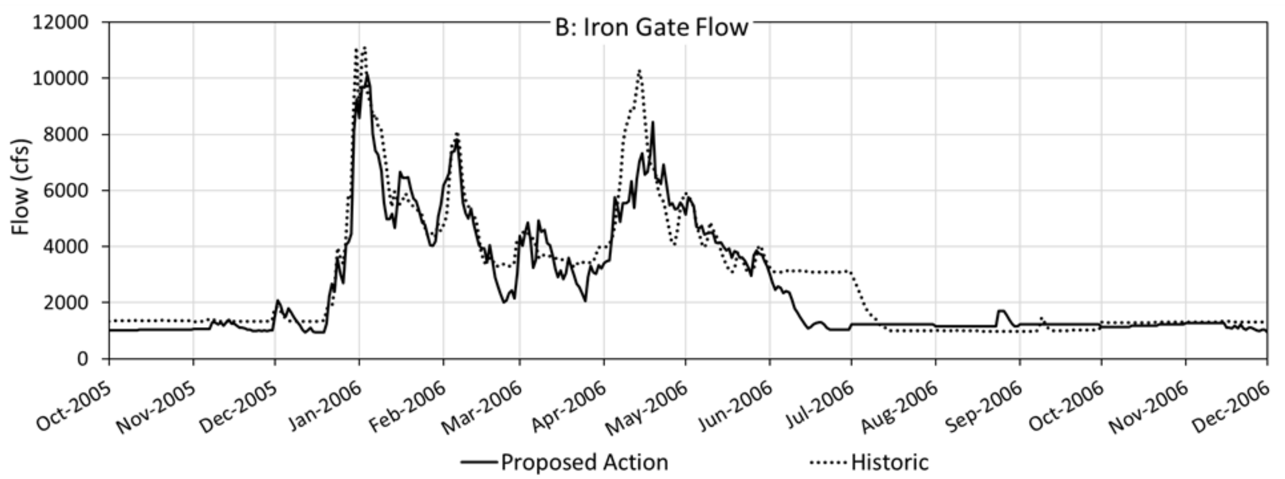
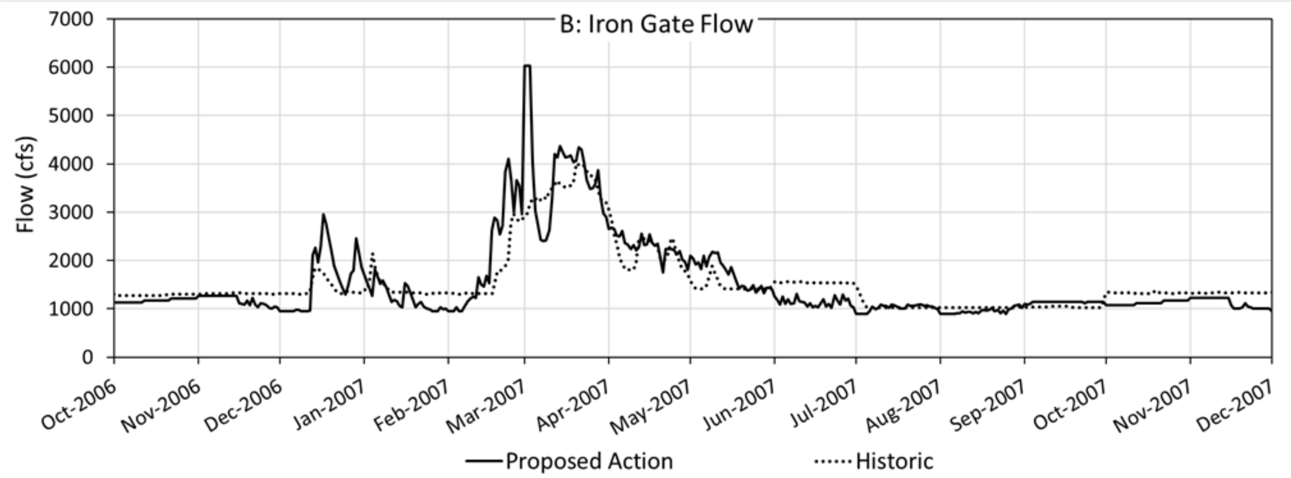
Sep-2003
Oct-2003
Nov-2003
Dec-2003
Proposed Action
Historic



B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2003
Nov-2003
Dec-2003
Jan-2004
Feb-2004
Mar-2004
Apr-2004
May-2004
Jun-2004
Jul-2004
Aug-2004
Sep-2004
Oct-2004
Nov-2004
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2004
Nov-2004
Dec-2004
Jan-2005
Feb-2005
Mar-2005
Apr-2005
May-2005
Jun-2005
Jul-2005
Aug-2005
Sep-2005
Oct-2005
Nov-2005
Dec-2005
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
Oct-2005
Nov-2005
Dec-2005
Jan-2006
Feb-2006
Mar-2006
Apr-2006
May-2006
Jun-2006
Jul-2006
Aug-2006
Sep-2006
Oct-2006
Nov-2006
Dec-2006
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2006
Nov-2006
Dec-2006
Jan-2007
Feb-2007
Mar-2007
Apr-2007
May-2007
Jun-2007
Jul-2007
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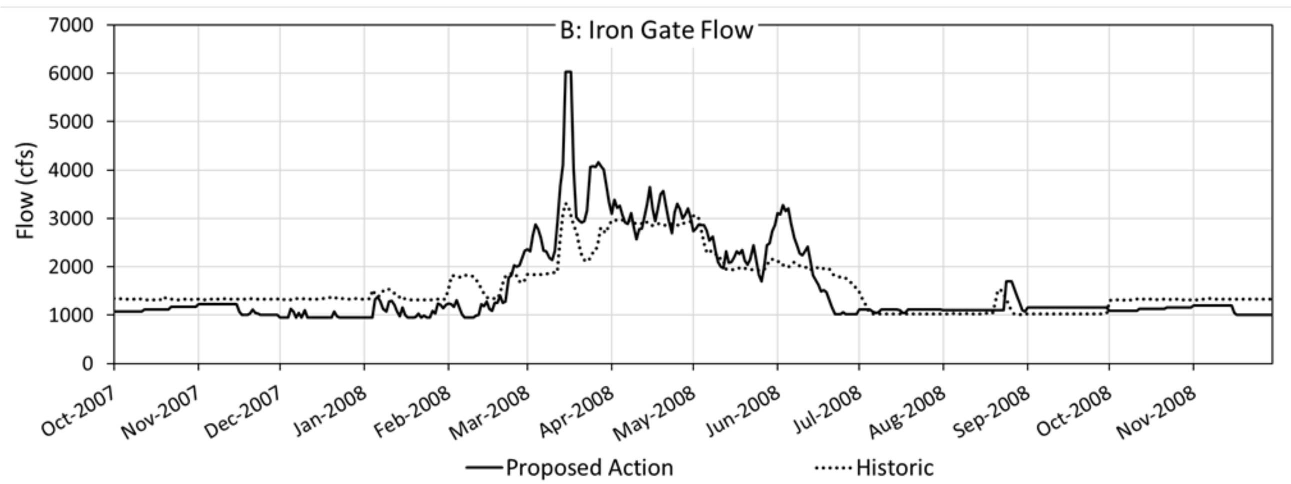
Sep-2007
Oct-2007
Nov-2007
Dec-2007
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2007
Nov-2007
Dec-2007
Jan-2008
Feb-2008
Mar-2008
Apr-2008
May-2008
Jun-2008
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Sep-2008
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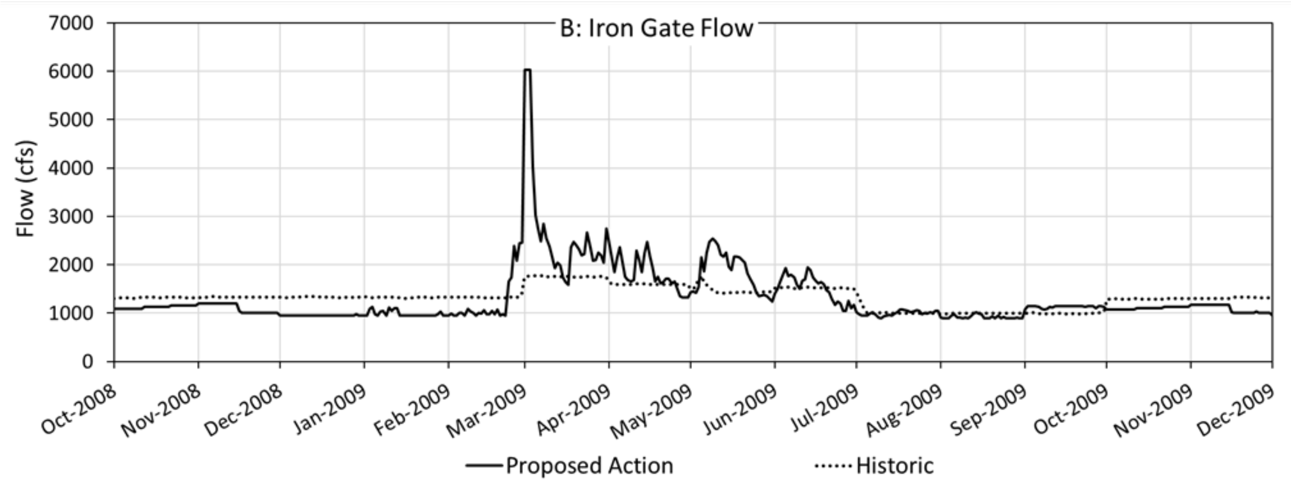
Nov-2008
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2008
Nov-2008
Dec-2008
Jan-2009
Feb-2009
Mar-2009
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May-2009
Jun-2009
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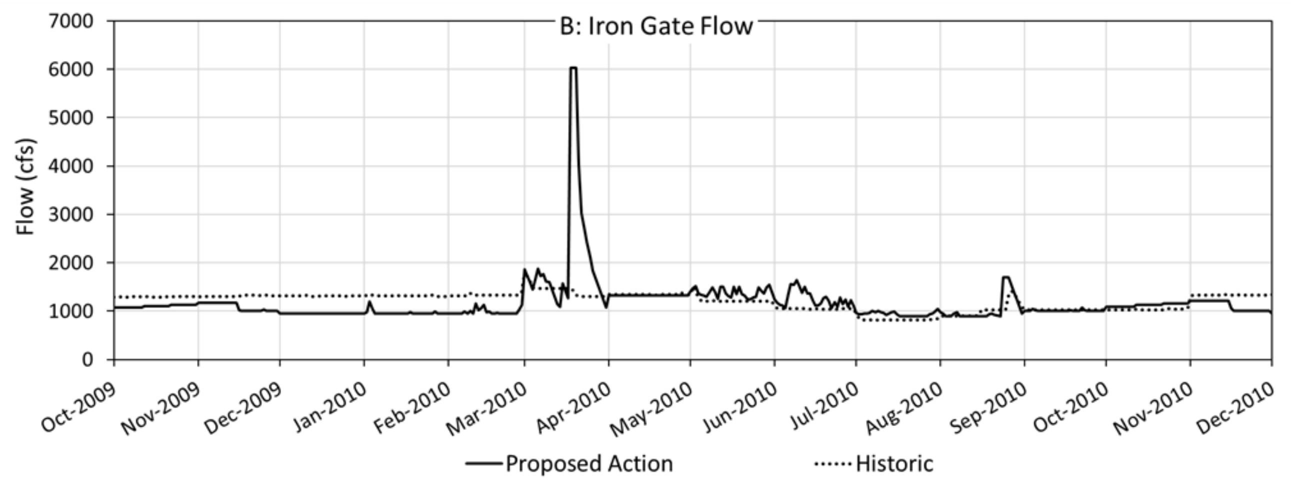
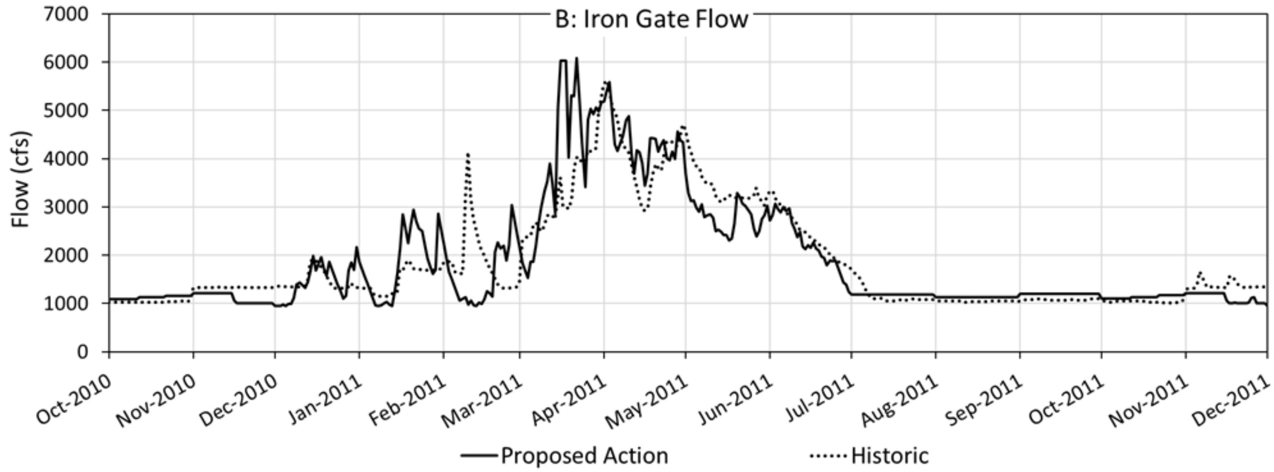
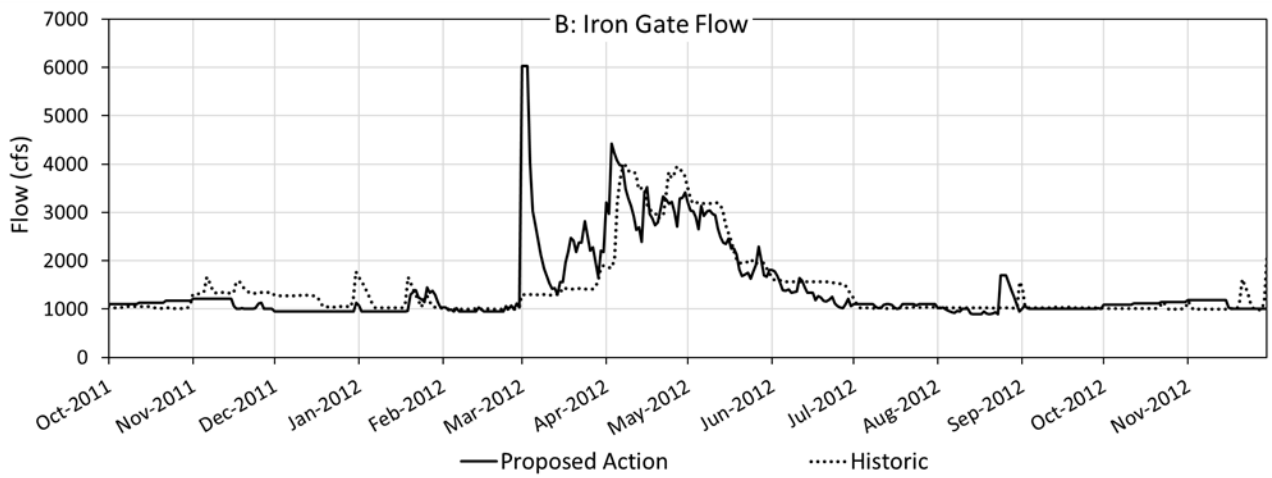
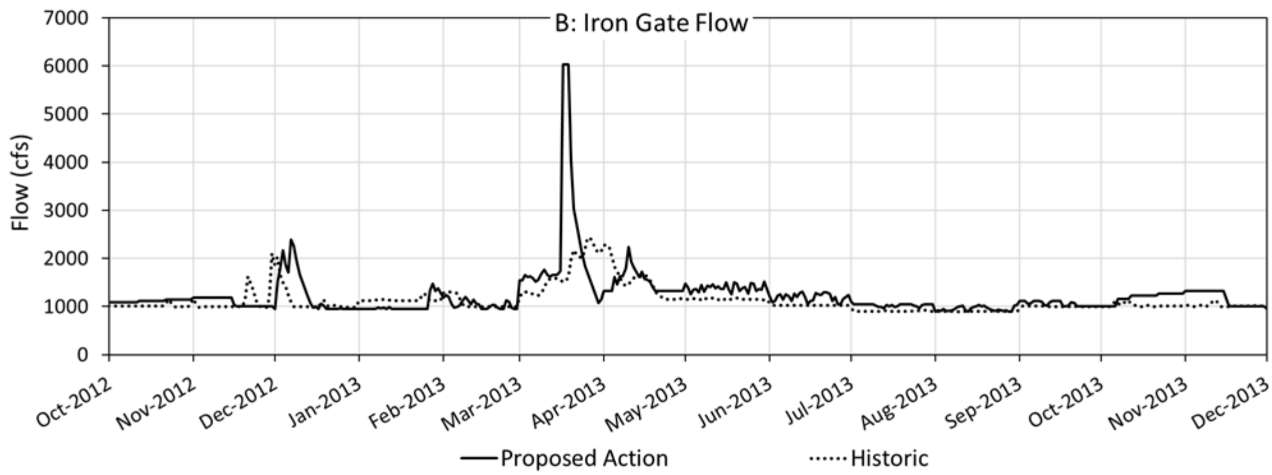
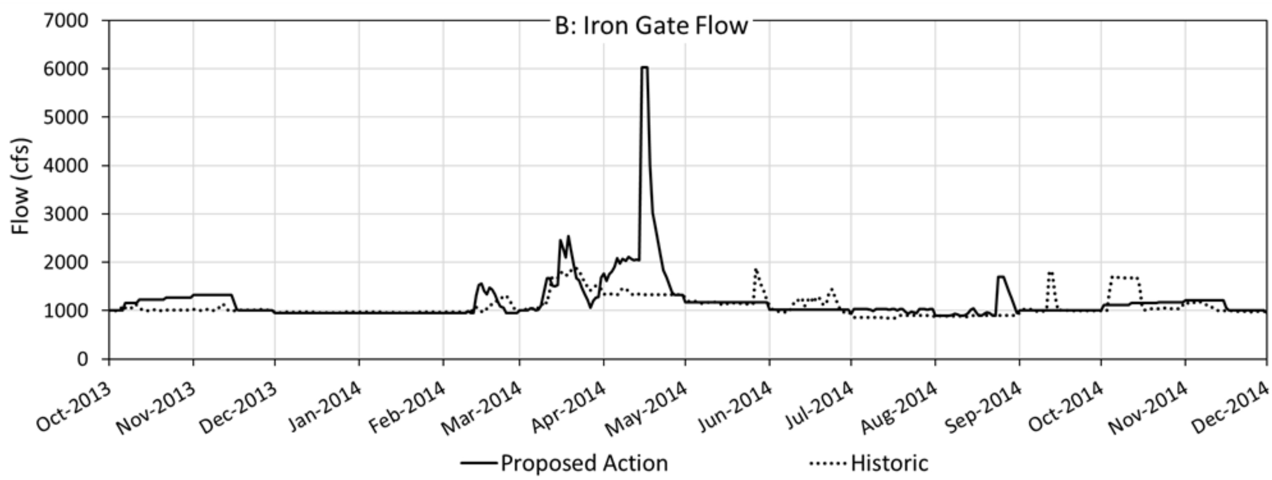
Oct-2009
Nov-2009
Dec-2009
Proposed Action
Historic

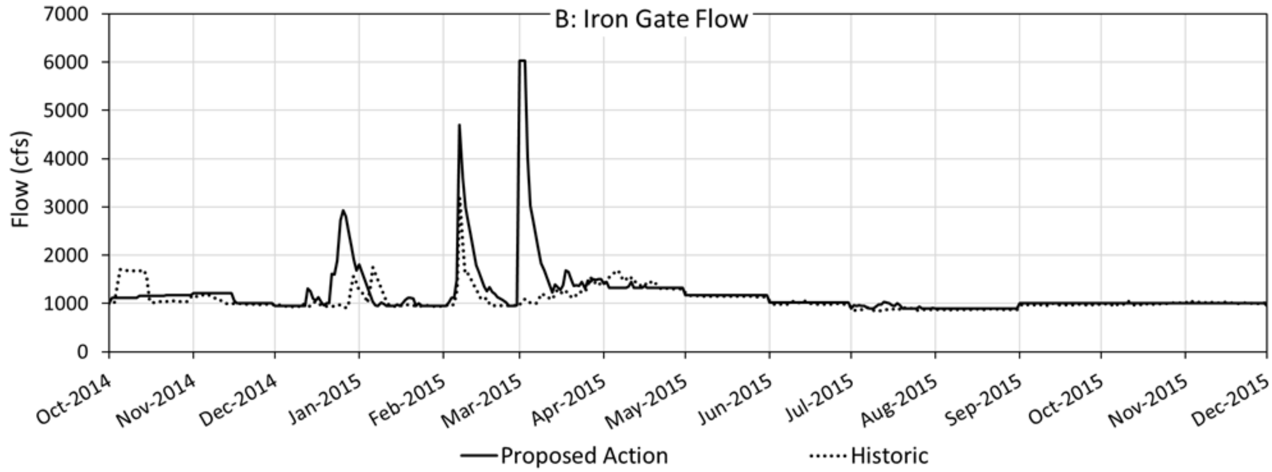

B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2009
Nov-2009
Dec-2009
Jan-2010
Feb-2010
Mar-2010
Apr-2010
May-2010
Jun-2010
Jul-2010
Aug-2010
Sep-2010
Oct-2010
Nov-2010
Dec-2010
Proposed Action
Historic

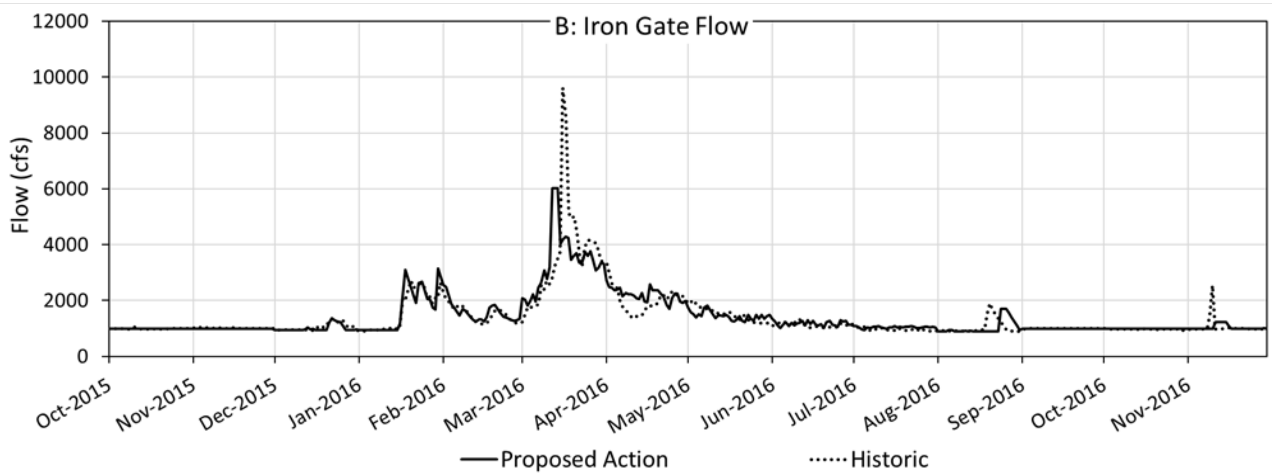

B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2010
Nov-2010
Dec-2010
Jan-2011
Feb-2011
Mar-2011
Apr-2011
May-2011
Jun-2011
Jul-2011
Aug-2011
Sep-2011
Oct-2011
Nov-2011
Dec-2011
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2011
Nov-2011
Dec-2011
Jan-2012
Feb-2012
Mar-2012
Apr-2012
May-2012
Jun-2012
Jul-2012
Aug-2012
Sep-2012
Oct-2012
Nov-2012
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2012
Nov-2012
Dec-2012
Jan-2013
Feb-2013
Mar-2013
Apr-2013
May-2013
Jun-2013
Jul-2013
Aug-2013
Sep-2013
Oct-2013
Nov-2013
Dec-2013
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2013
Nov-2013
Dec-2013
Jan-2014
Feb-2014
Mar-2014
Apr-2014
May-2014
Jun-2014
Jul-2014
Aug-2014
Sep-2014
Oct-2014
Nov-2014
Dec-2014
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Oct-2014
Nov-2014
Dec-2014
Jan-2015
Feb-2015
Mar-2015
Apr-2015
May-2015
Jun-2015
Jul-2015
Aug-2015
Sep-2015
Oct-2015
Nov-2015
Dec-2015
Proposed Action
Historic


B: Iron Gate Flow
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
Oct-2015
Nov-2015
Dec-2015
Jan-2016
Feb-2016
Mar-2016
Apr-2016
May-2016
Jun-2016
Jul-2016
Aug-2016
Sep-2016
Oct-2016
Nov-2016
Proposed Action
Historic