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

October 28, 2024 **Refer to NMFS No:** WCRO-2024-01599

Alan C. Heck, Jr.
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 October 1, 2024 through September 30, 2029

Dear Mr. Heck:

Thank you for your letter of June 14, 2024, requesting reinitiation of consultation with NOAA's National Marine Fisheries Service (NMFS) pursuant to Section 7 of the Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531 et seq.) for Klamath Project operations from October 1, 2024 through September 30, 2029, 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 consultation process, including the Bureau of Reclamation's June 14, 2024 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 this 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) (SRKW), or destroy or adversely modify designated critical habitat for the SONCC coho salmon ESU or SRKW. However, NMFS anticipates non-jeopardizing incidental take of SONCC coho salmon and SRKWs as a result of the proposed action. 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 Klamath 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 FRN File # 151422WCR2024AR00130

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 October 1, 2024 through September 30, 2029

NMFS Consultation Number: WCRO-2024-01599

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 (SRKW) (*Orcinus orca*)	Endangered	Yes	No	Yes	No

Table 2. Essential Fish Habitat and NMFS' Determinations:

Fishery Management Plan That Identifies EFH in the Klamath 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: October 28, 2024

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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 U.S.C. 1531 et seq.), as amended, and implementing regulations at 50 CFR part 402.

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

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

This Opinion and determinations are based on information provided in the United States Bureau of Reclamation's (Reclamation) Final Biological Assessment (BA) (2024), and other sources of the best scientific and commercial data available. This Opinion analyzes effects of proposed Klamath Project operations (Klamath Project) from October 1, 2024 through September 30, 2029.

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 and Reclamation's Klamath Project. More recently, removal of the Lower Klamath Project's four hydroelectric developments (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate) has occurred.

Federally-listed species, and in some cases their associated critical habitat, that fall under NMFS jurisdiction and are affected by Klamath Project operations include the Southern Oregon/Northern California Coastal (SONCC) coho salmon Evolutionarily Significant Unit (ESU), the Southern Resident Killer Whale (SRKW) Distinct Population Segment (DPS), Southern DPS Pacific Eulachon (Southern DPS eulachon), and Southern DPS of North American Green Sturgeon (Southern DPS green sturgeon).

Federally-listed species, and in some cases their associated critical habitat, that fall under the United States Fish and Wildlife Service (USFWS) jurisdiction and are also affected by Klamath Project operations include Lost River sucker (*Deltistes luxatus*), Shortnose sucker (*Chasmistes brevirostris*), bull trout (*Salvelinus confluentus*), Oregon Spotted Frog (*Rana pretiosa*), Northwestern Pond turtle (*Actinemys marmorata*), Applegate's milk vetch (*Astragalus* *applegatei*) and Monarch Butterfly (*Danaus plexippus*). The USFWS is preparing a separate, but closely coordinated, biological opinion regarding the effects of the proposed action on these species and affected critical habitat.

Between the late 1990s and 2019, NMFS and USFWS (collectively, the Services) completed a series of separate and combined biological opinions on the effects of Klamath Project operations on ESA-listed species and designated critical habitat.

In 2019, the Yurok Tribe and commercial fishing organizations filed an action in United States District Court that, as amended and among other things, challenged NMFS' 2019 biological opinion (Yurok Tribe *et al*. vs. Reclamation and NMFS 2019a; Yurok Tribe *et al*. vs. Reclamation and NMFS 2019b). In addition, later in 2019, Reclamation and the Services reinitiated formal consultation based on new information that revealed effects of Klamath Project operations on ESA-listed species and critical habitat in a manner or to an extent not previously considered (NMFS 2019d; Reclamation 2019b; Reclamation 2019a). From 2020 through the present, Reclamation has operated the Klamath Project according to the proposed action described in the 2018 BA and supplemented by the 2020 Interim Operations Plan (IOP), as well as Drought Plans and Temporary Operating Plans (TOPs). NMFS' 2019 biological opinion has remained in place and was extended through October 31, 2024. Since 2019, USFWS has subsequently issued additional biological opinions.

Separate from the Klamath Project and downstream, the Klamath River Renewal Corporation's (KRRC) Lower Klamath Project includes the removal of four hydroelectric developments on the Klamath River. Pursuant to the Klamath Hydroelectric Settlement Agreement (KHSA), in September 2016, PacifiCorp and the KRRC filed a Joint Application for Approval of License Amendment and License Transfer seeking a separate Federal Energy Regulatory Commission (FERC) license for the J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate developments (the Lower Klamath Project), and to transfer the license for the Lower Klamath Project from PacifiCorp to KRRC. At the same time, KRRC filed an Application for Surrender of License for Major Project and Removal of Project Works seeking the FERC's approval of an application to surrender the license for the Lower Klamath Project. In November of 2020, the KRRC filed an Amended License Surrender Application. In November 2022, the FERC approved the amended Application and issued the License Surrender Order approving facility removal and habitat restoration.

NMFS (2021a) issued a biological opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Surrender and Decommissioning of the Lower Klamath Hydroelectric Project No. 14803-001, Klamath County, Oregon and Siskiyou County, California, evaluating effects on ESA-listed species and their critical habitat. The dam removal proposed action will have been completed by or within the timeframe of the proposed action analyzed in this Opinion, therefore affecting the Environmental Baseline, including the breaching of the four dams prior to finalizing this consultation and Opinion.

1.2 Consultation History

Updates to the regulations governing interagency consultation (50 CFR part 402) were effective on May 6, 2024 (89 Fed. Reg. 24268). We are applying the updated regulations to this consultation. The 2024 regulatory changes, like those from 2019, were intended to improve and clarify the consultation process, and, with one exception from 2024 (offsetting reasonable and prudent measures), were not intended to result in changes to the Services' existing practice in implementing Section 7(a)(2) of the Act. 89 Fed. Reg. at 24268; 84 Fed. Reg. at 45015. We have considered the prior rules and affirm that the substantive analysis and conclusions articulated in this Opinion and ITS would not have been any different under the 2019 regulations or pre-2019 regulations. Reclamation has consulted with NMFS on proposed Klamath Project operations since 1998. Table 1-5 in Reclamation's BA (2024a) summarizes the history of ESA consultations undertaken by Reclamation since 1988, including consultations with NMFS.

On March 29, 2019, NMFS issued the currently operative biological opinion on Klamath Project operations, "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" (later extended to October 31, 2024). NMFS concluded the 2018 BA's proposed action was not likely to jeopardize the continued existence of the SONCC coho salmon ESU or the SRKW DPS or destroy or adversely modify the designated critical habitat for the SONCC coho salmon ESU. NMFS also concluded the action was not likely to adversely affect Southern DPS green sturgeon (*Acipenser medirostris*) and the Southern DPS eulachon (*Thaleichthys pacificus*) or critical habitat for the southern DPS of Pacific eulachon. Regarding the MSA EFH consultation requirements, NMFS concluded that the proposed action would adversely affect coho salmon and Chinook Salmon EFH and provided conservation recommendations accordingly. To the extent practicable, Reclamation implemented our conservation recommendations.

The 2018 BA included Reclamation's plan for operating the Klamath Project from 2019 to 2024. In March 2020, following extensive coordination and collaboration with the Services, Reclamation supplemented the 2018 plan with an IOP, which used hydrologic modeled output derived from the Klamath Basin Planning Model (KBPM) and provided additional water for the Klamath River under certain specified conditions. The IOP included enhanced spring flows and augmentation of the Environmental Water Account (EWA) in some water years, depending on Upper Klamath Lake (UKL) supply. Releases of the EWA augmentation were to occur through a release schedule recommended by NMFS, with input from USFWS and the Flow Account Scheduling Technical Advisory (FASTA) team and implemented by Reclamation.

NMFS determined that changes to the proposed action represented by the 2020 IOP did not warrant reinitiation of consultation, as the range of effects on listed species and critical habitat were anticipated to be consistent with those analyzed in the 2019 NMFS' biological opinion.

In January 2023, Reclamation released an updated TOP and associated Drought Plan to make certain adjustments to the IOP that would enable it to comply with UKL elevation requirements following three years of exceptional drought. NMFS responded to the 2023 TOP with a letter affirming that extending IOP operations was expected to result in effects consistent with the anticipated effects of the proposed action analyzed in NMFS' 2019 biological opinion through March 31, 2024.

In September 2023, Reclamation proposed continued operation of the Klamath Project under the plan described in the 2018 BA and 2020 IOP through October 2024. The extension was proposed to provide time to complete reinitiated ESA consultation, considering the impacts of necessary modifications to Klamath Project operations to accommodate the operational effects of the KRRC's removal of four mainstem Klamath River dams (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate). On March 26, 2024, NMFS responded that modifying the proposed action to extend it through October 31, 2024, did not have effects that extended beyond those previously analyzed. Thus, we extended our 2019 biological opinion through October 31, 2024, noting ongoing efforts toward completion of consultation over longer-term Klamath Project operations. NMFS also noted that dam removal activities on the Klamath River were being implemented consistent with NMFS' 2021 biological opinion to the FERC for the Surrender and decommissioning of the Lower Klamath Hydroelectric Project (NMFS 2021a). By October 31, 2024, these dam removal activities were expected to be completed, as was reinitiated consultation over longer-term Klamath Project operations.

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 Klamath 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 who met multiple times starting in January 2017 to develop a new proposed action (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).

Table 3. Chronology of ACT meetings for development of Reclamation's proposed action.

Meeting Type	Date Held	Location
Reclamation and the Services Meetings and Work Sessions		
ACT	8/30/2023	webinar/teleconference
ACT	1/9/2024	webinar/teleconference
ACT (Preparation)	4/18/2024	Medford, OR
ACT	4/19/2024	Medford, OR
ACT (Practitioner-Level)	5/16/2024	Klamath Falls, OR
ACT	5/31/2024	webinar/teleconference
ACT	6/13/2024	webinar/teleconference
ACT	7/25/2024	webinar/teleconference
NMFS Biological Opinion Terms and Conditions	10/21/2024	webinar/teleconference
Klamath Technical Meetings		
Klamath Basin Forecasting Workshop	9/20/2023	Ashland, OR
Klamath Basin Forecasting Workshop	9/21/2023	Ashland, OR
Klamath Basin Forecasting Workshop	9/22/2023	Ashland, OR

Meeting Type	Date Held	Location
ESA Consultation – Technical Team Meeting	10/26/2023	webinar/teleconference
ESA Consultation – Technical Team Meeting	11/9/2023	webinar/teleconference
Klamath Natural Flow Study Update Meeting	11/15/2023	webinar/teleconference
ESA Consultation – Technical Team Meeting	11/30/2023	webinar/teleconference
ESA Consultation – Technical Team Meeting	12/14/2023	webinar/teleconference
Klamath Technical Team Meeting	1/4/2024	webinar/teleconference
Klamath Technical Team Meeting	2/1/2024	webinar/teleconference
Klamath Technical Team Meeting	2/15/2024	webinar/teleconference
Klamath Technical Team Meeting	2/29/2024	webinar/teleconference
Klamath Technical Team Meeting	6/7/2024	webinar/teleconference
Klamath Ad Hock Team Use of Multiple Forecasts	7/12/2024	webinar/teleconference
Klamath Technical Team Meeting	7/18/2024	webinar/teleconference
Klamath Natural Flow Study Update	8/15/2024	webinar/teleconference
Klamath Technical Team Meeting	9/19/20024	webinar/teleconference
Klamath Project Operation Meeting	10/11/2024	webinar/teleconference
Tribal and Key Stakeholder Management Meetings		
Klamath ESA Consultation - Management Group Meeting #1	8/24/2023	webinar/teleconference
ESA Consultation - Management Group Meeting	9/20/2023	Ashland, OR
ESA Consultation - Management Team Meeting	10/10/2023	webinar/teleconference
ESA Consultation - Management Team Meeting	11/13/2023	Klamath Falls, OR
ESA Consultation - Management Team Meeting	12/7/2023	webinar/teleconference

Meeting Type	Date Held	Location
ESA Consultation - Management Team Meeting	2/7/2024	Ashland, OR
ESA Consultation - Management Team Meeting	3/20/2024	Ashland, OR
ESA Consultation - Management Team Meeting	4/17/2024	Eureka, CA
ESA Consultation - Management Team Meeting	5/15/2024	Ashland, OR
ESA Consultation - Management Team Meeting	6/28/2024	Ashland, OR
ESA Consultation - Management Team Meeting	8/21/2024	Eureka, CA
ESA Consultation - Management Team Meeting	9/18/2024	Klamath Falls, OR
NMFS Tribal Coordination – Klamath Project Operation biological opinion	10/18/2024	webinar/teleconference

On June 14, 2024, Reclamation sent its BA to NMFS pursuant to section 7(a)(2) of the ESA. On July 2, 2024, NMFS informed Reclamation that it had sufficient information to reinitiate consultation as of June 14, 2024, and noted that, consistent with discussions between the agencies, NMFS expected additional information clarifying two aspects of the BA. These clarifications were to include: (1) additional detailed information regarding Reclamation's proposed actions on Keno Dam fish passage improvements; and (2) additional detailed information on the Adaptive Management section of the 2024 BA regarding management benchmarks and how decisions will be made.

On August 27 2024, Reclamation sent an addendum to the Services modifying and clarifying components of the proposed action concerning conservation measures, fish passage at Keno Dam, fish screening, and adaptive management.

1.3 Proposed Federal Action

Under the ESA, "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (see 50 CFR 402.02). Reclamation described the proposed action in its June 14, 2024 BA, which it prepared pursuant to Section 7(a)(2) of the ESA, to evaluate the potential effects of the continued operation of Reclamation's Klamath Project on species listed as threatened or endangered under the ESA and on designated critical habitat. NMFS is including that proposed action in this section of the Opinion largely as it appeared in Reclamation's BA, with minor edits to correct typographical or reference errors and to clarify text. In addition, we specify any assumptions we make regarding the proposed action in order to ensure clarity around the action that has been analyzed in this Opinion. NMFS also understands that the proposed action description should be read in conjunction with Appendix A, which explains the model that Reclamation used to simulate the proposed action and outcomes that would meet its management objections and thus inform the proposed action.

The Klamath Project is located in south-central Oregon and Northeastern California and contains approximately 230,000 acres of irrigable land. Reclamation stores, diverts, and conveys waters of the Klamath and Lost Rivers to meet authorized Klamath Project purposes and contractual obligations in compliance with state and federal laws and carries out the activities necessary to maintain the Klamath Project and ensure its proper long-term functioning and operation. This proposed action is to undertake Klamath Project operations for a total of five years, both to allow monitoring and analysis of changes due to removal of four hydroelectric developments on the Klamath River and the Agency-Barnes Lake reconnection to UKL, as well as to provide adequate time to conduct a new ESA consultation effort covering longer-term operations. This proposed action, therefore will act as a "bridge" from the existing biological opinions and IOP to a longer-term biological opinion in the future after the effects of dam removal and reconnection of Agency-Barnes Lake are more fully known.

Major sections of the proposed action include:

- Modeling of proposed action.
- Proposed action; what has changed from the IOP.
- Operation and Maintenance (O&M) Activities.
- Compliance Monitoring.
- Adaptive Management.

In its 2024 BA, Reclamation noted how the information they relied upon significantly differed from that used in their 2018 BA, including the following:

- Flows projections are now based on Normalized Wetness Index (NWI), UKL Status, and Operations Index.
- UKL bathymetry has been revised.
- The compliance point for Klamath River flows has been moved from Iron Gate Dam (IGD)[1] to Keno Dam.
- Implications of Agency-Barnes Lake reconnection to UKL on hydrology and Klamath Project operations are assessed.
- Adaptive management has been further emphasized.
- Water supply for Lower Klamath National Wildlife Refuge (NWR) and Tule Lake NWR is included in the assessment.

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[1] IGD has been removed, but the location of the former IGD remains an important reference point. Use of the term "Iron Gate" refers to the location of the former IGD in this Opinion.

1.3.1 Proposed Action Background

The proposed action consists of the following three major elements:

1. Store waters of the Upper Klamath Basin and Lost River.
2. Operate the Klamath Project, or direct the operation of the Klamath Project, for the delivery of water for irrigation purposes, subject to water availability, 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 O&M activities necessary to maintain Klamath Project facilities to ensure proper long-term function and operation.

Each of the elements of the proposed action is described in detail in Sections 1.3.1.1 *Element One- Store Waters of the Upper Klamath Basin and Lost River*, 1.3.1.2 *Element Two- Operation and Delivery of Water from Upper Klamath Lake and the Klamath River*, and 0 *Element Three – Operation and Maintenance Activities*. Volume of water herein is expressed in units of either acre-feet (AF) or thousand acre-feet (TAF).

Reclamation has managed UKL elevations and Klamath River flows at IGD in accordance with a series of biological opinions from the Services. For the 2018 BA, Reclamation, in consultation with the Services, used the KBPM to simulate operations of the Klamath Project for the 1981 through 2016 period of record (POR) of historical hydrology for development of the proposed action. For the current proposed action, Reclamation has incorporated recent hydrologic data to expand the POR from 2016 through 2022 (i.e., 1981 to 2022). The KBPM (KRM version) simulates conditions since 1981. Reclamation's 2024 BA used the 1991 to 2022 period to compute the daily and monthly exceedances for UKL elevations and Klamath River flows to inform the proposed action. This 30-year period is also more consistent with other climatological data, such as the National Weather Service (NWS) climate normal, and acknowledges that decade-by-decade inflows have decreased (Figure 1). Extending the data set through 2022 captures the drought period that occurred during water years 2020 to 2022.

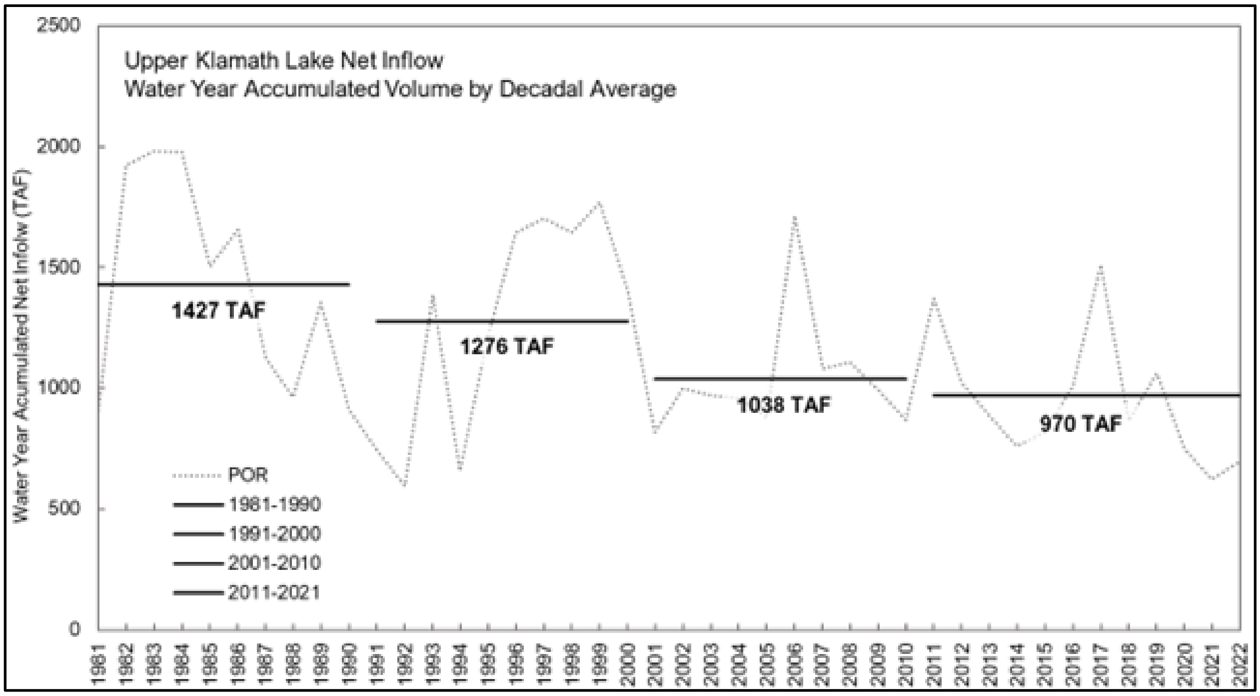

Figure 1. Decreasing trend in UKL total annual net inflow since water year 1981 as indicated by decadal average.

Reclamation has made substantial improvements to the KBPM structure and has incorporated data updates and refinements, including: revised accretions and UKL inflow datasets, a new UKL bathymetric layer, updated UKL net inflow estimates for the POR, and updated daily Klamath Project diversion data and return flows for the POR. Klamath Project operations using facilities that store and divert water from UKL, the Klamath River, and the Lost River were simulated in the KBPM over a wide range of hydrologic conditions for the period of October 1, 1980 through November 30, 2022 using daily input data to obtain daily, weekly, monthly, and annual results for river flows, UKL elevations, and Klamath Project diversions, including deliveries to the Lower Klamath and Tule Lake NWRs. 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 that incorporates KBPM logic from the final proposed action model run titled ‘Viewer_v11d for MST11b_DraftPA_Jan26’ to be used for real-time operations.

Reclamation emphasized that the full effects of climate change during the term of this proposed action are not completely understood, and the data suggests that the POR includes a climate change signal to some extent, as shown by the drying trend in Figure 1. That trend is expected to continue as similar trends have been observed in the Pacific Northwest over the past several decades (Mote 2003). NMFS notes that we included updated climate change information in Section 2.3.2.2.1 *Climate Change*.

Elevations used in this section are referenced to Reclamation’s datum for UKL, which is 2.01 feet (ft) lower than the North American Vertical Datum of 1988. Other Klamath Project facilities have their own unique datums as well.

A complete and detailed explanation of the proposed action and the updates to the KBPM used in development of the proposed action can be found below and in Appendix A of this Opinion.

1.3.1.1 Element One – Store Waters of the Upper Klamath Basin and Lost River

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

UKL Bathymetric data compiled by Reclamation in 2023 (including lake nearshore areas such as Upper Klamath NWR, and Tulana and Goose Bay farms), including the reconnected Agency-Barnes Lake units of Upper Klamath NWR, have a combined "active" storage volume of 645,627 AF between the elevations of 4,136.0 and 4,143.3 ft above sea level (Reclamation datum), which is the historical range of water surface elevations within which UKL has been operated. Clear Lake Reservoir has an active storage capacity of 467,850 AF (between 4,521.0 and 4,543.0 ft above sea level, Reclamation datum). Of this, 139,250 AF is reserved for flood control between 4,537.4 and 4,543.0 ft.

Gerber Reservoir has an active storage capacity of 94,270 AF (between 4,780.0 and 4,835.4 ft 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 most 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 deliveries occur between March and September, transitioning from live flow early in the season to storage in the latter months. 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 ft of usable storage when at full pool (approximately 645,627 AF). Gerber Reservoir also has limited storage capability. Clear Lake has somewhat more capacity but has never completely filled. 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 the volume and timing of inflows in that year and, to a much lesser extent, preceding years. Because of this limited capacity in reservoirs, snowpack plays a large role in water supply within the Klamath Basin.

1.3.1.2 Element Two – Operation and Delivery of Water from Upper Klamath Lake and the Klamath River

Reclamation proposes to operate the Klamath Project, or direct the operation of the Klamath Project, in a manner consistent with state and federal law, for the delivery of water for irrigation purposes, subject to water availability and the terms of the Klamath Project contracts, and consistent with flood control requirements while maintaining hydrologic conditions that avoid jeopardizing the continued existence of listed species and adverse modification of designated critical habitat. The Klamath Project has two service areas: the east side and the west side. The east side of the Klamath Project includes lands served primarily by water from the Lost River and Clear Lake and Gerber reservoirs. The west side of the Klamath Project includes lands that are served primarily by water from UKL and the Klamath River, although Reclamation has made occasional allocations of stored water from the east side of the Klamath Project for uses or offsets on the west side of the Klamath Project. The west side also may use other sources of water from the east side, such as winter runoff and return flows. Return flows are diverted 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. The Klamath Project is operated so that flows from the Lost and Klamath rivers are controlled, except during flood operation and control periods. The Klamath Project was designed based on use of a given volume of water several times. 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 (KSD). Return flows from water delivered from the reservoirs on the east side may also be reused several times.

The portion of the Klamath Project served by UKL and the Klamath River consists of approximately 230,000 acres of irrigable land, including areas around UKL, along the Klamath River (from Lake Ewauna to Keno Dam), 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 certain areas of the Klamath 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 (Reclamation 2019c). 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 Klamath Project. In addition to the A Canal, there are about 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 Link River Dam (LRD), for re-diversion from the Klamath River between Klamath Falls and the town of Keno. Water released from LRD flows into the Link River, a 1.5-mile river 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. Water elevations within the Keno Impoundment must be maintained within a relatively narrow range due to agreements with property owners whose lands were inundated by the construction of Keno Dam.

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 Lost River Diversion Channel (LRDC) where it can then be pumped or released for irrigation use either through the Miller Hill Pumping Plant or Station 48. The Miller Hill Pumping Plant (105 cfs capacity) is used to supplement water in the C-4 Lateral for serving lands within Klamath Irrigation District (KID) that otherwise receive water through the A Canal. KID operates and maintains the Miller Hill Pumping Plant.

Water re-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. Tulelake Irrigation District (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 and maintain Tule Lake Sump elevations, water is released from Station 48 to augment the available supply. In addition to Miller Hill and Station 48, there are other smaller, privately-owned pumps along the LRDC that serve individual tracts within KID.

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 operated by Klamath Drainage District (KDD). In addition to lands within the boundaries of KDD, the Ady Canal also delivers water to the California portion of Lower Klamath NWR. 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. These diversions require that the Keno Impoundment be operated within a narrow range of elevations. The area covered by Klamath 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 (ODFW). The remaining lands (1,285 acres) irrigated as part of the Klamath Project are privately owned. Reclamation estimates annual irrigation diversions associated with these lands under contract (excluding LRDC and North and Ady canals) to be approximately 8,000 to 15,000 AF, with the maximum duty allowed under Oregon law being 15,185.5 AF.

There are other irrigation diversions not associated with the Klamath Project (and thus NMFS understands them not to be part of the proposed action) in the Keno Impoundment, most notably KID, encompassing approximately 3,600 acres. Reclamation estimates these non-Klamath Project irrigation diversions to be approximately 9,000 to 12,000 AF annually.

Reclamation assumes demands for irrigation supply and historical wetland habitat deliveries over the proposed lifetime of this proposed action are similar to those that have occurred in the 42-year POR for water years 1981 through 2022. However, continued improvements in irrigation infrastructure and equipment combined with advances in irrigation practices and technology may help to reduce Klamath Project irrigation demand in the future. The irrigation “demand” is the amount of water required to fully satisfy the irrigation needs of the Klamath Project. While these historical demands are retained for analysis and comparison purposes, irrigation deliveries to the Klamath Project within this proposed action were modeled using the Agricultural Water Delivery Sub-model (see Reclamation 2019c). The proposed modeled deliveries during this 42-year POR generally fall within the range of historical Klamath 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 term of this proposed action.

Given their inclusion in the proposed action section of the BA, NMFS understands actions described in the present tense in the BA, and repeated below, to be Reclamation proposals for their continuation as part of the proposed action.

1.3.1.3 Element Three – Operation and Maintenance Activities

This section outlines the O&M activities that are performed on Reclamation's various features within the Klamath Project. Most of these activities have been ongoing throughout the history of the Klamath Project and Reclamation states that they have been implicitly included in previous consultations with the USFWS on Klamath Project operations (Section *1.3.3 Proposed Action vs Interim Operation Plan Mass Balance Analysis*). With the transfer of ownership of Keno Dam to Reclamation on July 30, 2024, Keno Dam O&M activities have been added to the proposed action. Additionally, given dam removal on the Klamath River, anadromous fish are expected to repopulate upstream of their previous extent at Iron Gate. O&M of Keno Dam, the fish ladder at Keno Dam, fish screens, headgates, and canals owned by Reclamation will now be conducted in a way that minimizes impacts to listed species.

O&M activities are carried out either by Reclamation or through contract by the appropriate irrigation district according to whether the specific facility is a reserved or transferred work, respectively.

1.3.1.4 Dams and Reservoirs

Generally, Klamath Project facilities, including but not limited to Link, Keno, Clear Lake, Gerber, and Lost River Diversion dams, will continue to be operated consistent with all applicable federal laws and regulations. Specific operating characteristics are detailed below.

Keno Dam will become the new reference point for assessing Klamath Project compliance with Klamath River flow requirements when the proposed action is implemented. NMFS understands this to mean that, as part of the proposed action, Reclamation is proposing flows that will be measured at Keno Dam. IGD was the site for such measurements in past Klamath consultations, but it was recently removed.

1.3.1.4.1 Exercising of Dam Gates

The gates at Gerber, Clear Lake, Link River, and Lost River Diversion dams are exercised bi-annually, before and after each irrigation season to be sure they properly operate. The approximate dates the gates are exercised are in March to April 15 and October 15 to November 30, and potentially in conjunction with any emergency or unscheduled repairs. The need for unscheduled repairs is identified through site visits. Once identified, the repair need is documented and scheduled.

Exercising gates requires anywhere from 10 to 30 minutes depending on the facility. The gates at Gerber, Link River, and Lost River Diversion dams are opened, and water is discharged during the exercising process. To maintain required downstream flows, as one gate is closed, another is opened by a corresponding amount. When exercising the gates at LRD, the Keno Impoundment elevation/storage would be drafted as needed to ensure NMFS' biological opinion required flows at Keno Dam are met; once the dam exercise operation was completed, the drafted volume would be replenished by increased releases at LRD. The following information describes facility-specific maintenance activities performed when exercising gates:

- LRD will be operated by Reclamation similar to PacifiCorp operations. The dam is operated continuously due to the daily flows required from UKL to the Klamath River. As such, the gates are considered exercised whenever full travel of the gates and a minimum flow of 250 cfs is achieved; Reclamation will document these occurrences. The stoplog gates at LRD are not exercised annually and are typically only removed under flood control operations and during infrequent stoplog replacement. A review of O&M inspection is expected to be performed every six years.
- Clear Lake Dam gate exercise activities include exercising both the emergency gate and the operation gate. Depending on water conditions, some water may be allowed to discharge to allow for sediment flushing. Flushing requires a release of flows that must be near 200 cfs for approximately 30 minutes. This activity occurs once a year generally between March and April and is contingent upon Clear Lake Reservoir surface water level elevations.
- The frost valves at Gerber Dam are exercised annually to prevent freezing of dam components. Valves are opened sometime in the fall, when the risk of freezing begins, at a flow rate of approximately two cfs and closed in the spring once persistent freezing temperatures have ceased.

1.3.1.4.2 Stilling Well Maintenance

Gage maintenance is required at various Klamath Project facilities to ensure accurate measurement of flows. 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 every five to 10 years, one structure is replaced. Stilling wells are cleaned once a year during the irrigation season, which typically occurs from April 1 through October 15.

1.3.1.4.3 Other Maintenance

To determine if repair and/or replacement of dam components is necessary, activities may include land-based observation and/or deployment of divers. Divers are deployed at Clear Lake Reservoir, Gerber Reservoir, Lost River Diversion Dam, LRD, and Keno Dam every six years prior to the Comprehensive Facilities Review for inspection of the underwater facilities. In addition, at Gerber Dam, the adjacent plunge pool is de-watered approximately every eight years for inspection of headgates, discharge works, and other components; fish salvage by Reclamation staff would be conducted for this effort. Through these inspections, if replacement is deemed necessary, Reclamation would evaluate the potential effects to federally-listed species and determine if separate ESA consultation would be required for the replacement activities.

Design Operation Criteria, which outlines O&M guidelines for facilities maintenance is required at LRD, Keno Dam, Clear Lake Dam, Gerber Dam, and the LRDC 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 respective 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 and are not on a set schedule. Trash racks are cleaned and debris removed daily, and maintenance is specific to each pump as individual pumps may or may not run year-round. Cleaning can take anywhere from one to eight hours.
- Fish screens (Section 1.3.1.6 *Primary Fish Screen Maintenance*).
- Concrete repair occurs frequently and as needed (not on a set time schedule). The amount of time necessary to complete repairs to concrete depends on the size and type of patch needed.
- Gate removal and repair/replacement are performed when needed (i.e., no set time schedule). Inspections of gates occur during the dive inspection prior to the Comprehensive Facilities Review every six years. Gates are continually visually monitored.

Boat ramps and associated access areas at all reservoirs must be maintained, as necessary, to allow all-weather boating access to carry out activities associated with O&M of the Klamath Project. If the boat ramp is gravel, it is expected to be maintained on a five-year cycle. If the structure is concrete, it is expected to be maintained on a 10-year cycle. Maintenance can include grading, geotextile fabric placement, and gravel augmentation/concrete placement depending on boat launch type. Reclamation does not perform maintenance of boat ramps on a time schedule, but rather as needed.

1.3.1.5 Canals, Laterals, and Drains

All canals, laterals, and drains are either dewatered after irrigation season (from approximately October 15 through April 15) or have the water lowered for inspection and maintenance every six years as required as part of the review of O&M or on a case-by-case basis. Inspection includes checking the abutments and examining concrete and foundations, mechanical facilities, pipes, and gates. The amount of time necessary for inspection is based on size and specific facility.

As with other typical facilities, the C Siphon, which replaced the C Flume in 2018, would be operated, maintained, and monitored in a similar manner. Along with the external inspection of the facility, maintenance staff would enter the siphon when de-watered to perform an inspection of the siphon’s internal features. Additionally, inspections of the concrete piers that support the siphon above the LRDC would be conducted. As necessary, hardware would be replaced throughout the life of the facility. Historically, dewatering of canals, laterals, and drains has included biological monitoring and (as needed) listed species salvage. This practice would continue under the current proposed action (Section 1.3 *Proposed Federal Action*).

The facilities are also cleaned to remove sediment and vegetation on a timeline ranging from annually to every 20 years. Inspections of all facilities take place annually. Inspections occur year-round or as concerns are raised by Klamath Project patrons; cleaning and maintenance takes place year-round on an as-needed basis. Cleaning the facilities may include removing sand bars in canals, silt from drains, or material filling the facilities. Animal burrows that may be impeding the facilities are dug up and compacted to repair them. Trees that are deemed to interrupt operations of facilities (and meet criteria outlined in the O&M guidelines) and/or pose a safety threat to the structural integrity of the facilities are removed and the ground returned to as close to previous conditions as practicable.

All gates, valves, and equipment associated with the facilities are to be exercised bi-annually before and after the irrigation season. Any pipes and structures located on dams or in reservoirs that are associated with irrigation facilities are replaced when needed and have an average lifespan of 30 years. Reclamation O&M staff replace approximately 10 sections of pipe per year and attempt to perform this maintenance activity when the canals are dry. The following information describes facility-specific maintenance activities performed when exercising gates:

- A Canal headgates include six gates that need to be checked. The A Canal headgates are only operated and exercised when the fish screens are in place. If the breakaway screens were to fail, the A Canal would still be operating until the screen is put back into place. This allows for uninterrupted operation at A Canal if a screen needs to be replaced to its previous position. Screens typically break once or twice a year (during normal operation). KID is notified through an alarm, and the screens are repaired at the earliest time practicable.

- The A Canal headgates are typically exercised in the spring (February through March timeframe) and fall (October through November timeframe). This activity occurs when the bulkheads are in place and the A Canal is drained and empty.

- The LRDC diagonal gates and banks should be inspected every six years. Review of O&M inspections alternate every six years and take place anywhere from October 15 through March 31. This inspection would require drawdown of the LRDC (i.e., drawdown at least once every six years; however, as maintenance requires, LRDC drawdowns may be more frequent). The drawdown of the LRDC would leave enough water to ensure that fish were not stranded during this activity. The appropriate drawdown level is coordinated by Reclamation O&M and fisheries staff. Biological monitoring would be incorporated, and, if necessary, flows would be increased for fish protection.

- The gates in the concrete structure in the railroad embankment immediately upstream of the Ady Canal are exercised annually. This activity includes closing and opening the gates and typically occurs in the July to September timeframe. All debris is also removed once a year, generally during the June through September timeframe.

1.3.1.6 Primary Fish Screen Maintenance

The A Canal fish screens have automatic screen cleaners. Cleaning is triggered by timing or head difference. When cleaned on a timer, the timing intervals are set at 12 hours, but intervals can be changed at operator's (KID) discretion for a period defined by hours or on a continuous basis.

Fish screens at Clear Lake Dam are manually cleaned periodically when 6 to 12 inches of head differential between forebay one and forebay two is encountered. The need for cleaning the fish screen is dictated by water quality and lake elevation and varies from year to year. For instance, in some years, such as 2009, the screen was cleaned every other day beginning approximately the end of June/early July until it was shut off. In contrast, in 2011, no cleaning took place during irrigation season because the head differential never exceeded 0.3 ft. There is an extra set of fish screens that the Reclamation O&M staff uses during the cleaning process. The extra fish screen is lowered in place behind the first set of screens so that no fish can pass. The primary screens are then lifted and cleaned and then placed behind the second pair of screens in the lineup. This process is continued until all screens are cleaned. This process can take up to 10 hours. Upon completion, the remaining set is stored away until the next cleaning which is anytime a head difference of 0.5 foot occurs. During flood releases (when Clear Lake Reservoir elevations are 4,543.0 ft or above), fish screens would not be in place.

1.3.1.7 Fish Ladder Maintenance

LRD fish ladder gate exercise activities include exercising both the head gate and the attraction flow gate, which includes closing and opening the gates and physical inspection of the ladder. This activity occurs twice annually and generally occurs in the February/March timeframe and again in the November/December timeframe. The amount of time necessary for the gates to be exercised is no longer than 15 minutes. This activity includes biological monitoring by Reclamation staff biologists.

1.3.1.8 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. This activity typically occurs annually. Pesticide spraying occurs generally from February through October (in compliance with the Pesticide Use Plan) and is applied according to the label. Vegetation control occurs on facilities where necessary throughout the year. Techniques used to control noxious weeds may include cultural, physical, and chemical methodologies for aquatic and terrestrial vegetation. Reclamation stated that the effects of these activities have been evaluated in previous ESA Section 7 consultations, and incidental take coverage was provided in the USFWS's biological opinions 1-7-95-F-26 and 1-10-07-F-0056 dated February 9, 1995 and May 31, 2007, respectively. In both biological opinions, the USFWS determined that the maintenance action of pesticide application would not jeopardize the continued existence of Lost River Sucker (LRS) and Shortnose Sucker (SNS). The products used for this maintenance activity are still being used to minimize take and are in compliance with current Integrated Pest Management Plans required by the Reclamation Manual's Directive and Standard ENV 01-01.

1.3.1.9 Pumping Facilities

All pumping plants are monitored yearly by visual evaluation. Dive inspections occur every six years according to the review of O&M inspection criteria. This activity would include dewatering of the adjacent facility and installation of coffer dams. Dive inspections and dewatering of the facilities typically occurs in the August to December timeframe. Biological monitoring occurs daily during the dewatering of the facility and has historically been, and will continue to be, incorporated into maintenance activities to ensure the protection of fish, as necessary. Aquatic weeds that collect on trash racks and around pump facilities are monitored continuously throughout the irrigation season and removed as needed. Weed removal typically occurs daily for those pumps that are operating continually through the season.

All pumps are greased, oil checked, cleaned, and exercised monthly if they are not in regular use. Pumps used for irrigation are maintained daily during the irrigation season. Drainage pumps would be maintained and operated daily, year-round. Pumps are greased and oiled according to the pump manufacturer's specifications. Excess grease and oil are removed and cleaned. When oil is being changed, oil spill kits are kept on site and used, as necessary.

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, during the de-watering process.

1.3.2 Modeling of the Proposed Action

As in the previous Section 7 ESA consultations on Reclamation Klamath Project operations, the KBPM was used to simulate operations under the proposed action. Various versions of the KBPM have been used for approximately 15 years, each based in the Water Resources Integrated Modeling System (WRIMS). This highly flexible modeling system enables implementation of operational alternatives in simulations. In the current re-consultation effort, removal of dams in the Lower Klamath Project required the downstream-most compliance point be moved from the United States Geological Survey (USGS) gage below the former IGD (USGS Station ID#11516530) to the USGS gage below Keno Dam (USGS Station ID#11509500). As a result, the version of the KBPM developed in support of this re-consultation has been named the Keno Release Model (KRM) [2] and is based on the model viewer entitled "Viewer_v11d for MST11b_DraftPA_Jan26," including two studies: MST11b_DraftPA_Jan26 and MST11b_DraftPA_PFoff_Jan26. The two studies are identical in rules, parameter settings, and results; however, one model study releases the Flexible Flow Account (FFA) in the form of a pulse flow, and the other releases the FFA evenly over a longer period of time in the spring/summer.

The operational strategy embodied in the proposed action is described below. The description conforms to the operational rules used to simulate the proposed action in the KRM except in specific instances which will be highlighted and discussed. A detailed description of the KRM model simulation of the proposed action is provided in Appendix A. NMFS understands this to mean that operating rules were developed for the model, reflecting the operational strategy that guided development of the proposed action. Those operating rules were then applied in the KBPM (KRM model) to generate outputs that simulate the proposed action.

The KRM simulation outputs were based on inputs that included the following critical assumptions:

- The upper Klamath River basin will experience water year types within the range observed in the POR.
- UKL inflows will be within the range observed in the POR.
- NWI inflow forecasts will be within the range and accuracy of historical inflow forecasts.

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[2] Throughout this Opinion, this version of the KBPM is referred to as the "KRM" or "KBPM (KRM version)".

- Accretions below LRD and Keno Dam will be consistent with accretion timing, magnitude, and volume assumed in the KRM.
- Water deliveries to the Klamath Project will be consistent with distribution patterns analyzed for the KRM.
- Revised UKL bathymetry in the model is reasonably representative of actual UKL bathymetry and therefore accurately represents UKL storage capacity.
- The Agency-Barnes Lake units of Upper Klamath NWR will be reconnected to UKL at the outset of operations under this Proposed Action and was therefore modeled as being connected.
- Due to the removal of the hydroelectric dams (J.C. Boyle, Copco No. 1, Copco No. 2, and IGD), the compliance point for discharges to the Klamath River is Keno Dam.
- Facility operational constraints and limitations, and/or associated maintenance activities, will be within the historical range for the POR.
- Water deliveries to Klamath Project lands will be consistent with the contractual, ESA, and other obligations Reclamation set forth in the development of the proposed action.
- Reclamation will implement the proposed action as described to the greatest extent practicable. However, implementation of the proposed action may not exactly replicate the modeled results and actual Klamath River flows and UKL elevations may differ slightly during real-time operations.

The KRM shows the results of applying the operating rules to a broad range of hydrologic conditions, using the conditions that occurred over the 42-year POR (1981 to 2022). A detailed description of the KRM model can be found in Appendix A.

1.3.2.1 Key Model Structural Variables

The KRM implements a consistent year-round operational strategy for making water management decisions focused on continuous tracking of the hydrologic conditions in the Upper Klamath Basin (NWI) and water storage conditions in UKL (UKL Status). These are then averaged into a single number, the Operations Index.

1.3.2.1.1 Normalized Wetness Index

Daily Version of the Normalized Wetness Index

The Daily NWI is an index expressing the hydrologic status (from dry to wet) of the Upper Klamath Basin that is used in two ways in the KRM. The continuous smoothed daily NWI is one component of the Operations Index, the main structural variable governing the movement of water in the KRM. Because the NWI was designed to track with UKL net inflow, with some modification from its daily form, it provides the means to forecast seasonal UKL net inflow volumes that are used in the KRM to allocate water to Klamath Project irrigation. This seasonal forecasting application of the NWI is described in Appendix A.

The Daily NWI incorporates information about recent UKL net inflow volume (30-day trailing sum), longer term (31 to 1,095-day trailing sum) precipitation, current snowpack (snow water equivalent), and various combinations of climate indices for the Pacific Ocean (Pacific Decadal Oscillation index and Niño 3.4 index). Each of these variables is multiplied by a date-specific weight, then summed to compute the daily Wetness Index, which is then normalized. Date-specific weights are developed in a manner that yields NWI values that track with the 91-day forward sum of UKL net inflow. The end result is an index that tracks well with UKL net inflow volumes summarized over time periods different than that to which the daily NWI was optimized (Figure 2).

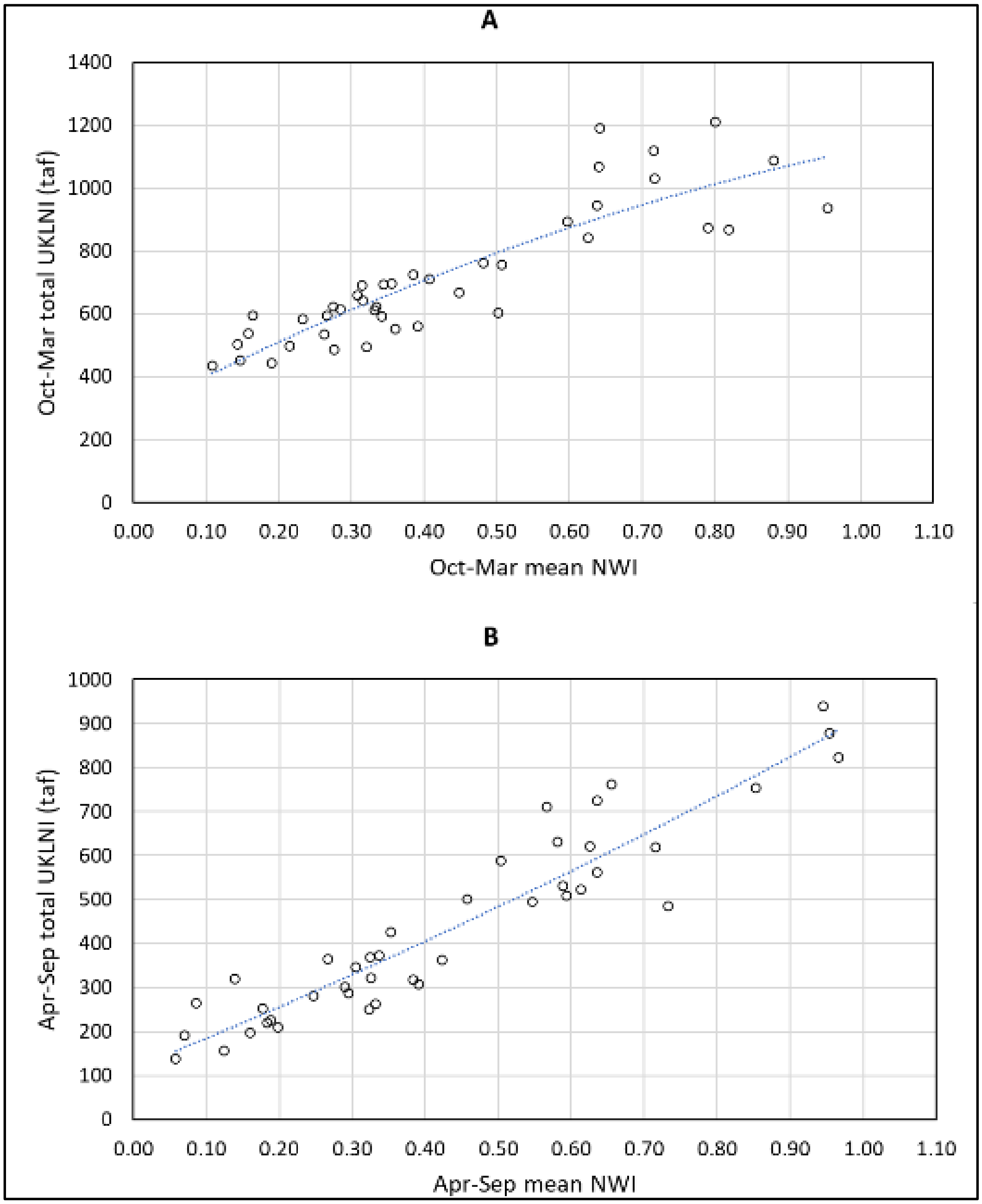

Figure 2. Daily NWI averaged over fall-winter (A) and spring-summer (B) periods relative to the actual UKL net inflow volumes for the same periods.

Seasonal Version of the Normalized Wetness Index

The NWI used for seasonal forecasting differs from the Daily NWI in how the date-specific weights are developed. Seasonal forecasts of UKL net inflow used in the KRM include April to September totals forecasted on March 1 and April 1, and forecast date through September totals forecasted on April 15, May 1 and 15, and June 1. For each forecast date, the date-specific weights used in the NWI calculation are derived in a manner that yields forecasts tracking with the seasonal UKL net inflow volumes being forecasted. After the date-specific weights are determined and the NWI calculated, quantile regression is used to compute the 50% and 95% exceedance forecasts of seasonal UKL net inflow that are subsequently used in computing allocations for Klamath Project irrigation.

A description of NWI computation for daily NWI values used in the Operations Index, as well as the NWI values used for seasonal forecasting, is provided in Appendix A.

In past biological opinions, spring/summer water allocations to the Klamath River and agriculture relied heavily on seasonal water supply forecasts from the Natural Resources Conservation Service (NRCS). These water supply forecasts were developed using principal components regression analysis based on antecedent streamflow conditions, precipitation, snowpack, temperature, and water levels in a monitoring well (Risley et al. 2005). Forecast error played a large role in how well the overall water management system functioned, since the allocations were made and fixed in the spring. NRCS intends to issue seasonal UKL net inflow forecasts using a machine-learning model beginning in 2024/2025.

The recent revision of the UKL bathymetry (Reclamation 2023) forced recalculation of the UKL net inflow time series. NRCS is working to reconstruct the forecasts that would have been made over the POR from water years 1981 to 2023 if their machine-learning model had been used. The California Nevada River Forecast Center (CNRFC) forecasting model should also be recalibrated to the revised net inflow time series before their forecasts are used in proposed action operations.

A team of hydrologists, consisting of federal agency personnel and stakeholders, was formed in 2022 to consider potential modifications to the IOP model structure in use since 2020. As a result, an NWI was developed in 2023 by Reclamation for use in the fall/winter (FW) period. Since then, the NWI has been developed into a year-round daily index that forms half of the Operational Index, from which many decisions are based on in the proposed action (e.g. Keno Release Targets). Because of the obvious potential to use the NWI in forecasting, a version of the NWI was developed specifically for use in seasonally forecasting UKL net inflow volumes. The seasonal version of the NWI relies upon the same variables as the daily version except for the treatment of climate indices.

In the proposed action, seasonal forecasts of net inflow into UKL are used only to determine allocations to Klamath Project irrigation. Because of the recent change in the UKL net inflow time series, the NWI is the only forecast model that has been calibrated using the new net inflow time series. Therefore, the KRM presently uses only the NWI to forecast UKL net inflows and calculate the seasonal progression of water volumes available for irrigation use. However, the KRM is structured to use the NRCS, CNRFC, and NWI models for forecasting either individually or in combination. Combined forecasts consist of an average weighted by the reflection of the mean absolute error (MAE) associated with each forecast model. The reflection is a simple transformation that flips the model-specific MAE relative to the mean of all the models so that the reflected MAE for the best performing model (i.e., the smallest MAE) will be the largest weight when combining the forecasts. Combined forecasts among some or all of the three main forecasting models frequently outperformed the individual models when this KRM component was built prior to the change in the UKL net inflow time series, and this will likely be true using the recalibrated models as well.

Table 4 and Table 5 compare the absolute values of the errors (actual – forecast) from the three forecast models. This is not yet a perfectly analogous comparison, because the NRCS and CNRFC forecasts are made for, and errors are computed from, the UKL net inflow time series used before the recent revision, whereas the NWI-based forecasts and errors use the revised UKL net inflow time series. Nonetheless, these comparisons illustrate the kind of evaluation that should be performed before finalizing the selection of forecast model products for use in the proposed action. Note that in this imperfect comparison, the NWI outperforms the other two models for the May 1 and June 1 forecasts and is intermediate for the April 1 forecast (Table 4 and Table 5), but on each date a combination of forecasts performs the best.

Table 4. Mean absolute errors of seasonal UKL net inflow forecasts among the three forecast models and the best performing combination of the three models.

Source	Mar 1 Apr-Sep	Apr 1 Apr-Sep	Apr 15 Apr 15-Sep	May 1 May-Sep	May 15 May 15-Sep	Jun 1 Jun-Sep
NRCS		47		38		20
CNRFC		54		41		27
NWI	72	50	40	32	31	16
Best combined		39		30		15

Table 5. Mean absolute percentage errors of seasonal UKL net inflow forecasts among the three forecast models and the best performing combination of the three models.

Source	Mar 1 Apr-Sep	Apr 1 Apr-Sep	Apr 15 Apr 15-Sep	May 1 May-Sep	May 15 May 15-Sep	Jun 1 Jun-Sep
NRCS		12.0%		15.7%		15.6%
CNRFC		14.1%		16.3%		19.9%
NWI	21.7%	13.3%	12.4%	14.4%	17.9%	15.7%
Best combined		10.6%		12.2%		12.3%

When the NRCS and CNRFC have finished reconstructing their forecasts, Reclamation and the Services will evaluate the forecast characteristics and the effects on the proposed action outcomes of using the best performing model or combination of models in the KRM. Reclamation and the Services will seek agreement on the specific forecast model or combination of models to be used for updating forecasts every two weeks from April 1 to June 1. Until then the proposed action will use the NWI-based forecasts.

Reclamation and the Services will evaluate the performance of the forecast combinations each year and decide whether changes from the previous year should be made.

1.3.2.1.2 Upper Klamath Lake Status

In addition to tracking the hydrologic condition of the Upper Klamath Basin using the NWI, the storage condition of UKL is another important consideration for water management. Before describing it, however, it is important to understand the use of shadow UKL levels in the KRM. As described in Section 1.3.2.1.4 *Releases from Keno Dam to the Klamath River*, the KRM implements a deferred use operation (FFA) for river flow through Keno Dam in which a specified proportion of calculated releases during October 1 through March 1 is stored in UKL for use during March 2 to June 30. A similar deferred use operation is employed for Klamath Project irrigation (Deferred Project Supply [see Section 1.3.2.2.4 *Deferred Project Supply* definition]) in which inflows or return flows from the Lost River and F/FF pumps (located on the KSD, which drains KDD and Lower Klamath NWR) that are discharged from the Klamath Project to the river to contribute to targeted releases from Keno Dam (when neither LRD nor Keno Dam is spilling) that can offset releases from UKL, accruing a volume there that can be used by irrigators, with specific approval by Reclamation, during the irrigation season. Deferred Project Supply can also be accrued when UKL water that is set aside for maintaining Sump 1A in Tule Lake NWR and Unit 2 in Lower Klamath NWR is replaced by inflows or return flows from the Lost River and F/FF pumps when neither dam is spilling.

Each of these deferred use operations is intended to provide flexibility to those using the water and is designed to have no or minimal impact on how water is used by other system components at any point in time. To achieve that end, a water accounting structure keeps daily track of what UKL levels would be if the deferred use operations were not occurring—this is called the UKL shadow level. By using the UKL shadow level to determine the UKL Status, and hence the Operations Index, the deferred use operations can proceed in a flexible manner without affecting the Operations Index which is a key component in the computation of river releases, Klamath Project irrigation allocation, etc. For example, if the FFA results in an extra 20,000 AF remaining in UKL, this would normally cause higher releases from UKL due to the greater volume. That would negate the benefit of retaining the extra water for later use. Thus, the shadow level tracking.

In the KRM, lower and upper bounds are set on UKL shadow levels, and daily UKL Status is calculated as the relative position of UKL shadow level (L) on day *d* between the specified lower (low) and upper (up) bounds for water years 1991 to 2022 using Equation 1:

$$UKL\ Status_d = \left(\frac{L_d - L_{low}}{L_{up} - L_{low}}\right) \tag{1}$$

When L_d is at or above the upper bound, UKL Status will be 1, and when L_d is at or below the lower bound, UKL Status will be 0. The lower bound is established as the 95% exceedance UKL shadow level on the first day of each month (interpolated for other days) as computed from the output of a particular simulation. Similarly, on the first day of each month (interpolated for other days), the upper bound is the flood release curve (Figure 3) minus 0.2 ft during December to March but is otherwise the highest simulated UKL shadow level. The upper and lower bounds are determined iteratively by repeatedly running the KRM and recalculating the lower and upper bounds for each iteration using the results from the prior simulation. After several iterations, the upper and lower bounds stop changing significantly.

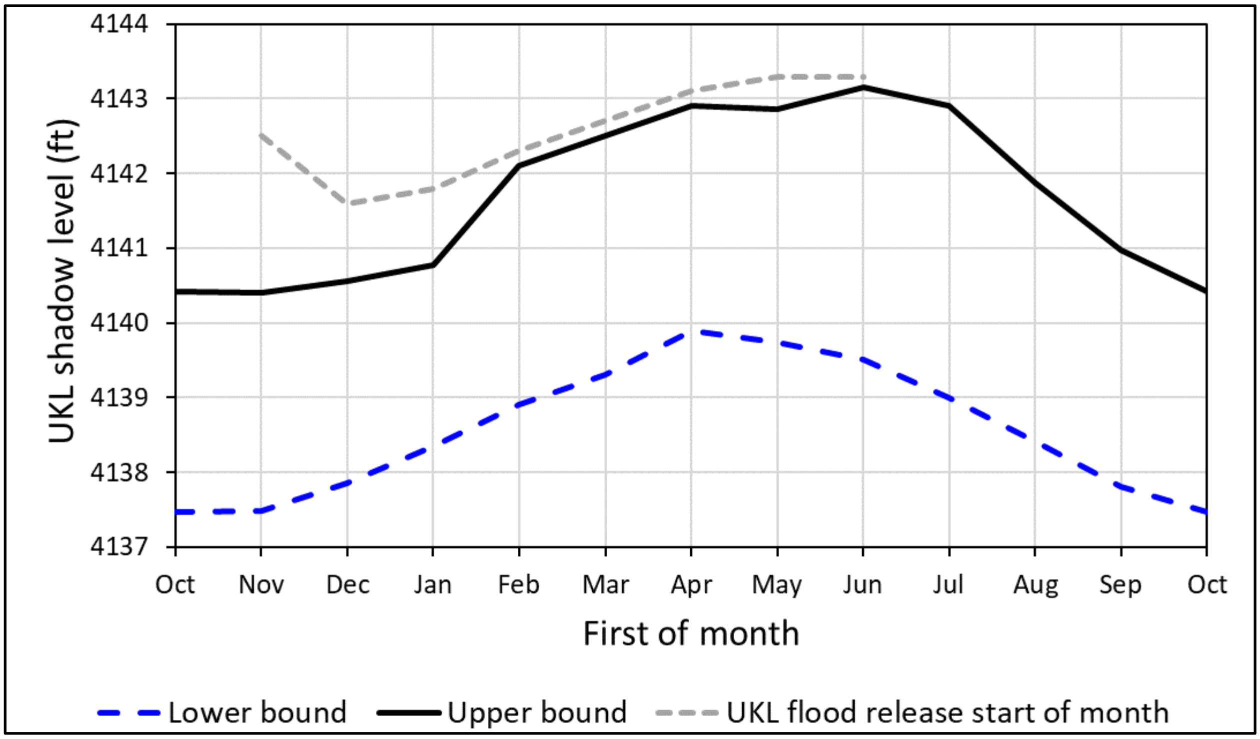

Figure 3. Lower and upper bounds used for computing UKL Status, and the winter/spring flood release curve for UKL.

UKL bounds do not prevent UKL levels from moving above or below them; they are not lake level requirements. Rather, they specify the UKL shadow level at which and below the UKL Status will be 0, or at which and above the UKL Status will be 1. The upper and lower bounds used in the KRM for the proposed action are in Figure 3. Additional information on flood control curves is found in Appendix A.

1.3.2.1.3 Operations Index

The Operations Index is the main structural variable governing the movement of water in the KRM. The KRM calculates the Operations Index on a daily basis as the average of the other two indices tracking hydrologic conditions (NWI) and storage in UKL (UKL Status). The hydrologic status of the Upper Klamath Basin is estimated using a daily NWI that is smoothed using a 14-day trailing average for use in the KRM. UKL storage conditions (elevations) are tracked by the daily UKL Status Index. Operations Index values range from 0 (driest, lowest storage) to 1 (wettest, highest storage) because the average of the NWI and UKL Status is rescaled (normalized).

In the KRM, normalized variables are rescaled to the minimum and maximum values for water years 1991 to 2022 using Equation 2:

$$Normalized_i = \left(\frac{X_i - X_{min}}{X_{max} - X_{min}}\right) \tag{2}$$

Where i is day of the water year and min/max are the minima/maxima for day i over water years 1991 to 2022. This simple rescaling of variables retains the relative patterns within each variable while ensuring that the normalized variable is 0 when the raw variable is at the minimum, and 1 when the raw variable is at the maximum.

In water years 1981 to 1990, which are also simulated, normalized variables are constrained to be no lower than 0 and no higher than 1, because the raw variable may in these years be lower or higher than the daily minimum or maximum from 1991 to 2022. The same approach is used for the NWI and UKL Status variables.

The Operations Index tracks consistently with UKL net inflow over seasonal periods. For example, October-March and April-September average Operations Index values show clear relationships to similarly averaged UKL net inflow volumes (Figure 4).

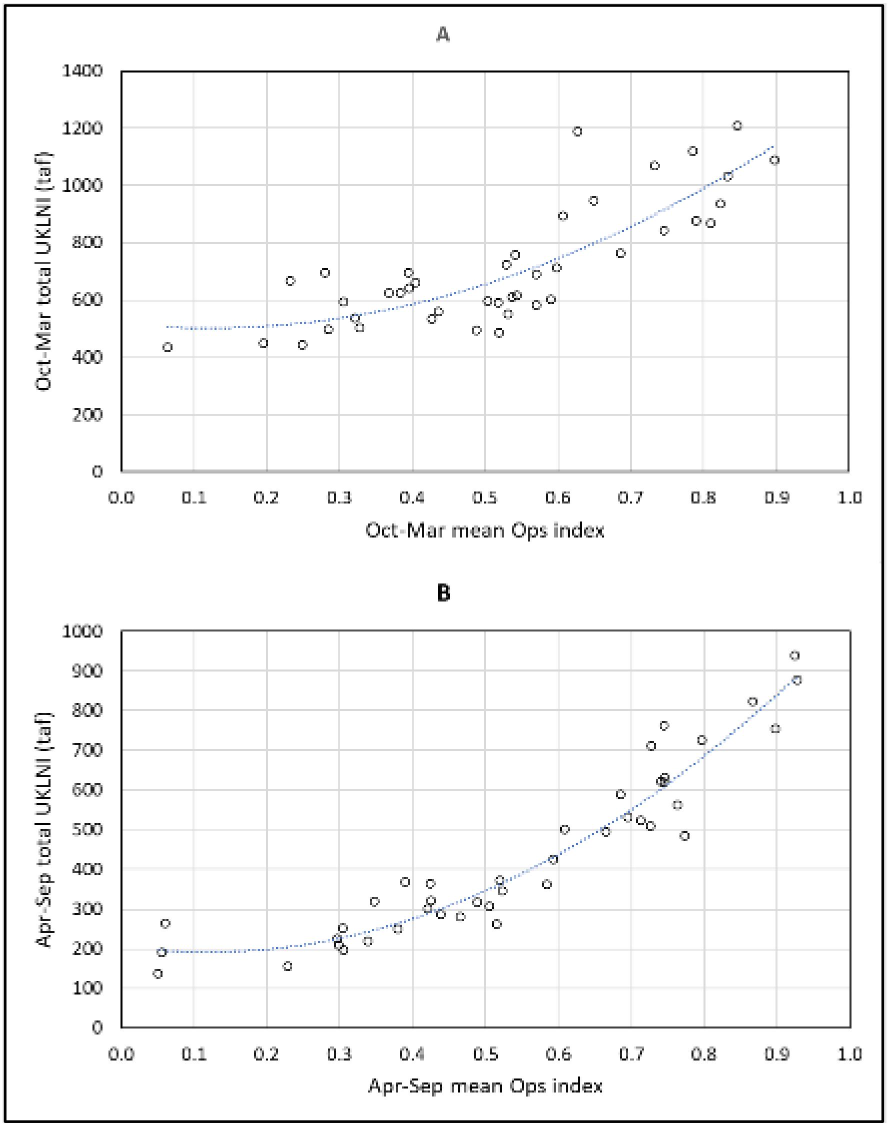

Figure 4. Seasonal relationship between the mean Operations Index and UKL net inflow volume for October-March (A), and April-September (B) in the proposed action.

1.3.2.1.4 Releases from Keno Dam to the Klamath River

A daily River Base Flow (RBF)3 regime for Keno Dam releases was established by specifying base flows for the center 15 days of each month and linearly interpolating flows for the remaining days (Figure 5). The RBF is the lowest flow that will ever be targeted for release from Keno Dam on any given day of the year, which would occur only when the Operations Index or the Keno Release Multiplier (KRmult) is 0. On each day (*d*) a Keno Release Multiplier is selected based on the Operations Index and the current month (Figure 5), and the Keno Release Target is computed:

$$Keno\ Release\ Target_d = RBF_d + (RBF_d \times KRmult_d) - FFAinc_d + FFAuse_d$$

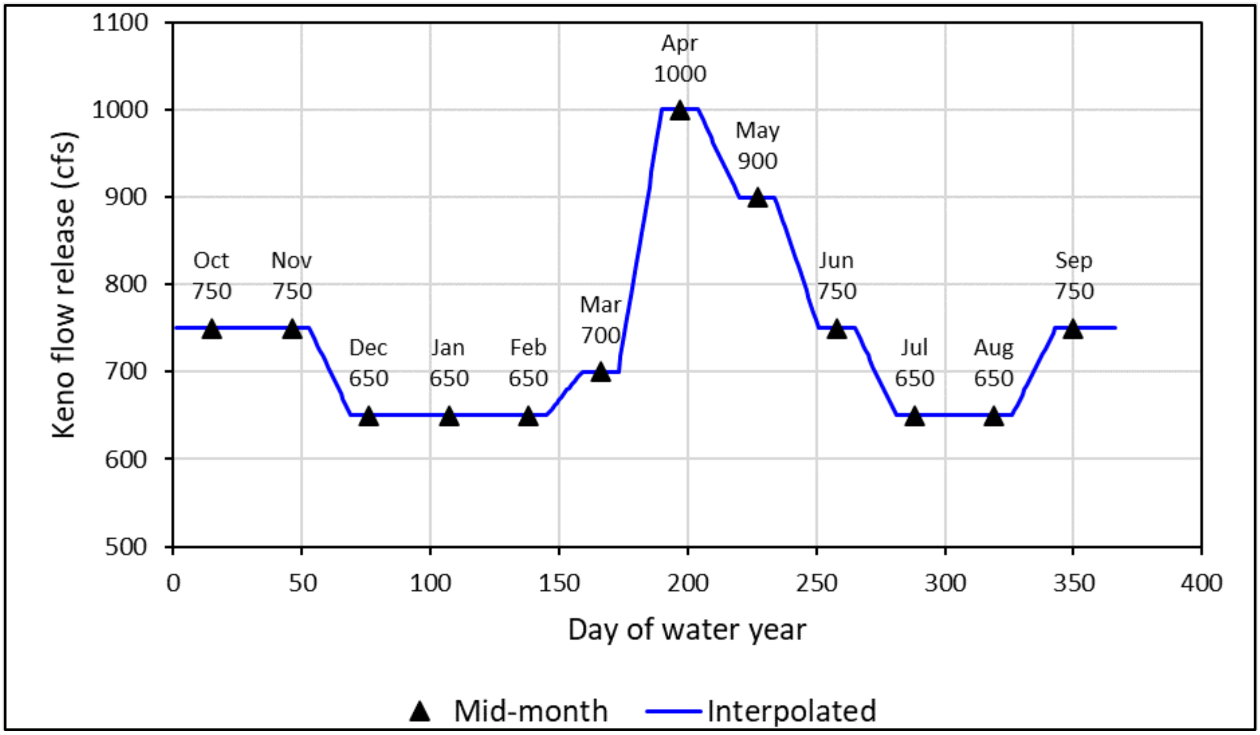

Figure 5. RBFs specified for 15 days centered on the fifteenth day of each month, with daily flows linearly interpolated between these periods.

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[3] Reclamation proposes the daily River Base Flow (RBF) regime for Keno Dam releases as "the lowest flow that will ever be targeted for release from Keno Dam on any given day of the year." Accordingly, NMFS understands that the proposed daily RBFs at Keno Dam are the daily average minimum flow releases at Keno, and throughout this Opinion also refers to them as Keno Dam minimum flows.

Table 6. Keno Release Multiplier lookup table used by the KRM.

Operations Index	Oct	Nov	Dec-Feb	Mar	Apr	May	Jun	Jul-Sep
0	0	0	0	0	0	0	0	0
0.2	0.06	0.06	0.07	0.17	0.14	0.11	0.14	0
0.4	0.09	0.09	0.16	0.35	0.27	0.4	0.17	0.01
0.6	0.14	0.16	0.6	0.93	0.62	0.74	0.33	0.05
0.8	0.34	0.6	2.05	2.49	2.19	1.73	0.72	0.23
1	1.08	2.43	4.78	6.28	5.3	4.18	2.5	0.68
Notes: Each day the Operations Index is computed and used to look up the associated multiplier values (interpolated as necessary).								

An FFA operation is used in the KRM that defers use of some water targeted for release to the River during FW ($FFAinc_d$), storing the accumulating volume in UKL during the October 1 to March 1 accrual period. Then during March 2 to June 30, the stored FFA water ($FFAuse_d$) is used in a manner that can vary each year. Key elements of this operation include the FFA reserve proportion (used to compute $FFAinc_d$) determined by the value of the Operations Index (Table 7) and the expectation that the full FFA volume will be released from Keno Dam to the Klamath River each year during the release period of March 2 to June 30. When the Operations Index exceeds 0.7, the FFA reserve proportion declines to 0, because with wetter conditions comes less need to augment flows or to shape a discrete event like a pulse flow. However, if the Operations Index drops back down below 0.7, the FFA will resume accrual once again as long as it is still within the accrual period. Also, in years when the Operations Index exceeds 0.7 and FFA ceases to accrue, the accrued volume does not disappear (unless it is spilled) and is designated for release between March 2 to June 30.

Table 7. FFA reserve proportion lookup table for the KRM.

Operations Index	FFA Reserve Proportion
0	0.9
0.6	0.7
0.7	0
1	0
Notes: Reserve proportions are interpolated to correspond with the computed Operations Index.	

Use of the FFA volume ($FFAuse_d$) may take different forms year to year. Pulse flows may be implemented from the FFA volume or the volume may be used to augment flows. Reclamation provided two simulations of the proposed action (MST11b_DraftPA_Jan26 and MST11b_DraftPA_PFoff_Jan26) to illustrate the flexibility intended for the use of the FFA. In one (MST11b_DraftPA_Jan26), a pulse flow operation is implemented annually based upon a set of criteria intended to provide a realistic (but not prescriptive) representation of how pulse flows could be implemented. In the other simulation (MST11b_DraftPA_PFoff_Jan26), no pulse flows are implemented and the FFA volume is added to the Keno Release Targets according to one of many possible distribution shapes.

The conditions governing pulse flow operations in the KRM are not intended to constrain real-time operations. Operationally, Reclamation stated that sizing the peak release based on ramping rates (which typically govern the descending limb of the pulse flow) and release targets immediately before the pulse flow must be done in a manner that prevents using more volume for the pulse flow event than is available in the FFA. Reclamation proposed that if the entire FFA volume is not consumed during implementation of a pulse flow, the remainder of the FFA volume will be used in a manner agreed upon by Reclamation, NMFS, and USFWS. NMFS understands this proposal not to limit NMFS's ability to request, through the Real-time Operations (RTO) team process, FFA volume releases in distributions that differ from the modeled default pulse flows.

Flood control releases from LRD or Keno Dam will stop the accrual of FFA volume. Flood control releases from LRD will spill the stored FFA volume after the Deferred Project Supply volume (another deferred use operation; Section 1.3.2.2 *Project Allocations for Irrigation*) has been spilled.

1.3.2.1.5 Keno Dam Operations

Given that Keno Dam is the new compliance point for Klamath River flows under this proposed action, Reclamation will make flow release adjustments as needed at LRD and/or Keno Dam to ensure that daily average Keno Release Targets are met or exceeded. This includes periods when the monthly minimum Keno Dam River Base Flow (Figure 5) is being released, when daily Keno Dam releases above the Keno Dam River Base Flow (Keno Base x Keno Release Multiplier) are prescribed/required, or when the FFA is being released for pulse flows or augmentation. The latter actions may require multiple adjustments within a day, whereas the former may not require any adjustments for days. Reclamation's proposed action assumes the proposed daily average Keno Dam releases are targets that Reclamation will follow to the greatest extent practicable and will only make flow adjustments when daily Keno Release Targets vary by 25 cfs or greater due to operational constraints and streamflow gage precision (i.e., the smallest possible incremental flow adjustment at LRD and Keno Dam is 25 to 30 cfs).

Reclamation acknowledges that there are many points of diversion as well as return flows in the Keno Impoundment reach (LRD to Keno Dam) that could have considerable negative or positive impacts on Link River releases intended to meet Keno Release Targets. Accordingly, Reclamation is committed to close coordination with the water users in the Keno Impoundment reach to ensure that those Klamath Project operations/diversions do not prevent Reclamation from meeting its ESA obligations in terms of Keno releases to the Klamath River. Additionally, Reclamation has committed to operating the Keno Impoundment within a 1-foot elevation range, within the historical 1.5-foot operating range used by PacifiCorp (Reclamation 1967) (PacifiCorp 2022).

Facility control limitations, changing accretions/diversions between LRD and Keno Dam, wind effects on UKL and Lake Ewauna, and stream gage measurement error may limit Reclamation's ability to manage precise releases from Keno Dam. In addition, facility control emergencies and maintenance may arise that warrant a temporary reduction in the proposed Keno Release Targets. Therefore, Reclamation recognizes that minor variations in Keno Release Targets (within 5% of daily average targets) may occur for short durations and that all daily Keno Dam releases proposed above are targets. Reclamation anticipates that there may be unique conditions that may result in deviations from proposed Keno Release Targets greater than 5% due to facility control limitations, stream gage error, maintenance of facilities (including replacement of fish tracking antenna arrays in the river), and/or emergency situations. However, these deviations are expected to occur infrequently, and in coordination with NMFS, and will be corrected as quickly as practicable. NMFS understands that these deviations have been extremely rare in the past and will continue to be rare under the proposed action.

For the reasons described above, Reclamation proposes to allow a maximum reduction of 5% below the daily required Keno Dam Release Targets, not to exceed 48 hours in duration, unless otherwise coordinated with NMFS. Additionally, Reclamation proposes to perform Keno Dam release volumetric evaluations at least biweekly to ensure that the required flow volume released at Keno Dam (based on the formulaic distribution of Keno Dam releases as informed by the KRM's Operations Index) is reconciled so that the total flow volume released at Keno Dam is equal to the required flow volume that should have been released for a given period under the proposed action. Reclamation proposes that, under circumstances where the Keno Dam release flow volume for a given day or week is greater than would be required under the anticipated biological opinion from NMFS (i.e., this Opinion), Reclamation may reduce daily Keno Release Targets by up to 5% to recover the volume of water that was over-released from Keno, above what was required. Regardless, flows will not be reduced below Keno Dam River Base Flow minimums as described in Figure 5. Under circumstances where the Keno Dam release flow volume for a given day or week is less than what was required to be released, there is no limit on the magnitude of the subsequent, corresponding flow increases to reconcile the difference between required and released flow volumes for a given period.

1.3.2.1.6 Ramp Rates

Ramp rates limit rapid fluctuations in streamflow downstream of dams. Reclamation proposes to implement the down-ramping rates used in the KRM that includes a ramping rate structure that varies by release rate at Keno Dam. The proposed KRM ramp rates at Keno Dam were designed to approximate ramp rates at the Iron Gate gage similar to those evaluated under previous biological opinions, including 2019 (Table 8). On July 30, 2024, Reclamation took ownership and operation of Keno Dam, and the ramp rates will be implemented by Reclamation as part of Keno Dam operations.

Table 8. Ramp rates for releases from Keno Dam under the proposed action compared to those for releases from the former IGD evaluated under previous biological opinions.

Keno Dam Release Threshold (cfs)	**Keno Dam Ramp Rate (cfs/day)**	**IGD Release Threshold from IOP (cfs)**	**IGD Ramp Rate (cfs/day)**
<1,400	150	<1,900	150
<2,800	300	<3,300	300
<3,100	600	<3,600	600

Keno Dam Release Threshold (cfs)	**Keno Dam Ramp Rate (cfs/day)**	**IGD Release Threshold from IOP (cfs)**	**IGD Ramp Rate (cfs/day)**
<3,500	$C13_{-1}$ - 2,500	<4,000	$C15_{-1}$ - 3,000
<4100	1,000	<4,600	1,000
≥4,100	Min (2,000, $C13_{-1}$ - 3,100)	≥4,100	Min (2,000, $C15_{-1}$ - 3,600)
Notes: $C13_{-1}$ and $C15_{-1}$ are the prior day releases from Keno Dam and IGD, respectively.			

Reclamation proposed the following: "The target ramp-down rates at Keno, when possible are as follows:

- When flows from Keno Dam are greater than or equal to 4,100 cfs: decreases in flows of 1,000 to 2,000 cfs per 24-hour period and no more than 500 cfs per 6-hour period.
- When flows from Keno Dam are less than 4,100 cfs but equal to or greater than 3,500 cfs: decreases in flows of 1,000 cfs or less per 24-hour period and no more than 250 cfs per 6-hour period.
- When flows from Keno Dam are less than 3,500 cfs but equal to or greater than 3,100 cfs: decreases in flows of 600-1,000 cfs or less per 24-hour period and no more than 200 cfs per 6-hour period.
- When flows from Keno Dam are less than 3,100 cfs but equal to or greater than 2,800 cfs: decreases in flows of 600 cfs or less per 24-hour period and no more than 150 cfs per 6-hour period.
- When flows from Keno Dam are less than 2,800 cfs but equal to or greater than 1,400 cfs: decreases in flows of 300 cfs or less per 24-hour period and no more than 75 cfs per 6-hour period.
- When flows from Keno Dam are 1,400 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 Keno Dam. 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% of targets) may 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, changing accretions/diversions between LRD and Keno Dam, wind effects on UKL/Lake Ewauna, stream gage error, and/or emergency situations; however, deviations will occur infrequently and in coordination with the Services, they will be corrected as quickly as practicable.

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 Keno Dam. Reclamation proposed that, in coordination with the Services, they may explore more flexible ramp rates to determine under what conditions those rates would be appropriate to implement. Simulated proposed action outcomes for the Klamath River expressed as percent exceedance, maximum and minimum of daily flows computed by month for water years 1991 to 2022 are in Table 9 and Table 10 for the USGS gage below Keno Dam (USGS Station ID#11509500) and Table 11 and Table 12 for the USGS gage below the former IGD (USGS Station ID#11516530)[4]. Note that tables are provided for each of the proposed action simulations (pulse flows on and off).

Table 9. Simulated proposed action outcomes for the Klamath River with pulse flows on, Keno gage.

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,418	2,281	3,335	6,705	7,772	6,046	6,878	5,759	4,654	1,658	1,370	1,189
5%	1,161	1,475	2,088	2,164	3,381	3,978	4,612	3,307	1,851	893	1,220	1,072
10%	975	1,104	1,428	1,628	2,510	2,877	3,796	2,549	1,368	839	1,034	897
15%	948	1,041	1,165	1,271	1,787	2,604	3,128	2,264	1,294	797	920	872
20%	937	907	785	992	1,224	2,427	2,855	2,141	1,219	776	846	848
25%	869	860	758	764	1,074	2,233	2,500	2,039	1,176	757	790	831
30%	840	803	746	751	909	1,717	2,237	1,932	1,148	748	768	823
35%	794	784	736	737	758	1,470	2,070	1,714	1,098	737	745	815
40%	779	777	726	725	735	1,375	1,947	1,563	1,052	698	727	791
45%	773	773	719	717	713	1,224	1,841	1,484	1,026	681	708	777
50%	771	770	710	708	699	1,182	1,651	1,446	1,001	677	690	771
55%	770	765	701	697	691	1,123	1,545	1,405	990	673	678	766
60%	767	763	689	687	686	1,049	1,472	1,345	978	669	673	757
65%	764	760	679	679	681	982	1,417	1,304	969	665	666	755
70%	762	759	673	674	677	943	1,363	1,235	956	659	662	754
75%	762	758	669	671	673	921	1,300	1,188	930	655	656	753
80%	760	755	665	665	669	904	1,260	1,140	913	654	654	751
85%	758	752	663	660	662	881	1,210	1,107	874	653	653	750
90%	757	742	661	658	658	821	1,138	1,030	831	651	651	745
95%	752	726	656	656	655	756	1,043	948	783	650	650	730
Min	751	706	650	650	650	675	877	840	708	650	650	709

Notes:
Values are flow rates (cfs) at the Keno gage. Statistics are computed from daily flows for water years 1991-2022 for the specified months.

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[4] Reclamation's simulated proposed action outcomes for flows observed at the Iron Gate gage (located at the former IGD site) are a result of the flows released at Keno Dam (plus tributary flows) under the proposed action.

Table 10. Simulated proposed action outcomes for the Klamath River with pulse flows off, Keno gage.

Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Max	1,418	2,281	3,335	6,705	7,772	6,046	6,878	5,759	4,654	1,658	1,370	1,189
5%	1,161	1,475	2,087	2,164	3,381	3,656	4,504	3,307	1,851	893	1,220	1,072
10%	975	1,104	1,429	1,628	2,510	2,712	3,531	2,674	1,366	839	1,034	897
15%	948	1,045	1,165	1,271	1,787	2,474	3,141	2,365	1,298	799	920	872
20%	937	914	785	993	1,231	2,313	2,752	2,250	1,231	776	846	849
25%	869	864	759	764	1,096	1,534	2,385	2,140	1,183	757	791	832
30%	840	808	749	751	912	1,363	2,211	2,039	1,150	748	767	823
35%	802	784	736	737	757	1,283	2,044	1,914	1,111	737	745	816
40%	779	777	726	726	734	1,208	1,900	1,783	1,069	698	727	791
45%	773	773	720	717	712	1,172	1,780	1,698	1,043	681	708	777
50%	772	770	711	708	699	1,119	1,637	1,649	1,009	677	690	771
55%	770	765	701	697	691	1,066	1,570	1,593	985	673	679	766
60%	767	763	689	688	685	997	1,522	1,527	967	669	673	757
65%	764	760	680	679	681	952	1,491	1,463	956	665	666	755
70%	762	759	673	674	677	930	1,434	1,407	943	659	662	754
75%	762	758	669	671	673	914	1,371	1,346	926	655	656	753
80%	760	755	666	665	669	897	1,318	1,288	907	654	654	751
85%	758	752	663	660	662	870	1,237	1,239	879	653	653	750
90%	757	742	661	658	658	821	1,150	1,115	825	651	651	745
95%	752	726	656	656	655	757	1,100	1,016	799	650	650	730
Min	751	706	650	650	650	675	877	885	703	650	650	709

Notes:
Values are flow rates (cfs) at the Keno gage. Statistics are computed from daily flows for water years 1991-2022 for the specified months.

Table 11. Simulated proposed action outcomes for the Klamath River with pulse flows on, Iron Gate gage.

Statistic	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**
Max	1,902	3,231	6,609	12,735	10,344	8,341	7,855	6,251	5,406	2,163	1,768	1,555
5%	1,549	1,887	3,043	3,799	4,721	5,042	5,546	4,235	2,449	1,336	1,568	1,444
10%	1,446	1,553	1,981	2,338	3,329	3,977	4,718	3,330	1,981	1,254	1,363	1,291
15%	1,333	1,450	1,756	1,997	2,692	3,509	4,120	3,000	1,803	1,200	1,306	1,233
20%	1,301	1,339	1,527	1,783	2,243	3,295	3,591	2,762	1,669	1,160	1,230	1,204
25%	1,259	1,281	1,351	1,541	1,797	3,079	3,251	2,642	1,608	1,134	1,166	1,182
30%	1,207	1,227	1,262	1,406	1,557	2,895	3,005	2,527	1,572	1,096	1,115	1,166
35%	1,171	1,191	1,205	1,317	1,472	2,559	2,864	2,306	1,502	1,077	1,080	1,146
40%	1,152	1,167	1,172	1,258	1,374	2,307	2,691	2,141	1,442	1,040	1,062	1,133
45%	1,140	1,147	1,143	1,223	1,292	2,050	2,524	2,027	1,398	1,023	1,041	1,122
50%	1,133	1,134	1,119	1,187	1,230	1,866	2,296	1,932	1,360	1,009	1,019	1,109
55%	1,122	1,125	1,100	1,151	1,195	1,724	2,203	1,877	1,338	999	1,005	1,096
60%	1,110	1,117	1,079	1,121	1,160	1,584	2,090	1,815	1,319	990	988	1,081
65%	1,096	1,109	1,065	1,097	1,131	1,503	1,980	1,754	1,301	980	975	1,069
70%	1,084	1,100	1,052	1,081	1,105	1,424	1,881	1,675	1,275	972	967	1,059
75%	1,072	1,088	1,039	1,061	1,087	1,361	1,741	1,612	1,259	958	955	1,049
80%	1,054	1,078	1,022	1,041	1,069	1,310	1,669	1,532	1,235	948	945	1,038
85%	1,036	1,066	1,003	1,021	1,048	1,276	1,637	1,483	1,207	940	934	1,027
90%	1,024	1,051	984	992	1,019	1,236	1,564	1,369	1,149	927	924	1,010
95%	1,015	1,026	961	969	996	1,129	1,421	1,264	1,070	917	913	998
Min	986	978	918	912	930	1,024	1,250	1,102	1,001	898	883	958

Notes:
Values are flow rates (cfs) at the Iron Gate gage. Statistics are computed from daily flows for water years 1991 to 2022 for the specified months.

Table 12. Simulated proposed action outcomes for the Klamath River with pulse flows off, Iron Gate gage.

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,902	3,231	6,609	12,735	10,344	8,341	7,855	6,251	5,406	2,163	1,768	1,555
5%	1,549	1,887	3,043	3,799	4,721	4,719	5,517	4,235	2,465	1,337	1,570	1,444
10%	1,448	1,553	1,981	2,338	3,329	3,693	4,559	3,423	1,996	1,254	1,363	1,291
15%	1,334	1,455	1,756	2,002	2,692	3,347	4,106	3,173	1,796	1,200	1,306	1,232
20%	1,300	1,344	1,530	1,782	2,243	3,094	3,550	2,852	1,674	1,159	1,230	1,203
25%	1,261	1,280	1,351	1,541	1,801	2,851	3,171	2,757	1,617	1,135	1,166	1,183
30%	1,208	1,230	1,262	1,405	1,565	2,478	3,009	2,634	1,569	1,098	1,115	1,166
35%	1,173	1,197	1,206	1,318	1,488	2,272	2,867	2,499	1,519	1,077	1,080	1,146
40%	1,152	1,168	1,171	1,261	1,380	2,076	2,576	2,332	1,455	1,040	1,062	1,133
45%	1,142	1,148	1,143	1,227	1,303	1,949	2,434	2,216	1,410	1,023	1,041	1,123
50%	1,134	1,134	1,118	1,188	1,234	1,780	2,265	2,133	1,371	1,009	1,019	1,109
55%	1,123	1,125	1,100	1,151	1,198	1,702	2,191	2,058	1,351	999	1,005	1,096
60%	1,111	1,117	1,081	1,121	1,160	1,566	2,123	1,994	1,320	990	988	1,081
65%	1,097	1,109	1,066	1,097	1,131	1,495	2,028	1,911	1,291	980	975	1,069
70%	1,084	1,100	1,052	1,081	1,105	1,418	1,855	1,845	1,267	972	967	1,059
75%	1,072	1,088	1,039	1,063	1,087	1,359	1,803	1,771	1,247	958	955	1,049
80%	1,054	1,078	1,022	1,041	1,069	1,312	1,760	1,706	1,223	948	945	1,038
85%	1,036	1,066	1,003	1,022	1,048	1,276	1,667	1,632	1,190	940	934	1,027
90%	1,024	1,051	984	992	1,019	1,235	1,562	1,447	1,139	927	924	1,010
95%	1,015	1,026	961	970	996	1,130	1,476	1,361	1,081	917	913	998
Min	986	978	918	913	931	1,025	1,250	1,159	993	898	883	958

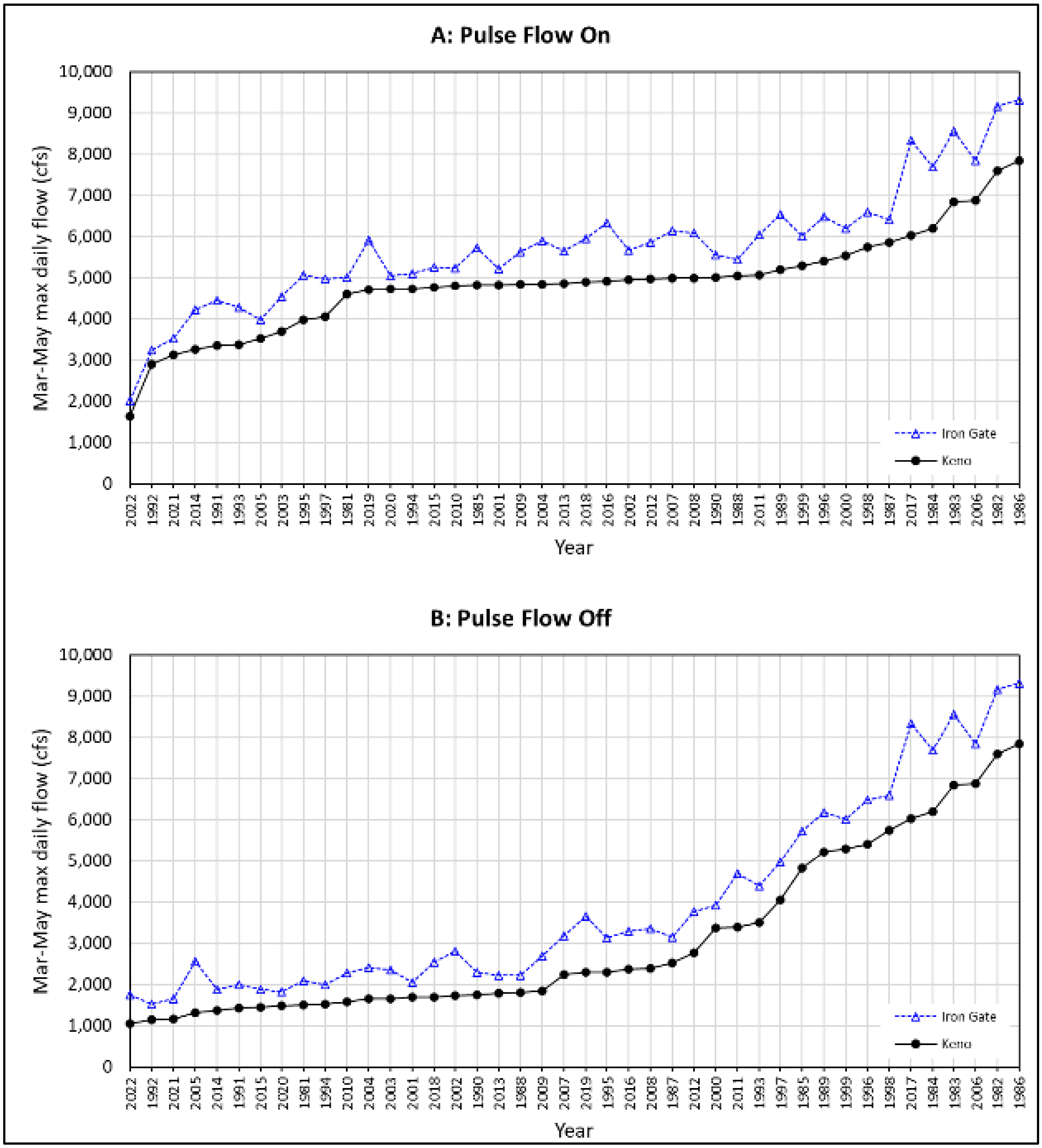
Notes:
Values are flow rates (cfs) at the Iron Gate gage. Statistics are computed from daily flows for water years 1991 to 2022 for the specified months.

The volume used from the FFA each year for each of the proposed action simulations is very similar (Table 13). In 1989, less FFA water was used when the pulse flow was off because in that scenario some of the FFA volume spilled (after all the Deferred Project Supply volume spilled).

Table 13. FFA volumes (thousand-acre feet [TAF]) used by the Klamath River each year for each of the proposed action simulations (pulse flows on and off).

Year	FFA Used with Pulse Flows On	FFA Used with Pulse Flows Off	Year	FFA Used with Pulse Flows On	FFA Used with Pulse Flows Off
1981	22	22	2002	34	34
1982	0	0	2003	18	18
1983	0	0	2004	24	25
1984	7	7	2005	16	16
1985	15	15	2006	22	22
1986	0	0	2007	35	35
1987	35	35	2008	36	36
1988	36	36	2009	36	36
1989	36	30	2010	25	25
1990	36	36	2011	36	36
1991	17	17	2012	36	36
1992	12	12	2013	35	35
1993	12	12	2014	16	16
1994	34	34	2015	25	25
1995	20	20	2016	34	34
1996	0	0	2017	11	11
1997	0	0	2018	27	27
1998	8	8	2019	24	24
1999	5	5	2020	34	34
2000	20	20	2021	14	14
2001	35	35	2022	4	4

Maximum daily flows at Keno Dam and the former IGD with pulse flows on and off are shown in Figure 6. IGD flows are higher and show more variability due to accretions downstream of Keno Dam.



Notes: Years are sorted based on the magnitude of the Mar-May max daily flow at Keno Dam.

Figure 6. Maximum daily flow for March through May in each year for the pulse flow on (A) and pulse flow off (B) scenarios of the proposed action.

1.3.2.2 Project Allocations for Irrigation

1.3.2.2.1 Project Supply from Upper Klamath Lake

Water available for irrigation use from UKL during the spring-summer (SS) period is divided into firm and variable components (defined in this section) from UKL storage and inflow. The Project Share of storage or inflow components is determined by the Operations Index (Table 14).

Table 14. Project Share of storage and inflow components of Project allocation.

Operations Index	**Project Share**
0	0.12
0.2	0.17
0.4	*0.26
0.6	0.26
0.8	0.25
1	0.24
Notes: Project Share values are linearly interpolated based on the value of the Operations Index	

Starting on March 1 and repeated on April 1, UKL storage above 4,138.8 ft (Reclamation KB datum) is determined as UKL shadow storage minus UKL storage at 4,138.8 ft. This is multiplied by Project Share on March 1 to determine the provisional Project Supply from Storage, and on April 1 to determine the Firm Project Supply from Storage (see Appendix A).

Estimates of UKL net inflow volume for April through September are used to calculate the Project Supply from Inflow. Such estimates are comprised of the actual UKL net inflow volume since April 1 plus the forecasted UKL net inflow volume from the forecast date through September. The variable Apr95vol is the 95% exceedance forecast on April 1 of April to September UKL net inflow. Then on April 15 Apr95vol is the 95% exceedance forecast of April 15 to September UKL net inflow plus the actual UKL net inflow from April 1 through 14. The April 15 Apr95vol multiplied by the Project Share is the Firm Project Supply from Inflow. Note that this is constrained to not exceed the maximum Klamath Project allocation of 350 TAF minus Firm Project Supply from Storage. On April 15, the Firm Project Supply is the Firm Project Supply from Storage plus the Firm Project Supply from Inflow.

Another component of Project Supply computed every two weeks after April 1 varies until becoming firm on June 1. On day d this supply is computed as:

$$Variable\ Project\ Supply_d = (Apr50vol_d - Apr95vol_d) \text{ x } Project\ Share_d \text{ x } PSM_d \quad (4)$$

Apr50vol is computed in the same manner as Apr95vol using the 50% exceedance forecast instead of the 95% exceedance forecast. PSM_d is the Project Supply Multiplier on day d that is determined by the exceedance quantile of the cumulative actual UKL net inflow volume since April 1 (Table 15). As actual UKL net inflow increases above the median (the exceedance quantile declines from 0.5), the Project Supply Multiplier increases above 1 and increases the Variable Project Supply. The opposite occurs when the inflows decline below the median (the exceedance quantile increases from 0.5).

Table 15. The Project Supply Multiplier is determined by the exceedance quantile for cumulative UKL net inflow volume since April 1.

Inflow Exceedance Since Apr 1	Project Supply Multiplier
0.05	1.5
0.5	1
0.95	0.5
Notes: Exceedance is computed for water years 1991-2022	

The final Project Supply from UKL becomes firm on June 1 and consists of the sum of the Firm Project Supply from Storage, the Firm Project Supply from Inflow, and the June 1 Variable Project Supply. No further adjustments to the final Project Supply would be made after June 1.

1.3.2.2.2 Project Supply from Other Surface Water Sources

There are two additional sources of water to the Klamath Project and NWRs. They are Lost River inflow to Wilson Reservoir and F/FF Pump Station returns to the Keno Impoundment. This water can be used directly during the irrigation season or collected as deferred supply in UKL to be used later by the Klamath Project or NWRs. Deferred Project Supply in UKL can also be accumulated when NWR use of their allocation from UKL is replaced by irrigation returns or water from the Lost River.

1.3.2.2.3 Project Direct Use of Lost River and F/FF Pump Station Returns

During the irrigation season, the Klamath Project can re-divert F/FF Pump Station returns to Keno Impoundment or Lost River water diverted into the LRDC (Lost River water diverted into the LRDC will be referred to as “LR Diversions”). To be counted as direct use from Lost River, the re-diversion for Klamath Project use must occur on the same day the water becomes available in the system as return flow. The points of diversion where this re-diversion is simulated in the KRM are Station 48, Miller Hill, North Canal, and Ady Canal. Irrigation season project diversions at Station 48, Miller Hill, North Canal, and Ady Canal first rely on all available Lost River water and F/FF returns. Irrigation season Klamath Project diversions at Station 48, Miller Hill, North Canal, and Ady Canal only count against UKL Klamath Project supply (or deferred supply; discussed below) once the Lost River and F/FF sources are exhausted. Note that FW KDD diversions are assumed to be from UKL.

1.3.2.2.4 Deferred Project Supply

Deferred Project Supply is water that Reclamation has allocated to Klamath Project irrigators after meeting all relevant legal obligations, including but not limited to tribal water rights and the ESA, but that Klamath Project irrigators forego for the potential for future diversion when Reclamation determines that it has available supply. The term “Deferred Project Supply” is solely used as a term of art to describe how Reclamation would provide additional flexibility to allocation usage. Deferred Project Supply may be derived from either UKL or from the Lost River. For example, LR Diversions and F/FF pumping into the Keno Impoundment that is not directly re-diverted (Section 1.3.2.2.3 *Project Direct Use of Lost River and F/FF Pump Station*

Returns), can accumulate as a Deferred Project Supply in UKL when Keno Impoundment is balanced, meaning:

- Releases at LRD are in balance with Klamath Project deliveries out of the Keno Impoundment, targeted flow releases from Keno Dam, and operational storage levels within the Keno Impoundment.
- Keno Impoundment is not in flood control operations (see Appendix A).
- UKL is not in flood control operations (see Appendix A).
- The date is on or between November 1 and September 30. No Deferred Project Supply is accumulated in October.
- LR Diversions and F/FF pumping result in a calculable reduction in Link releases (through mass balance) needed to meet targeted flow releases from Keno Dam.

The calculated reduction in releases from LRD is the Deferred Project Supply. Each day Deferred Project Supply is calculated under the above conditions, it is added to the Deferred Project Supply account in UKL.

Deferred Project Supply can also be accumulated in UKL using the 43,000 AF dedicated historical wetland habitat supply from UKL storage that is intended to keep Lower Klamath NWR Unit 2 and Tule Lake NWR Sump 1A water surface elevations at specified environmental thresholds (see Appendix A). If these environmental thresholds can be maintained through a combination of redistributed drainage from irrigated lands and flow from the Lost River, the 43,000 AF (or remaining portion of the dedicated historical wetland habitat supply) will be credited to the Klamath Project on a uniform schedule from April 2 to September 30. Reclamation and the Services will coordinate throughout the irrigation season to ensure that there are sufficient water supplies for Unit 2 and Sump 1A before any of the UKL historical wetland habitat supply is dedicated to Deferred Project Supply.

Use of Deferred Project Supply begins with irrigation season Klamath Project diversions from UKL. Each day water is diverted from UKL, Deferred Project Supply is withdrawn in proportion to its contribution to remaining available Klamath Project water volume in UKL. Diversions of Deferred Project Supply are deducted from the UKL Deferred Project Supply account daily during the irrigation season. This is necessary to continually update the UKL shadow operation for correct calculation of UKL Status. Any Deferred Project Supply remaining in the UKL Deferred Project Supply account at the end of October is converted to general UKL storage on November 1.

If UKL enters flood control operations, UKL Deferred Project Supply spills first (prior to the FFA for Klamath River flows). The daily quantity of UKL Deferred Project Supply that spills is calculated as the minimum of the flow in excess of required flow at Link River or flow in excess of targeted flow at Keno Dam plus any spill diverted to Tule Lake NWR or Lower Klamath NWR. To prevent or reduce spill of UKL Deferred Project Supply, early withdrawals from the account can be made and distributed to Lower Klamath NWR or Tule Lake NWR in priority with other uses. Where physically practicable, Deferred Project Supply moved to Lower Klamath NWR or Tule Lake NWR to avoid spill may be rediverted for agricultural irrigation use at a later date, in coordination with Reclamation and USFWS. Note that Deferred Project Supply diverted to the NWRs may be subject to evaporative and transmission loss that may reduce the volume available for rediversion at a later date.

1.3.2.2.5 Project Outcomes under the Proposed Action

Under the proposed action (with pulse flows on), the firm supply on June 1 of water available to the Klamath Project irrigators from UKL without considering Deferred Project Supply volumes (Table 16) ranges from 32 to 307 TAF. The firm supply on June 1 sums the firm supply on April 15 and the final calculated variable supply on June 1. By design, the firm supply on June 1 can only increase from the firm supply on April 15, although the increase may be small or nonexistent. The firm and variable Project Supplies are finalized on June 1 and will not be altered after June 1 of each year.

Table 16. Project irrigation supply (TAF) from UKL under the proposed action (with pulse flow on) without consideration of Deferred Project Supply.

Year	Firm Storage Apr 1	Firm Inflow Apr 15	Firm Supply Apr 15	Variable Apr 1	Variable Apr 15	Variable May 1	Variable May 15	Firm Variable Jun 1	Firm Supply Jun 1
1981	63	58	121	13	12	6	2	6	127
1982	95	143	238	76	31	10	26	29	267
1983	89	185	274	103	40	37	14	14	288
1984	96	167	263	91	37	37	25	45	307
1985	76	115	191	69	28	51	53	41	232
1986	101	103	204	58	24	19	31	29	232
1987	93	67	160	27	15	3	12	7	167
1988	93	41	134	10	9	17	22	20	155
1989	92	126	218	83	29	32	50	36	255
1990	87	46	133	15	10	16	17	19	152
1991	53	58	111	14	10	9	1	5	116
1992	18	14	32	3	3	7	6	3	35
1993	58	162	220	68	35	26	15	7	227
1994	59	38	97	6	8	3	0	0	97
1995	76	102	177	54	23	29	44	38	216
1996	95	91	186	41	22	41	44	71	257
1997	89	95	183	40	20	37	40	39	222
1998	90	141	231	70	32	0	11	62	293
1999	70	179	248	101	39	43	37	39	287
2000	87	84	171	53	20	57	83	70	241
2001	72	54	126	14	10	9	2	1	127
2002	69	58	127	23	13	24	33	25	152
2003	68	71	139	19	16	24	37	25	164
2004	72	61	133	33	14	19	21	20	153
2005	26	38	63	8	7	7	25	73	136
2006	72	149	221	68	32	45	49	58	279

Year	Firm Storage Apr 1	Firm Inflow Apr 15	Firm Supply Apr 15	Variable Apr 1	Variable Apr 15	Variable May 1	Variable May 15	Firm Variable Jun 1	Firm Supply Jun 1
2007	90	76	165	30	17	21	28	19	185
2008	72	114	186	56	24	15	13	16	202
2009	79	83	161	27	14	0	11	15	177
2010	60	70	130	15	13	12	9	5	135
2011	89	131	220	68	29	30	13	13	233
2012	89	110	199	35	25	4	6	5	203
2013	73	68	141	14	15	9	5	1	143
2014	56	47	104	9	10	3	0	0	104
2015	66	36	102	7	7	2	0	2	104
2016	82	70	152	37	15	9	12	8	161
2017	97	143	240	77	32	24	14	15	255
2018	71	67	138	15	14	14	7	12	150
2019	63	112	175	38	26	29	25	21	196
2020	50	42	92	7	7	0	0	4	96
2021	20	16	36	4	3	2	2	2	39
2022	5	15	20	1	3	10	14	12	32

Notes:
Firm supply decisions are finalized for the various components on the specified dates. The variable component varies every two weeks until becoming firm on June 1.

Annual irrigation diversions from all available surface water sources are summarized in Table 17. The inclusion of winter water and other water sources yields higher diversions than in Table 16. The SS period consists of A Canal and net Station 48/Miller Hill diversions from March through November 15, and North and Ady canal diversions to the Klamath Project from March through September. The totals from UKL are larger than in Table 16, because they include Deferred Project Supply. The FW period consists of irrigation diversions under winter water rights from October through February. Because the proposed action simulation ends on November 30, 2022, the FW diversion reported for KDD in 2022 in Table 17 is small because includes only October to November diversions.

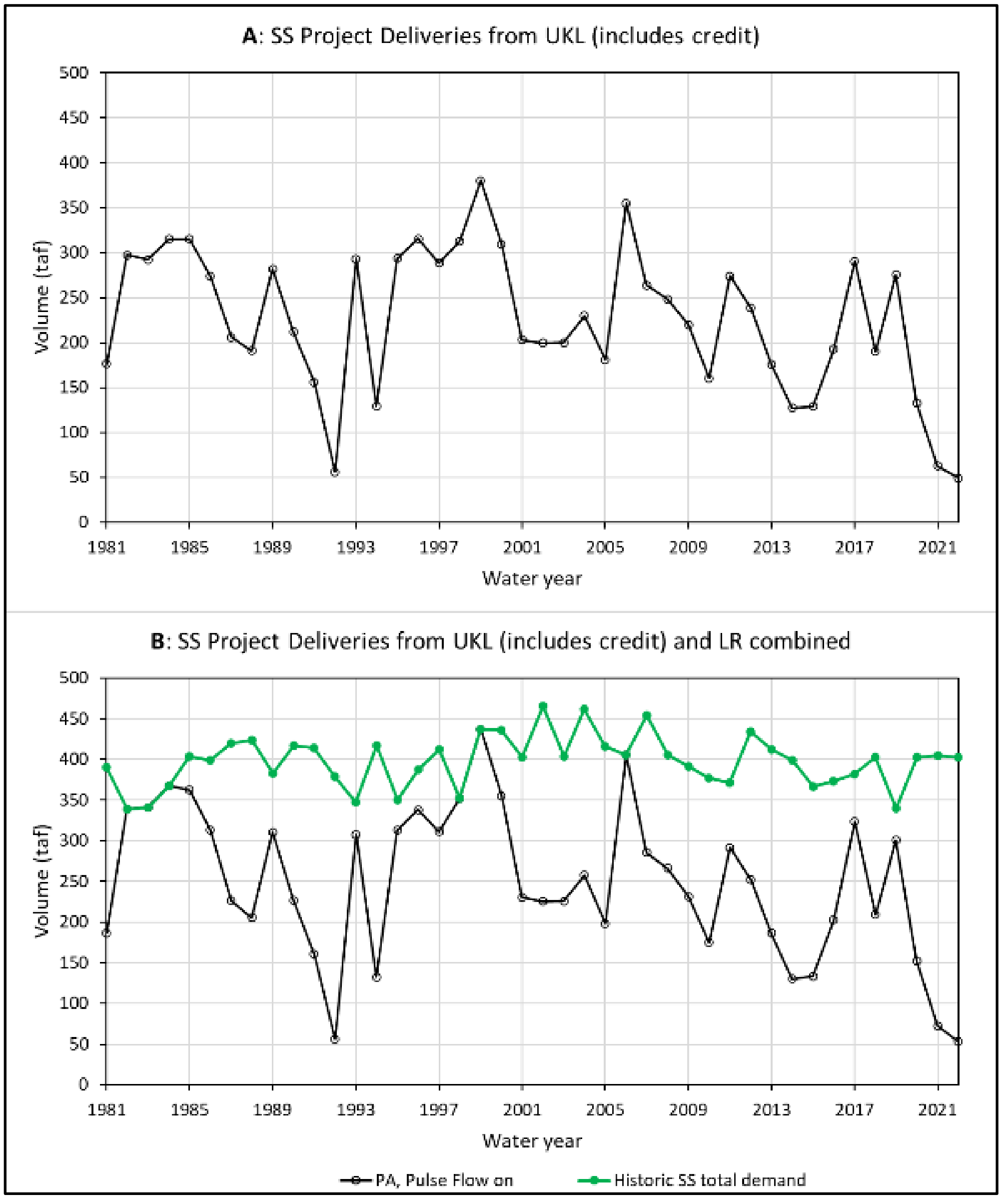
Table 17. Simulated irrigation diversions (TAF) under the proposed action (with pulse flows on) from all surface water sources.

Year	SS from UKL	SS from Returns	SS Total	FW Ag Diversion	Total Annual Ag Diversion
1981	176	10	187	29	216
1982	297	42	339	29	368
1983	292	49	341	29	370
1984	315	53	368	29	397
1985	315	47	362	29	391

Year	SS from UKL	SS from Returns	SS Total	FW Ag Diversion	Total Annual Ag Diversion
1986	274	39	313	29	342
1987	206	20	226	29	255
1988	191	14	205	29	234
1989	282	29	311	29	340
1990	212	15	227	29	256
1991	156	5	161	27	188
1992	56	0	56	27	83
1993	293	15	308	29	337
1994	129	3	132	29	161
1995	293	19	313	29	342
1996	315	23	338	29	367
1997	288	23	311	29	340
1998	313	40	353	29	382
1999	380	57	437	29	466
2000	309	46	355	29	384
2001	203	27	230	29	259
2002	199	26	226	29	255
2003	200	26	226	29	255
2004	230	28	258	29	287
2005	181	17	198	29	227
2006	355	50	405	29	434
2007	264	21	285	29	314
2008	248	18	266	29	295
2009	220	11	231	29	260
2010	160	15	175	29	204
2011	274	17	291	29	320
2012	238	14	252	29	281
2013	176	10	186	29	215
2014	127	3	130	29	159
2015	129	5	134	29	163
2016	193	10	203	29	232
2017	290	33	323	29	352
2018	190	19	209	29	238
2019	275	25	300	29	329
2020	133	20	152	28	180
2021	63	10	72	25	97
2022	49	4	53	8	61

Notes:
‘From UKL’ reports all diversions from UKL including the use of Deferred Project Supply. ‘From returns’ reports use of irrigation returns to the LRDC and returns from pumps F and FF. ‘SS total’ is the SS diversions from UKL and returns combined. ‘FW Ag Diversion’ is the FW diversion using winter water rights.

Simulated SS deliveries from UKL including diversion of Deferred Project Supply are shown in Figure 7(A), whereas SS diversions from all surface water sources are in Figure 7 (B). The latter illustrates how the proposed action simulation caps Klamath Project deliveries at the estimated historical demand. The median total annual Klamath Project diversion calculated using the last column in Table 17 for the 1991 to 2022 POR is approximately 260,000 AF from all surface water sources.



A: SS Project Deliveries from UKL (includes credit)

B: SS Project Deliveries from UKL (includes credit) and LR combined

Note: Simulated Project deliveries are capped by historical demand.

Figure 7. Simulated SS Klamath Project irrigation deliveries under the Proposed Action (pulse flows on) from UKL including diversion of Deferred Project Supply (A) and deliveries from all surface water sources (B).

Simulated SS deliveries from all surface water sources can be readily visualized by sorting years from lowest to highest deliveries, as is done in Figure 8. SS deliveries range from 53 to 437 TAF.

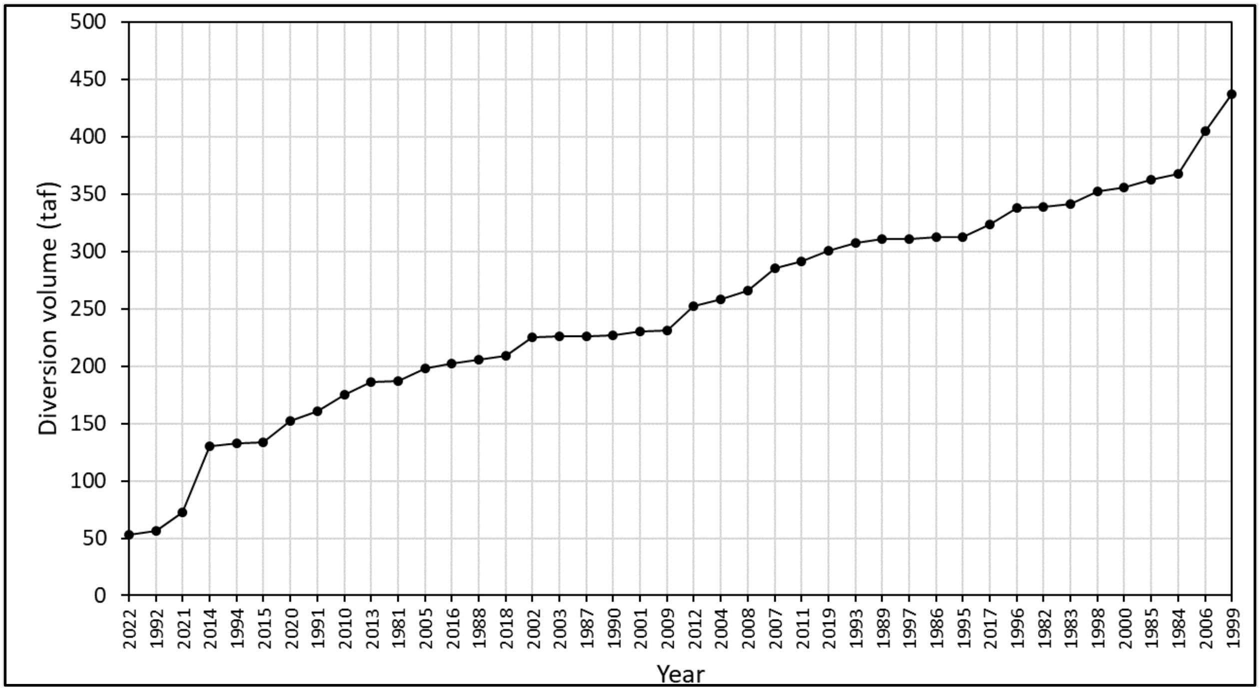


Figure 8. Total SS deliveries from all surface water sources sorted by year from lowest to highest diversion.

It is important to note that Project Supply formulation in the KRM was reliant upon inclusion of Deferred Project Supply as a key component of the overall supply. Reclamation stated that the model took an appropriately conservative approach to evaporative loss and return flows to the system to ensure that water available to the Klamath Project was not overestimated. However, Reclamation will coordinate closely with the Services to take advantage of opportunities, as they arise in the course of prescribed operations under the proposed action, to maximize the availability of Deferred Project Supply in a manner that ensures that modeled outcomes in the Klamath River and UKL are realized for the benefit of the ecosystem and species.

1.3.2.3 Upper Klamath Lake

UKL flood control elevations are used 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 while allowing UKL to fill. The UKL flood control elevations shown in Table 18 are intended to be used as guidance, and professional judgment will be utilized by Reclamation in combination with hydrologic conditions, snowpack, forecasted precipitation, public safety, and other factors in the actual operation of UKL during flood control operations.

For example, the elevation at which flood control is triggered in December is lower than that in March to allow enough capacity for anticipated large winter inflows, whereas in March there are fewer wet months remaining.

Flood release rules used in the KRM consist of UKL level thresholds inherited from PacifiCorp above which UKL will spill (Table 18). In this proposed action, operations other than the flood release curve contribute to flood avoidance. The additional storage associated with the wetland restoration and reconnection to UKL in the Upper Klamath NWR increases the active storage capacity of UKL. Targeted releases from Keno Dam to the Klamath River when the Operations Index is very high are intentionally large to retain the integrity of deferred use operations (i.e., FFA and Deferred Project Supply), which also contributes to flood avoidance. Operationally, situations may arise in which flood releases may need to occur at lower elevations than UKL flood level thresholds.

Table 18. Flood release threshold levels for UKL used in the KRM on the first day of each month.

Start of Month	Flood Release Threshold (ft)
Jan	4141.8
Feb	4142.3
Mar	4142.7
Apr	4143.1
May	4143.3
Jun	4143.3
Jul	4143.3
Aug	4143.3
Sep	4143.3
Oct	4142.5
Nov	4142.5
Dec	4141.6

Notes:
Daily values are interpolated.

Simulated outcomes for UKL levels under the proposed action with pulse flows on are presented as daily minimum and maximum levels by month and percent exceedance of daily levels by month for water years 1991 to 2022 in Table 19. When pulse flows are off, UKL levels are occasionally up to 0.2 ft higher for a brief time after the pulse flow would have been released, an effect that rapidly diminishes to 0 as the FFA volume is released to the Klamath River in one of many other possible distribution shapes.

Table 19. Simulated proposed action outcomes for UKL with pulse flows on.

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	4,140.4	4,140.6	4,141.0	4,142.3	4,142.7	4,143.1	4,143.3	4,143.3	4,143.3	4,143.0	4,142.0	4,141.0
5%	4,140.1	4,140.2	4,140.7	4,141.8	4,142.5	4,142.9	4,143.2	4,143.3	4,143.3	4,142.6	4,141.6	4,140.6
10%	4,139.9	4,140.1	4,140.6	4,141.3	4,142.3	4,142.8	4,143.1	4,143.2	4,143.1	4,142.4	4,141.3	4,140.4
15%	4,139.8	4,140.0	4,140.4	4,141.1	4,142.1	4,142.7	4,143.1	4,143.1	4,142.9	4,142.2	4,141.2	4,140.3
20%	4,139.8	4,139.9	4,140.3	4,141.0	4,141.9	4,142.6	4,142.9	4,143.1	4,142.8	4,142.1	4,141.1	4,140.2
25%	4,139.8	4,139.9	4,140.3	4,140.9	4,141.7	4,142.5	4,142.9	4,143.0	4,142.7	4,141.9	4,140.9	4,140.1
30%	4,139.7	4,139.8	4,140.2	4,140.9	4,141.6	4,142.3	4,142.8	4,142.9	4,142.6	4,141.8	4,140.8	4,140.0
35%	4,139.7	4,139.8	4,140.1	4,140.8	4,141.5	4,142.2	4,142.7	4,142.8	4,142.5	4,141.6	4,140.7	4,139.9
40%	4,139.6	4,139.7	4,140.1	4,140.7	4,141.4	4,142.1	4,142.5	4,142.6	4,142.3	4,141.4	4,140.5	4,139.8
45%	4,139.4	4,139.5	4,140.0	4,140.6	4,141.3	4,142.0	4,142.4	4,142.4	4,142.2	4,141.3	4,140.4	4,139.6
50%	4,139.3	4,139.4	4,139.8	4,140.5	4,141.3	4,141.9	4,142.4	4,142.3	4,141.9	4,141.2	4,140.2	4,139.4
55%	4,139.1	4,139.3	4,139.7	4,140.4	4,141.2	4,141.8	4,142.4	4,142.2	4,141.8	4,141.0	4,140.1	4,139.3
60%	4,139.0	4,139.2	4,139.6	4,140.3	4,141.1	4,141.7	4,142.2	4,142.1	4,141.6	4,140.9	4,140.0	4,139.2
65%	4,138.8	4,139.0	4,139.5	4,140.2	4,141.0	4,141.7	4,142.2	4,142.0	4,141.5	4,140.7	4,139.8	4,139.1
70%	4,138.7	4,138.9	4,139.4	4,140.0	4,140.8	4,141.6	4,141.9	4,141.6	4,141.4	4,140.6	4,139.7	4,139.0
75%	4,138.6	4,138.8	4,139.3	4,139.9	4,140.7	4,141.5	4,141.8	4,141.5	4,141.2	4,140.4	4,139.6	4,138.9
80%	4,138.6	4,138.7	4,139.1	4,139.8	4,140.5	4,141.2	4,141.7	4,141.4	4,141.1	4,140.3	4,139.4	4,138.8
85%	4,138.5	4,138.7	4,139.0	4,139.7	4,140.2	4,141.0	4,141.5	4,141.3	4,140.9	4,140.1	4,139.3	4,138.6
90%	4,138.3	4,138.3	4,138.8	4,139.4	4,140.0	4,140.5	4,140.8	4,140.9	4,140.4	4,139.5	4,138.7	4,138.0
95%	4,137.6	4,137.8	4,138.2	4,138.8	4,139.4	4,140.2	4,140.4	4,140.0	4,139.5	4,138.9	4,138.3	4,137.7
Min	4,137.1	4,137.2	4,137.7	4,138.4	4,138.9	4,139.2	4,139.5	4,139.5	4,138.9	4,138.5	4,137.7	4,137.2
Notes: Values are UKL levels (ft, Reclamation KB datum). Statistics are computed from daily flows for water years 1991-2022 for the specified months.												

Springtime and end-of-season UKL levels are important characteristics of the lake outcomes. Table 20 reports these outcomes, which are also plotted in Figure 9.

Table 20. Simulated UKL levels (ft, Reclamation KB datum) under the proposed action with pulse flows on during spring and mid-summer, and minimum (September to November) UKL levels at the end of-season.

Year	**Mar 31**	**Apr 30**	**Jul 31**	**Minimum**	**Year**	**Mar 31**	**Apr 30**	**Jul 31**	**Minimum**
1981	4142.1	4142.0	4139.9	4138.1	2002	4142.2	4142.3	4140.3	4138.6
1982	4142.9	4143.3	4142.5	4140.9	2003	4141.8	4142.0	4140.4	4138.8
1983	4143.0	4142.8	4142.4	4140.7	2004	4142.3	4142.4	4140.5	4138.4
1984	4143.1	4143.0	4141.8	4140.4	2005	4140.9	4140.8	4140.5	4138.7
1985	4142.9	4143.3	4141.0	4140.0	2006	4142.8	4143.3	4141.9	4139.8
1986	4143.0	4142.8	4141.1	4139.7	2007	4143.0	4143.1	4141.0	4139.5
1987	4143.0	4142.6	4141.0	4139.8	2008	4142.1	4142.5	4141.4	4139.8
1988	4143.0	4142.6	4140.8	4139.0	2009	4142.4	4142.4	4141.0	4139.3
1989	4143.1	4143.3	4141.2	4139.9	2010	4141.8	4141.7	4140.4	4139.0
1990	4143.0	4142.8	4140.7	4139.3	2011	4142.9	4142.8	4142.0	4140.3
1991	4141.5	4141.5	4139.9	4138.2	2012	4142.8	4142.8	4141.3	4139.7
1992	4140.6	4140.4	4138.5	4137.1	2013	4142.3	4142.4	4140.3	4139.2
1993	4141.7	4143.1	4141.8	4140.1	2014	4141.6	4141.6	4139.6	4138.4
1994	4142.0	4141.6	4139.4	4137.8	2015	4142.2	4141.7	4139.9	4138.6
1995	4142.3	4142.9	4142.0	4139.5	2016	4142.5	4142.4	4140.5	4138.9
1996	4142.9	4143.1	4141.5	4139.7	2017	4143.1	4143.0	4141.2	4139.7
1997	4142.7	4142.9	4141.3	4139.8	2018	4142.2	4142.2	4140.5	4139.0
1998	4143.1	4143.1	4142.0	4139.7	2019	4141.8	4143.0	4141.2	4139.7
1999	4143.1	4143.3	4141.7	4140.0	2020	4141.8	4141.4	4140.0	4138.7
2000	4142.9	4143.3	4141.2	4139.6	2021	4140.6	4140.2	4138.5	4137.5
2001	4142.5	4142.4	4140.1	4138.6	2022	4139.5	4139.6	4138.7	4137.5

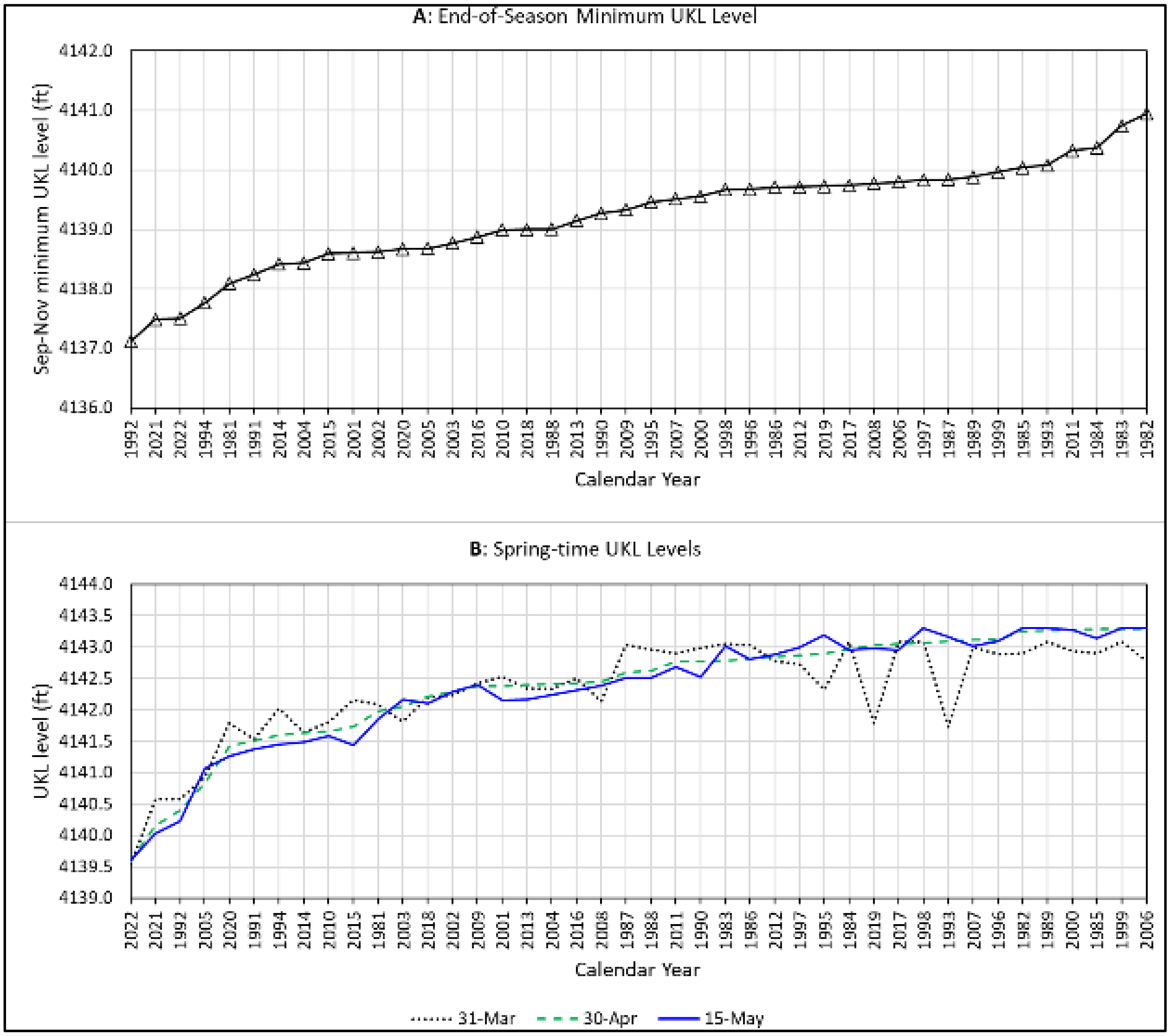


Figure 9. Simulated UKL levels (ft, Reclamation KB datum) under the proposed action with pulse flows on for end-of-season (A, sorted by minimum UKL level) and spring dates (B, sorted by April 30 UKL level).

The KRM does not include any explicitly modeled UKL minima. Lake elevations in the output tables and graphs above are the result of the interactions of model parameters and inputs and represent the range of elevations that might reasonably be expected to result from operations during the period of this action. However, since there are no seasonal or annual UKL elevation restrictions built into the model, there are instances in which UKL elevations realized in past operations may not be reproduced under the proposed action.

1.3.2.3.1 Wetland Restoration within Upper Klamath National Wildlife Refuge

The USFWS intends to reconnect a full gradient of wetlands within a diked and drained portion of the Upper Klamath NWR known as Agency-Barnes Lake by breaching dikes and hydrologically reconnecting the area to the UKL-Agency Lake complex (Stantec 2023).

Providing a wide range of benefits to many species, including migratory water birds and historical wetland habitat, the project is also intended to improve water quality and physical habitat for endangered suckers and salmonids. Potential effects of this project on issues related to water management were analyzed in Stantec's (2023) Environmental Assessment prepared for USFWS, and by Dunsmoor et al. (2022).

The KRM includes the model code that was incorporated into an earlier version of the KBPM as described in Dunsmoor (2022). The proposed action uses this code, assuming the reconnection of this area within the Upper Klamath NWR. Functionally, this addresses changes that will occur as a result of reconnection. The model code adjusts the measured UKL net inflow for the changes to evapotranspiration that will accompany the transition from pasture and hay back to wetlands and open water, and then simulates UKL dynamics using an elevation-capacity relationship that reflects the addition of the volume of the reconnected area to the volume of UKL.

1.3.2.3.2 Tule Lake and Lower Klamath National Wildlife Refuges

The Tule Lake and Lower Klamath NWRs are dependent on live flow in UKL and the Klamath River as well as the Lost River for water supply.

1.3.2.3.3 Dedicated National Wildlife Refuge Supply from Upper Klamath Lake

Each irrigation season, 43,000 AF from UKL is dedicated to the NWRs when consistent with Oregon water rights for the purpose of keeping Lower Klamath NWR Unit 2 and Tule Lake NWR Sump 1A at specified surface water elevations to maintain habitat for endangered suckers at these locations. This volume can be delivered to the NWRs from April to October as required to overcome evaporative or other losses that may impact available habitat. The rate of cumulative delivery should not exceed the rate that would occur with uniform daily delivery of the dedicated supply from April to October.

If delivery of the dedicated supply is below the maximum cumulative rate, the volume of under delivery is transferred to Deferred Project Supply so that it does not affect UKL Status and targeted Klamath River flows. Whether this credit is delivered to the Klamath Project or to historical wetland habitat depends on coordination between USFWS and Reclamation regarding other potential replacement water supplies to maintain Unit 2 and Sump 1A.

In the KRM, 21,000 AF of the 43,000 AF dedicated historical wetland habitat supply is reserved for Lower Klamath NWR. The remaining 22,000 AF of supply is reserved for Tule Lake NWR. The division of dedicated supply in real-time operations should be based solely on the immediate needs of the individual NWRs in meeting specified environmental thresholds. Figure 10 plots annual deliveries of dedicated UKL supply to the Lower Klamath NWR, and Figure 11 shows deliveries to the Tule Lake NWR.

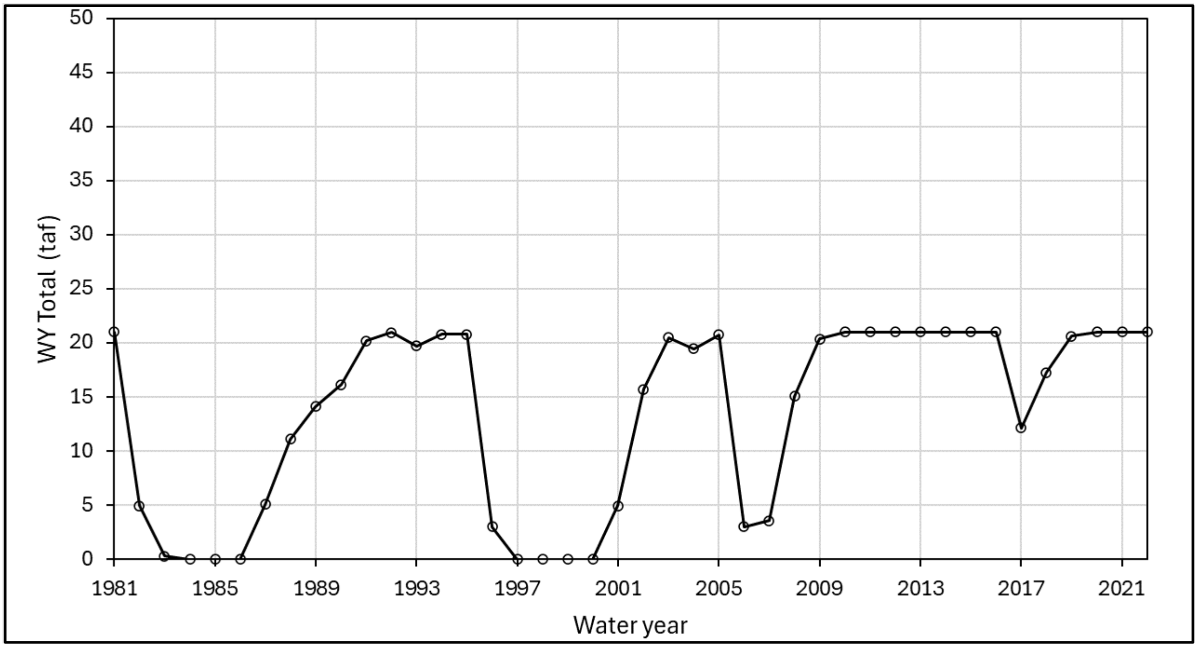


Figure 10. Delivery of dedicated UKL historical wetland habitat supply to Lower Klamath NWR in the KRM proposed action simulation, April to October through Ady Canal.

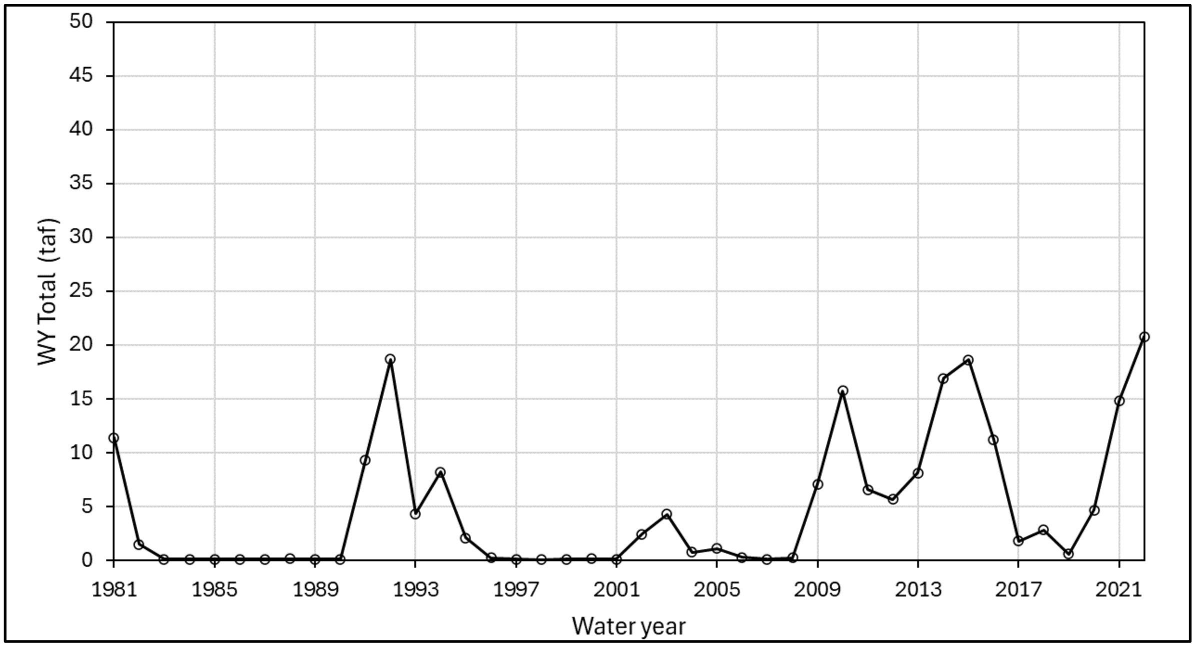


Figure 11. Delivery of dedicated UKL historical wetland habitat supply to Tule Lake NWR in the KRM proposed action simulation, April to October.

Note the years that there is less than 21,000 AF of UKL supply delivered to Lower Klamath NWR or less than 22,000 AF delivered to Tule Lake NWR. These are years where all or a portion of the dedicated supply was credited to the Klamath Project because the Lower Klamath

NWR Unit 2 and Tule Lake NWR Sump1A environmental thresholds were met using other water sources (i.e., Lost River, Deferred Project Supply, FFA Spill discussed below). Reclamation will coordinate closely with the Services and Klamath Project contractors to identify opportunities to use available water supplies in a manner that maximizes water availability for Klamath Project irrigation while also optimizing historical wetland habitat on NWR lands and meeting obligations to listed species.

Lost River Refuge Supply

Throughout the year, water from the Lost River can be allowed to flow to the Tule Lake NWR. This water may be used to replenish storage in Sump 1A, Sump 1B, and, during the winter, to pre-irrigate agricultural lands (called Sump 3 in the KRM) in the Tule Lake NWR lease lands. Additionally, throughout the year, any Lost River water that is diverted into the LRDC, not re-diverted by irrigators, and not needed for UKL Deferred Project Supply can be diverted at Ady Canal and conveyed to the Lower Klamath NWR.

Surplus Lost River water and TID irrigation drainage can be delivered to the Lower Klamath NWR through D Plant. There is no specified schedule for D Plant pumping in the proposed action, but it is assumed that D Plant pumping will occur at the discretion of TID and USFWS.

The KRM proposed action simulated Lost River water that flowed to the Tule Lake NWR including D Plant is shown in Figure 12, and the KRM proposed action simulated Lost River water conveyed to the Lower Klamath NWR by way of the LRDC and Ady Canal is shown in Figure 13.

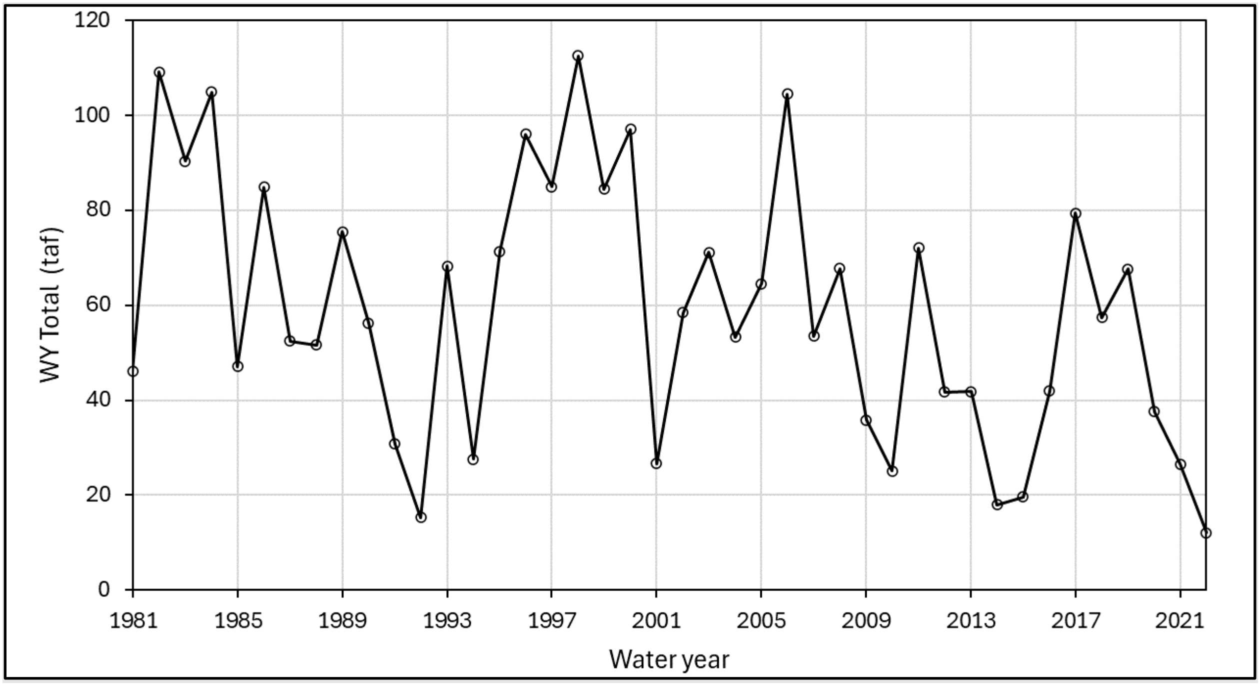


Figure 12. Lost River water flowing to Tule Lake sumps and, a fraction of the flow, through D Plant.

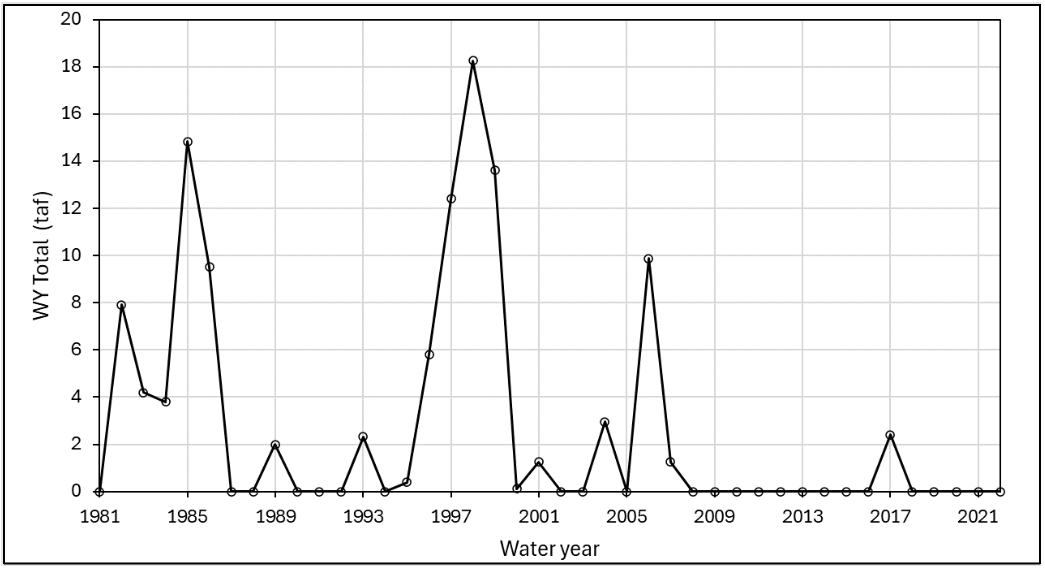


Figure 13. Lost River water flowing through the LRDC and diverted at Ady Canal to the Lower Klamath NWR.

Flood Control Releases of Deferred Project Supply for Historical Wetland Habitat

If it is determined by Reclamation in coordination with water users that there is a high likelihood that Deferred Project Supply will have to be released for flood control, early release of Deferred Project Supply can be made from UKL for distribution to the Tule Lake and Lower Klamath NWRs. When UKL is in flood control and Deferred Project Supply is spilling, the spill can be diverted to the Tule Lake and Lower Klamath NWRs. Figure 14 shows Deferred Project Supply redistributed to the Tule Lake and Lower Klamath NWRs before and during UKL flood control operations in the KRM proposed action simulation.

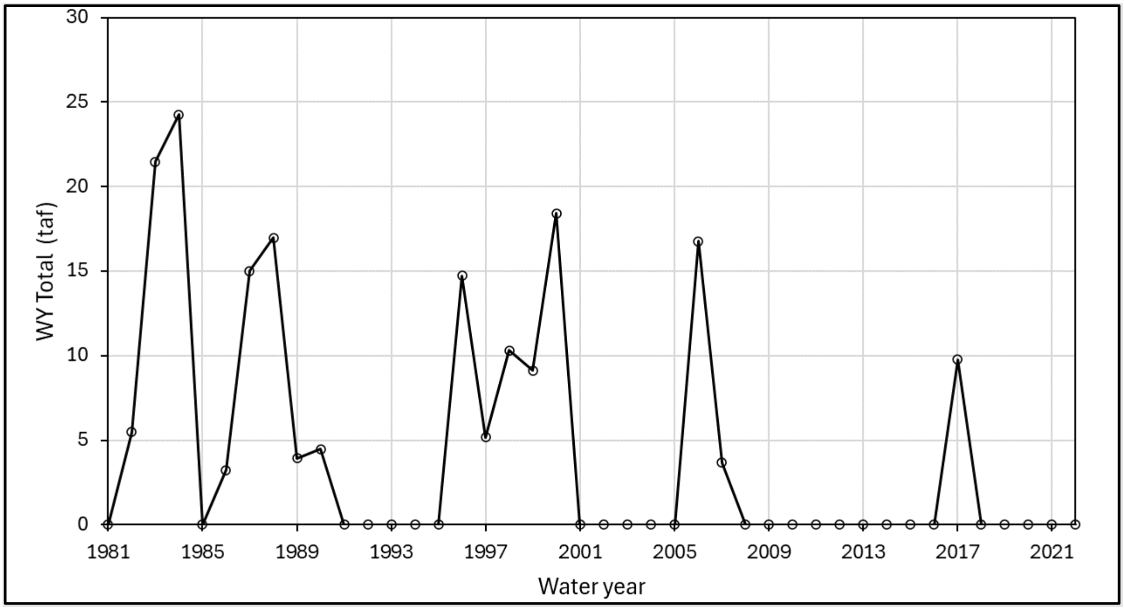


Figure 14. Flood control redistribution of Deferred Project Supply for Historical Wetland Habitat.

FFA Spill and Lower Klamath NWR

Any spill of FFA due to flood control is not available for diversion by the refuge or irrigators. Spill of FFA must result in flow to the Klamath River at Keno Dam. However, once FFA is exhausted, any UKL spill for flood control can be diverted at Ady Canal to the Lower Klamath NWR in priority with other uses at that time. Figure 15 shows water year UKL spills captured at Ady Canal and delivered to the Lower Klamath NWR as simulated in the KRM.

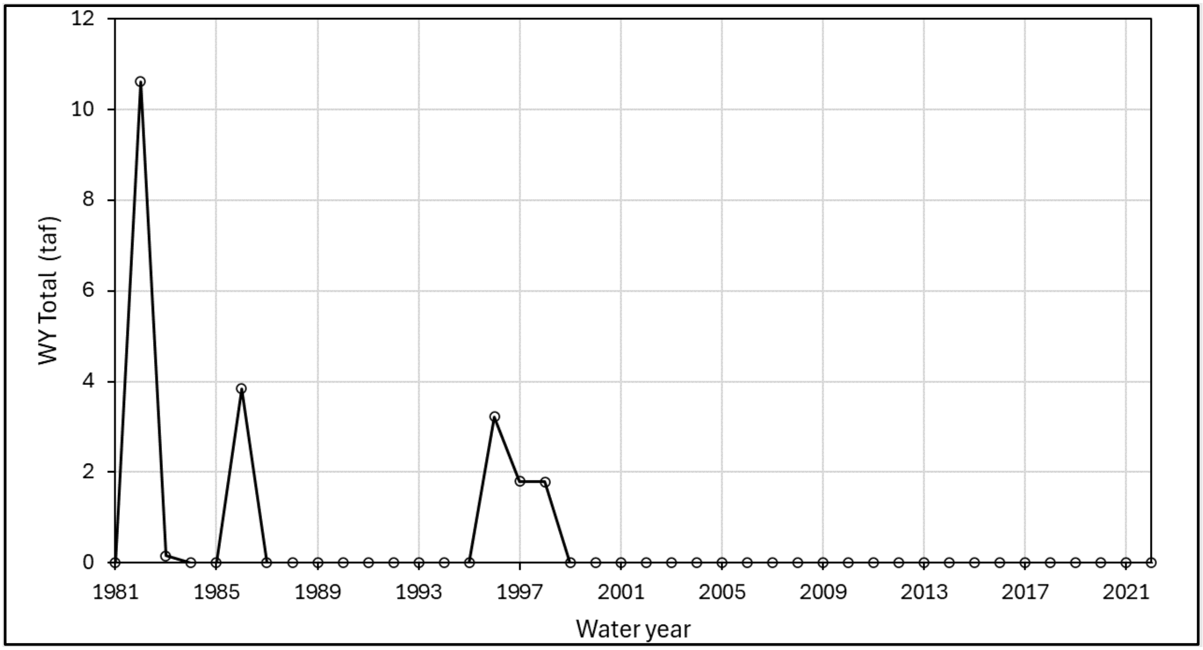


Figure 15. Lower Klamath NWR capture of UKL flood control releases after all FFA released to the Klamath River

1.3.3 Proposed Action vs. Interim Operation Plan Mass Balance Analysis

Comparing this proposed action to the IOP, both the annual average flow released at Keno Dam (former IGD under the IOP) and Klamath Project diversions of UKL water were reduced. This section explains, through mass balance over the POR on an annual average basis, where the water that was available in the IOP is going under the proposed action. Mass balance dictates that within a specified control volume and time frame:

Inflow – Outflow = Change in Storage

First, consider a control volume that includes UKL, the Keno Impoundment, and Wilson Reservoir. As in the KRM, assume no change in storage in the Keno Impoundment or Wilson Reservoir.

1.3.3.1 Inflows

In the proposed action and IOP, the modeled inflows into the defined control volume are:

1. UKL net inflow.
2. Lost River flow into Wilson Reservoir.
3. F/FF Pumping.
4. Keno Impoundment accretions (closure term).

Table 21 lists the water year change in inflows between the proposed action and the IOP. The last row of Table 21 lists the water year average change of each inflow over the POR. UKL net inflow is reduced by an average of 9.3 TAF due to the Agency-Barnes Lake reconnection. Lost

River flow into Wilson Reservoir is reduced by 8.0 TAF due to reduction in irrigation return flow resulting from reduction in A Canal diversion. F/FF Pumping is reduced by 37.5 TAF due to new assumptions regarding KDD returns to the KSD, reflecting recently increased capability to reuse water instead of returning it through F/FF pumps. Keno Impoundment accretions are reduced by 6.8 TAF because ungaged diversions are now part of the closure term (this means the Klamath Project will not have to reduce UKL Klamath Project supply by an additional 7 TAF under the proposed action as it was under the IOP).

Annual average change in inflow = –9.3 – 8.0 – 37.5 – 6.8 = –61.6 TAF

Table 21. Change in control volume inflows (TAF) compared to IOP.

Water Year	UKL Net Inflow	Lost River	F/FF Pumps	Keno Impoundment Accretions
1981	-10	-5	-35	-8
1982	-4	-13	-44	-6
1983	-9	-15	-53	-7
1984	-9	-11	-53	-7
1985	-17	-9	-60	-7
1986	-15	-16	-52	-8
1987	-16	-10	-44	-8
1988	-10	-6	-46	-6
1989	-9	-15	-59	-8
1990	-16	-3	-56	-7
1991	-17	1	-39	-8
1992	-4	0	7	-7
1993	-8	-11	-44	-16
1994	-14	-1	-25	-8
1995	-9	-11	-39	10
1996	-17	-8	-42	20
1997	-9	-11	-56	-8
1998	-17	-11	-59	-8
1999	-8	-2	-56	-11
2000	-28	-7	-54	-6
2001	-9	-12	-26	0
2002	-18	-12	-37	-12
2003	-11	-12	-12	-7
2004	-14	-8	-32	-8
2005	-10	-11	-55	-8
2006	-8	-6	-58	-17
2007	-6	-4	-59	-8
2008	-11	-12	-49	-7
2009	-11	-6	-46	-7
2010	-15	-13	-38	-8

Water Year	UKL Net Inflow	Lost River	F/FF Pumps	Keno Impoundment Accretions
2011	-14	-15	-59	-7
2012	-13	-7	-44	-7
2013	-3	-9	-37	-8
2014	-12	1	-2	-7
2015	3	-5	-29	-7
2016	-3	-12	-13	-8
2017	3	-12	-32	-7
2018	4	-8	-16	-7
2019	-1	-6	-48	-7
2020	-3	-3	-3	-8
2021	3	2	17	-7
2022	1	0	15	-8
Average	-9.3	-8.0	-37.5	-6.8

1.3.3.2 Outflows

In the proposed action and IOP, the modeled outflows into the defined control volume are:

1. Diversion to Klamath Project (AG).
2. Diversion to Tule Lake NWR (note this diversion was 0 TAF in the IOP).
3. Diversion to Lower Klamath NWR.
4. Keno Release.

Table 22 lists the water year change in outflows between the proposed action and the IOP. The last row of Table 22 lists the water year average change of each outflow over the POR. Diversion to the Klamath Project is reduced by 77.3 TAF on average. Diversion to Tule Lake NWR is increased by 64.8 TAF acknowledging that the IOP specified diversions to Tule Lake NWR was 0 TAF. Diversion to Lower Klamath NWR through Ady Canal was reduced by 0.5 TAF on average, and flow at Keno Dam was reduced by 46.3 TAF.

Annual average change in outflow = –77.3 + 64.8 – 0.5 – 46.3 = –59.3 TAF

Table 22. Change in control volume outflows (TAF) compared to IOP.

Water Year	Diversion to Project	Diversion to Tule Lake NWR	Diversion to Lower Klamath NWR	Flow at Keno Dam
1981	-99	58	-11	-27
1982	-96	111	4	-135
1983	-110	94	-3	-63
1984	-89	105	2	-9
1985	-79	47	-7	-91

Water Year	**Diversion to Project**	**Diversion to Tule Lake NWR**	**Diversion to Lower Klamath NWR**	**Flow at Keno Dam**
1986	-133	85	-8	-45
1987	-121	62	-11	-38
1988	-98	63	-6	-26
1989	-128	76	-4	-70
1990	-68	59	-4	-4
1991	-24	40	4	-49
1992	38	34	7	-7
1993	-91	73	5	-231
1994	-13	36	-1	42
1995	-87	73	6	-156
1996	-79	98	1	-37
1997	-109	85	-3	-19
1998	-93	113	5	-147
1999	-24	85	-2	-84
2000	-78	99	-5	-120
2001	-66	27	-16	-36
2002	-134	61	-4	-10
2003	-97	75	6	-19
2004	-87	54	6	5
2005	-119	66	4	-49
2006	-51	105	4	-193
2007	-63	55	-15	-59
2008	-123	68	-7	6
2009	-93	43	-2	-11
2010	-106	41	1	0
2011	-126	79	-4	-113
2012	-87	47	-1	-46
2013	-105	50	0	63
2014	4	35	7	7
2015	-83	38	-1	-62
2016	-114	53	8	-14
2017	-108	83	2	-1
2018	-81	60	-5	25
2019	-62	68	6	-137
2020	-29	42	7	-3
2021	40	41	8	26
2022	27	33	8	-7
Average	-77.3	64.8	-0.5	-46.3

Note that in the IOP, simulated irrigation season surface water diversions were not constrained by historical demand. This is not the case in this proposed action where SS diversions are not allowed to exceed demand. Post-processing the IOP surface water diversion results by capping them at historical demand reduces the IOP diversions by 18.6 TAF on an annual average basis. The reductions in diversion occur entirely in wet years and more accurately reflect the actual demand. The difference between the water year total proposed action diversion to the Klamath Project and the demand-capped IOP diversion to Klamath Project is -58.7 TAF, significantly less than the -77.3 TAF reduction reported above. However, the actual historical demand still shows that demand exceeded supply in drier years.

1.3.3.3 Yurok Tribe Boat Dance Ceremony

The Boat Dance is part of a traditional Yurok religious ceremony held to restore and renew the balance of the world. The ceremony, including the Boat Dance, is held in late summer on an annual basis and has been practiced on the river since time immemorial. In even-numbered years, the Boat Dance is supported by water released from UKL; in odd-numbered years, the Boat Dance is supported by water released from Trinity Reservoir at Lewiston Dam to the Trinity River. In the Boat Dance, Yurok religious practitioners dance in large hand carved redwood canoes and travel on the Klamath River within the Yurok Reservation. To safely conduct the ceremony, it is necessary to have sufficient flows in the river to provide predictable currents and a water depth that allows for the canoes to pass over a riffle. If the Boat Dance cannot take place, the Tribe’s world renewal ceremony cannot be completed. Reclamation would increase water releases from LRD to the lower Klamath River to support the Boat Dance. In the past, 7 TAF has been used to support this event. The bi-annual Yurok Tribal Boat Dance flows are anticipated to serve as environmental cues for early returning coho salmon adults and parr coho salmon and enhance passage opportunities. Reclamation will determine the timing and quantity of Boat Dance flows in consultation with the Yurok Tribe.

1.3.3.4 Change in Storage

UKL starts with the same storage in the proposed action as in the IOP. Between October 1, 1990 and September 30, 2022 (the end of water year 2022), the cumulative difference in storage between the proposed action and the IOP is -96.5 TAF. Divide -96.5 by 42 years (number of water years in the POR) to get the annual average change in storage: -2.3 TAF. This accounts for the difference between the water year average change in inflow (-61.6 TAF) and the water year average change in outflow (-59.3 TAF).

1.3.4 Compliance Monitoring

Reclamation will monitor flows daily at LRD, Keno Dam, Clear Lake Reservoir, Gerber Reservoir, and all major diversion points (A Canal, Station 48, Miller Hill, North Canal, and Ady Canal). Reclamation will also continue monitoring at other locations necessary to effectively manage the Klamath Project, such as the LRDC, pumping plants E/EE and F/FF, and Harpold Dam. Reclamation will also continue to fund USGS gages at Sprague River, Williamson River, UKL, LRD, Keno Dam, and other locations within the Klamath Project area. Reclamation will also work with USGS, Oregon Water Resources Department (OWRD), NMFS, and USFWS to identify other locations necessary to effectively administer the Klamath Project.

In addition, Reclamation will closely coordinate with agricultural or other diverters to anticipate and adjust for any significant changes in diversions that could affect releases from Keno Dam to the Klamath River.

If in the course of monitoring these various hydrologic gaging stations, or through coordination with the Services, it becomes apparent that flows are not in compliance with the modelled outcomes in the proposed action, Reclamation will immediately take steps to adjust operations to bring them back in compliance. Any volumetric difference in prescriptive flows will be assessed and remedied through an equal release as soon as practicable.

1.3.5 Special Studies

Special studies address areas of scientific uncertainty on the reasonable balance among competing demands for water, including the requirements of fish, wildlife, and agriculture. While special studies do not avoid, minimize, or mitigate adverse effects on federally-listed species, over time they may inform the effectiveness of measures taken to avoid, minimize, or mitigate incidental take. The criteria for identification of a special study in the proposed action balances uncertainty and flexibility. Reclamation would not rely on uncertain outcomes from a study but may require incidental take to conduct the study. Reclamation may from time to time modify and refine the special studies listed below in collaboration with the Services.

1.3.5.1 Klamath River Basin Natural Flow Study

In the early 2000s, Klamath Basin Area Office (KBAO) partnered with the Reclamation's Technical Service Center (TSC) located in Denver, Colorado, to produce a study to estimate the natural flow of the Klamath River at the Keno Dam location. Only the effects of agriculture development were accounted for to produce the document titled *Natural Flow of the Upper Klamath River* (Reclamation 2005).

The 2005 document underwent internal review by Reclamation and external review by the National Research Council (NRC) in 2008. The NRC comments focused on issues with the 2005 study monthly time step, effects of groundwater use, and the issue that only agricultural changes to the Upper Klamath Basin were addressed. Other landscape scale changes to the Klamath Basin were not accounted for.

In 2020, KBAO decided to revise and improve the 2005 document by incorporating the NRC recommendations and using the latest available technology/data to produce an updated document. The TSC is providing the support and resources to produce this revised and updated Natural Flow Study with an anticipated final publication in 2025. The main goals/motivation to produce the revised study were:

- Contribute to the Klamath Basin Science Initiative.
- Provide rigorous scientific information to support habitat studies, drought planning, and water supply/allocation planning.
- Address deficiencies in the 2005 study outlined by the NRC.

The revised Natural Flow Study document that is currently being developed by the TSC is taking a comprehensive, unified approach that relies on a partnership with the Desert Research Institute and USGS, collaboration with NMFS, USFWS, and OWRD, and engagement with local stakeholders. The study evaluates natural streamflow within the Klamath River Basin, which includes 11 watersheds and over 10 million acres in southern Oregon and Northern California. The updated Natural Flow Study is relying on best science practices to provide essential information to develop near-term and long-term solutions for the Klamath River Basin.

1.3.5.2 Updated Bathymetry Inflow/Storage Study

Concerns were raised about bathymetric data availability for UKL—field surveys showed water depths that were significantly different from data generated as part of those bathymetric survey efforts. Due to these concerns and given the importance of accurate elevation-area-volume relationships for UKL planning efforts, Reclamation developed a new bathymetric surface for UKL, including Agency Lake, in early 2023. The new bathymetry was developed by combining Light Detection and Ranging (LiDAR) data, collected in late 2020, for the upland areas around UKL with data collected by boat during a bathymetric (underwater) survey of the wetted UKL area in November 2020, April 2021, and October 2022. Additional details regarding the UKL bathymetric survey can be found in the *Upper Klamath Lake 2020-2022 Sedimentation Survey Report* (Reclamation 2023).

This new bathymetry was used to develop new area-capacity tables for UKL and to recompute UKL inflows for the POR. The recomputed UKL inflows were used for the proposed action modeling and to reconstruct the historical NRCS inflow forecasts.

1.3.6 Monitoring Studies

Reclamation will continue to support research and monitoring projects that inform managers on the status of ESA-listed species populations as appropriated funds allow. These studies will inform stakeholder technical working groups such as the Adaptive Management Team (Section 1.3.9 *Adaptive Management*). Each effort will be used to evaluate the impact the Klamath Project on listed species including estimating incidental take, but also represent research that advances understanding of the species needs.

1.3.7 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 Klamath Project. During the FW period, Reclamation coordinates directly with KDD and USFWS regarding Klamath Project water availability and demands (for both NWR and irrigation purposes). Reclamation does not make public announcement of the volume of water available during the FW period for delivery to the Klamath Project, including Lower Klamath NWR.

Near the beginning of the SS irrigation season, Reclamation issues an annual Operations Plan, which identifies the anticipated volume of water available from the various sources used by the Klamath 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 Klamath 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 Langell Valley Irrigation District, Horsefly Irrigation District, 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 Klamath Project. If the volume of water or the timing when it is available is less than the anticipated demands of the repayment districts (KID and TID), Reclamation may determine it necessary to issue an Annual 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 Klamath Project water. The Annual Drought Plan is posted on Reclamation's website, a press release is issued, and affected Klamath Project water users are provided a copy and notified by letter of the volume of water available under their respective contract.

The Annual Drought Plan will identify an initial allocation from UKL and the Klamath River for entities and individuals by order of contractual priority. 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 staff attends district board meetings, calls contractors by telephone, and answers direct inquiries related to the Annual Drought Plan allocation.

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

Consistent with Reclamation policy, Reclamation may administratively approve the transfer of water between districts and individual water users within the Klamath Project. Such transfers do not increase the amount of water available to the Klamath Project or expand the Klamath Project's service area but rather simply temporarily change the place of use within the Klamath 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 Klamath Project water. Overall, these types of transfers promote the efficient and economical use of water.

Internal Klamath Project transfers are also available for irrigable lands within Lower Klamath and Tule Lake NWRs, subject to the approval of USFWS. Water made available to an 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.

Reclamation may also engage in irrigation demand reduction activities within the Klamath Project. Similar 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 Klamath Project water or to pump supplemental groundwater.

1.3.8 Conservation Measures

Conservation measures will be taken by the Federal agency or applicant, and serve to minimize or compensate for, Klamath Project effects on the species under review. These may include actions taken prior to the initiation of consultation, or actions which the Federal agency or applicant have committed to complete in a biological assessment or similar document. The following proposed conservation measures would 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 (2) avoiding actions that jeopardize the continued existence of listed species.

1. Fish salvage at Klamath Project canals occurs when canals are: (1) temporarily dewatered for a discrete action related to maintenance and/or repairs at Klamath Project facilities inclusive of canals, canal banks, levees, levee roads, water control structures, and drain features (Reclamation 2024a; Reclamation 2024b) and (2) when canal systems are dewatered at the end of each irrigation season. Under both circumstances fish are salvaged from pools where they are stranded. Reclamation proposes, in coordination with both Services, to continue the Klamath salvage of suckers and salmon species both during routine maintenance and repair at Project structures and at conclusion of the irrigation season when Klamath Project canals, laterals, and drains are dewatered consistent with past salvage efforts since 2005 as some canals do not seasonally dewater.
2. Reclamation proposes to continue support of a captive rearing effort by the USFWS for LRS and SNS. The intention is to improve the numbers of suckers reaching maturity in UKL. Ultimately, a captive rearing program's function would be to promote survival and recovery of the sucker populations that suffer losses from entrainment due to the Project or other threats. Captive propagation is already an important part of listed fish recovery efforts nationwide, including at least three sucker species (i.e., June sucker, razorback sucker, and robust redhorse sucker).

1.3.9 Adaptive Management

Reclamation (2024a) describes the use of an adaptive management process during implementation of the proposed action in an effort to collaborate and provide transparency with Klamath Basin stakeholders. To that end, Reclamation has initiated, and will continue to support through the duration of the proposed action and beyond, adaptive management that meets the long-term management, research, and monitoring needs of the Klamath Basin. Reclamation envisions continuing stakeholder conversations initiated in 2023 with both a management/policy group and a technical group—collectively, the Adaptive Management Team—that represents the multiple entities and interests in the Klamath Basin, supported by facilitation.

In an addendum to the BA, Reclamation (2024b) describes their intent to implement a structured decision making (SDM) framework to establish a formal, transparent, and collaborative process to develop quantifiable and measurable objectives and determine the best alternatives to meet those objectives using quantitative models. KBAO intends to utilize SDM as the process to transparently and collaboratively gather and analyze data associated with implementation of the proposed action. Further, Reclamation intends to adaptively manage those actions through a combination of evaluating current and future data and external expertise to support SDM.

1.3.10 Inter-Seasonal and Intra-Seasonal Management

While the adaptive management program addresses the long-term science and management needs of the Klamath Basin, there remains a need for transparent communication and collaboration with regard to short- and long-term seasonal operation of the Project to ensure consistency with the anticipated outcomes of the proposed action. Therefore, Reclamation has created a technical team to speak to specific needs such as the RTO team (formerly known as the

FASTA team) and if needed will convene a longer-term Water Year Operations team (WYOps) (formerly known as the Klamath Project Operations (KPO) team).

The RTO will support seasonal (with a forward-looking time horizon of roughly 30 days to the end of the Water Year horizon) water management operations through regular engagement with Reclamation on hydrologic conditions and flow management. This team will fill a similar role to the previous FASTA team, meeting as often as weekly during critical time periods to offer technical input to Reclamation staff. This team will attempt balanced representation in the Klamath Basin, consisting of technical representatives from Klamath Basin Tribes, Klamath Water Users Association, federal and state agencies, and other groups with appropriate and relevant expertise. Among other tasks, the RTO will work with Reclamation to support decisions around release distribution of the FFA, allocation of historical wetland habitat water to the Deferred Project Supply, and drought-related water shortage planning.

If the RTO is inadequate to address the longer-term planning needs required by the Opinion, Reclamation will convene the WYOps to meet this need. The WYOps will support long term seasonal (with a focus on forward-looking time horizon of roughly six months) water management operations, also through regular engagement with Reclamation on hydrologic conditions and flow management. With similar representation as the RTO, the WYOps will work with Reclamation to focus on optimizing the Klamath Project's ability to successfully transition from the current season into the next water year.

1.3.11 Fish Passage at Keno Dam

Reclamation and ODFW are addressing items related to fish passage at Keno Dam via a multi-agency and stakeholder working group (aka- working group) to prioritize short- and long-term fish passage improvements at Keno Dam. The Keno Dam fish ladder was constructed in 1968 and now requires maintenance, repairs, and upgrades for optimal operation. The working group will utilize the Keno Dam Fish Passage Facility Memo (ODFW 2023) as a basis for development, design, and implementation of fish passage improvements. Reclamation anticipates fish passage improvements will begin in 2024/2025 with the minor modifications to the fish ladder. The more complex, high priority improvements are scheduled to begin in 2025. Implementation of action items will be based on the long-term plans and operational procedures of Keno Dam. Reclamation (2024b) describes a multi-entity working group that evaluates and implements fish passage improvement and operational measures, such as:

- Convene a working group to identify data needs and fish passage methodologies, evaluate and prioritize passage requirements, review engineered design sets, and assist with regulatory requirements for improvements.
- Review the Keno Dam Fish Passage Facility Memo (ODFW 2023) and determine feasibility of the short-term and long-term actions to improve fish passage and operations of facilities.
- Address minor repairs and modifications of the fish ladder (e.g., installation of monitoring equipment, repair cracked and eroding concrete, cut larger fish openings between cells, add catwalks and railings, remove former fish trap.). Consider, plan, and design other improvements (e.g., redesign of flow adjustment gates, alteration to attraction flows, modification to dam gate).

- Monitor and evaluate effectiveness of fish passage improvements to inform and update a prioritized list of improvements for dam operation.

Reclamation (2024a) describes minimization measures associated with work at the Keno Dam and fish ladder site. These minimization measures include:

- The fish ladder will be dewatered during site evaluations, repairs, or modifications, primarily occurring outside of fish migration periods, and in accordance with ODFW's in-water work guidelines (e.g., July 1 through September 30 below Keno Dam and July 1 through January 31 above Keno Dam).
- Any fish encountered during dewatering of the ladder will be recorded (species, length, and weight) and moved upstream of the dam if water temperature allows.
- When water temperatures >17° C all fish will be released immediately downstream of the dam and handling will be minimized.
- During site evaluations and construction activities, dust abatement and sediment catchment measures will be employed to capture excess material, and materials will be disposed off-site when activity is complete.
- All vehicles and equipment will be kept on established access routes, with on-site and easily accessible spill prevention kits during evaluations, repairs, and modifications.
- During on-site activities, construction personnel will be accompanied by fish biologists or trained on fish handling and release procedures.

Reclamation does not anticipate encountering any coho salmon during evaluation, repair, or modification activities at Keno Dam. Historically, coho salmon were found in the mainstem Klamath River up to Spencer Creek, and it was presumed they spawned in Spencer Creek. Coho salmon were not known to occupy habitats above Spencer Creek, which is 5.8 miles downstream of Keno Dam, and therefore occurrence at Keno Dam would be extremely rare. Therefore, Reclamation does not anticipate handling any adult or juvenile coho salmon at Keno Dam. Any coho salmon found during repair and/or maintenance of Keno Dam or its fish ladder will be immediately released downstream of Keno Dam. If coho salmon are found during operations, maintenance, or monitoring of Keno Dam, NMFS and ODFW will be notified. If possible, the construction activity will be postponed until after conversations with NMFS and ODFW.

1.3.12 Fish Screen Technical Assistance

Reclamation is evaluating fish screen needs and deterrent or avoidance measures for Klamath Project diversions to reduce or alleviate fish entrainment in irrigation canals. Reclamation and ODFW will convene a multi-agency and stakeholder working group to assess, prioritize, and select the best screening alternatives for each diversion site. The working group will build off the agency and stakeholder produced, prioritized fish screen assessment, titled, *Klamath Reservoir Reach Restoration Prioritization Plan* (O'Keefe et al. 2022), where over 50 unscreened irrigation diversions were evaluated along the Klamath River above the former IGD. The project will evaluate fish screens and/or non-structural fish barriers (bubblers, sound, light, etc.), develop designs given site conditions, and construct/install screens. Reclamation envisions the multi-entity working group to evaluate and implement entrainment reduction measures, such as:

- Convene the working group to identify data needs and screening methodologies, review and prioritize screen types and sites, review engineered design sets, and assist with regulatory requirements for improvements.
- Work with landowners and engineers to design site-specific fish entrainment reduction measures that could include structural and non-structural solutions.
- Conduct site evaluations, inclusive of cultural resources, to select appropriate sites and develop the designs.
- Finalize designs and complete environmental compliance documentation for the fish screens currently in the planning stage.

In their addendum (Reclamation 2024b), Reclamation describes minimization measures that will reduce impacts to fish as a result of fish screen evaluations. These measures include:

- All work will avoid any streambank disturbance and/or work in open water (stream or wetlands),
- Wetland habitats and/or wetland vegetation will be mapped during site investigations and activities will minimize disturbance to these habitats,
- Barriers to sediment transport (e.g., silt fencing and straw wattles) will be used to reduce sedimentation to waterbodies from site investigations, and
- All vehicles and equipment will remain on established access routes, spill prevention kits will be on-site and easily accessible during any ground disturbing site investigations.

Reclamation does not expect any disturbance of fish species or their habitats during the site visits and/or investigations for fish screens. The site evaluations, soil testing, and other minor disturbance activities will not affect fish species, or their habitats, given the minimization measures for these activities. Effects to terrestrial animals and plants are anticipated to be minimal and of short duration.

We considered, under the ESA, whether the proposed action would cause any other activities not described herein and determined that it would not cause additional activities.

2 ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

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

Reclamation determined the proposed action is not likely to adversely affect both the Southern DPS green sturgeon and the Southern DPS eulachon or critical habitat for the Southern DPS eulachon (Reclamation 2024a). Our concurrence and determination is documented in Section 2.9 *Not Likely to Adversely Affect Determinations*. Therefore, an ITS for these species is unnecessary.

2.1 Analytical Approach

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

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 SRKWs, which focuses on effects of the proposed action on Klamath River Chinook salmon, which are a preferred prey for SRKWs. Later in this Opinion, we analyze the effects of the proposed action on SRKWs, including additional elements specific to our analysis of SRKWs such as the importance of Klamath River Chinook salmon to the available prey base of SRKWs and the magnitude of effects from the proposed action on Chinook salmon survival to ocean entry.

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

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

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

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

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

2.1.1 Overview of NMFS' Assessment Framework

While the 2024 BA includes sufficient information to reinitiate formal consultation, we, after considering the information Reclamation provided in the BA, will develop the environmental baseline and analysis of the effects of the proposed action on proposed and listed threatened and endangered species and their designated critical habitat.

NMFS uses a series of sequential analyses to assess the effects of proposed 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 additive 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 DPSs[5] of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (that is, the probability of extinction or probability of persistence) of listed species depends on the viability of the populations that comprise the species. Similarly, the continued existence of populations is determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so).

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

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

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[5] The ESA of 1973, as amended, 16 U.S.C. 1531 et seq. defines "species" to include any DPS of any species of vertebrate fish or wildlife which interbreeds when mature." To identify DPSs of salmon species, NMFS follows the "Policy on Applying the Definition of Species under the ESA to Pacific Salmon" (56 FR 58612, November 20, 1991). Under this policy, a group of Pacific salmon is considered a DPS and hence a "species" under the ESA if it represents an ESU of the biological species.

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 et al. 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 16). 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. 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. These viability parameters are described in greater detail in the following section. 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.

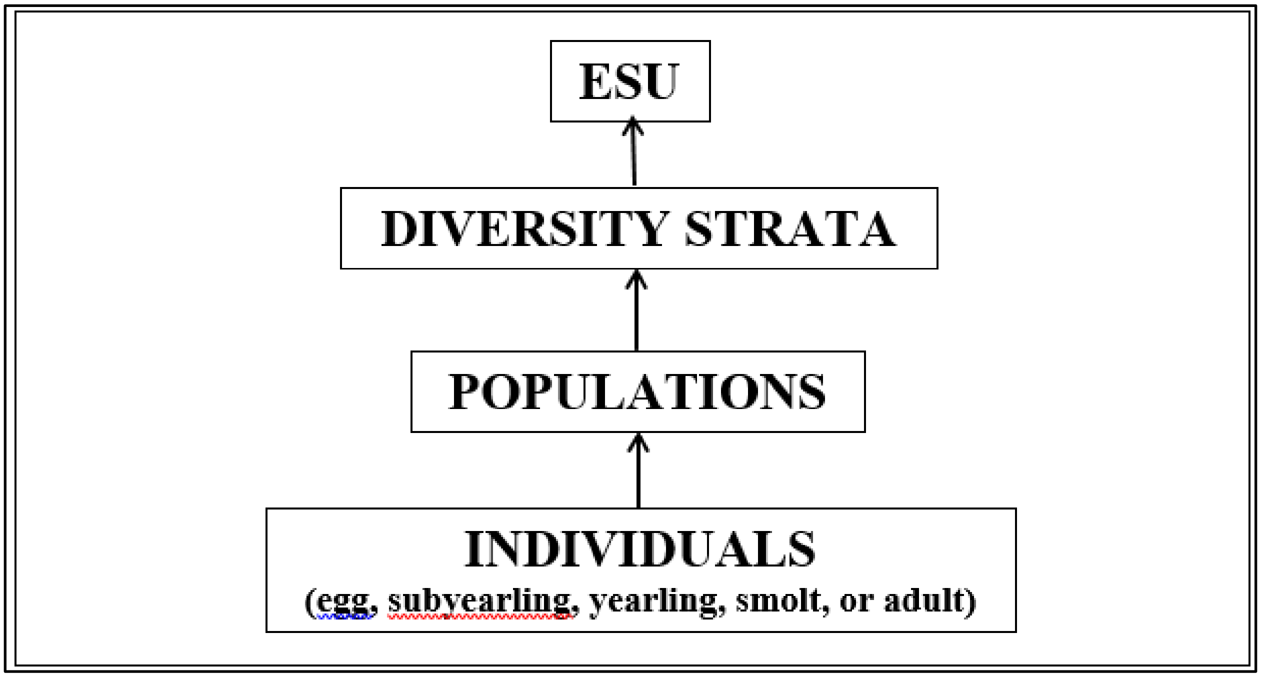

Figure 16. Conceptual model of the hierarchical structure that is used to organize the jeopardy risk assessment for the SONCC coho salmon ESU.

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: (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 et al. 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 et al. 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.

2.1.1.4 Hydrologic Data used to Analyze the Proposed Action

When conducting analyses of the effects of proposed flow regimes, NMFS often looks to natural or unimpaired conditions as a guide to conditions associated with self-sustaining and self-regulating populations. Where used, these conditions serve as an important reference point for gauging the effects of projects on the species' ability to survive in the current ecosystem. Similarly, throughout this Opinion, NMFS uses the concept of a natural flow regime to guide our analysis of 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).

As the basis for our conclusions in this Opinion regarding hydrologic effects of the proposed action, NMFS considers the effects of the proposed action in relation to the Klamath River natural flow regime. NMFS recognizes that environmental and human-caused factors have influenced the Klamath River natural flow regime over time, including the effects of past and present Klamath Project operations, as well as factors other than the Klamath Project operations (e.g., climate change, increased municipal water use, off-Project water use).

Variability of the natural flow regime is inherently critical to ecosystem function and native biodiversity (Poff et al. 1997; Puckridge et al. 1998; Bunn et al. 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; 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 et al. 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 (Waples et al. 2001). For the current consultation effort (as described in the proposed action above), Reclamation has incorporated recent hydrologic data to expand the POR from 2016 through 2022 (i.e., 1981 to 2022). Although the KBPM (KRM version) used to develop the proposed action simulates conditions since 1981, daily and monthly exceedances for UKL elevations and Klamath River flows are computed using the 1991 to 2022 period. This 30-year period represents best available science, and is most representative of the expected hydrologic conditions during the term of the proposed action. The more recent POR (1991 to 2022) is also more consistent with other climatological data, such as the NWS climate normal, and acknowledges that over the last 40 years, decade-by-decade inflows have decreased (Figure 1). Using the data set through 2022 captures the drought period that occurred during water years 2020 to 2022.

Reclamation also has incorporated numerous data updates and refinements in the KBPM (KRM version), including: revised accretions and UKL inflow datasets, a new UKL bathymetric layer, updated UKL net inflow estimates for the POR, and updated daily Klamath Project diversion data and return flows for the POR. Project operations using facilities that store and divert water from UKL, the Klamath River, and the Lost River were simulated in the KBPM over a wide range of hydrologic conditions for the period of October 1, 1980, through November 30, 2022, using daily hydrologic input data to obtain daily, weekly, monthly, and annual results for river flows, UKL elevations, and Klamath Project diversions, including deliveries to the Lower Klamath and Tule Lake NWR's. The resulting simulations produced daily flow results from Keno Dam (as measured at the USGS gage below Keno Dam, Station ID#11509500) for the KBPM's (KRM version) formulaic approach based on the Operations Index, as described in the proposed action. Daily IGD flow results (as measured at the USGS gage at the former IGD, Station ID#11516530) were also produced as an output of the KRM simulations. These simulated daily IGD flow results are expected to be observed at the Iron Gate USGS gage under the proposed action as a result of daily releases from Keno Dam, plus tributary flows (estimated from historical data) between Keno Dam and Iron Gate USGS gage. NMFS' effects analyses focus on the daily IGD flow results in this Opinion (although Keno Dam is the compliance point) because the flows at Iron Gate represent an important reference point for understanding exposure to anadromous salmonids and is the upstream extent of critical habitat for SONCC coho salmon. Additionally, NMFS utilizes the best available science on flow/habitat relationships for which to evaluate the effects of the proposed action, which was developed for the reaches downstream of IGD. For the purposes of our analyses in this Opinion, the modeled daily flow results at the former IGD site will be referred to as 'Iron Gate flows'. Under implementation of the proposed action, Reclamation will develop an operational model that incorporates KBPM logic from the final proposed action model run viewer titled 'Viewer_v11d for MST11b_DraftPA_Jan26' to be used for real-time operations. The model viewer contains two studies: MST11b_DraftPA_Jan26 and MST11b_DraftPA_PFoff_Jan26. The two studies are identical in rules, parameter settings, and results; however, one model study releases the FFA in form of a pulse flow, and the other releases the FFA evenly over a longer period of time in the spring/summer (i.e., March 2 to June 30).

Reclamation's KBPM (KRM version) and resulting output files used to analyze Klamath Project effects in the 2024 BA include analyses of the 1981 to 2022 POR under multiple scenarios (Reclamation 2024b) and an alternative model run of the 1981 to 2022 POR applying all of the rules associated with the proposed action. The resulting model outputs reflect what the hydrological conditions (i.e., UKL elevations, Keno Release Targets, Project deliveries) would have been if Klamath Project operations had been managed under the proposed action from 1981 through 2022. However, as stated above, for purposes of the effects analyses, NMFS will analyze the daily Klamath River flows at Keno Dam and Iron Gate, and monthly exceedances computed using the 1991 to 2022 POR. Technical experts for Reclamation, USFWS, and NMFS agreed that the more recent 30-year period (1991 to 2022) is best available science and most representative of current (and likely future) climatologic and hydrologic conditions in the Klamath River Basin during the term of the proposed action, and thus, a more appropriate POR to use for our analyses.

In the BA, Reclamation offered two alternative water balance modeling scenarios (i.e., Flow Through or Run of River (ROR) and Maximum Storage (MS) scenarios) to inform the effects of Reclamation's discretionary actions. The details and assumptions included in the alternative model runs are described in Section 4, Seasonal Operations of Reclamation's (2024a) BA. Reclamation clarified that neither of the scenarios were intended to constitute the environmental baseline itself, but were offered as analytical tools. In summary, Reclamation provided the ROR scenario to represent conditions without the storage of water where all inflows into Klamath reservoirs are passed downstream, physical flow control structures are not actively operated and remain in an "open" configuration, and no diversions to the Klamath Project would occur. In contrast, Reclamation presents the MS scenario to represent conditions that would exist without the release of water where Klamath reservoirs would maximize storage and make releases only when required for flood control or other settlement contractor obligations. Similar to the ROR scenario, no diversions to the Klamath Project would occur.

NMFS considered these scenarios and finds that the alternative runs rely upon unrealistic assumptions that confound the results of the model runs. Furthermore, these hypothetical operational scenarios are unlikely to occur and are not actions Reclamation is proposing to operate to at this time. NMFS is therefore skeptical about the reliability of these scenarios and their grounding in the best scientific and commercial information available. Accordingly, we did not rely on them in our analysis. Instead, we relied upon a more general approach to the effects of Reclamation's discretionary actions. The Klamath Project operations under the proposed action would have consumed an annual median value of approximately 260,000 AF from all surface water sources over the 1991 to 2022 POR. We recognize that the effects of this net reduction of water to the Klamath River will vary widely, but NMFS expects the effects will result in an annual hydrograph that diverges from the natural flow regime, which is affected by the environmental baseline.

2.1.1.5 Effects Analysis for the SRKW DPS

The SRKW effects analysis is based on potential reductions to the SRKW prey base, an important PBF of SRKW critical habitat. Chinook salmon, which are not listed under the ESA in the Klamath River Basin, are the preferred prey of SRKW. Thus, an accompanying analysis of impacts to Klamath Chinook salmon will be performed using an analytical approach similar to that for listed fishes to support assessment of effects on the SRKW prey base PBF. This analysis of effects to SRKW relies on the expected impacts of the proposed action on the abundance and availability of Chinook salmon for prey and how any expected changes in prey availability will affect the fitness, and ultimately the abundance, reproduction, and distribution, of SRKW. Given the similar nature of these effects' pathways relative to the prey PBF for SRKW critical habitat, the analysis of the proposed action's effects on the value of SRKW critical habitat as a whole relies heavily on the effects analysis of the impacts of the proposed action on the abundance and availability of Chinook salmon as SRKW prey.

2.1.2 Flow and Rearing Habitat Analysis

In general, the best available science for analyzing the effects of this proposed action is the same best available science that was used in NMFS' 2019 biological opinion. Although that science reflects pre-dam removal conditions it generally remains valid and applicable until new science becomes available considering post-dam removal conditions and is foundational to our effects analyses again in this Opinion. Where new science is available, we incorporate it into this Opinion. NMFS acknowledges that dam removal has likely resulted in changes to river channel (stream) morphology, sediment composition, mobilization and transport processes, flow-habitat relationships, water quality conditions (e.g., temperature, DO, pH), and disease dynamics below Iron Gate. However, the extent of these changes will remain somewhat unknown until additional data can be collected, analyzed, and new science developed. For the purposes of our analysis we do make and identify some assumptions about the expected changes based on science that was used to analyze the anticipated effects of dam removal and science gathered post dam removal in other river systems. In some cases, new science is available for the Klamath River (e.g., short term monitoring of disease and water quality) and we incorporate that into this Opinion. A detailed list of the main resources representing best available science that NMFS considered in this Opinion can be found below in Section 2.1.3 *Evidence Available for the Consultation*.

NMFS used the relationships of flow and habitat formulated by Hardy (2012) and Hardy et al. (2006) to describe how the relationship between juvenile coho salmon habitats vary with water discharge in the mainstem Klamath River below Iron Gate. Although a quantitative analysis cannot be performed using the same model, NMFS relies on the relationships described in Hardy (2012) to make inferences about habitat availability both upstream and downstream of Iron Gate. Reclamation's BA (2024a) provided updated modeling utilizing different study sites than previously modeled (Hardy 2012) and combined both fry and parr habitat. The new sites were originally selected for the sole purpose of annelid habitat modeling and do not necessarily characterize juvenile coho habitat in general (Som 2024). Therefore, NMFS uses the new information to describe only general relationships and does not provide quantitative conclusions. The use of these studies represents the best available science at this time.

As in previous opinions (NMFS and USFWS 2013; NMFS 2021a) NMFS expects that at least 80% of maximum available habitat provides for the conservation needs of coho salmon, and flows that provide at least 80% 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% of maximum available habitat for each reach. Instream maximum available habitat of 80% 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% 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% 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 Weighted Usable Area (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.

2.1.3 Evidence Available for the Consultation

To conduct these analyses, NMFS considered all relevant information available through published and unpublished sources that represent evidence of 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)).
- Synthesis of Continuous Water Quality Data for the Lower and Middle Klamath River, 2001 to 2011 (Asarian et al. 2013).
- Simulating Post-Dam Removal Effects of Hatchery Operations and Disease on Juvenile Chinook Salmon *(Oncorhynchus tshawytscha)* Production in the Lower Klamath River, California (USGS 2022b).
- Technical Memorandum. Revised coho fry habitat versus discharge relationships for the Klamath River (Hardy 2012).
- Evaluation of Flow Needs in the Klamath River Phase II. Final Report (Hardy et al. 2006).
- 2019 USGS memo updating weighted usable area curves for Klamath River coho salmon (USGS 2019).
- Using the Stream Salmonid Simulator (S3) to Assess Juvenile Chinook Salmon Production in the Klamath River under Historical and Proposed Action Flows (Plumb et al. 2019) .
- Simulating post-dam removal effects of hatchery operations and disease on juvenile Chinook salmon production in the Lower Klamath River (Perry et al. 2023).
- Final rule designating critical habitat for the SONCC coho salmon ESU (64 FR 24049 (May 5, 1999).
- The SONCC coho salmon recovery plan (NMFS 2014b).
- NMFS' 2010 biological opinion on the Klamath Project (NMFS 2010b).
- NMFS and USFWS joint (2013) biological opinion on the Klamath Project.
- NMFS (2019c) biological opinion on the Klamath Project.
- NMFS (2021a) biological opinion on the Surrender and Decommissioning of the Lower Klamath Hydroelectric Project (Klamath Dam Removal).
- (NMFS 2023b) SONCC coho salmon viability assessment.
- The most recent NMFS five-year status review for SONCC coho salmon (NMFS 2016a).
- The NRC's assessment of Klamath River Basin fishes and hydrology (NRC 2008).
- USFWS technical memorandum addressing prevalence of *C. shasta* infections in salmonids (USFWS 2016a).
- USFWS technical memorandum addressing polychaete (annelid worm) distribution and infection (USFWS 2016b).

- USFWS technical memorandum addressing *Ceratanova shasta* (C. shasta) waterborne spore stages (USFWS 2016c).
- USFWS technical memorandum addressing Sediment Mobilization and Flow History in Klamath River below IGD (USFWS 2016d).
- Measures to Reduce *Ceratanova Shasta* Infection of Klamath River Salmonids. A Guidance Document (Hillemeier et al. 2017).
- Deconstructing dams and disease: predictions for salmon disease risk following Klamath River dam removals (Bartholomew et al. 2023).
- Final rule listing the SRKW DPS as endangered (70 FR 69903 (November 18, 2005)).
- The recovery plan for SRKWs (NMFS 2008c).
- The most recent five-year status review for SRKWs (NMFS 2021d).

2.1.4 Critical Assumptions

NMFS relies on a number of critical assumptions to both clarify uncertainties in the proposed action and to complete the effects analysis using best available science, despite a rapidly changing environmental baseline, post dam removal. The quantitative and qualitative analyses in this Opinion are based upon the best available commercial and scientific data on species biology, the physical and biological features of critical habitat, and the effects of the action. Where data are limited or equivocal, we have occasionally needed to make reasonable determinations based upon our best professional judgment to bridge the gap in the available data. Sometimes, the best available information may include a range of values for various habitat parameters (e.g., habitat availability, volume of flow) necessary to support ESA listed species. In all instances the approach to our analysis is explained, including how uncertainty, causation, and the choice among a range of values are evaluated and addressed.

To address the uncertainties related to the proposed action's effects and species responses, NMFS relied on a set of key assumptions that are essential to our analysis of the effects of the proposed action 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 our analysis of the effects of the proposed action. If new information later indicates an assumption listed below (or in other sections of the Opinion) is invalid, reinitiation of consultation may be necessary (50 CFR 402.16).

Changing Baseline Conditions – Extent of SONCC Coho and Chinook salmon Range

As previously discussed, dams and other facilities at four developments (J.C. Boyle, Copco No. 1, Copco No. 2, and Iron Gate) were recently removed on the Klamath River. Restoration activities have also been undertaken in association with the dam removal project[6]. Our

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[6] For that project, NMFS (2021a) issued a Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response ("for the Surrender and Decommissioning of the Lower Klamath Hydroelectric Project No. 14803-001, Klamath County, Oregon and Siskiyou County, California"), which evaluated effects on ESA-listed species and their critical habitat. The effects of that action were described in that biological opinion and are reflected in the environmental baseline for this action. It is important to note, as explained above, however, that our understanding of the potential future effects of that action is still evolving.

understanding of the future effects of this action is at a landscape scale, considering broad ecological patterns, and is still evolving. Due to the dynamic nature of the environment, we lack the data to understand exactly how conditions will change over the next five years. While more data and studies are needed to fully understand future conditions, these efforts will take time. Therefore, for the current analysis, we are making informed assumptions based on available information until further research is conducted and data becomes available.

For the purposes of this Opinion, NMFS assumes coho salmon will have access to reaches upstream of Iron Gate site but will not pass upstream of Keno Dam. Historical studies show that the most upstream range of coho salmon in the Klamath River Basin was Spencer Creek (Huntington 2004; Hamilton et al. 2005; Dunsmoor et al. 2006; Hamilton et al. 2011; USDOI and NMFS 2013; ODFW and the Klamath Tribes 2021) which is located a few miles downstream of Keno Dam. However, based on these same historical studies, NMFS assumes fall and spring run Chinook salmon will repopulate reaches upstream including tributaries to UKL. Therefore, NMFS assumes Chinook may be exposed to elements of the Klamath Project including Keno Dam and LRD passage facilities and Klamath Project diversions.

Additionally, Agency-Barnes Lake is expected to be connected just prior to the implementation of the proposed action. As described in Section 1.3.2.3.1 *Wetland Restoration within Upper Klamath National Wildlife Refuge*, the proposed action uses model code to account for the Agency-Barnes Lake reconnection. Functionally, this addresses changes that will occur as a result of the reconnection including evapotranspiration and increased volume of UKL. The reconnection of Agency-Barnes Lake does not change baseline conditions for ESA-listed species considered in this Opinion, other than its relation to flow management. Because the Agency-Barnes Lake reconnection and its impact to flow management are accounted for in the proposed action through the model assumptions and inputs, NMFS does not otherwise consider, in isolation, the effects of the reconnection or changes to baseline conditions in this Opinion. Rather, consideration of the effects of the proposed action through the modeled outputs necessarily includes that consideration.

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 KRM version of the KBPM, many critical assumptions were identified by Reclamation and the Services, using the best available scientific data. NMFS also applied these assumptions to the proposed action in order to perform our effects analysis. The following is a list of these critical assumptions that were identified for the KRM and informed our analysis.

- The upper Klamath River Basin will experience water year types and UKL inflows within the range observed in the POR 1991 to 2022.
- Accretions from LRD to Iron Gate will be consistent with accretion timing, magnitude, and volume for the POR.
- NWI, NRCS, and CNRFC UKL net inflow forecasts will be within the range and accuracy of inflow forecasts for the POR.
- UKL bathymetry in the model accurately represents actual UKL bathymetry and storage capacity, including Agency-Barnes Lake reconnection.

- Water deliveries to the Klamath Project and off the Klamath Project will be consistent with average historical distribution patterns for the POR.
- 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 Keno Release Targets and UKL elevations will differ slightly during real-time operations.
- Reclamation will implement the proposed action as described in Reclamation's 2024 BA to the greatest extent practicable and will not deviate from the rules and parameter settings applied in the KBPM (KRM version) modeling (e.g., no deviations from the daily calculated UKL status, NWI, Operations Index and resulting Keno Release Target calculations, Project Supply calculations, etc.).

Assumptions that Ensure Clarity Regarding the Action Analyzed in this Opinion Comparison to IOP

Reclamation's BA provided information regarding how the proposed action compares to previous years' operational approaches for informational purposes and to add clarity to what Reclamation currently proposed. NMFS does not consider this information to be part of the proposed action, and we note that NMFS' effects analysis would not involve a comparative analysis against past actions.

Operation and Maintenance Activities

Reclamation stated in the BA that they "attempted to include in the proposed action all maintenance activities necessary to maintain Klamath Project facilities and to continue proper long-term functioning and operation." Reclamation also stated that they "recognize that this is not an exhaustive list of O&M activities and that there may be items that were "inadvertently omitted." In considering this aspect of the proposed action, NMFS analyzes the specifically-proposed O&M actions listed in the proposed action, Section 0 *Element Three – Operation and Maintenance Activities*. NMFS also assumes that there may be some additional O&M activities that are materially similar in scope, scale, and location to those described (but which have been inadvertently omitted) and therefore has taken those activities into account in analyzing the effects of the action. Before undertaking O&M activities that were inadvertently omitted, Reclamation should verify with NMFS whether those activities fall within the assumptions NMFS made about similarity in scope, scale, and location. To the extent such activities do not fall within NMFS assumptions, separate Section 7(a)(2) consultation may be required.

Use of Special Studies, Adaptive Management, and Structured Decision Making

In their BA, Reclamation describes "special studies," some of which may involve incidental take of ESA listed species. Reclamation also states that it may modify and refine the special studies listed in their proposed action. In this Opinion, NMFS analyzes the effects of the listed studies where sufficient detail was provided and where Reclamation's involvement or control is clear, as further noted in their proposed action. However, separate consultation may be required for studies not listed in their proposed action, for modifications or refinements of the listed studies, or for studies listed that do not contain sufficient detail to analyze.

In their addendum to the BA (Reclamation 2024b), Reclamation describes their intent to utilize an Structured Decision Making (SDM) process to adaptively manage elements of their proposed action. NMFS understands this proposal for adaptive management and SDM will be used to guide determinations regarding long-term science, monitoring, and management needs. If adaptive management, SDM, or inter-seasonal and intra-seasonal management were to result in actions that alter the proposed action in a manner not previously considered, a separate ESA consultation or reinitiation of consultation may be required (50 CFR 402.16).

This Opinion includes background and analysis material for SONCC coho salmon first (Section 2.3 *Southern Oregon/Northern California Coastal (SONCC) Coho Salmon*), followed by material for SRKWs (Section 2.4 *Southern Resident Killer Whale DPS*).

2.2 Action Area

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

The action area includes all areas where Klamath Project water is diverted from, locations where water is diverted to, and downstream of diversion points until effects of the diversions become undifferentiable from background conditions, and all areas where our listed species are directly or indirectly affected by those actions. The action area extends from UKL, in south central Oregon, and Gerber Reservoir and Clear Lake Reservoir in the Lost River drainage in southern Oregon and Northern California, to approximately 254 miles downstream to the mouth of the Klamath River, and then out into the Pacific Ocean (Figure 17). In the ocean, the action area includes the range wherein Klamath origin Chinook salmon overlap with SRKWs and their designated critical habitat (Figure 18).

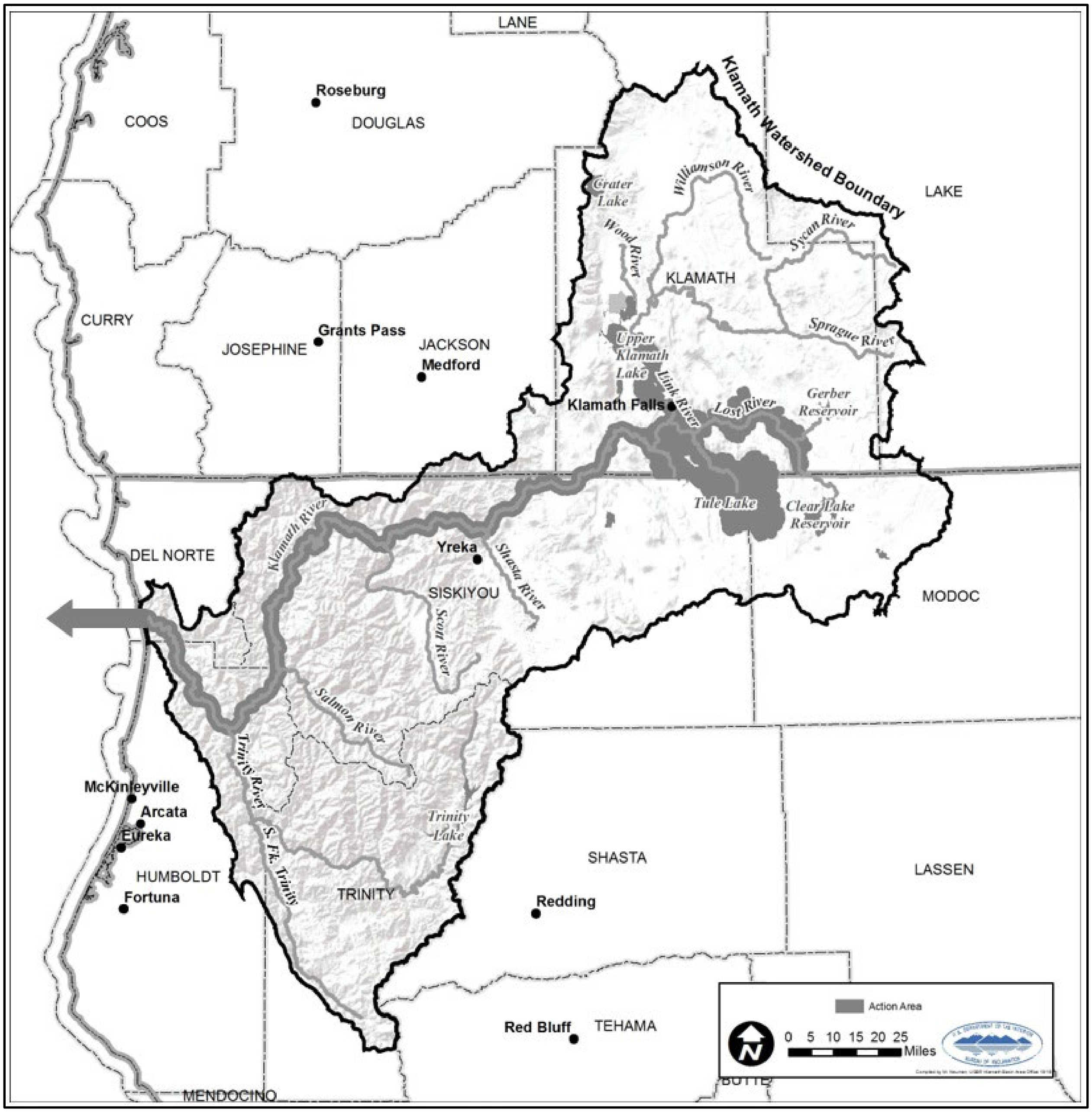

Figure 17. Map of the action area, excluding SRKW portion of the action area (Reclamation 2024a).

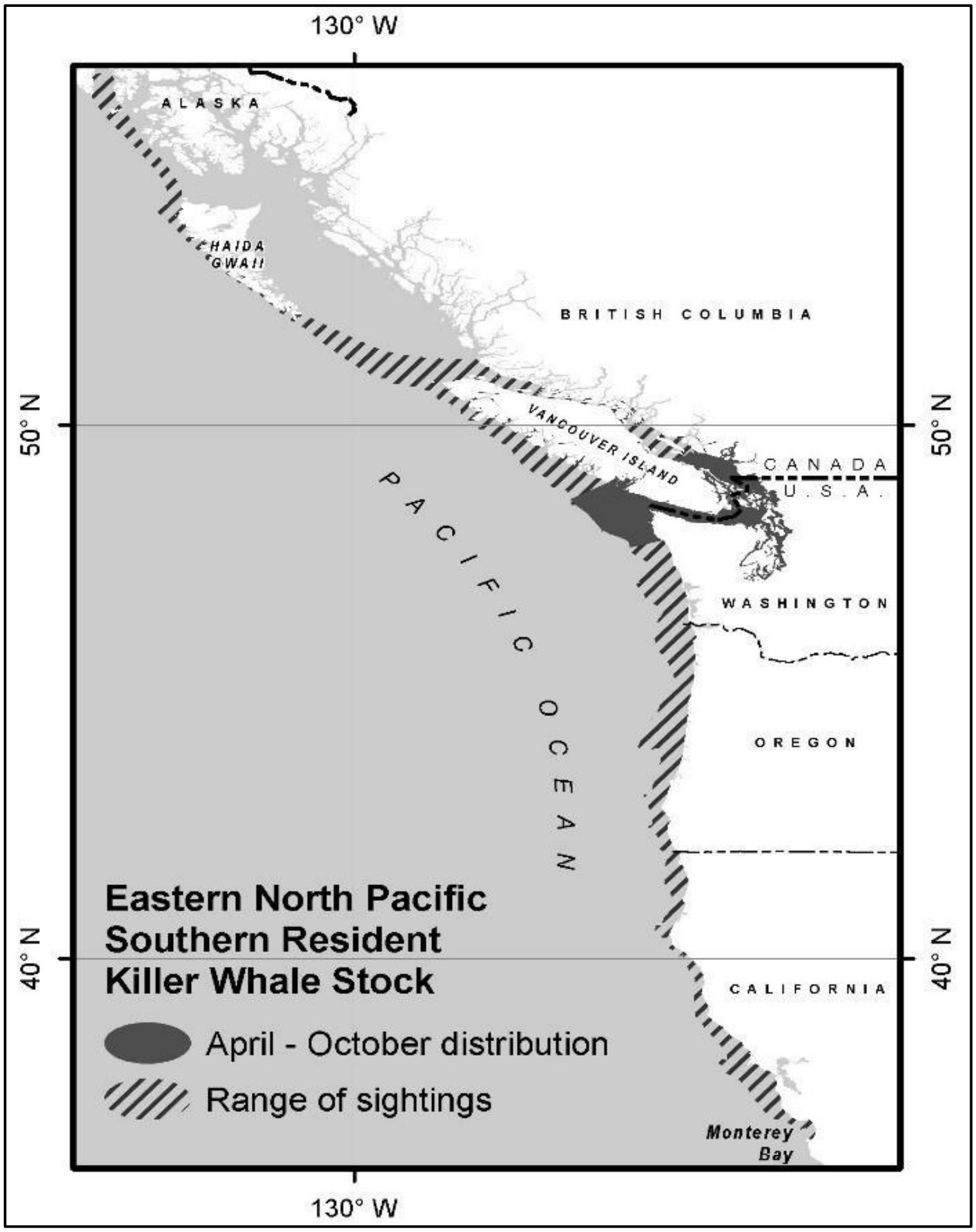

Figure 18. Geographic range of SRKWs. The action area includes the portion of their geographic range where SRKWs overlap with Klamath Chinook salmon (reprinted from Carretta et al. 2021).

The Klamath River Basin is typically divided into three geographic areas: Upper Klamath Basin, Middle Klamath Basin, and Lower Klamath Basin. The Upper Klamath Basin includes Upper Klamath Lake and its tributaries downstream to Keno Dam. The Middle Klamath Basin is defined as the portion of the Klamath River watershed between Keno Dam and the Trinity River confluence. The Lower Klamath Basin includes the Trinity River confluence to the confluence with the Pacific Ocean. Within the Upper Klamath Basin, the action area includes Agency Lake, UKL, Keno Impoundment (Lake Ewauna), Lost River including Miller Creek, and all

Reclamation-administered facilities including reservoirs, diversion channels and dams, canals, laterals, and drains, including those within Tule Lake and Lower Klamath NWRs, as well as all land, water, and facilities in or providing irrigation or drainage for the service area of the Klamath Project. The Action Area includes Keno Dam, which is the new compliance point for Klamath River flows following the removal of IGD (the previous compliance point for Klamath River flows was at IGD, which was removed in 2024).

Effects in the action area vary according to species because the population distribution and the specific effects vary among species. For example, with dams removed, the upstream extent of anadromy for SONCC coho salmon in the Klamath Basin is expected to extend to Spencer Creek (RM 233.4), while the upstream extent of anadromy for Chinook salmon (preferred prey of SRKWs) in the Klamath Basin is expected to extend further upstream of the action area into the tributaries above UKL. The difference in the amount of habitat that coho salmon and Chinook salmon are expected to utilize post dam removal is due to morphometric and life history differences (e.g., adult run timing) between the two species, and is based on historical studies (Huntington 2004; Hamilton et al. 2005; Dunsmoor et al. 2006; Hamilton et al. 2011; USDOI and NMFS 2013; ODFW and the Klamath Tribes 2021). The action area extends to locations where SRKW experience indirect effects of the action, and into the Pacific Ocean where SRKW feed on concentrations of adult Chinook salmon. The exact boundaries of this area cannot be precisely defined based upon current information; however, it includes nearshore waters along the United States West Coast from Northern California through the Washington coast including Puget Sound. Models predicting the oceanic distribution of Fall-run Chinook stocks from Northern California where Klamath ESUs originate suggest that co-occurrence could extend as far south as Point Sur, California, the southern end of the SRKW range and through Vancouver Island, though overlap is likely rare in Canadian Waters (Shelton et al. 2018; Shelton et al. 2021). SRKW are also known to consume California origin Chinook salmon far from their stream of origin, such as Central Valley Chinook salmon that were consumed in Puget Sound (Hanson et al. 2021), so there is also potential for SKRW to encounter Klamath River Chinook in northern waters.

2.3 Southern Oregon/Northern California Coastal (SONCC) Coho Salmon

2.3.1 Rangewide Status of the Species and Critical Habitat

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

2.3.1.1 Species Description and General Life History

The SONCC ESU of coho salmon is listed as threatened and is described as naturally spawned coho salmon originating from coastal streams and rivers between Cape Blanco, Oregon, and Punta Gorda, California. Also, the SONCC ESU includes coho salmon from the following artificial propagation programs: Cole Rivers Hatchery Program; Trinity River Hatchery (TRH) Program; and the Iron Gate Hatchery (IGH)/Fall Creek Hatchery (FCH) Program[7] (50 CFR 223.102(e)). SONCC coho salmon have a generally simple three-year life history. The adults typically migrate from the ocean and into bays and estuaries towards their freshwater spawning grounds in late summer and fall, and spawn by mid-winter. Adults die after spawning. The eggs are buried in nests, called redds, in the rivers and streams where the adults spawn. The eggs incubate in the gravel until fish hatch and emerge from the gravel the following spring as fry. Individual fish produced during the same year are considered from the same "year class" or cohort. Fish typically rear in freshwater for about 15 months before migrating to the ocean. The juveniles go through a physiological change during the transition from fresh to salt water called smoltification. Coho salmon typically rear in the ocean for two growing seasons, returning to their natal streams as three-year old fish to renew the cycle. However, a percentage of adult males, known as "jacks", return to spawn as two-year old fish.

2.3.1.2 Status of Species and Critical Habitat

As described in more detail in the Section 2.1 *Analytical Approach*, NMFS assesses four population viability parameters to help us understand the status of each salmonid 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 SONCC coho salmon Recovery Plan (NMFS 2014b), most recent status review (NMFS 2016a), and most recent viability assessment (NMFS 2023b) to determine the general condition of each population and factors responsible for the current status of the ESU. We use these population viability parameters as surrogates for reproduction, numbers, and distribution; the criteria found within the regulatory definition of "jeopardize the continued existence of" (50 CFR 402.02). This Opinion also examines the condition of critical habitat throughout the designated area, evaluates the conservation value of the various watersheds and coastal and marine environments that make up the designated area, and discusses the current function of the PBFs that help to form that conservation value.

2.3.1.2.1 Status of SONCC Coho Salmon

2.3.1.2.1.1 SONCC Coho Salmon Abundance and Productivity

NMFS considered the most recent status review (NMFS 2016a) and recovery plan (NMFS 2014) and incorporates them by reference. 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 (NMFS 2011b) for populations in this ESU for populations in this ESU (NMFS 2016a; NMFS 2023b). Based on the available data, while the extinction risk category is still moderate, the recent extinction risk trend of the SONCC coho salmon ESU is declining (i.e., less viable) since the previous assessment (NMFS 2023b). 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

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[7] The IGH facility, which is part of the Lower Klamath Project, lost its water supply once Iron Gate Reservoir was drawn down beginning January 2024. Hatchery production at IGH was moved to a revitalized hatchery facility at Fall Creek (FCH) beginning in 2023. This is further discussed in Section 2.3.2.2.4 Hatcheries below.

determine abundance. Of the seven time series available for the most recent assessment (NMFS 2023b), positive abundance trends were observed in the Elk and Scott rivers; the Elk River abundance trend was significantly different from zero, although the annual average abundance (166) and most recent 12-year average abundance (296) are well below the population recovery target of 2,400. The remaining five populations had negative abundance trends, only the Shasta River population trend was significantly different from zero. All independent populations that are included in this viability assessment and were included in the previous assessment five years earlier had a lower average annual abundance in this most recent assessment, including the Scott River (McElhany et al. 2000; NMFS 2014b; NMFS 2023b).

2.3.1.2.1.2 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 2001; Good et al. 2005; NMFS 2011b; NMFS 2016a; NMFS 2023b). Extant populations can still be found in all major river basins within the ESU (70 FR 37160 (June 28, 2005)). In addition, with removal of four dams in the Klamath basin, SONCC coho salmon are expected to repopulate previously accessible habitat as high upstream as Spencer Creek (NMFS 2021a). 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. The ESU is considered not viable and at a moderate risk of extinction (NMFS 2023b).

2.3.1.2.2 Status of Critical Habitat

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

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

The factors that caused declines include hatchery practices, ocean conditions, habitat loss due to dam building, degradation of freshwater habitats due to a variety of agricultural and forestry practices, water diversions, urbanization, over-fishing, mining, climate change, and severe flood events exacerbated by land use practices (Good et al. 2005; NMFS 2016a; NMFS 2023b). 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 to 2016, the drought in California reduced stream flows and increased temperatures, further exacerbating stress and disease. Drought conditions returned to the Klamath Basin in 2020 (Reclamation 2020), and the state of Oregon declared a state of drought emergency in the upper Klamath River Basin in early 2021 due to unusually low snow pack and lack of precipitation (Oregon 2021). Reduced flows can cause increases in water temperature, resulting in increased heat stress to fish and thermal barriers to migration.

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

Average annual air temperatures, heat extremes, and sea level increased in California over the last century (Kadir et al. 2013). Snowmelt from the Sierra Nevada has declined (Kadir et al. 2013). Although coho salmon are not solely dependent on snowmelt driven streams, they have likely already experienced some detrimental impacts from climate change through lower and more variable stream flows, warmer stream temperatures, and changes in ocean conditions. California experienced well below average precipitation during the 2012 to 2016 drought, as well as record high surface air temperatures in 2014 and 2015, and record low snowpack in 2015 (NMFS 2016a). Paleoclimate reconstructions suggest the 2012 to 2016 drought was the most extreme in the past 500 to 1,000 years (Williams et al. 2016; Williams et al. 2020; Williams et al. 2022). Anomalously high surface temperatures substantially amplified annual water deficits during 2012 to 2016. California entered another period of drought in 2020 that continued through 2023. These drought periods are now likely part of a larger drought event (Williams et al. 2022). This recent long-term drought, as well as the increased incidence and magnitude of wildfires in California, have likely been exacerbated by climate change (Diffenbaugh et al. 2015; Williams et al. 2019; Williams et al. 2020; Williams et al. 2022).

The threat to coho salmon from global climate change is expected to increase in the future. Modeling of climate change impacts in California suggests that average summer air temperatures are expected to continue to increase (Lindley et al. 2007; Moser et al. 2012). Heat waves are expected to occur more often, and heat wave temperatures are likely to be higher (Hayhoe et al. 2004; Moser et al. 2012; Kadir et al. 2013). Total precipitation in California may decline and the magnitude and frequency of dry years may increase (Lindley et al. 2007; Schneider 2007; Moser et al. 2012). Similarly, wildfires are expected to increase in frequency and magnitude (Westerling et al. 2011; Moser et al. 2012). Increases in wide year-to-year variation in precipitation amounts (droughts and floods) are projected to occur (Swain et al. 2018). Estuarine productivity is likely to change based on changes in freshwater flows, nutrient cycling, and sediment amounts (Scavia et al. 2002).

In marine environments, 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). Some of these changes, including an increased incidence of marine heat waves, are likely already occurring, and are expected to increase (Frölicher et al. 2018). In fall 2014, and again in 2019, a marine heatwave, known as “The Blob”, formed throughout the Northeast Pacific Ocean, which greatly affected water temperature and upwelling from the Bering Sea off Alaska, south to the coastline of Mexico. The marine waters in this region of the ocean are utilized by salmonids for foraging as they mature. Although the implications of these events on salmonid populations are not fully understood, they are having considerable adverse consequences to the productivity of these ecosystems and presumably contributing to poor marine survival of salmonids.

In coastal and estuarine ecosystems, the threats from climate change largely come in the form of sea level rise and the loss of coastal wetlands. Sea levels will likely rise exponentially over the next 100 years, with possibly a 43 to 84 centimeter rise by the end of the 21st century (IPCC 2019). This rise in sea level will alter the habitat in estuaries and either provide an increased opportunity for feeding and growth or in some cases will lead to the loss of estuarine habitat and a decreased potential for estuarine rearing.

2.3.2 Environmental Baseline

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

While Section 2.3.1.2.12.3.1.2.1 *Status of SONCC Coho Salmon* 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 from Spencer Creek to the Pacific Ocean. Although the action area as a whole includes the Pacific Ocean due to effects on prey resources for SRKW, SONCC coho salmon are not exposed to effects from the proposed action in the Pacific Ocean. Thus, this section will not address conditions in the Pacific Ocean. For a summary of environmental baseline conditions in the Pacific Ocean pertinent to SRKW, see Section 2.4.2 *Environmental Baseline*.

Coho salmon were once numerous and widespread within the Klamath River basin (Snyder 1931). Today, due to migration barriers (Figure 19) habitat degradation, and other factors, the small populations that remain currently occupy a fraction of their historical area, in limited habitat within the tributary watersheds (e.g. Shasta River, Scott River, and Trinity River) and the mainstem Klamath River just below Iron Gate (NRC 2004).

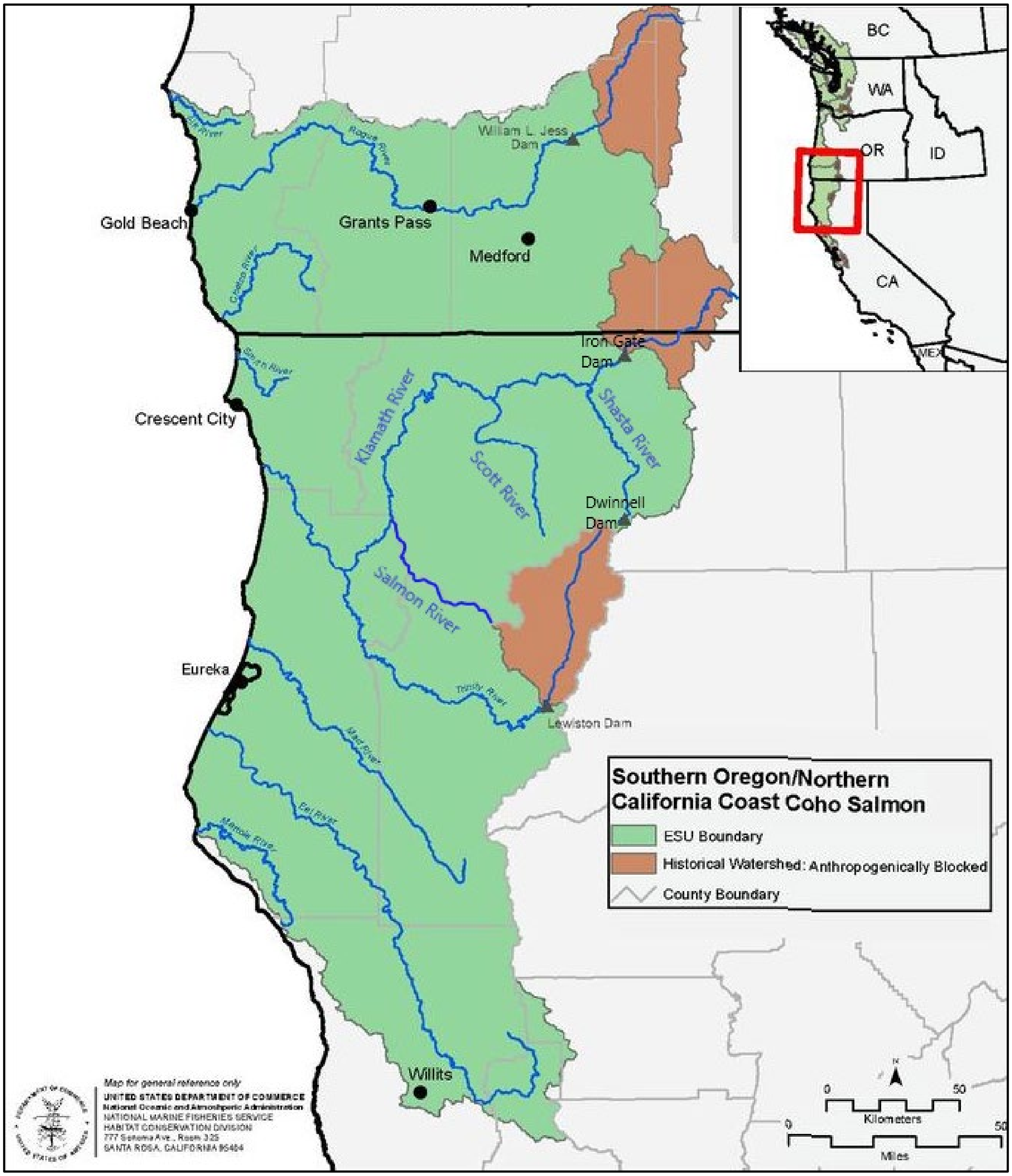

Figure 19. Map showing the SONCC coho ESU boundary and current major barriers including the former IGD on the Klamath River. SONCC coho salmon are anticipated to migrate upstream as far as Spencer Creek in Oregon to the upstream extent of their historical range.

Coho salmon in the action area occupy temperate coastal regions and arid inland areas stretching from the former IGD site downstream to the estuary. With the dams removed, the upstream extent of anadromy for SONCC coho salmon in the Klamath Basin is expected to extend to Spencer Creek (RM 233.4). Coho salmon that utilize 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 the Lower Klamath River population of the Central Coastal Diversity Stratum, occur in the action area during some stage of their life cycle (Figure 20). 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 above Iron Gate at RM 190 up to Spencer Creek [RM 230], 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 Trinity River (RM 43), the Salmon River (RM 66), the Scott River (RM 144), and the Shasta River (RM 177).

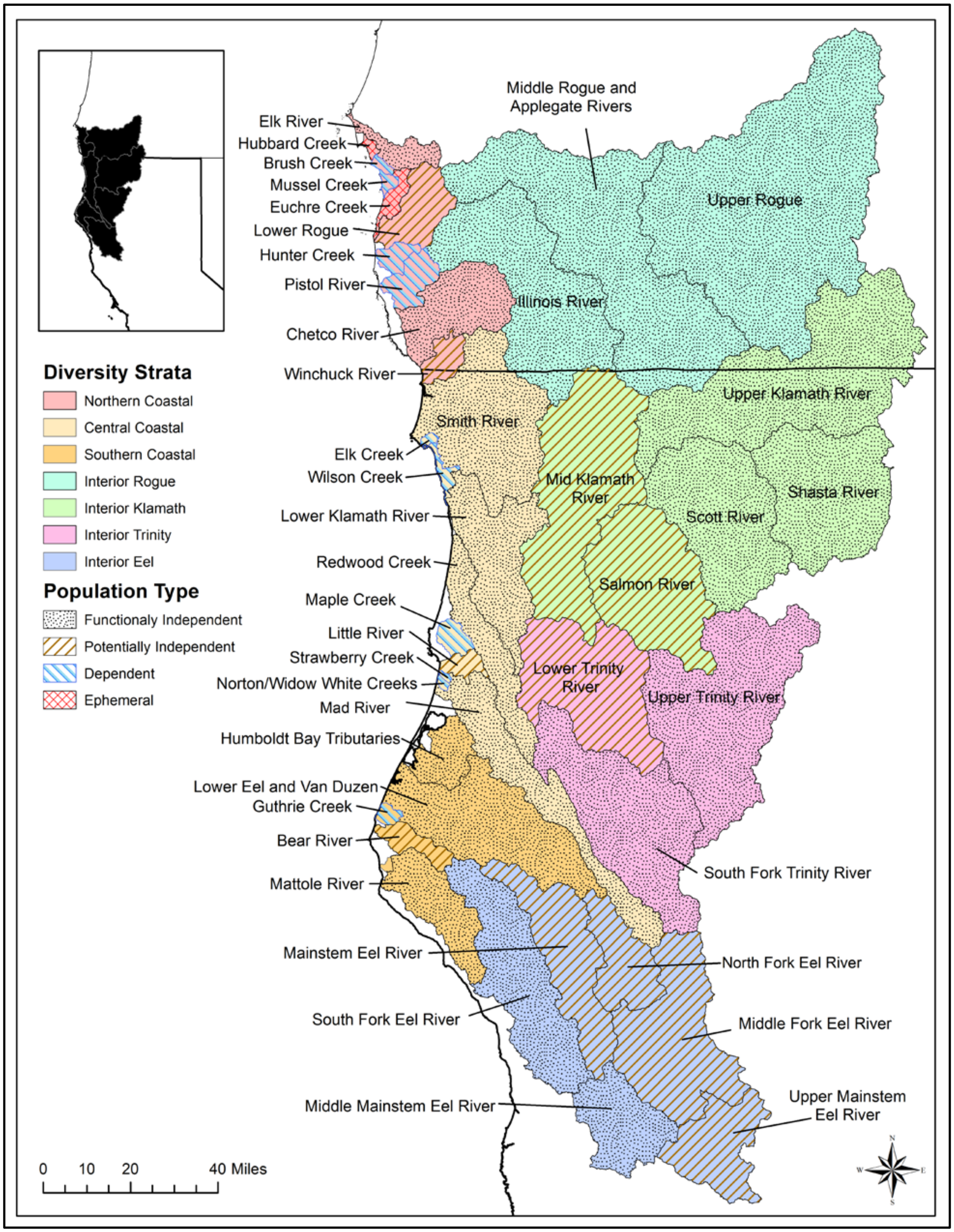

Figure 20. Historic population structure of the SONCC coho salmon ESU, including populations and diversity strata, as described in NMFS (2016a).

2.3.2.1 Status of Critical Habitat in the Action Area

2.3.2.1.1 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 23). 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 2014b). Since the dams have been removed, NMFS has observed short term impacts to water quality in the form of increased suspended sediment concentrations (SSCs) and decreased DO. However, post reservoir drawdown, the water temperature returned to a more natural regime. These conditions are described in greater detail in the following sections.

Table 23. Water bodies listed as water-quality impaired under Section 303(d) of the Clean Water Act and stressors for locations that contain SONCC coho salmon populations that may be affected by the proposed action.

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

Notes:
*Selected minor tributaries that are impaired for sediment and sedimentation/siltation include Beaver, Cow, Deer, Hungry, and West Fork Beaver creeks (USEPA 2010; CSWRCB 2022).
**Minor tributaries that are impaired for sediment and sedimentation/siltation include China, Fort Golf, Grider, Portuguese, Thompson, and Walker creeks (USEPA 2010; CSWRCB 2022).

2.3.2.1.2 Water Temperature

Unsuitable water temperature is one of the most widespread and significant stresses in the SONCC coho salmon ESU (NMFS 2016a), and is a recognized stressor seasonally throughout the action area. Optimal water, sub-optimal, and lethal temperatures for coho salmon are life stage 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 (2014b) 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. Conditions immediately downstream of Iron Gate have historically been impacted to a large degree by the thermal sink created by the reservoir; often exceeding temperatures optimal for coho salmon. 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.

Daily mean temperature (averaged over 2001 to 2011) exceeded 21°C from early July to late August in the Klamath River below Iron Gate (Asarian et al. 2013). In 2017, an "extremely wet year," using the United States Environmental Protection Agency (USEPA) guidelines, migrating adult salmon and rearing juvenile salmon temperature criteria were exceeded between three months and four summer months at all focal monitoring locations in the action area (Romberger et al. 2018). Prior to dam removal, water released from the Iron Gate Reservoir, when compared with modeled conditions without the dams, was 1°C 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 et al. 2006; NCRWQCB2010; Risley et al. 2012). Water temperature is expected to return to a more natural regime post dam removal and has already been documented in the spring following reservoir drawdown (Figure 21).

Although the water temperature regime is improving downstream of Iron Gate, NMFS expects temperature impacts will remain downstream of Keno Dam. Reduced flow volume and velocity in Lake Ewauna will result in warmer water temperatures being released from the dam into downstream reaches.

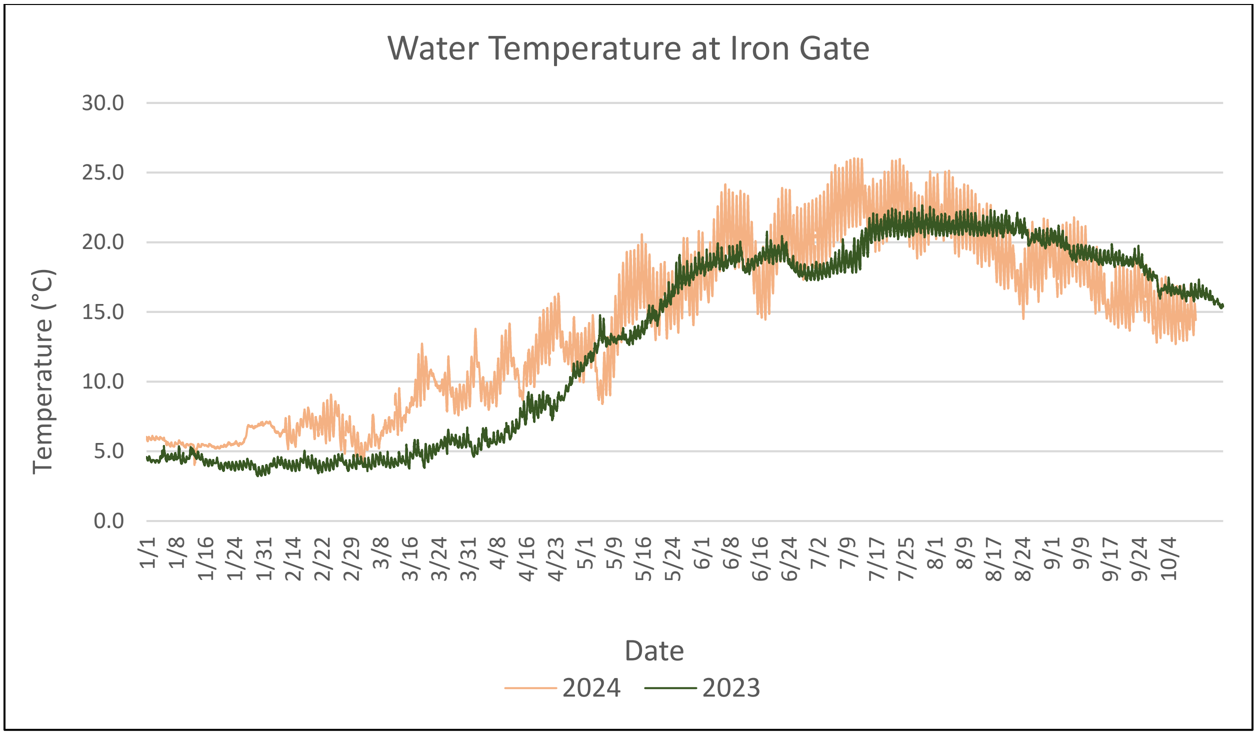

Figure 21. Comparison of temperature values at the USGS Iron Gate gage from 2023 and 2024 (KRRC 2024).

2.3.2.1.3 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 6.0 milligrams/liter (mg/L) DO before production impairment was observed for most life stages, and a minimum 3.0 mg/L DO for acute mortality.

Historically, DO concentrations in the Klamath River below the former IGD exceeded minimum DO requirements for salmonids and other coldwater species (Asarian et al. 2013). However, annual minimum DO concentrations from 2001 to 2011 were as low as 3.5 mg/L at the former IGD, with a general upward trend from 2001 to 2011 (Asarian et al. 2013). Asarian et al. (2013) indicated that the lowest DO concentrations (daily minimum DO, averaged over 2001 – 2011) occurred 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 the former IGD and RM 100 (approximately the location of Happy Camp). However, after the reservoirs were drawn down the DO returned to a more natural regime as seen in Figure 22 (KRRC 2024). Keno Dam is expected to impact DO in a similar manner as described above for water temperature. Although preliminary information reflects that dam removal has resulted in significant improvements to DO downstream of the former IGD location, additional monitoring is needed to understand the extent of impacts to DO from Keno Dam.

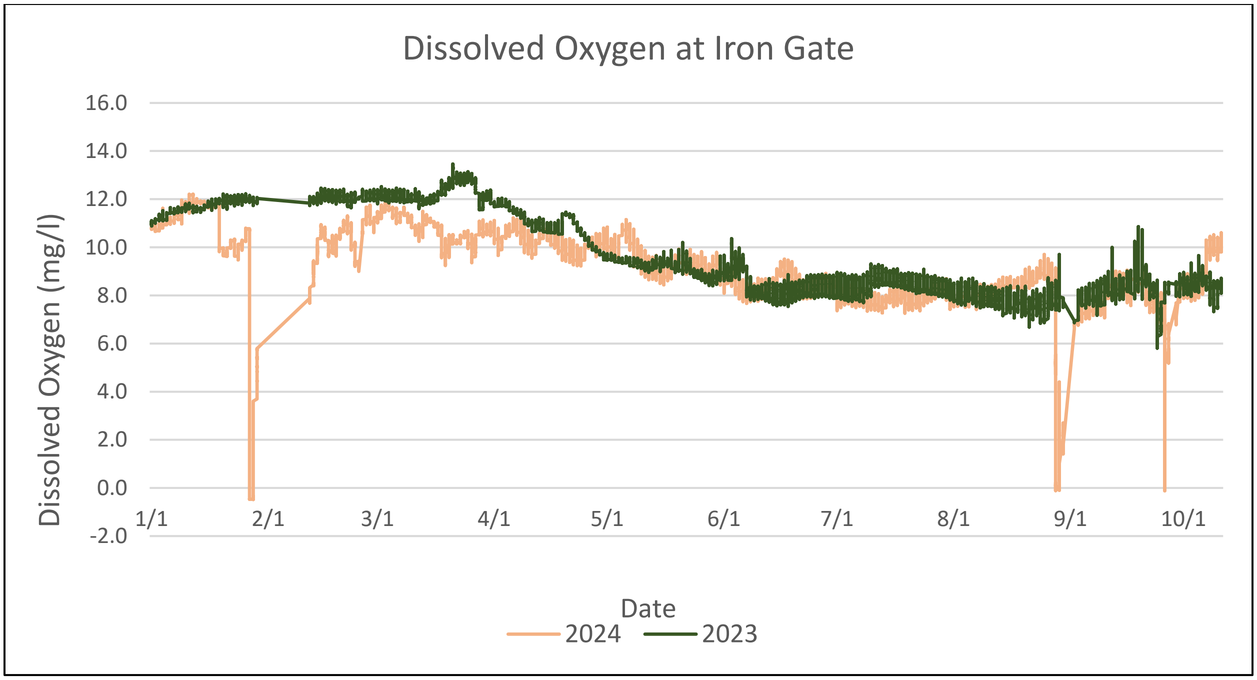

Figure 22. Comparison of DO concentrations at the USGS Iron Gate gage from 2023 and 2024 (KRRC 2024).

Recent wildfires and subsequent debris flows have affected DO concentrations in the mainstem Klamath River. As discussed in Section 2.3.2.2.8.1 *Wildfires*, there have been several recent wildfires within the Klamath Basin. Specifically, the McKinney fire in 2022 impacted 60,325 acres of land immediately adjacent to the Klamath River. Intense precipitation on the recently denuded landscape triggered debris flows that severely impacted water quality in the effected tributaries and mainstem Klamath River. Baseline conditions for DO in the Klamath River at Seiad Valley (in the vicinity of the McKinney fire) ranged from about 6 to 10 mg/L prior to the debris flow. Recorded data from the gage show that DO increased slightly during the peak discharge and then rapidly decreased when the turbidity increased around 10am (Figure 23). The DO improved briefly between debris flow events before recovering the morning of August 4 (Witmore et al. 2023).

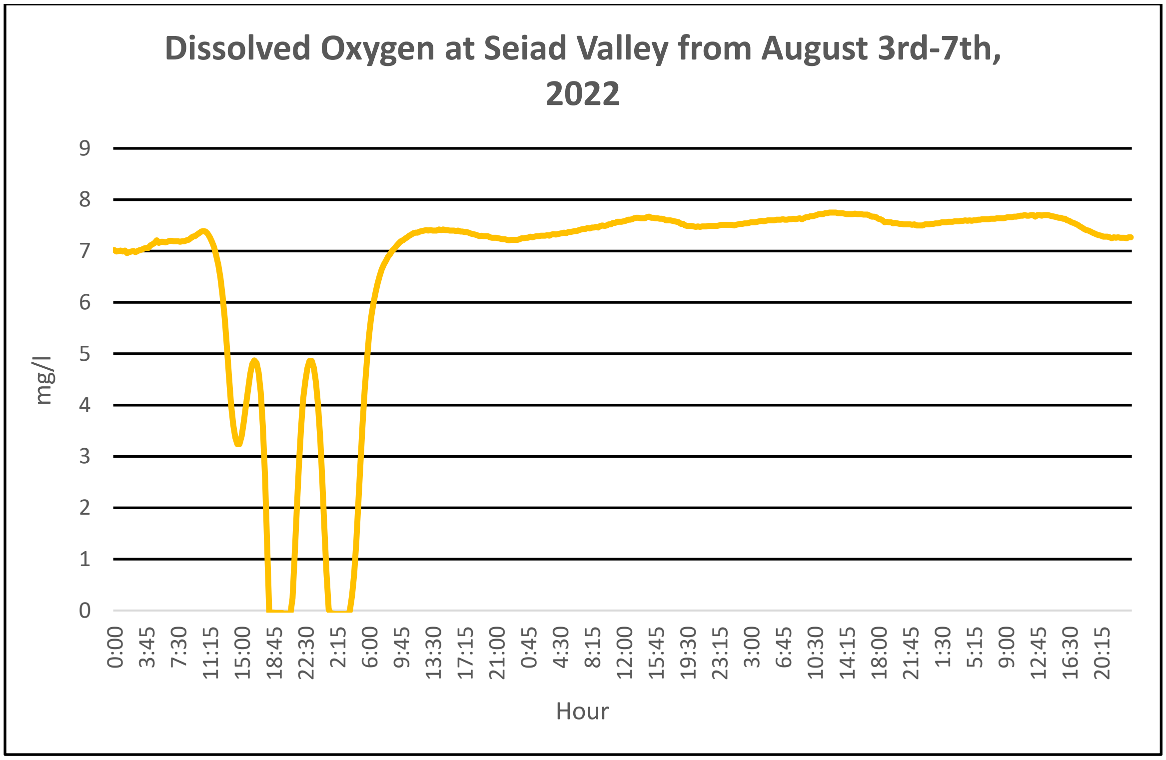

Figure 23. Klamath River DO measured at Seiad Valley from August 3 to 7 (Witmore et al. 2023).

2.3.2.1.4 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 DO levels. Historically, phosphorus and nitrogen concentrations in Klamath River were influenced by the former Iron Gate Reservoir with the greatest impacts occurring just downstream of the dam and diluting in reaches further downstream.

Although, four dams on the mainstem Klamath were removed in 2024, Keno Dam (RM 239.2) and Link River Dam (RM 260.5) remain in place and contribute to toxic algae blooms in Lake Ewauna and UKL. The upper Klamath Basin in particular, has an overabundance of nutrients, contributed in part by agriculture and loss of wetlands. Legacy sediments and point sources throughout the upper Klamath Basin are the sources contributing phosphorus that drives water quality concerns in the Lake Ewauna Keno Impoundment reach.

Low DO due to the decomposition of organic matter has been observed in Lake Ewauna and the Klamath River in Oregon. In 2003, DO concentrations were reported below 4.0 mg/L for many weeks in the summer and early fall, and were less than 1.0 mg/L for some days (USGS 2003). The transport of algal organic matter from UKL into Lake Ewauna and the Klamath River above Keno Dam contribute to periods of hypoxia that extends throughout the water column. These low DO levels can be detrimental to the survival of fish and other aquatic organisms.

2.3.2.1.5 Suspended Sediment Concentrations

Rivers transport numerous materials in suspension including sediments (i.e., clay, silts, and sands) and fine organic matter (e.g., leaves, needles, algae, plankton, and microbes). High levels of sediment transport can reduce habitat and water quality for salmonids, and are also of concern because high densities of *M. speciosa* (freshwater annelid worms) have been observed in these habitats (Hillemeier et al. 2017; Som et al. 2017). Suspended sediment refers to the settleable fine sediments (i.e., clays, silts, and sand) transported in suspension by a river or stream. These fine sediments tend to settle out due to their density but during flow events are repeatedly re-suspended into the flow by turbulent fluid forces until the streamflow recedes or sediments are transported into zones with weak fluid forces (e.g., backwater areas). Suspended sediment refers to the settleable fine sediments (i.e., clays, silts, and sand) transported in suspension by a river or stream. These fine sediments tend to settle out due to their density. However, during flow events, they are repeatedly re-suspended into the flow by turbulent fluid forces until the streamflow recedes or sediments are transported into zones with weak fluid forces (e.g., backwater areas). Suspended sediment refers to these settleable suspended material in the water column. Two types of suspended material are important to water quality in the Klamath Basin and are discussed below: algal-derived (organic) suspended material and mineral (inorganic) suspended material. Sources of each type of suspended material differ, as do spatial and temporal trends for each, in the throughout the Klamath basin (FERC 2021; FERC 2022).

Between Link River at Klamath Falls and Keno Dam, algal-derived (organic) suspended material is the predominant form of suspended material affecting water quality. Summer and fall algal-derived (organic) suspended materials decrease with distance downstream, as algae are exported from UKL and into Lake Ewauna, where they largely settle out of the water column (Sullivan et al. 2011).

Below Keno Dam, during reservoir drawdown in the winter of 2024, mineral and algal SSCs peaked in the mainstem Klamath River as the impounded sediment was mobilized downstream (KRRC 2024). In March 2024, Reclamation conducted three geomorphic flows to facilitate sediment evacuation. The geomorphic flows were released from Keno Dam, had a duration of one to three days and a magnitude between approximately 1,400 to 2,000 cfs with baseline flows approximately 1,000 cfs.

As vegetation in the former hydroelectric reach upstream of the former IGD is established following dam removal, sediment is expected to be largely stabilized. However, some evacuation will occur naturally from precipitation events.

In addition, as discussed in Section 2.3.2.2.8.1 *Wildfires*, wildfires in the surrounding vicinity have increased turbidity and therefore SSCs in the mainstem Klamath River and its tributaries (Witmore et al. 2023). Increased SSCs from wildfires can continuously affect water quality until restoration has occurred or vegetation is reestablished.

2.3.2.1.6 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. Migratory habitat must be available year round because 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 24). Emigration rate tends to increase as fish move downstream (Stutzer et al. 2006).

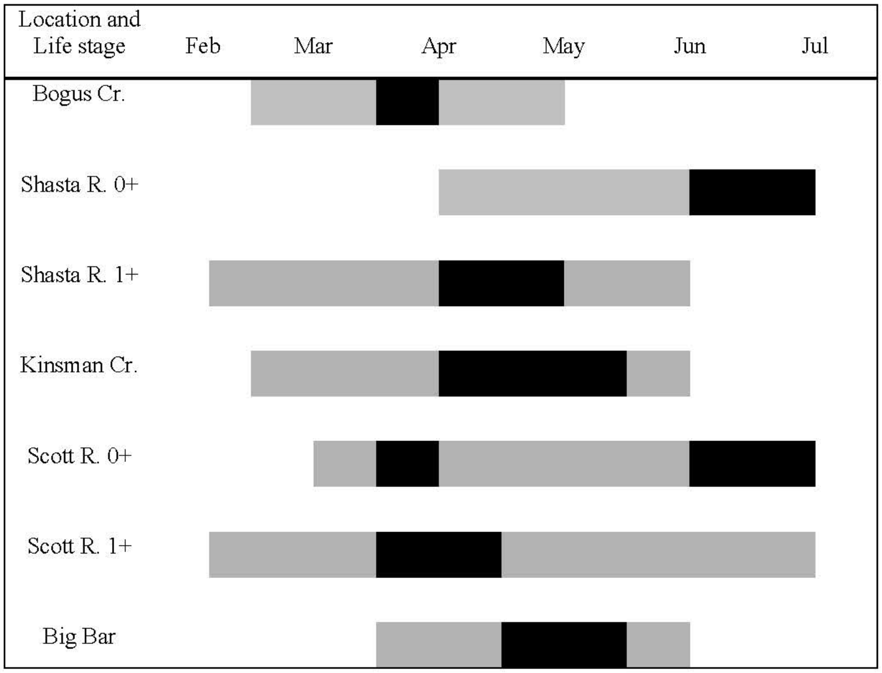

Figure 24. General emigration timing for coho salmon smolt within the Klamath River and tributaries. Black areas represent peak migration periods, those shaded gray indicate non-peak periods. 0+ refers to young-of-year while 1+ refers to smolts (Pinnix et al. 2007; Daniels et al. 2011).

The mainstem migratory corridor for the Upper Klamath and Mid Klamath River population areas includes the mainstem Klamath River from the mouth of Spencer Creek, downstream to the confluence of the Trinity River. Beginning in January 2024, this reach (particularly the Upper Klamath portion) has been significantly disturbed as the reservoirs upstream of the former IGD were drawn down, sediment was mobilized and re-deposited, and dams were removed. Over the course of the spring and summer of 2024, water quality conditions have continued to improve and habitat has stabilized. NMFS expects that winter flow events will continue to flush fine sediments from the channel, pools will scour, and the mainstem Klamath will rapidly return to a pre-dam or improved habitat condition.

In addition to the recent disturbance from dam removal, the 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. 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 172), have been found to have had a substantial impact on the survival of juvenile coho salmon in this stretch of river (NMFS 2014b). NMFS expects rates of disease to decline post dam removal, as a more natural sediment transport and water temperature regime is restored. However, 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 and Mid Klamath River population areas may go subsurface in the summer near their confluence with the mainstem Klamath River, creating low flow passage barriers. When the downstream sections of these tributaries go dry, the shaded, forested sections upstream provide cold water and high-quality summer rearing habitat for juvenile coho salmon. Distribution of juvenile coho salmon in the spring and summer has been well documented in the Klamath River and is an important life history strategy for all populations in the Klamath Basin. Redistribution requires the use of the mainstem migratory corridor and is critical to their survival and ability to find non-natal rearing habitats such as the small tributaries described. Decreased spring and summer flows in the mainstem can degrade water quality and quantity so that coho salmon can neither migrate to, nor access, these tributaries that provide cold water refugia. By early spring, when emigration of smolt coho salmon typically occurs, tributary flows are elevated and connectivity to the mainstem Klamath River allows the smolts to emigrate (NMFS 2014b).

2.3.2.1.7 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.

With dams removed, diurnal water temperature fluctuations are expected to be become more broad and variable (PacifiCorp 2004). October temperatures will average 4ºC cooler (Perry et al. 2011) when adult coho salmon begin entering the mainstem. This more natural temperature regime will be more synchronous with historical migration and spawning periods for coho salmon (Stillwater Sciences 2009; Hamilton et al. 2011). The current physical and hydrologic conditions of the adult migration corridor in the mainstem of the Upper and Middle Klamath River population areas are likely functioning in a suitable manner. Water quality and flow volume is expected to be sufficient for upstream adult migration.

2.3.2.1.8 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 et al. (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 summer rearing areas in the Upper and Middle Klamath River population areas has been compromised by low flow conditions, high water temperatures, insufficient DO 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. In the summer months, water temperatures are frequently stressful to juvenile coho salmon, with solar warming creating instream temperatures as high as 26ºC (NRC 2004). The excessively warm conditions have likely created a temporal limitation to fry and juvenile rearing, as well as smolt emigration by shortening the window when conditions are suitable for them to occupy the habitat. 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. Cold water refugia in the mainstem Klamath River are most often located at the confluences of cooler tributaries. With the dams removed, coho salmon in the Upper Klamath River population area will have access to additional refugia upstream of the former IGD. These include sites such as those located near the mouth of Fall Creek, Beaver Creek, and Shovel Creek. Ultimately, summer rearing habitat is limited in the mainstem Klamath River. However, we do expect positive improvements to the water temperature regime with the dams removed. Without the thermal sink of Iron Gate Reservoir, the mainstem Klamath will warm more quickly in the spring and cool more quickly in the fall, as well as experience more broad diurnal temperature fluctuations (NMFS 2021a).

Evidence of this change to the baseline conditions was documented in the spring of 2024, following reservoir drawdown (Figure 21).

Overwinter rearing habitat may be a limiting factor for juvenile coho salmon in the Upper and Middle Klamath River population areas. Anthropogenic activities such as mining and agriculture have significantly altered the mainstem into a more simplified channel with limited access to the floodplain. Additionally, much of the mainstem Klamath in the Upper Klamath River population area 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 2014b).

2.3.2.1.9 Spawning Habitat Conditions

While coho salmon are typically tributary spawners, a portion of the Upper Klamath River population spawn annually in the mainstem. For example, in 2023, 64 redds were observed during Klamath River mainstem surveys between the former IGD and Seiad Creek (MKWC 2023). However, upstream dams have historically blocked 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 the former IGD (FERC 2022). With dams removed, we expect the condition of spawning habitat to improve in this reach over time with some short-term degradation due to deposition of fine material from upstream reservoir footprints. The former Hydroelectric Reach upstream of the former IGD has stretches of high-quality spawning habitat between former reservoirs. The former reservoir reaches are expected to recruit spawning gravel through functioning transport processes over the next several years.

Water temperatures and water velocities are generally sufficient in the mainstem reach for successful adult coho salmon spawning. With dams removed, we expect to see coho salmon return to upstream tributaries, in particular Spencer Creek which represents the upstream-most range of coho distribution in the Klamath Basin and is located just downstream of Keno Dam (Huntington 2004; Hamilton et al. 2005; Dunsmoor et al. 2006; Hamilton et al. 2011; USDOI and NMFS 2013; ODFW and the Klamath Tribes 2021). During this period, we expect a similar proportion of the Upper Klamath River population to spawn in the mainstem between Keno Dam and the former IGD.

Downstream of Seiad, where the Middle Klamath River population area occurs, the river 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 is unclear if there was historically much mainstem spawning in this reach.

2.3.2.2 Factors Affecting Critical Habitat in the Action Area

2.3.2.2.1 Climate Change

In the action area, climate change effects will vary widely on 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 et al. (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 (<6,000 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 et al. 2007; Barnett et al. 2008), has caused a decrease in the proportion of precipitation falling as snow (Feng et al. 2007).

Basins below approximately 5,900 to 8,200 ft in elevation appear to be the most impacted by reductions in snowpack (Knowles et al. 2004; Regonda et al. 2005; Mote 2006). Over the last 50 years, some of the largest declines in snowpack over the western United States have been in the Cascade Mountains and Northern California (Mote et al. 2005a; Mote 2006). Regonda et al. (2005) analyzed western United States data from 1950 to 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% reduction in snow water equivalent.

Declines in snowpack, largely in part due to anthropogenic climate change (e.g., warming temperatures), and increased drought conditions are expected to continue (Diffenbaugh et al. 2015; Williams et al. 2019; Williams et al. 2020; Williams et al. 2022), and are likely to affect the Klamath Basin. Air temperatures over the region have increased by about 1.8 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 et al. 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 two 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 et al. 2011). Analyses completed in NMFS 2013 biological 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 UKL and flow in the Williamson and Sprague rivers are strongly dependent on climate, particularly precipitation (Mayer et al. 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 et al. 2011).

Projections of the effects of climate change in the Klamath Basin suggest temperature will increase in comparison to 1961 to 2000 time period (Reclamation 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 the proposed action) compared to the 1990s range from 0.9to 1.4° F (0.5 to 0.8° C) (Reclamation 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 both decreases and increases. During the 2020s, Reclamation (2011a) projects an annual increase in precipitation of approximately 3% 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% while June through August precipitation is expected to decrease between 15 and 23% (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% in the high plateau areas of the upper Klamath Basin, including the Williamson River drainage. Snow water equivalent is expected to decrease by 50 to 100% 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%. 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% (Reclamation 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%, with increases of approximately 22% during December through March and decreases of approximately 3% during April through July. The Klamath River below the former IGD is expected to experience an approximate 5% increase in annual flow volume, with increases of approximately 30% during December through March and decreases of approximately 7% during April through July (Reclamation 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. Significantly, the projected increases in inflow to UKL as a result of increased runoff may be neutralized by warmer temperatures that increase agricultural demand and evaporation rates from UKL, which contributes to decreased annual net inflow to UKL (Figure 1).

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

Global climate change has been occurring for at least the past 50 years and is expected to continue for decades into the future. However, the “signal” of climate change in available projections is difficult to be distinguished from the “noise” of natural climate variability over short time periods (i.e., ~10 years or less). For at least 10 years into the future, and up to 50 years at the regional scale, expected climate is dominated by annual and decadal natural variability and the signal of climate change is difficult to distinguish or project. In terms of future climate change effects on coho salmon in the Klamath Basin, NMFS believes that within the period of the proposed action (i.e., five years), climate change will continue to have noticeable effects on coho salmon or its critical habitats similar to, or beyond, what has already been occurring. Specific projections during the period of the proposed action that are expected to affect coho salmon and their habitat include changes in seasonality of runoff, decreased snow water equivalent, decreased snowpack, and warmer air and water temperatures (Reclamation 2011a). These predicted changes are part of our analysis in Section 2.3.5 *Integration and Synthesis.*

2.3.2.2.2 Hydrology

2.3.2.2.2.1 Natural Flow Regime

As described in Section 2.1 *Analytical Approach*, NMFS uses the concepts of a natural flow regime (Poff et al. 1997) to help 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 et al. 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 et al. 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 et al. 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 a 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 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 et al. 2002).

2.3.2.2.2.2 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 LRD. 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 acres of irrigated farmlands in the upper Klamath Basin (Reclamation 2012).

Hecht et al. (1996) analyzed the hydrologic records for similar water years (pre- and post-Klamath Project) at several locations on the Klamath River. The authors concluded that the timing of peak and base flows on the Klamath River changed significantly after construction of the Klamath Project, and that Klamath Project operations generally increase flows in October and November and decrease flows in the late spring and summer as measured at Keno Dam, Seiad, and Klamath USGS gage sites. Their report also noted that water diversions also occur in areas outside the Klamath Project boundaries. IGD was completed in 1962 to re-regulate flow releases from the Copco dam facilities. However, IGD did not restore the pre-Klamath Project hydrograph. Fall flows were slightly increased in some of the driest years while winter, spring and summer flows were substantially reduced in nearly all years. The modeled data for Keno, Oregon clearly shows a decrease in the magnitude of peak flows, a two-month shift in timing of flow minimums from September to July, as well as reduction in discharge volume in the summer months (Figure 25). 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 25 displays the daily average Klamath River discharge at Keno, Oregon, during three different time periods. The 1905 to 1913 dataset represents historical, relatively unimpaired river flow, while two more modern time periods represent discharge after implementation of the Klamath Project. Figure 25 is presented to examine daily historical and more recent Klamath River discharge patterns at Keno, Oregon.

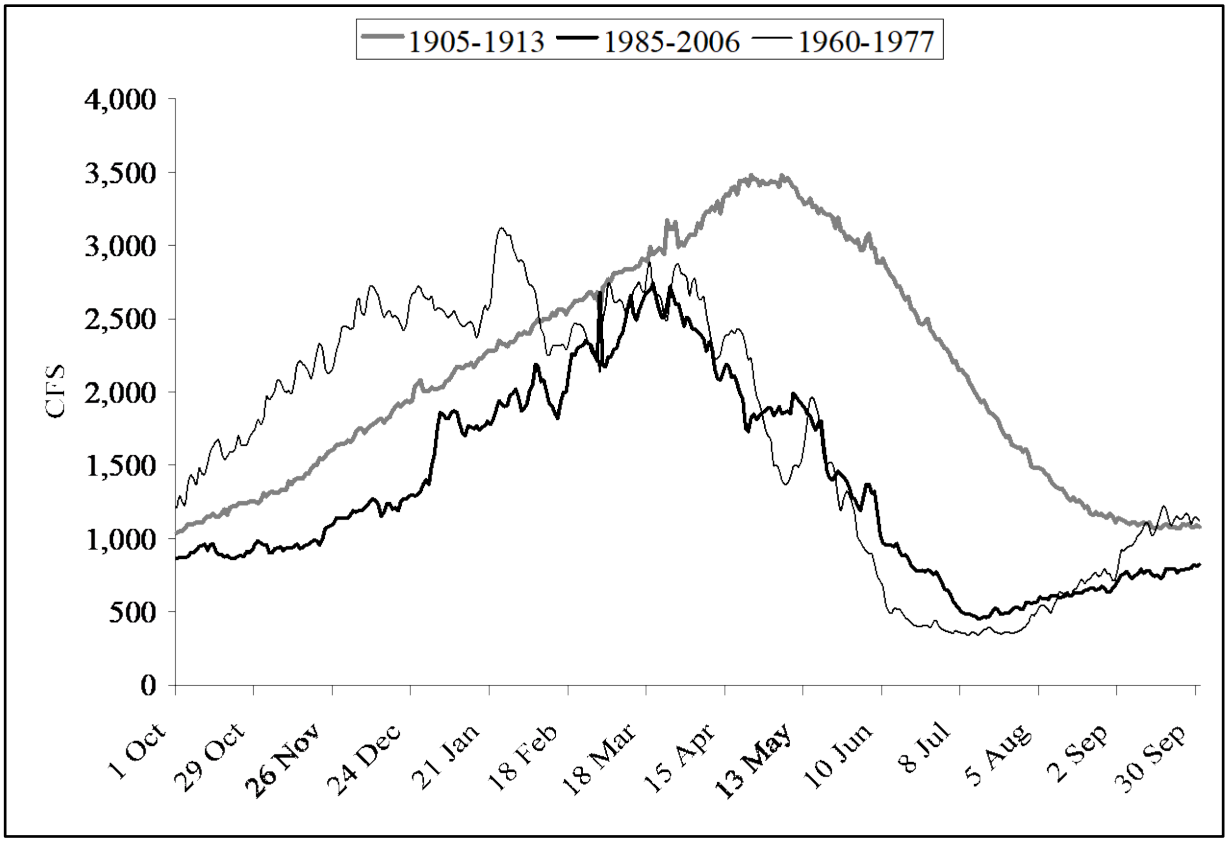

Figure 25. Daily average Klamath River discharge at Keno, Oregon, during three different time periods. The 1905 to 1913 dataset represents historical, relatively unimpaired river flow, while two more modern time periods represent discharge after implementation of the Project.

The 1905 to 1913 period represents historical unimpaired flows in the Klamath River at Keno, Oregon. However, because diversions to the A Canal of Reclamation's Klamath Project began in 1906, 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, provide some insight into the effects of Reclamation's Klamath Project facilities and operations. These time periods were chosen because the local 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 operations may be examined under relatively wet (1960 to 1977) and relatively dry (1985 to 2006) climate conditions.

Data presented in Figure 25 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 in the 1905 to 1913 period to approximately 2,700 cfs 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 associated with the construction of, and long-term operation of the Klamath Project 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-Klamath 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).

Following listing of species and critical habitat under the ESA, Reclamation has managed UKL elevations (since 1991) and Klamath River flows at the former IGD (since 2001) as described in a series of biological opinions from the Services. For the 2012 BA, Reclamation, in consultation with USFWS and NMFS, utilized the KBPM to simulate operations of the Klamath Project for the 1981 to 2011 period of record of historical hydrology for development of the proposed action at that time. The corresponding 2013 joint biological 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's exceeding the *C. shasta* infection rates in the 2013 biological opinion's incidental take statement (ITS).

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 the agencies failed to reinitiate formal consultation after the ITS 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.[8] The court ordered (as modified in an order dated March 24, 2017)[9] Reclamation to implement two types of flows until formal consultation was completed: (1) winter-spring flushing flows designed to dislodge and flush out annelid 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

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[8] 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).

[9] 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).

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 the former 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 and 24. 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 2.3.2.2.3 *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).

On April 1, 2019, NMFS and USFWS issued new biological opinions, effectively ending the injunctive relief flows described above. It was later discovered, and confirmed in October 2019, that inaccurate information related to WUA curves, provided by a third party, was used in the consultations. Concerned that this revealed effects of the 2018 proposed action on listed species or critical habitat (specifically to SONCC coho salmon) in a manner or to an extent not previously considered, Reclamation requested reinitiation of formal consultation with both Services on November 13, 2019 under the ESA implementing regulations (50 C.F.R. § 402.16(a)(2).

Subsequently, Reclamation proposed to operate the Klamath Project in accordance with the IOP, which augmented the EWA in the earlier proposed action by up to 40,000 AF in certain water year types. NMFS concluded that such operations would be consistent with the 2019 NMFS biological opinion. The agencies also began formulating a new, longer term ESA consultation that would consider Klamath Project operations following removal of the lower Klamath dams, which was anticipated to occur in the near future.

NMFS agreed with Reclamation’s conclusion that the IOP was expected to provide additional habitat availability for SONCC coho salmon which would contribute towards meeting the habitat conservation standard and potentially reduce disease risk for this species (NMFS 2020a). As such, NMFS agreed with Reclamation’s conclusion that implementation of the proposed IOP was expected to result in reduced effects from those previously analyzed in NMFS’ 2019 biological opinion, and therefore was expected to be consistent with NMFS’ determinations that Klamath Project operations were not likely to jeopardize the continued existence of SONCC coho salmon or destroy or adversely modify its designated critical habitat.

Water year 2019 was wetter than average so a surface flushing flow (6,030 cfs release at the former IGD for 72 hours) was implemented in early April and a deep flushing flow (11,250 cfs release at the former IGD for 24 hours) was attempted, but not achieved due to operational constraints and flood concerns, as IGD flows peaked at a daily average of 9,570 cfs on April 10, 2019. The EWA was allocated to be approximately 546 TAF, and approximately 547 TAF was released for EWA purposes by September 30, 2019.

Hydrologic conditions changed dramatically for the worse and the Klamath Basin entered into an extreme drought cycle for water years 2020 to 2022. Due to the extraordinarily dry hydrologic conditions, Reclamation triggered the Meet and Confer process described in the Services' 2019 biological opinions and operated the Klamath Project under a series of annual TOPs. This resulted in former IGD river flows that met minimum biological opinion flow requirements, but only modified/reduced surface flushing flows were released at the former IGD in 2020 and 2022, and in 2021, no attempt was made to release a surface flushing flow.

UKL inflows remained low for much of the fall/winter in water year 2023 as cold temperatures and significant snowfall prevailed. Due to Reclamation's concerns of not meeting required UKL elevations for shoreline spawning suckers as it did in 2022, Reclamation reduced flows at the former IGD below what was analyzed for minimum flows in NMFS' 2019 biological opinion from February 14 through March 13, 2023. Subsequently, minimum flows at the former IGD were met for the rest of water year 2023 and a full surface flushing flow was implemented on April 20, 2023, consistent with the IOP.

2.3.2.2.3 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:

- 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).
- Final Environmental Impact Statement for Hydropower License Surrender and Decommissioning for the Lower Klamath Project (FERC 2022).
- USFWS and NMFS (2013) biological opinions, a series of USFWS Technical Memoranda (USFWS 2016a; USFWS 2016b; USFWS 2016c; USFWS 2016d),
- NMFS (2019c) biological opinion.
- Final Environmental Impact Report for the Lower Klamath Project License Surrender (CSWRCB 2020).
- NMFS (2021a) biological opinion.
- Bartholomew et al. (2023) expert predictions for salmon disease risk following the Klamath River dam removals.

Existing 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 *C. shasta* (causes ceratomyxosis) and *Parvicapsula minibicornis*.

Ich and columnaris have occasionally had a substantial impact on adult salmon in the Klamath River, 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 annelid 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 worm, *Manayunkia occidentalis* (previously identified as *Manayunkia speciosa)* (Bartholomew et al. 1997; Bartholomew et al. 2006; Atkinson et al. 2020). Once the annelids are infected, they release *C. shasta* actinospores into the water column. Temperature and actinospore longevity are inversely related.

In one study, actinospores remained intact the longest at 4°C, but were short-lived at 20°C. Actinospores are generally released when temperatures are above 10°C, and remain viable (able to infect salmon) from three to seven 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 et al. 2010). USFWS (2016c) states that myxospores released from adult salmon carcasses contribute the bulk of myxospores to the system, mostly from carcasses upstream of the confluence with the Shasta River.

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 annelid worms by the myxospores (Bartholomew et al. 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 the former IGD is characterized as Type II; the genotype that affects Chinook salmon is Type I.

The annelid host for *C. shasta* is present in a variety of habitat types, including runs, pools, riffles, and edge-water; as well as sand, gravel, boulders, bedrock, and aquatic vegetation; and is frequently present with *Cladophora* (a type of algae) (Bartholomew et al. 2010). The altered river channel downstream of the former IGD has resulted in an atypically stable river bed, which provides favorable habitat for the annelid worm. Slow-flowing habitats may have higher densities of annelids, and areas that are more resistant to disturbance, such as eddies and pools with sand and Cladophora, may support increased densities of annelid populations (Bartholomew et al. 2010), especially if flow disturbance events are reduced or attenuated. High annelid densities increase parasite loads, which leads to higher rates of infection and mortality for coho salmon. Alexander et al. (2016) concluded that the summer distribution of *M. occidentalis* is related to observed hydraulic and substrate conditions during base discharge (summer) and modeled hydraulic and substrate conditions during peak discharge (late winter to early spring).

In the Klamath River, the annelid host for *C. shasta* and *P. minibicornis* is aggregated into small, patchy populations mostly concentrated between the Interstate 5 Bridge and the Trinity River confluence, and especially upstream of the Scott River (Stocking et al. 2007). The reach of the Klamath River from the Shasta River to the Salmon River was recently known to be a highly infectious zone with high actinospores, especially from April through August (Beeman et al. 2008), although within and between years the size of the infectious zone and the magnitude of parasite densities may vary geographically (True et al. 2016; Voss et al. 2018; Voss et al. 2019; Voss et al. 2020; Voss et al. 2022; Voss et al. 2023; Voss et al. 2024). The myxospore input that drove this infectious zone likely came from the high densities of adult salmon that spawned directly downstream from the former IGD and the adjacent former hatchery (Bartholomew et al. 2023).

Despite potential resistance to the disease in native populations, fish (particularly juvenile fish, and more so at higher water temperatures) exposed to high levels of the parasite may be more susceptible to disease (Ray et al. 2012). High infection rates can result in high mortality of juvenile salmonids. 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% 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) suggested that higher spring discharge increased smolt survival (Beeman et al. 2008; Beeman et al. 2012). Prevalence of infection and prevalence of mortality are variable based on year, species, and population (USGS 2019). Som et al. (2019) found that *C. shasta* related mortality rate estimates in coho ranged from 0% to 68% for the Shasta and Scott river coho salmon populations between 2005 and 2016, and that the Shasta River population experienced higher mortality rates than the Scott River population due to their prolonged exposure history in the mainstem Klamath River. USFWS estimated a *C. shasta* related mortality rate of 11.8% for juvenile coho salmon from the Shasta River (FERC 2021). USGS simulated an overall prevalence of mortality of 34.8% of naturally produced juvenile Chinook salmon and 87.0% of hatchery-origin juvenile Chinook salmon caused by *C. shasta* during the 2020 outmigration at the Kinsman trap on the Klamath River downstream of the former IGD (FERC 2021).

As previously mentioned, reinitiation of consultation on the joint USFWS and NMFS (2013) biological opinion was triggered when the prevalence of *C. shasta* infection exceeded the metric in the ITS. Chinook salmon infection rates were used as a surrogate for incidental take of SONCC coho salmon from increased disease risk. Between 2009 and 2023, the mean prevalence of infection for outmigrating Chinook salmon was 51%, and ranged from 17 to 91% (Voss et al. 2024). In 2021, during a warm, dry spring, weekly monitoring documented a peak *C. shasta* infection prevalence of 98% in juvenile Chinook and more than half of the fish sampled were determined to have a fatal infection (Voss et al. 2022).

The prevalence and severity of infection vary with both environmental conditions and management actions, including targeted flow releases. The processes that influence *C. shasta* impacts on Klamath River salmon are increasingly understood (Robinson et al. 2020). Robinson et al. (2020)'s results suggested that hatchery-origin smolts may exacerbate the impacts of the disease as evidenced by an associative relationship between the prevalence of infection in outmigrating hatchery fish with the densities of water-borne *C. shasta* spores in subsequent seasons. In addition, periodic scour and substrate disturbance are considered to be integral for managing disease induced mortality of juvenile and adult salmonids (Alexander et al. 2014; Curtis et al. 2021). Turecek et al. (2021) investigated the efficacy of reducing streamflow to desiccate annelid hosts to reduce disease risk. Stocking et al. (2007) noted that the ability of some annelid populations to persist through disturbances (e.g., large flow events) indicates that the lotic populations are influenced by the stability of the microhabitat they occupy.

Risk of disease infection to coho salmon is expected to change under new environmental conditions with four dams now removed on the Klamath River. A more natural hydrograph, sediment transport, a change in hatchery location and operations are expected to reduce the prevalence of *C. shasta* in the mainstem Klamath River. Bartholomew et al. (2023) described predicted changes to physical features, fish movements and associated host-pathogen interaction and disease on a reach scale for the Klamath River. They estimate the reach extending from the former IGD to Keno Dam will see the greatest change in both physical and biological diversity as salmon and other species re-establish. A large amount of uncertainty exists regarding future temperatures and flows, and where and when fish will be migrating in this reach. Downstream of the former IGD location, annelid worms are expected to have a patchier distribution due to a more variably flow regime. Additionally, the removal of IGD will shift to earlier and more temporally dispersed juvenile salmon migration through this reach. Therefore, juvenile coho salmon are expected to have decreased overlap with peak annelid population densities that should reduce infection. Downstream of Portuguese Creek, minimal physical changes to the environment are expected, however changes in the outmigration timing and reduced hatchery production are expected to reduce transmission of disease and lower infection risk.

Disease effects are likely to negatively impact all of the VSP parameters of the Interior-Klamath populations and the Lower Klamath River population, 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.

2.3.2.2.4 Hatcheries

Two hatchery programs have historically released anadromous salmonids in the Klamath Basin: IGH on the Klamath River, and TRH on the Trinity River. IGH began operation in 1966 as a mitigation hatchery for lost spawning and rearing habitat between the former Copco No. 2 Dam and IGD. California Department of Fish and Wildlife (CDFW) and PacifiCorp completed a Hatchery and Genetic Management Plan (HGMP) for the IGH coho program in 2014 (CDFW and PacifiCorp 2014). The primary goal of an HGMP is to devise biologically based hatchery management strategies that ensure the conservation and recovery of salmon and steelhead species. CDFW and PacifiCorp anticipated that the 2014 HGMP would cover hatchery operations until mainstem Klamath River dams of the Klamath Hydroelectric Project were removed (FERC 2021). The IGH facility, which is part of the Lower Klamath Project, lost its water supply once Iron Gate Reservoir was drawn down beginning January 2024. Hatchery production at IGH was moved to a revitalized hatchery (FCH) facility at Fall Creek beginning in 2023. Prior to this transfer, CDFW developed an HGMP for the FCH coho salmon program HGMP (CDFW 2023b), which is an update to the 2014 HGMP developed for the coho salmon program at IGH (CDFW and PacifiCorp 2014). The 2023 HGMP (CDFW 2023b) covered activities related to the artificial production of coho salmon at FCH during the transition of the program from IGH, and will continue for eight years following dam removal.

The coho salmon propagated at IGH/FCH and TRH are part of the ESA listed SONCC coho salmon ESU (50 CFR 223.102(e)). TRH produces coho salmon, Chinook salmon, and steelhead that will pass through the action area, specifically the lower Klamath River reach, and these fish could be impacted by the proposed action. In addition, the fish that are produced at TRH could adversely affect coho salmon in the action area through competition in the lower Klamath River. Therefore, production at TRH is included in this section (Table 24).

Table 24. FCH/IGH and TRH production goals.

Hatchery	Species	Run	Number Released	Life Stage Released	Released Target Date
FCH*	Chinook Salmon	Fall	3,000,000	smolts	April 1 – June 15
FCH*	Chinook Salmon	Fall	250,000	yearlings	Oct. 15 – Nov. 20
FCH*	coho salmon		75,000	yearlings	March-May
TRH	Chinook Salmon	Fall	2,000,000	smolts	May-June
TRH	Chinook Salmon	Fall	900,000	yearlings	
TRH	Chinook Salmon	Spring	1,000,000	smolts	November
TRH	Chinook Salmon	Spring	400,000	yearlings	
TRH	Steelhead	Winter	448,000	smolts	April
TRH	coho salmon		300,000	yearlings	March

Notes:
*Historic targets for Chinook salmon at IGH were 5,100,000 smolts and 900,000 yearlings released. IGH also historically produced steelhead, but no steelhead have been produced at IGH since 2012 due to low adult returns, and production of steelhead will not be continued at FCH.

Based on mitigation goals established when IGH was constructed in 1962, the IGH historically released a target of six million Chinook salmon, 75,000 coho salmon and 200,000 steelhead annually. 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 were released from the IGH, about 5.1 million were released as smolts from mid-May through early June and about 900,000 were released as yearlings from mid-October through November. The 75,000 coho salmon were released as yearlings after March 15th each spring. Beginning in 2024, with the transition of the program from IGH to FCH, the new production target for Chinook salmon is 3,000,000 smolts and 250,000 yearlings.

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 the former IGD.

Similar to production targets and associated release numbers, release timing is also variable each year. The timing of release for Chinook salmon at the IGH was dependent on fish growth and environmental conditions. In 2021, due to inhospitable in-river conditions in the Klamath River, no IGH Chinook salmon were released during the typical smolt release timing, and instead were held at TRH during the summer before being returned to IGH to be released during the typical yearling timing in the fall (CDFW 2021a). In 2022, 2.8 million unmarked and untagged IGH hatchery-origin Chinook salmon were released early to avoid releasing fish into inhospitable in-river conditions, and one million IGH hatchery-origin Chinook salmon were also again held at TRH and then returned to IGH to be released during the typical yearling timing in the fall (CDFW 2022). Release timing may continue to be variable at FCH based on adaptive management by CDFW, NMFS, and other basin managers.

As discussed above, an HGMP for coho salmon was developed for FCH as part of the CDFW's application for an ESA Section 10(a)(1)(A) permit for the FCH coho salmon program (CDFW 2023b) The FCH 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. The primary purpose of the FCH coho program is to protect the genetic resources of the Upper Klamath Population Unit and reduce extinction risks prior to and after the removal of the four Klamath River dams for eight years. The purpose would be achieved by integrating natural-origin adults into broodstock and using a genetically based spawning matrix to reduce inbreeding. The natural-origin fish required to integrate the program will be obtained from Bogus Creek, the IGH auxiliary fish ladder, Fall Creek (e.g., via seine or dip net), and fish volitionally entering FCH as described in the broodstock collection document (CDFW 2021c). The secondary purpose of the Program is to provide adult coho salmon that could disperse to newly accessible habitat (~76 miles) made available from dam removal (FERC 2022). The potential dispersal of program adult coho salmon results from fish straying to tributaries other than Fall Creek and by releasing adult coho salmon surplus to broodstock needs back to the mainstem Klamath River near Fall Creek.

There are likely some effects on wild (i.e., natural origin) juvenile coho salmon in the Klamath River from the annual release of up to 3,250,000 hatchery-reared Chinook salmon smolts/yearlings from FCH. 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.

2.3.2.2.5 Harvest

In the ocean, SONCC coho salmon primarily occur off the coast of California and southern Oregon. Coho salmon-directed ocean fisheries, and retention of coho salmon incidentally captured in other fisheries, have been prohibited off the coast of California since 1996. Ocean fishing mortality of SONCC coho salmon results from non-retention impacts in California and Oregon in fisheries targeting Chinook salmon, impacts in Oregon's hatchery-selective coho salmon fisheries, and impacts in Oregon's coho salmon fisheries. Exploitation rates for SONCC coho salmon in ocean fisheries have been estimated for years 1986 to 2019 using postseason runs of the Fishery Regulation Assessment Model (FRAM). Exploitation rates have been low and relatively stable since the early 1990s (average of 4.9% for years 1994 to 2022), which contrasts sharply with the much higher rates estimated for the 1980s and early 1990s.

In 2022, the Pacific Fishery Management Council (PFMC) adopted a new fishery Harvest Control Rule (HCR) for SONCC coho salmon under Amendment 23 to the Pacific Coast Salmon Fishery Management Plan (PFMC 2022b) which NMFS evaluated under ESA Section 7 (NMFS 2022c). This new HCR accounts for impacts of all tribal and non-tribal fisheries in ocean, tidal, and freshwater areas where SONCC coho salmon occur. The HCR manages for a lower overall exploitation rate compared to what was previously in place, particularly for Klamath River Basin coho salmon populations. Through this HCR, ocean salmon fisheries are constrained to total exploitation rates of (1) 16% for the Trinity population unit (Upper Trinity River, Lower Trinity River, and South Fork Trinity River; and (2) 15% for each of the remaining individual populations within the SONCC Coho Salmon ESU. Adherence to these limits requires accounting for impacts from all fisheries that may encounter SONCC coho salmon, including those fisheries managed by states and tribes in freshwater areas.

2.3.2.2.5.1 Tribal Fisheries

The Hoopa Valley Tribe and the Yurok Tribe manage their own fisheries in California. There are no tribal fisheries within the SONCC coho salmon range in Oregon. The 10-year (2010 to 2019) average exploitation rates for the fisheries of the Hoopa Valley Tribe and Yurok Tribe were 3.4 and 6.4% , respectively (NMFS 2022b). In 2021, the Hoopa Valley Tribe submitted a Tribal Resource Management Plan (TRMP) to NMFS for evaluation under the ESA Tribal 4(d) Rule (NMFS 2022b). On August 4, 2022, NMFS issued a final determination on the Hoopa Valley Tribe TRMP (87 FR 47724). The approved TRMP provides a framework through which tribal salmon fisheries can be implemented while meeting requirements specified under the ESA Tribal 4(d) Rule (NMFS 2022b). In 2023, the Yurok Tribe submitted a TRMP for their Klamath River salmonid fisheries, which is under NMFS review. Additionally, the impacts of the fisheries of the Hoopa Valley Tribe and Yurok Tribe are accounted for within the overall exploitation rates identified in the 2022 HCR described above.

2.3.2.2.5.2 State Fisheries

California's freshwater sport fishing regulations (CDFW 2023a) prohibit retention of coho salmon. However, capture and release of coho salmon does occur. The California Fish and Game Commission has established partial protection measures (e.g., low-flow fishing closures) to provide fishing opportunities while reducing threats to federally listed salmonids.

Oregon's freshwater sport fishing regulations allow a recreational fishery for hatchery-origin coho salmon in the Rogue River. In other Oregon rivers within the range of the SONCC Coho Salmon ESU, incidental catch of natural-origin SONCC coho salmon occurs in recreational fisheries that target fall Chinook salmon and winter steelhead.

2.3.2.2.6 Predation

Predation of adult and juvenile coho salmon occurs 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 the former IGH (Nickelson 2003). While the extent of predation is not well understood, given the small number of wild juvenile coho salmon, predation at any level may be having an adverse effect on coho salmon in the action area (NMFS 2014b).

2.3.2.2.7 Restoration Activities

There are various restoration and recovery actions underway in the Klamath Basin, specifically in the action area 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 2014b). Planned and implemented actions intended to help recover SONCC coho salmon, in the action area on the mainstem of the Klamath River as guided by the recovery plan and other Klamath Basin focused plans, include but are not limited to:

- *Horse Trough Springs Off Channel Restoration Project* - The purpose of this proposed project is to increase the viability and production of the Upper Klamath River population of SONCC coho salmon. This will restore and create suitable habitat that provides year-round rearing habitat for juveniles, and summer and winter refuge habitat for juveniles from tributaries below the former IGD and from populations upstream of the former dam reach. The specific goal of this project is to restore quality off-channel habitat for coho salmon on a floodplain that has been severely degraded by historical industrial-scale mining that left mounds of tailings on a floodplain,

- *Floodplain Activation downstream of Shovel Creek* – The purpose of this proposed project is to activate approximately 60 acres of floodplains for juvenile salmonid rearing downstream of Shovel Creek. In addition, a side channel will be constructed in the low-lying areas for rearing, spawning and high-water refugia. This project is scheduled to begin construction in 2026.
- *Former Hydroelectric Dam Sites* – The four hydroelectric dams (Iron Gate, Copco No. 1, Copco No. 2, and J.C. Boyle) have been removed. The former dam footprints have been primarily restored through channel bed grading and boulder placement to increase roughness to reduce velocities and provide seams for fish passage. Fish passage monitoring at the former dam footprints will be conducted until approximately 2029.

These projects, along with newly restored sediment transport processes and more dynamic flows, are expected to improve the baseline, allowing rapid recovery of mainstem and tributary habitat in the action area over the next five years. These benefits will be most significantly realized in the former reservoir footprints and the riverine reaches between Keno Dam and the former IGD.

2.3.2.2.8 Land Use/Management Activities

2.3.2.2.8.1 Wildfires

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. Prior to dam removal and since 2008 many large wildfires (i.e., wildfires greater than 10,000 acres) occurred downstream of the former hydroelectric dams, including the Siskiyou Complex in 2008, Fort Complex in 2012, Beaver and Happy Camp Complex in 2014, Bear in 2015, Gap in 2016, Prescott and Abney in 2017, Klamathon and Natchez in 2018, Slater/Devil in 2020, McCash and Lava in 2021, McKinney in 2022, and the Smith River Complex and Happy Camp Complex in 2023 (CalFire 2024). Specifically, the McKinney fire in 2022 impacted 60,325 acres of land immediately adjacent to the Klamath River and in the small town of Klamath River. Intense precipitation on the recently denuded landscape triggered debris flows that severely impacted water quality in the effected tributaries and mainstem Klamath River. Due to the slow regrowth of vegetation and proximity to the mainstem Klamath River, continuous sediment runoff occurs after medium and large precipitation events.

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 Water Drafting Specifications which, when followed, avoid dewatering drafting sites while also avoiding fish impingement on, and entrainment into, water drafting hardware (NMFS 2022d).

2.3.2.2.8.2 Timber

Legacy timber harvest severely altered salmonid habitat in the Klamath Basin. The SONCC coho salmon recovery plan (NMFS 2014b) describes many legacy habitat stresses from past timber harvest, such as reduction in instream large wood and simplified channel structure, and increases in sediment and water temperatures. The recovery plan also describes continued threats from forest management activities, but at a reduced level due to more recent improvements in practices, such as the State of California Anadromous Salmonid Protection Rules and the Northwest Forest Plan (NWFP). The NWFP was developed in the mid-1990s within the range of the Northern spotted owl on federal forest lands in response to its listing, as well as the listing of many salmon species on the West Coast. The NWFP provided a new management approach to federal forests in western Oregon and Washington, and Northern California, one that is an integrated, comprehensive approach for ecosystem management, intergovernmental and public collaboration, and rural community economic assistance. The NWFP includes the Aquatic Conservation Strategy (ACS) for conserving and improving aquatic habitat through a system of Riparian Reserves where aquatic values are given the highest priority. Since adoption of the NWFP in 1994, timber harvest and road building on federal forest lands in the Klamath Basin have decreased and road improvement or decommissioning has increased. In addition to the improvements in habitat due to implementation of the NWFP, many national forests have active aquatic habitat restoration programs, actively improving instream and floodplain habitat.

However, the United States Forest Service (USFS) also launched the Wildfire Crisis Strategy (WCS) in 2022, which includes many high priority landscapes and firesheds within the Klamath Basin. These landscapes and firesheds require fuel reduction and the reintroduction of fire to reduce the risk of catastrophic wildfire on communities, forests, and species. The Klamath Basin has experienced many high intensity, large scale wildfires in the past 10 years, with the threat of wildfire increasing due to climate change, fire suppression and lack of cultural burning, and unhealthy forest stands due to mismanagement and insect disease. Catastrophic wildfires have led to numerous debris torrents, increased erosion, and in some cases, fish kills in the Klamath and Trinity rivers. In addition, post-fire salvage logging has increased on national forests, which can also result in increased erosion on sensitive post-fire soils.

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. The HCP also places restrictions on timber harvest on unstable slopes, harvest that could increase the risk of mass wasting. The HCP is, therefore, expected to reduce sediment related impacts of Green Diamond’s timber operations on aquatic species habitat overtime. However, we do not expect a significant increase in large wood delivery or shade on these privately held forests.

2.3.2.2.8.3 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 the Klamath Project, estimated average consumptive use in the upper Klamath Basin is approximately 800,000 AF. Eighty-nine percent of this demand is for agricultural irrigation (Reclamation 2016).

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 AF of water from the Klamath River basin at Jenny Creek into the Rogue River Basin (Reclamation 2013). An additional 6,600 AF is diverted annually from Fourmile Creek into the Rogue River Basin; however, 2,200 AF of the Fourmile diversion is lost through canal leakage and assumed to stay in the Klamath Basin (RRVID 2018). Thus, roughly 28,400 AF of water is diverted annually from the Klamath River Basin to the Rogue River Basin via those diversion systems (NMFS 2012a).

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 flows at Link River and Keno dams 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 et al. 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.

2.3.2.2.8.4 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).

2.3.2.3 Status of Coho Salmon in the Action Area

2.3.2.3.1 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, DO near 100% 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 DO concentrations), substrate stability during high flows, and, for most species, water temperatures of 14ºC or less (Quinn 2005). Figure 26 depicts the seasonal periodicities of coho salmon in the action area.

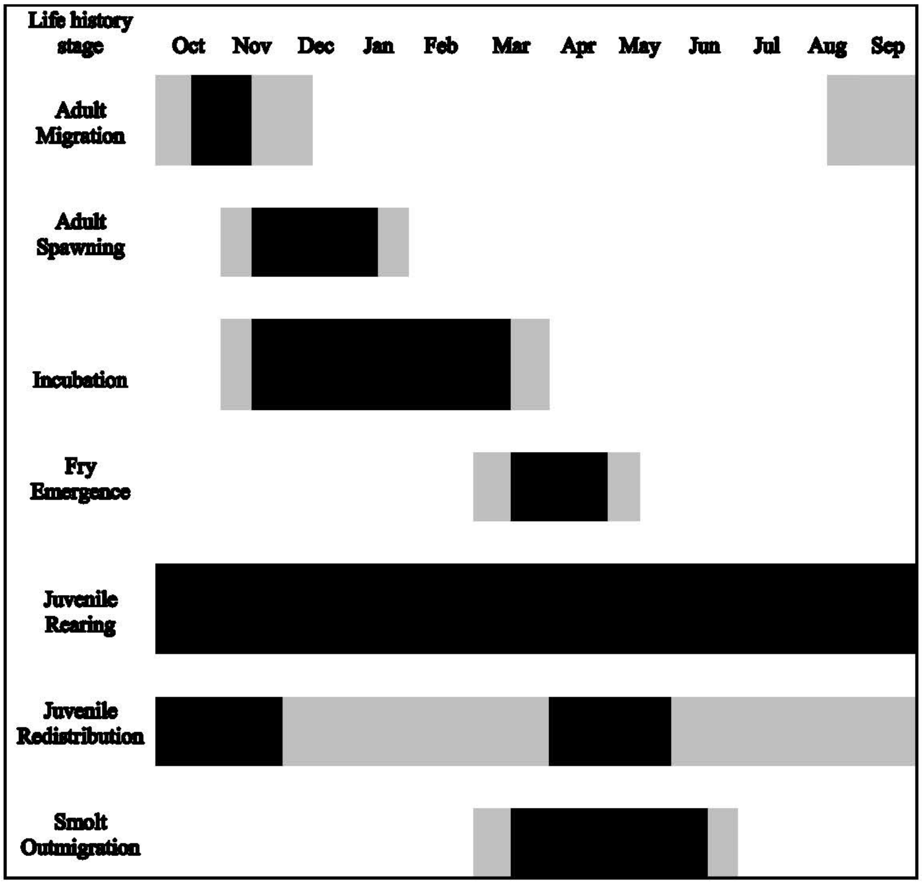

Figure 26. Life stage periodicities for coho salmon within the Klamath River Basin. Black areas represent peak use periods, those shaded gray indicate non-peak periods (Leidy et al. 1984; NRC 2004; Justice 2007; Carter et al. 2008).

2.3.2.3.2 Abundance and Distribution

Robust abundance estimates are not available for all populations of coho salmon that utilize the action area. However, population estimates of adult coho salmon in the basin that are available are all reduced from historic numbers and are all estimated to be below the viability threshold each year since 2009 (Table 25; NMFS (2014b), updated through 2022). The most robust data sets of natural populations in the Klamath Basin come from the Shasta River, Scott River, and Bogus Creek, at which CDFW maintains video weirs (Table 25) (Giudice et al. 2023b; Giudice et al. 2023a; Knechtle et al. 2023a; Knechtle et al. 2023b). Abundance estimates in most other locations are derived from spawner surveys (e.g. MKWC 2023). The Trinity River has had the largest runs of SONCC coho salmon in the Klamath Basin in most recent years, but the Scott River also maintains a strong run, which has occasionally been larger than the Trinity River in recent years (Table 25). Abundance and seasonal distribution characteristics are summarized for each sub-basin population in Section 2.3.2.3.2.1 *Upper Klamath Population* to Section 2.3.2.3.2.7 *Lower Klamath River Population*.

Table 25. Estimated coho salmon adult escapement and recovery targets for populations in or adjacent to the action area.

Population	**Origin**	**Recovery Target** (NMFS 2014b)	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Iron Gate Hatchery [a]	Hatchery	NA	485	586	644	1,268	384	72	86	122	200	116	242	1150	821
Upper Klamath Population [b]	Natural	8,500	<350	<300	<300	<300	<300	<300	<300	<300	~330	~280	~450	~640	~920
Bogus Creek [c]	Natural	NA	154	142	185	446	97	14	85	48	47	67	187	343	201
Middle Klamath Population [d]	Natural	450	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500
Shasta River [e]	Natural	4,700	44	62	114	163	46	45	48	41	39	50	37	53	47
Scott River [f]	Natural	6,500	927	355	201	2,752	485	212	226	382	739	346	1,766	852	238
Salmon River [g]	Natural	450	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50
Trinity River [h]	Natural	9,700	3,522	10,186	10,422	15,275	9,629	1,282	798	235	744	424	1,028	2,348	3,044
Trinity River Hatchery [h]	Hatchery	NA	4,425	4,810	8,236	6,631	3,908	3,337	527	420	742	649	2.334	2,346	3,507
Lower Klamath River [i]	Natural	5,900	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500	< 1,500

a (Giudice et al. 2023b)
b Estimates based on Bogus Creek counts, which are shown in the row below (Knechtle et al. 2023a) plus an estimated numbers of mainstem and tributary spawners derived from redd counts (Corum 2011; Mid Klamath Watershed Council (MKWC) 2022; Mid Klamath Watershed Council (MKWC) 2023).
c (Knechtle et al. 2023a)
d Projected using the highest estimates (i.e., 2004) from Ackerman et al. (2006) (see discussion below).
e (Giudice et al. 2023a)
f (Knechtle et al. 2023b)
g Continues from Ackerman et al. (2006) estimates for the Salmon River.
h (Kier et al. 2023)
i Regular monitoring of coho salmon escapement does not occur annually for this population. Projected using the estimates from Ackerman et al. (2006). The majority of spawning occurs in Blue Creek (Gale et al. 1998; Gale 2009; Antonetti et al. 2012; Antonetti et al. 2013)

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 six to seven miles of the Klamath River (Soto et al. 2016). Juvenile coho salmon (parr and smolts) have been observed residing within the mainstem Klamath River between the former IGD and Seiad Valley throughout the summer and early fall in thermal refugia during periods of high ambient water temperatures (>22ºC). 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).

In summary, abundance and seasonal distribution of coho salmon by sub-basin are described in the following sections.

2.3.2.3.2.1 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 the previous location of 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 that flow into the action area (i.e., Horse Creek and Seiad Creek) provide sources of cold water where juvenile coho salmon can be found over summering and low velocity reaches and off channel habitat features that provide low velocity refugia during the winter rearing period.

Coho salmon within the Upper Klamath River population spawn and rear primarily within several of the larger tributaries between Portuguese Creek and the former IGD including Horse and Seiad creeks. Coho salmon presence was confirmed in surveyed tributary streams including Horse, Seiad, Grider, West Grider, Beaver, Walker, and O'Neil creeks (Garwood 2012; MKWC 2023). The Mid Klamath Watershed Council (MKWC) has completed redd surveys in these tributaries, and has observed the number of coho salmon redds increase in recent years (MKWC 2022; MKWC 2023) (Table 25). 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 2014b).

Escapement of adult coho salmon entering Bogus Creek has been monitored by the CDFW annually since approximately 2004. Over that period the number of adult coho salmon estimated to have entered Bogus Creek has ranged between 7 fish (2009) and 446 fish (2013) and the proportion of hatchery coho salmon present in the run has averaged 0.47 and ranged between 0.09 (2019) and 0.91 (2020). Between 2014 and 2019 the total number of adult coho salmon observed was less than 100 fish, down substantially from the average run size between 2004 and 2013, but the 2020 return was 187 fish, but coho salmon returns in 2020, 2021, and 2022 were 187 fish, 343 fish, and 201 fish, respectively (Knechtle et al. 2023a). Due to the low numbers of the Upper Klamath River population, IGH origin coho salmon strays are currently an important component of the adult returns for this population because of their role in increasing the likelihood that wild coho salmon find a mate and successfully reproduce (NMFS 2014b). FCH origin coho are less likely to stray into Bogus Creek than were IGH origin coho salmon, as they will be released farther upstream at their new hatchery site, and because IGD is no longer blocking upstream passage just above the mouth of Bogus Creek.

Prior to dam removal, the upstream-most extent of anadromous habitat in the Klamath Basin was IGD. Critical habitat for SONCC coho salmon is not designated upstream of the former IGD. However, now that the dams have been removed, coho salmon are expected to re-populate their historic habitat above IGD, which is believed to be as far upstream as Spencer Creek (Huntington 2004; Hamilton et al. 2005; Dunsmoor et al. 2006; Hamilton et al. 2011; ODFW and the Klamath Tribes 2021). Implementation plan for the reintroduction of anadromous fishes into the Oregon portion of the Upper Klamath Basin, described coho habitat extending as far upstream as Spencer Creek, and recommends a volitional approach to coho salmon reintroduction, in which no active measures will initially be taken to assist in repopulating habitat in the Upper Klamath Basin. The habitat in the former IGD to Keno Dam reach supports a population of potadromous rainbow/redband trout (*Oncorhynchus mykiss*), and evaluation of the rainbow trout habitat usage may inform potential usage by anadromous species when access is restored (Hamilton et al. 2011). The majority of spawning habitat for rainbow/redband trout in the former IGD to Keno Dam reach is found in Spencer and Shovel creeks; however, various life stages of rainbow/redband trout utilize other tributaries and sections of the reach, including cold water refugia at J.C. Boyle Springs and Fall Creek (Hamilton et al. 2011).

Ramos (2020) conducted habitat surveys and specifically analyzed the repopulation potential for coho salmon in the largest tributaries to the Klamath River between the former IGD and Spencer Creek. Ramos (2020) used temperature and other physical features of six tributaries (i.e., Scotch, Camp, Jenny, Fall, Shovel, and Spencer creeks) to assess their capacity to support juvenile coho salmon following dam removal, and found that the six newly accessible tributary streams will provide greater than 33 kilometers (km) of newly accessible habitat, and maintained significant juvenile coho salmon summer rearing capacity, redd capacity, and intrinsic potential for adult coho salmon spawner escapement. Ramos (2020) concluded that there were prolific cold-water temperatures throughout Scotch, Camp, Fall, Shovel, and portions of Spencer creeks, and that newly accessible habitat in the study tributaries would provide substantial rearing and spawning habitat for coho salmon after dam removal. Building on the work done by Ramos (2020), O'Keefe et al. (2022) initiated habitat surveys in additional smaller tributaries in this reach, including areas of the Ramos (2020) tributaries that were previously inaccessible. These habitat surveys identified additional habitat features, including spawning gravel in Spencer Creek and Camp Creek, a complex of unnamed coldwater springs flowing into Copco Lake, and cold water refugial rearing areas (e.g., several springs on Shovel Creek, East Branch and West Branch Long Prairie Creek, and Frain Creek) that could be utilized by coho salmon (O'Keefe et al. 2022).

2.3.2.3.2.2 Middle Klamath River Population

Limited data exist on adult coho salmon abundance and distribution for the Middle Klamath River population. Adult spawning surveys and snorkel surveys have been conducted by the USFS and Karuk Tribe, but data from those efforts are insufficient to draw definitive conclusions on run sizes (Ackerman et al. 2006). Ackerman et al. (2006) relied on professional judgment of local biologists to determine what run sizes would be in high, moderate, and low return years to these tributaries; therefore, the run size approximations are professional judgment-based estimates. Juvenile coho salmon surveys have been conducted over the past several decades by various parties including the Karuk Tribe, MKWC, and USFS. These surveys have found coho salmon juveniles rearing in Hopkins, Aikens, Bluff, Slate, Red Cap, Boise, Camp, Pearch, Whitmore, Irving, Stanshaw, Sandy Bar, Rock, Dillon, Swillup, Coon, Kings, Independence, Titus, Clear, Elk, Grider, Little Grider, Cade, Tom Martin, China, Thompson, Fort Goff, Seiad, Horse, Beaver, and Portuguese creeks (NMFS Sutton et al. 2012; 2014b; Soto et al. 2016; Faukner et al. 2019). NMFS (2014b) identified the Middle Klamath River population at a moderate risk of extinction. Most of the juveniles observed in the Middle Klamath have been in the lower parts of the tributaries, which suggests many of these fish are non-natal rearing in these refugial areas. Adults and juveniles appear to be well distributed throughout the Middle Klamath; however, use of some spawning and rearing areas are restricted by water quality, flow, and sediment issues. Although the Middle Klamath River population's spatial distribution appears to be good, many of the Middle Klamath tributaries are used for non-natal rearing, and little is known to infer its extinction risk based on spatial structure.

2.3.2.3.2.3 Shasta River Population

Adult coho salmon returns to the Shasta River have been low in recent years. Since 2007 the number of adult coho salmon observed entering the Shasta River has ranged from a high of 249 fish in 2007 to a low of only nine fish in 2009 (Giudice et al. 2023a). From 2014 to 2022 the number of adult coho salmon have been 53 or less fish annually (Giudice et al. 2023a). To reduce the risk of local extirpation, all IGH surplus adult coho salmon have been released back to the Klamath River since 2010. Some of these surplus adults have been observed entering the Shasta River which is about 14 river miles downstream from the former IGH. Since that time the percentage of hatchery-origin coho salmon observed in the Shasta River spawning population has ranged from about 25 to 80%. Due to the low numbers of the Shasta River population, IGH/FCH origin fish play an important role in increasing the likelihood that wild coho salmon find a mate and successfully reproduce. The proportion of hatchery-origin adults in the spawning population for most recent years (2015 to 2019, 2021, and 2022) was unknown because sampling efforts were unable to recover any adult carcasses during this time, but the proportion of hatchery spawners in the Shasta River in 2020 was 43% (Giudice et al. 2023a).

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 2014b).

2.3.2.3.2.4 Scott River Population

Abundance estimates on the Scott River are relatively robust due to the presence of a video fish counting weir, which has been utilized since 2007. In 2020, 2021, and 2022, adult coho salmon returns to the Scott River were estimated to be 1,766, 852, and 238 fish, respectively (Knechtle et al. 2023b). 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 2014b).

2.3.2.3.2.5 Salmon River Population

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 2014b). Juvenile presence/absence and abundance data from a variety of surveys indicate that many of the tributaries throughout the watershed are used for spawning, including tributaries to the lower Salmon River, Wooley Creek, and the North and South Fork Salmon (NMFS 2014b). Annual adult coho salmon abundance observed in the Salmon River has varied between 0 and 14 spawning adults since 2002 (Hotaling et al. 2010). Between 2002 to 2007 only 18 adults and 12 redds (average of four 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 et al. 2010). There was a recorded observation of two individuals building a redd in 2017 (Meneks 2018). 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.

2.3.2.3.2.6 Trinity River Populations

Information regarding population size of individual SONCC coho salmon population units in the Trinity Basin is limited because systematic monitoring on the coho salmon populations in the area is limited. Because adult coho salmon from all three population units of the Interior-Trinity Diversity Stratum pass through the Willow Creek weir on the lower Trinity, it is not known which population of coho salmon is captured at the weir. As such, the weir provides an aggregate population estimate for all unmarked coho salmon upstream of the weir. The mean natural area spawners for the five year period of 2018 to 2022 was 1,397 fish (Kier et al. 2023). The natural area coho salmon spawner estimate for the 2022 spawning season was 3,044 fish (Kier et al. 2023). Coho salmon continue to be present in many of the tributary streams in this population unit, but low adult returns in recent years have left some habitat unoccupied. Although there may be robust numbers of spawners occasionally in some years, the overall number of naturally produced coho salmon in the Upper Trinity River watershed is low compared to historic conditions, and hatchery fish dominate the run. The Upper Trinity River Population unit has the greatest degree of temporal and spatial exposure to hatchery fish of any of the population units in the action area. SONCC coho salmon in this population unit are exposed to both genetic interactions through breeding with TRH coho salmon, as well as ecological interactions (predation, competition and disease transfer) with hatchery coho salmon, Chinook salmon, and steelhead. Limited data exists for the Lower Trinity population and the South Fork Trinity population as few surveys have been completed.

2.3.2.3.2.7 Lower Klamath River Population

Coho salmon have a wide distribution throughout the Lower Klamath, but generally low abundances, based on the results of juvenile surveys, spawner surveys, and outmigrant trapping. Moderate densities of coho salmon are found in Blue, McGarvey and Ah Pah creeks. The majority of spawner observations have been made in Blue Creek (Gale 2009; Antonetti et al. 2012; Antonetti et al. 2013; Antonetti 2023b; Antonetti 2023a), but Terwer and McGarvey creeks also support coho salmon spawning (Antonetti 2023b; Antonetti 2023a). Adult coho salmon population abundance, estimated by Ackerman et al. (2006) ranged from 14 to approximately 1,500 spawners between 2002 and 2006 (NMFS 2014b).

2.3.3 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action but that are not part of the action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.02).

2.3.3.1 Effects to SONCC Coho Salmon ESU Critical Habitat

The proposed action is expected to effect SONCC coho salmon critical habitat in the action area. As described in Section 2.1 *Analytical Approach*, NMFS considers the effects of the proposed action in relation to the Klamath River natural flow regime. NMFS recognizes that environmental and human-caused factors have influenced the Klamath River natural flow regime over time, including the effects of past and present Klamath Project operations. We also consider the current state of the environmental baseline due to factors other than the Klamath Project operations, (e.g., climate change, increased municipal water use, off-Klamath Project water use). Secondly, NMFS will use best available science, such as that developed to describe relationships between flow and habitat (Hardy et al. 2006; Hardy 2012) to assess impacts to the designated critical habitat for SONCC coho salmon.

2.3.3.1.1 Klamath Project Operations

This hydrologic effects analysis is based on 1) daily Keno Release Target flow (including daily Keno minimum flows) and daily Iron Gate flow results from the KBPM's (KRM version) formulaic approach based on the Operations Index, as described in the proposed action, and 2) adaptive management, where details provided by Reclamation are sufficient to analyze. Note that the use of the term "proposed action" in this section refers to the Klamath Project operations component of the proposed action (including Elements 1, 2 and 3), as described earlier in the Section 1.3 *Proposed Federal Action*.

The KBPM (KRM version) results include the use of the FFA, released as either a pulse flow event of short duration, or released evenly over a longer period of time between March 2 and June 30. The KRM logic does not limit NMFS' ability to request release of the FFA volumes in alternative distributions that deviate from the default pulse flow distribution, using the RTO Team process described in the Section 1.3 *Proposed Federal Action*.

NMFS understands that any deviations from the formulaic approach via the proposed adaptive management process would only 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 RTO team (formerly known as the FASTA team) that are presented to Reclamation for approval and implementation. Considerations of the RTO team will include balancing the costs and benefits of deviations from the formulaic approach to both listed suckers and coho salmon.

Under the proposed action, the median annual Klamath Project delivery from all surface water sources for the more recent 1991 to 2022 POR is approximately 260,000 AF (231,000 AF in spring/summer, 29,000 AF in fall/winter) with a minimum of 61,000 AF and a maximum of 466,000 AF. The majority of this Klamath Project water comes from UKL, as the median annual Klamath Project diversion from UKL is approximately 211,000 AF. The rest of Klamath Project water is supported by diversions from other sources, primarily the Lost River and LRDC/KDD return flows. The median annual Klamath Project delivery of 260,000 AF is approximately 27% of the median annual UKL net inflow (980 TAF) for the 1991 to 2022 POR. Overall, the inter-annual operations of the Klamath Project as described in the proposed action result in a significant reduction in water availability for the Klamath River below Keno Dam.

2.3.3.1.2 Hydrologic Effects

To analyze the hydrologic effects of Reclamation's proposed Klamath Project operations (i.e., proposed action), NMFS analyzes how the proposed action impacts the Klamath River natural flow regime and critical habitat, accounting for both historical data and contemporary changes in the Klamath River's hydrology.

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). Reclamation's proposed action affects all components of the natural flow regime. NMFS assesses the proposed Klamath Project operations' effects on flow volume, magnitude, timing, duration, and variability, and on 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 daily average Keno Dam minimum flows, Keno Release Targets, and Iron Gate flows provided from KRM output in the 2018 BA for the 1991 to 2022 POR (Reclamation 2018). As in previous biological opinions (NMFS and USFWS 2013), the hydrograph produced at Keno Dam as a result of the proposed action is evaluated with respect to 1) the general tendencies (i.e., magnitude, duration, timing) of the relatively unimpaired conditions defined by the 1905 to 1913 discharge dataset at Keno, Oregon before construction of the complete Project[10], and 2) the Klamath River natural flow regime as influenced by the current environmental baseline. For these analyses, NMFS assumes that accretions (i.e., tributary flows) from Keno Dam to the former IGD site in the 1991 to 2022 POR are the best available representation of future accretions during the five-year term of the 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 proposed action, NMFS considers the effects of the proposed action in relation to the Klamath River natural flow regime. NMFS recognizes that environmental and human-caused factors have influenced the Klamath River natural flow regime over time, including the effects of past and

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[10] The 1905 to 1913 discharge dataset at Keno, Oregon is used because an unimpaired, historic daily discharge dataset at the current Keno Dam is not available.

present Klamath Project operations, as well as factors other than the Klamath Project operations (e.g., climate change, increased municipal water use, off-Klamath Project water use).

NMFS acknowledges that the 1905 to 1913 historic discharge dataset at Keno, Oregon is limited and likely does not represent the potential range of hydrologic conditions that occurred in the 1991 to 2022 POR. The long-term rainfall record for Klamath Falls, Oregon, suggests that the 1905 to 1913 period had slightly above average precipitation (i.e., 104% of average for the period 1905 to 1994), with slightly above average runoff for much of the upper Klamath Basin (Hecht et al. 1996). The 1905 to 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 1991 to 2022 POR does contain both wet and dry water years which likely encompasses the full range of hydrologic conditions expected to occur. NMFS also acknowledges that the historic discharge dataset at Keno Dam does not include the effects of climate change, and overall decreasing inflows to UKL due to the fact that the upper Klamath Basin is generally warmer and drier than it was over 100 years ago (Mayer 2008; Mayer et al. 2011; Reclamation 2011a; Swain et al. 2018).

2.3.3.1.2.1 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 et al. 2002; Beechie et al. 2006).

As part of the proposed action, Reclamation proposes to manage flows in the Klamath River in a manner that approximates the natural flow regime, represented by real-time hydrologic conditions as defined by the UKL status, NWI, and resulting Operations Index (Section 1.3 *Proposed Federal Action*). For this discussion, the 1905 to 1913 discharge dataset at Keno, Oregon, is used to represent the natural hydrograph. The 1905 to 1913 Keno discharge dataset includes historic and relatively unimpaired river flow before complete construction and operation of the Klamath Project. Below, NMFS describes the hydrologic effects of the proposed action at Keno in relation to the 1905 to 1913 discharge dataset, with the assumption that SONCC coho salmon may be present downstream of Keno with dams removed and during the term of the proposed action. Critical habitat for SONCC coho salmon is not designated upstream of the former IGD site; however, impacts to their habitat downstream of Keno Dam could have effects to individuals. NMFS also considers Iron Gate flows (observed at the USGS gage located downstream of the former IGD site) in relation to effects to individuals and critical habitat.

Reclamation's proposed action of storing and delivering Klamath Project water limits the volume of water available to approximate the Klamath River natural flow regime. NMFS recognizes that other factors, such as actions necessary to meet needs of endangered ESA-listed suckers as described in the BA, and effects that are not a result of Reclamation's proposed action (e.g., municipal water use, climate change, off-Klamath Project water users) also limit the water available to approximate the natural flow regime. This hydrologic effects analysis analyzes the effects of the proposed action in the context of these other factors, which inform the environmental baseline. As stated earlier, under the proposed action, the median annual Klamath Project delivery of 260,000 AF is approximately 27% of the median annual UKL net inflow (980 TAF). Overall, the proposed action would result 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. However, in large part as a result of operating the Klamath Project, the Klamath River annual flow volume, spring peak magnitude and duration, and flow variability will be reduced under the proposed action relative to the natural hydrograph (Figure 27).

Under the proposed action, the average annual hydrograph at Keno, Oregon for the 1991 to 2022 POR, would resemble the natural hydrograph (shape, timing, variability); however, the peak discharge magnitude is substantially reduced and the timing is shifted approximately one month earlier, from early May to early April, relative to the historic average annual hydrograph at Keno for the 1905 to 1913 period. Additionally, fall/winter, spring and summer discharge is considerably reduced (Figure 27). Historically, Klamath River discharge did not reach base flows until September. After factoring in implementation of the proposed action in addition to other factors described above, base flows now typically occur in early June in dry years and at the beginning of July in average and wet years, a shift in base flow timing of approximately two to three months earlier. Figure 27 displays the proposed action average annual hydrographs at Keno for two periods of record: 1981 to 2022 and 1991 to 2022. The figure shows that the proposed action average annual hydrograph at Keno for the 1991 to 2022 POR is reduced when relative to the proposed action average annual hydrograph at Keno for the 1981 to 2022 POR. The more recent 1991 to 2022 POR reflects a period of drier and warmer conditions that are more representative of current, and likely future, Klamath Basin hydrologic conditions. Note the short duration flow event near the end of August in the proposed action average annual hydrographs at Keno 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.

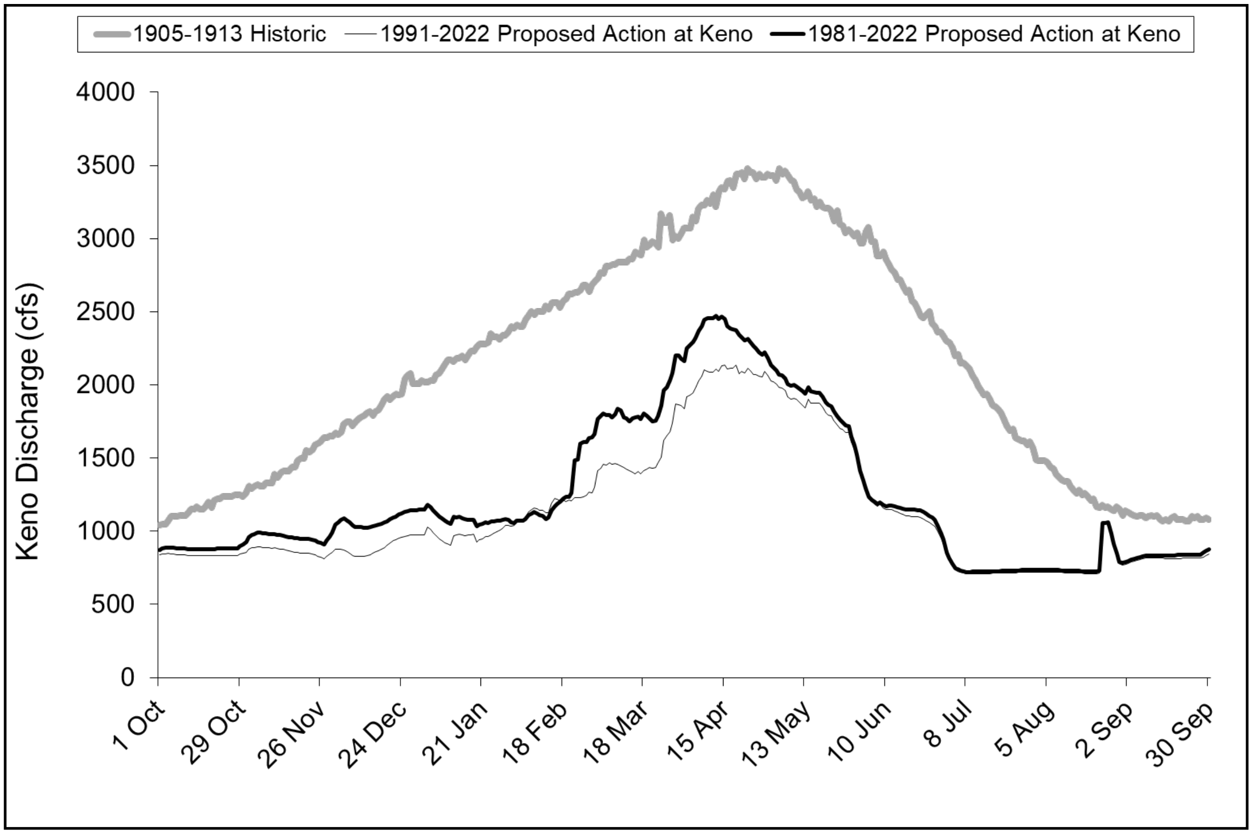

Figure 27. Proposed action average annual hydrograph at Keno for 1981 to 2022 and 1991 to 2022 POR's, and historic average annual Klamath River discharge at Keno, Oregon. The 1905 to 1913 dataset represents historic and relatively unimpaired river flow before complete construction and operation of the Klamath Project.

The overall Project effects of a median 27% reduction in water volume available to the Klamath River will result in lower base flows and smaller incremental increases in flow in the FW period from October through February relative to the natural hydrograph (Figure 27). This departure from the natural hydrograph is partly a result of the proposed action's prioritization of refilling UKL during this period rather than releasing water downstream. Without the Klamath Project operating, end of summer UKL elevations would be higher due to no agricultural diversions, resulting in higher base flows in the Klamath River in the fall and winter that would incrementally increase as inflow and precipitation increase because a smaller percentage of UKL inflow would be required to refill UKL. Instead, particularly in below average and dry years, the majority of fall and winter inflows are stored in UKL rather than naturally flowing through 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% exceedance; see Table 26), Keno Release Target flows released from Keno Dam under the proposed action are expected to incrementally increase through the FW 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 Keno Dam. The proposed action average annual hydrograph at Keno Dam also indicates an earlier and lower peak discharge in the spring, an earlier return to base flows in the summer, and flows that are generally lower in magnitude relative to the natural hydrograph (Figure 27).

Additionally, the Klamath Project's inter-annual water year effects from diverting and consuming water, lowers the elevation of UKL throughout the winter, spring, summer and fall, thereby increasing the amount of inflow 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 Klamath 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 2012) and a drier climate in the upper watershed as suggested by the more recent ten to twenty years of data (FERC 2022). Because of the annual, and inter-annual effects of water diversion for Klamath Project irrigation, the proposed action creates drier conditions in the Klamath River and increases the likelihood of consecutive drier years in the Klamath River (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 Keno Release Target flows at Keno Dam (Table 26). 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% POE represents a dry year, 50% POE represents an average year, and 5% POE represents a wet year). The yellow highlighted cells in Table 26 identify the wide range of POEs (i.e., hydrologic conditions) when proposed action Keno Release Target flows from Keno Dam will be at or near (within 25 cfs) Reclamation's proposed Keno Dam minimum flows[11]. The yellow highlighted cells in Table 27 identify a much narrower range of POEs (i.e., hydrologic conditions) when daily average Iron Gate flows[12] will be at or near (within 25 cfs) NMFS' 2019 biological opinion IGD minimum flows. NMFS considers the daily average Iron Gate flow results in relation to NMFS' 2019 biological opinion IGD minimum flows (although Keno Dam is the compliance point) because it represents an important reference point for understanding exposure to salmonids and is the upstream most extent of designated critical habitat for SONCC coho.

Additionally, NMFS utilizes the best available science on flow/habitat relationships for which to evaluate the effects of the proposed action which was developed for the reaches downstream of Iron Gate. It is important to note the significantly narrower range of POEs in July through February that Iron Gate flows are at or near (within 25 cfs) NMFS' 2019 biological opinion IGD minimum flows relative to the percentage of days that proposed action Keno Release Target flows at Keno Dam are at or near (within 25 cfs) Reclamation's proposed Keno Dam minimum flows. This difference is largely a result of the tributary flows (e.g., J.C. Boyle springs, Spencer, Fall, and Jenny Creeks) that contribute to the volume of water released from Keno Dam and impart additional flow variability to the mainstem Klamath River between Keno Dam and the former IGD site. This result confirms NMFS' expected positive effects that dam removal has on flow variability in the mainstem Klamath River at the former IGD site and downstream. The effects of Keno Dam minimum flows on the essential PBFs of critical habitat vary seasonally and are described in detail later in the effects analysis.

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[11] A table of the minimum flows from Keno Dam that Reclamation proposed for each month can be found in Section 1.3 *Proposed Federal Action*, and in Table 28 below.

[12] Reclamation's Iron Gate flows are expected to be observed at the Iron Gate gage (located downstream of the former IGD site) as a result of the flows released at Keno (plus tributary flows) under the proposed action. A table of NMFS' 2019 biological opinion minimum flows for each month can be found in Table 29 below.

Table 26. Exceedance table for proposed action daily average Keno Release Target flows (cfs) at Keno Dam for 1991 to 2022 POR. The yellow highlighted cells identify the wide range of probabilities of exceedance when proposed action Keno Release Target flows will be at or near (within 25 cfs) Reclamation's proposed Keno Dam minimum flows found in Table 28 below.

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	752	726	656	656	655	756	1,043	948	783	650	650	730
90%	757	742	661	658	658	821	1,138	1,030	831	651	651	745
85%	758	752	663	660	662	881	1,210	1,107	874	653	653	750
80%	760	755	665	665	669	904	1,260	1,140	913	654	654	751
75%	762	758	669	671	673	921	1,300	1,188	930	655	656	753
70%	762	759	673	674	677	943	1,363	1,235	956	659	662	754
65%	764	760	679	679	681	982	1,417	1,304	969	665	666	755
60%	767	763	689	687	686	1,049	1,472	1,345	978	669	673	757
55%	770	765	701	697	691	1,123	1,545	1,405	990	673	678	766
50%	771	770	710	708	699	1,182	1,651	1,446	1,001	677	690	771
45%	773	773	719	717	713	1,224	1,841	1,484	1,026	681	708	777
40%	779	777	726	725	735	1,375	1,947	1,563	1,052	698	727	791
35%	794	784	736	737	758	1,470	2,070	1,714	1,098	737	745	815
30%	840	803	746	751	909	1,717	2,237	1,932	1,148	748	768	823
25%	869	860	758	764	1,074	2,233	2,500	2,039	1,176	757	790	831
20%	937	907	785	992	1,224	2,427	2,855	2,141	1,219	776	846	848
15%	948	1,041	1,165	1,271	1,787	2,604	3,128	2,264	1,294	797	920	872
10%	975	1,104	1,428	1,628	2,510	2,877	3,796	2,549	1,368	839	1,034	897
5%	1,161	1,475	2,088	2,164	3,381	3,978	4,612	3,307	1,851	893	1,220	1,072

Table 27. Exceedance table for daily average Iron Gate flows (cfs) for 1991 to 2022 POR. The yellow highlighted cells identify the wide range of probabilities of exceedance when Iron Gate flows will be at or near (within 25 cfs) NMFS' 2019 biological opinion IGD minimum flows found in Table 29 below.

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
95%	1,015	1,026	961	969	996	1,129	1,421	1,264	1,070	917	913	998
90%	1,024	1,051	984	992	1,019	1,236	1,564	1,369	1,149	927	924	1,010
85%	1,036	1,066	1,003	1,021	1,048	1,276	1,637	1,483	1,207	940	934	1,027
80%	1,054	1,078	1,022	1,041	1,069	1,310	1,669	1,532	1,235	948	945	1,038
75%	1,072	1,088	1,039	1,061	1,087	1,361	1,741	1,612	1,259	958	955	1,049
70%	1,084	1,100	1,052	1,081	1,105	1,424	1,881	1,675	1,275	972	967	1,059
65%	1,096	1,109	1,065	1,097	1,131	1,503	1,980	1,754	1,301	980	975	1,069
60%	1,110	1,117	1,079	1,121	1,160	1,584	2,090	1,815	1,319	990	988	1,081
55%	1,122	1,125	1,100	1,151	1,195	1,724	2,203	1,877	1,338	999	1,005	1,096
50%	1,133	1,134	1,119	1,187	1,230	1,866	2,296	1,932	1,360	1,009	1,019	1,109
45%	1,140	1,147	1,143	1,223	1,292	2,050	2,524	2,027	1,398	1,023	1,041	1,122
40%	1,152	1,167	1,172	1,258	1,374	2,307	2,691	2,141	1,442	1,040	1,062	1,133
35%	1,171	1,191	1,205	1,317	1,472	2,559	2,864	2,306	1,502	1,077	1,080	1,146
30%	1,207	1,227	1,262	1,406	1,557	2,895	3,005	2,527	1,572	1,096	1,115	1,166
25%	1,259	1,281	1,351	1,541	1,797	3,079	3,251	2,642	1,608	1,134	1,166	1,182
20%	1,301	1,339	1,527	1,783	2,243	3,295	3,591	2,762	1,669	1,160	1,230	1,204
15%	1,333	1,450	1,756	1,997	2,692	3,509	4,120	3,000	1,803	1,200	1,306	1,233
10%	1,446	1,553	1,981	2,338	3,329	3,977	4,718	3,330	1,981	1,254	1,363	1,291
5%	1,549	1,887	3,043	3,799	4,721	5,042	5,546	4,235	2,449	1,336	1,568	1,444

The proposed action will result in lower base flows and provide less variability in the FW period (October to February) than the natural flow regime due to prioritization of refilling UKL in this period, particularly in below average and dry years. Figure 28 illustrates this pattern where UKL net inflows incrementally increase and are highly variable, whereas Keno Release Target flows at Keno Dam remain relatively low and stable. Consecutive years of relatively dry climatological conditions will likely result in relatively low flows with minimal variability at Keno Dam as in water years 1991 and 1992, for example (Figure 28).

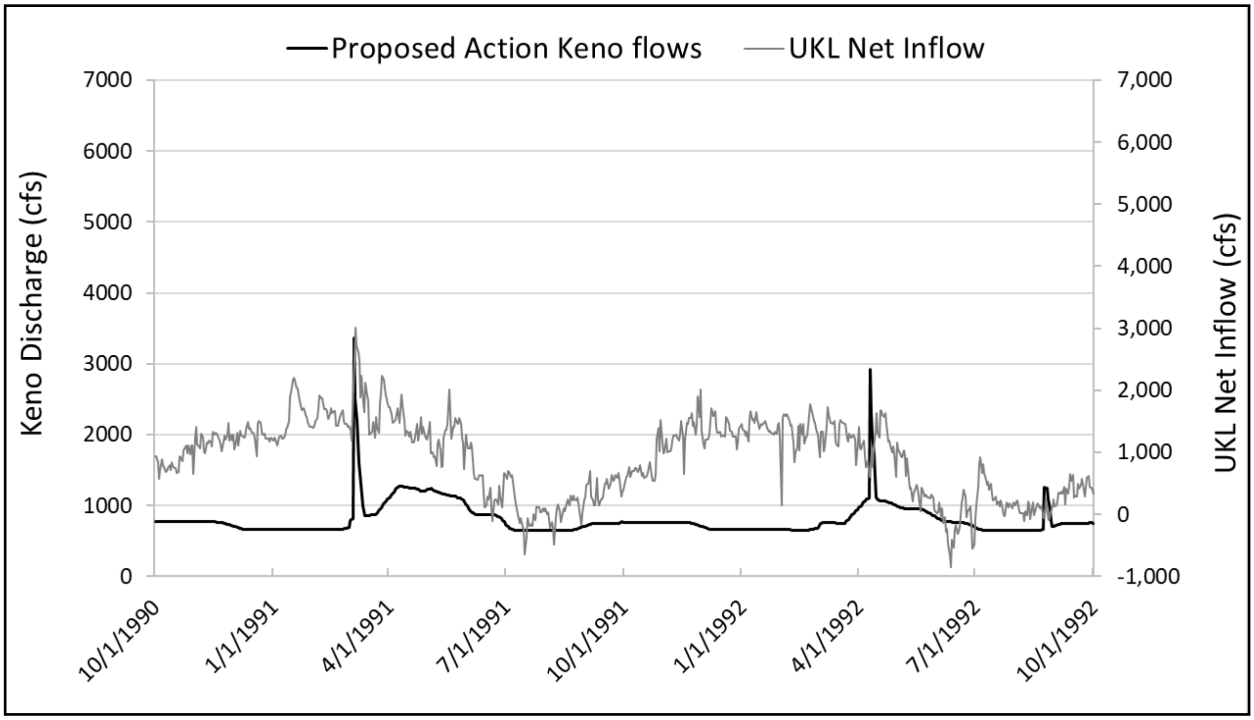

Figure 28. Proposed action Keno Release Target flows from Keno Dam and UKL net inflow for consecutive dry water years 1991 and 1992.

While in general, the proposed action results in Klamath River flows that are lower than the natural flow regime, there are exceptions. For example, the proposed action reduces fall releases from LRD 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 results in Reclamation making 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; however, this generally only occurs in above average or wet water years. Additionally, in critically dry years such as 1991 and 1992, accelerated refill of UKL in the fall can enhance storage and water availability in the spring, providing increased FFA volumes to implement pulse flows for sediment maintenance or disease mitigation that would otherwise not likely occur, as seen above in Figure 28.

Overall, the proposed action reduces Klamath River annual flow volume and peak flows relative to the natural hydrograph (Figure 27). The proposed action will also result in an earlier return to lower base flows in the summer and less flow variability in the FW period from October through February relative to the natural hydrograph (Figure 27). The proposed action also shifts volumes of water from the FW (October to February) and summer (July to Sept) periods to the spring period (March to June) as evidenced by the yellow highlighted cells in Table 26.

2.3.3.1.2.2 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 et al. 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 et al. 2002), which can increase the growth and survival of juvenile salmon (Jeffres et al. 2008). Flow variability is particularly important in the Klamath River where low, stable flows have led to the proliferation of fish diseases in the mainstem (Hillemeier et al. 2017). Arthington et al. (2006) stated that simplistic, static, environmental flow rules are misguided, and will ultimately contribute to further degradation of river ecosystems. As described earlier in Section 1.3.2 *Modeling of the Proposed Action*, the proposed action does not rely on static flow rules. Instead, Keno Release Targets at Keno Dam are calculated daily based on the Daily Operations Index. This element of the proposed action results in flow releases from Keno Dam that are adjusted daily based on changing hydrologic conditions, often providing daily flow variability and reducing long periods of static flows out of Keno Dam.

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 (i.e., NWI, UKL Status) in the upper Klamath Basin. However, because Klamath Project deliveries reduce UKL elevations and increase the amount of inflow required to refill UKL on an annual basis, the proposed action will continue to contribute to diminished daily flow variability (e.g., reduced incremental increases of fall and winter base flows) relative to the natural hydrograph, particularly in below average and dry water years (Figure 28). Given the recent removal of the four lower dams on the Klamath River, flow variability at the former IGD site is expected to improve under the proposed action; however, two dams (LRD and Keno Dam) still exist and, due to operational constraints of managing flows at the two dam sites, achieving relatively unimpaired flow variability similar to the natural hydrograph is not feasible.

The spring period of March, April and May (and in some years June) is naturally a period of high flow variability in the Klamath River. Under the proposed action, water storage in UKL generally peaks in these months as well. In average and wetter years, rainfall events and sudden increases in snowmelt can result in variable flows from Keno Dam in the spring period as Reclamation treats hydrological fluctuations as 'run-of-the-river' (i.e., UKL inflow equals outflow from UKL) when UKL elevations reach flood control thresholds (see Reclamation (2024a) BA Appendix C, Addendum 1). Therefore, when UKL elevations reach flood control thresholds, the proposed action would pass through any additional inflow coming into UKL so that flood control thresholds are not exceeded. However, in large part as a result of the proposed action storing and delivering Klamath Project water, UKL elevations will not reach flood control thresholds in most dry years and some average years, resulting in a reduction in daily flow variability at Keno Dam in those years.

The effects of the proposed action on flow variability will be greatest closest to Keno Dam and diminish downstream, as tributary flows (e.g., J.C. Boyle springs, Spencer, Fall, and Jenny creeks) contribute to the volume of water and impart additional flow variability to the mainstem between Keno Dam and the former IGD site. By early April, contributions from the Shasta River (approximately 14 river miles below the former IGD) are expected to be reduced by non-Klamath Project water diversions for agricultural practices, and tributaries provide relatively minor contributions downstream until contributions from the Scott River (approximately 34 river miles below former IGD) increases flow variability. By mid-June, as Scott River flows decrease substantially from water diversions and lack of precipitation and snowmelt, the Klamath Project's effects on flow variability will be heightened throughout the middle Klamath River reach. With a strong likelihood that current climatological trends, including increased drought severity and frequency, and warm spring conditions will continue over the period 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 et al. 2011), NMFS anticipates earlier peak flows and reduced late spring accretions during the implementation of the proposed action 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 Klamath Project operations, the ability to model and evaluate the range of daily flow variability had been constrained to monthly or biweekly time-step output. Under the current proposed action, flows released from Keno Dam are a result of daily calculations that incorporate several key indicators of natural hydrologic conditions (UKL Status, NWI, Operations Index, accretions below LRD, etc.). NMFS evaluated the expected daily change in flow at Keno Dam under the proposed action by comparing the percentage of days that modeled proposed action Keno Release Target flows for the 1991 to 2022 POR are at or near (plus 5%) Reclamation's proposed Keno minimum flows (Table 28). NMFS also evaluated the daily change in flow at the former IGD by comparing the percentage of days that modeled proposed action Iron Gate flows for the 1991 to 2022 POR are at or near (plus 5%) NMFS' 2019 biological opinion minimums at the former IGD (Table 29). These evaluations were completed using Reclamation's proposed action Keno Dam minimums, Keno Release Targets, Iron Gate flows (as a result of the Keno Release Targets), and NMFS' 2019 biological opinion minimum flows at the former IGD 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).

Currently, there is no instream flow and habitat study completed for the Keno Dam to former IGD reach of the Klamath River. Although NMFS acknowledges that relatively minor changes have likely occurred to the flow/habitat relationships in the Klamath River downstream of the former IGD site post dam removal, we assume the Hardy Phase II report is still considered to be the best available science regarding flow/habitat relationships in the Klamath River, until a new study can be completed. Hardy et al. (2006) discussed the concept of an environmental base flows (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% 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, under the ESA, NMFS must focus its effects analysis on consequences to listed species or critical habitat that are caused by the proposed action, here, the effects on listed SONCC coho salmon and its designated critical habitat (as noted above, NMFS also analyzes effects of the proposed action on Chinook salmon, which are prey for listed SRKWs). Nevertheless, Hardy et al. (2006) instream flow recommendations provide NMFS with a useful reference when analyzing the proposed Keno Release Target flows, and Iron Gate flows produced as a result of the releases from Keno Dam 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.

Table 28. Percentage of days that modeled proposed action Keno Release Target flows for the 1991 to 2022 POR are at or near (plus 5%) Reclamation's proposed Keno Dam minimum flows.

Percentage of days that modeled proposed action Keno flows are at or near (plus five percent) Proposed Action Keno minimum flows		
MONTH	**Proposed Action Keno Minimums (CFS)**	**Percentage of days at or near Proposed Action Keno Minimums (%)**
October	750	65
November	750	66
December	650	45
January	650	38
February	650	39
March	700	**4**
April	1,000	**4**
May	900	**5**
June	750	**6**
July	650	62
August	650	52
September	750	58

Table 29. Hardy et al. (2006) EBF and NMFS’ 2019 biological opinion IGD minimums by month. Percentage of days that modeled Iron Gate flows for the 1991 to 2022 POR are at or near (plus 5%) NMFS’ 2019 biological opinion IGD minimums.

Percentage of days that Iron Gate flows are at or near (plus five percent) NMFS' 2019 BiOp IGD minimum flows			
MONTH	**Hardy's EBF (CFS)**	**NMFS' 2019 BiOp IGD Minimums (CFS)**	**Percentage of days at or near NMFS' 2019 BiOp IGD Minimums (%)**
October	1,395	1,000	20
November	1,500	1,000	12
December	1,260	950	13
January	1,130	950	11
February	1,415	950	**6**
March	1,275	1,000	**0**
April	1,325	1,325	**4**
May	1,175	1,175	**3**
June	1,025	1,025	**6**
July	805	900	19
August	880	900	20
September	970	1,000	25

Table 28 demonstrates a substantial percentage of days at which modeled proposed action Keno Release Target flows for the 1991 to 2022 POR are at or near (plus 5%) Reclamation’s proposed Keno Dam minimums in July through February[13]. Specifically, proposed action Keno Release Target flows are at or near Reclamation’s proposed Keno Dam minimums between 38 and 66% of days for October through February, and between 52 and 62% of days 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. In the March through June period, proposed action Keno Release Target flows are at or near Reclamation’s proposed Keno Dam minimums for a much smaller percentage of time, between 4 and 6% of days (Table 28). These low percentages in the spring time are more representative of the natural flow regime and are also consistent with the Hardy Phase II report that adopted EBF flows equal to the monthly 95% exceedance level of their instream flow recommendations (i.e., flows should meet or exceed minimums 95% of the time, or stated in an alternative manner, flows should be at or near minimums only 5% of the time).

Table 29 demonstrates that the percentage of days at which modeled Iron Gate flows for the 1991 to 2022 POR are at or near (plus 5%) NMFS’ 2019 biological opinion former IGD minimums in July through January is also substantial, but considerably lower percentages than at

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[13] Modeled Keno Release Target flows from Keno Dam are greater than 5% above Reclamation’s proposed Keno Dam minimums for the remainder of the time under the proposed action.

Keno[14]. Specifically, Iron Gate flows are at or near NMFS' 2019 biological opinion former IGD minimums between 11 and 20% of days for October through January, and between 19 and 25% of days for July through September periods. In the February through June period, Iron Gate flows are at or near NMFS' 2019 biological opinion former IGD minimums for a much smaller percentage of days, between 0 and 6% (Table 29). Therefore, NMFS expects the greatest likelihood of flow variability to occur below Keno and at Iron Gate during the spring (March through June) period. It is also important to note the significantly lower percentage of days in July through February that Iron Gate flows are at or near (plus 5%) NMFS' 2019 biological opinion former IGD minimum flows relative to the percentage of days that proposed action Keno Release Target flows are at or near (plus 5%) Reclamation's proposed Keno Dam minimum flows. These results confirm NMFS' expected positive effects that dam removal will have on flow variability in the mainstem Klamath River at the former IGD site and downstream.

Even though flow variability will improve under the proposed action at the former IGD site and downstream (in large part due to dam removal), the Keno Release Target flows are at or near Reclamation's proposed Keno Dam minimum flows between 38 and 66% for the July through February period, with little to no variability (Table 28). Absent the proposed Klamath Project operations effects, Keno Release Target flows generally would be higher with more variability during this period. However, during the March through June period, proposed action Keno Release Target flows are at or near (plus 5%) Reclamation's proposed Keno Dam minimums between 4 and 6% of days (Table 28); similar to what NMFS would expect under a natural flow regime, where minimum flows would likely only occur approximately 5% of the time in the Klamath River (95% exceedance flows). The months of March (4%), April (4%), May (5%) and June (6%) have the lowest percentage of days at or near Reclamation's proposed Keno Dam minimum flows (Table 28). The March through June results are more representative (than the rest of the year) of a natural flow regime during the critical period of coho salmon's life history in the spring.

2.3.3.1.2.3 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 et al. 2002; NMFS 2010b; Poff et al. 2010; USFWS 2016d) (USFWS 2016d). 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, *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 (Holmquist-Johnson et al. 2010; 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*

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[14] Modeled Iron Gate flows are greater than 5% above NMFS's 2019 biological opinion minimums at the former IGD for the remainder of the time under the proposed action.

in the Klamath River Basin (Stocking et al. 2007). NMFS evaluates the effects of the frequency and magnitude of sediment maintenance and geomorphic flows, and the duration of immobile bed conditions expected to occur during the proposed action relative to the Klamath River natural flow regime, given the current environmental baseline.

Three past studies have developed estimates of sediment transport thresholds for the Klamath River below the former 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. NMFS acknowledges that the flow thresholds identified above are approximate and may have been altered due to the likely change in sediment composition and sediment mobilization and transport processes resulting from the large influx of accumulated sediment released to the river during dam removal. However, until a sediment mobilization/transport study is completed for the Klamath River reach between Keno and the former IGD site, NMFS will use the flow thresholds identified above as likely approximations given the basic hydrology and geomorphology of the Klamath River, and consider it to represent the best available science.

Utilizing the criteria for defining sediment mobilization and transport thresholds as described in the three past studies and synthesized in USFWS' Sediment Mobilization technical memorandum (USFWS 2016d), flow ranges are divided into three categories for the following evaluation: (1) immobile bed conditions (i.e., flows <2,500 cfs) cause suspended fine sediment and organic material to settle on the streambed and are not re-suspended until subsequent sediment maintenance flows occur; (2) sediment maintenance flows (i.e., flows ranging between 5,000 and 15,000 cfs) are intended to entrain, transport and remove sediment from a channel, disturb armor layers and/or modify substrate composition; and (3) geomorphic flows (i.e., flows > 15,000 cfs) are intended to move the armor layer, and maintain channel form and floodplains. Note that flows ranging between 2,500 and 5,000 cfs are likely to mobilize surface sediment, but any suspended sediment in the water column will likely remain in transport in this flow range (Holmquist-Johnson et al. 2010). NMFS acknowledges that the flow ranges identified above are approximate and that the three studies' estimated sediment transport thresholds varied due to differences in study methods and the dates when channel substrate and channel conditions were evaluated (USFWS 2016d).

KRM output for the Pulse Flow On, scenario A (Figure 6) indicates that some form (magnitude and duration) of a pulse flow would occur in 41 of 42 years of the POR. The only year in the modeled record the FFA was insufficient to provide a meaningful pulse flow magnitude was 2022, one of the driest years in the POR at the end of a three-year drought cycle. The modeling results indicate that the FFA volume accrued in the FW period was large enough to release a maximum daily Keno Release Target flow that would result in an Iron Gate flow of approximately 5,000 cfs or higher in 34 of 42 years (Figure 6). NMFS considers the flow threshold for when fines begin to become entrained below the former IGD to be approximately 5,000 cfs (USFWS Holmquist-Johnson et al. 2010; 2016d).

NMFS expects flows of 5,000 cfs or higher below the former IGD will disturb surface sediment along the river bottom and disrupt the life cycle of *Manayunkia speciosa*, which is a secondary host for the *C. shasta* parasite central to salmonid disease dynamics in the Klamath River (Hillemeier et al. 2017). Figure 6 indicates that under the proposed action, Keno Release Target flows in the range of approximately 4,000 to 4,500 cfs will produce flows of 5,000 cfs or higher below the former IGD (depending on tributary flow contributions below Keno Dam). Given what we know about the basic hydrology and geomorphology of the Klamath River right now, NMFS expects that Keno Release Target flows in the range of 4,000 to 4,500 cfs will be sufficient for sediment maintenance purposes; especially when Keno Release Target flows are released in conjunction with precipitation and/or runoff events that provide enhanced tributary flows, resulting in higher magnitude flows at and below the former IGD. However, until new sediment mobilization/transport studies are completed for the Keno Dam to former IGD reach, it is uncertain whether the proposed maximum daily Keno Release Target flows will be sufficient to disrupt the river bed in the newly formed river channel from Keno Dam to the former IGD site, with dams removed, and will need to be monitored.

Implementation of pulse flows in nearly all years is likely to be of a similar frequency and magnitude relative to the natural flow regime; however, Keno Release Target flows over 4,000 to 4,500 cfs and over 5,000 cfs at the former IGD likely did not occur under the natural flow regime in protracted drought conditions with consecutive dry years, unless significant precipitation or snowmelt runoff events occurred in those years. Sediment maintenance flows have been shown to be effective at reducing risks to coho salmon associated with *C. shasta* infection as recently as water years 2016, 2017 2018, 2019, and 2020 (NMFS 2021a). Therefore, NMFS concludes that this element of the proposed action will likely provide an adequate magnitude and frequency of sediment maintenance flows that will likely help disrupt the river bed, mobilize fine sediment, and reduce disease risks to coho salmon associated with *C. shasta* downstream of Keno Dam. NMFS expects the RTO team to provide recommendations on the release timing for the pulse flow so that its benefit is maximized. For example, release of a pulse flow during a spring runoff event could increase the benefit of the disturbance to downstream reaches near Iron Gate and Scott River through the added volume of accretion flows.

KRM output for the Pulse Flow Off, scenario B (Figure 6) indicates that if the FFA volume is not released as a pulse flow (and alternatively distributed evenly over the March 2 to June 30 period), the maximum daily Keno Release Target flow released from Keno Dam results in an Iron Gate flow that meets or exceeds the 5,000 cfs threshold in only 12 out of the 42 years. This illustrates the importance of releasing the entire FFA volume in the form a pulse flow on an annual basis for sediment maintenance purposes. Therefore, NMFS expects that Reclamation will release the FFA volume as a pulse flow on an annual basis, as modeled in scenario A, unless the RTO team recommends releasing the FFA volume more evenly throughout the March 2 to June 30 period. Modeling results show that pulse flows have very small, temporary effects to UKL elevations compared to releasing the FFA evenly over the spring period. Under scenario B with pulse flows off, UKL levels are occasionally up to 0.2 ft higher for a brief time after the pulse flow would have been released, an effect that rapidly diminishes to 0 as the FFA volume is released to the Klamath River in one of many other possible distribution shapes (Reclamation 2024a).

Figure 29 graphically represents the percentage of each water year (1991 to 2022) that Iron Gate daily average flows are 2,500 cfs or less, the flow range at which immobile bed conditions occur (Holmquist-Johnson et al. 2010; USFWS 2016d). For more than half of the years (19 out of 32 years), immobile bed conditions occur for greater than 90% of each water year, and in all years immobile bed conditions occur in greater than 50% of each water year under the proposed action (Figure 29). Therefore, the proposed action will likely result in increased durations of immobile bed conditions at the former IGD site and downstream in most years relative to the natural flow regime. NMFS expects that the proposed action will result in similar durations of immobile bed conditions in the Keno Dam to former IGD reach, given what we know about the overall hydrology and geomorphology of the Klamath River right now.

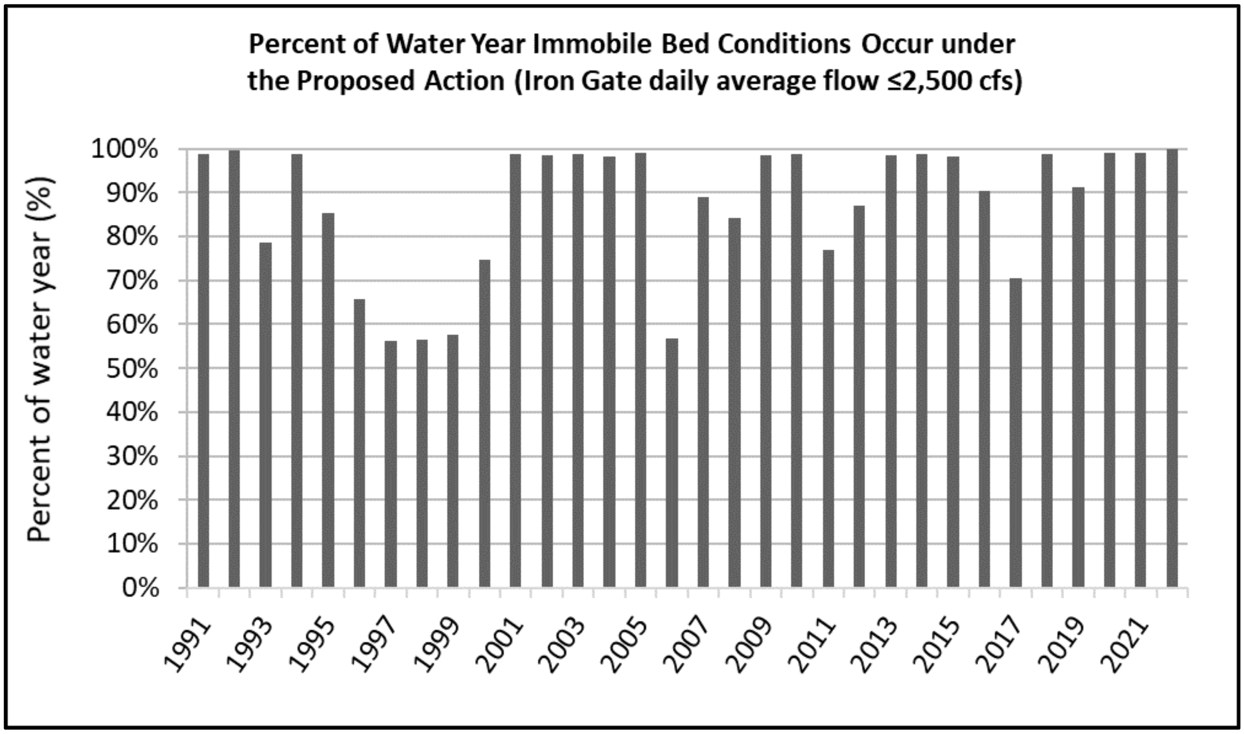

Figure 29. Percent of water year where immobile bed conditions occur at former IGD site under the proposed action (USFWS 2019b).

Reclamation provided NMFS with a flood frequency analysis applying the Log-Pearson Type III distribution to the observed daily flows at Keno Dam and the former IGD, and the modeled proposed action daily Keno Release Target flows and Iron Gate flows for the 1991 to 2022 POR with pulse flows on (Table 30 and Table 31). The flood frequency analyses were performed on the observed, historical daily flow data sets from the Keno Dam and Iron Gate gaging stations to identify the flood values that have actually occurred for the POR from 1991 to 2022. The flood frequency analyses were also performed on the proposed action Keno Release Target flows, and the Iron Gate flows that were produced as a result of Keno Release Targets from Keno Dam under the proposed action. This type of flood frequency analysis incorporates the daily flow data for the POR and identifies the flood value that occurred for the given flood frequency recurrence interval (i.e., 1.5-yr, 2-yr, 5-yr, etc.). Generally, the flood frequency analysis shows that the magnitude of 1.5 and 2-yr flood frequency flows have increased under the proposed action at Keno Dam and Iron Gate relative to the observed; whereas the magnitude of 5, 10, and 25-yr flood frequency flows have decreased under the proposed action at Keno Dam and Iron Gate relative to the observed values (Table 30 and Table 31).

Table 30. Flood frequency analysis on Klamath River for Keno Dam gage observed daily flows and proposed action daily Keno Release Target flows for the POR from 1991 to 2022.

Flood Frequency	Keno Dam Gage Flow (CFS)	
	Observed Daily	Proposed Action Daily
1.5-yr Flood	2,612	3,864
2-yr Flood	3,588	4,704
5-yr Flood	6,474	6,423
10-yr Flood	8,598	7,241
25-yr Flood	11,451	7,542

Table 31. Flood frequency analysis on Klamath River for IGD gage observed daily flow and modeled Iron Gate flow under the proposed action for the POR from 1991-2022.

Flood Frequency	IGD Gage Flow (CFS)	
	Observed Daily	Proposed Action Daily
1.5-yr Flood	3,347	4,563
2-yr Flood	4,568	5,437
5-yr Flood	8,370	7,587
10-yr Flood	11,347	8,951
25-yr Flood	15,571	10,210

Releasing the FFA volume as pulse flows on an annual basis under the proposed action would increase the 1.5-yr flood and the 2-yr flood values at both Keno and Iron Gate relative to the observed flood frequency values. Although the 1.5-yr and 2-yr flood values under the proposed action are likely lower than what would occur under the natural flow regime, NMFS expects that this element of the proposed action will likely provide an adequate magnitude and frequency of sediment maintenance flows based on what we have observed and learned from implementing pulse flows of similar magnitude and frequency over the past 5 to 7 years from the former IGD.

However, under the proposed action, the 5-yr, 10-yr, and 25-yr flood values would decrease at both Keno and Iron Gate relative to their respective observed flood frequency value (Table 30 and Table 31). The Klamath Project's inter-annual median consumption of approximately 260,000 AF of water annually under the proposed action lowers the elevation of UKL throughout the winter, spring, summer, and fall, thereby increasing the amount of inflow required to refill UKL; this decreases the probability of filling UKL, thereby decreasing the frequency and magnitude of larger flood releases (i.e., the 5-yr, 10-yr, and 25-yr flood values) occurring from UKL relative to the natural flow regime. This effect of the proposed action will reduce the frequency of large magnitude geomorphic flows needed to maintain floodplain and functional habitat. However, the decreased frequency, magnitude and duration of the 5-yr, 10-yr, and 25-yr flood values are not likely solely due to the proposed action (i.e., annual diversions for Klamath Project irrigation, and the inter-annual effect of increasing the amount of inflow needed to refill UKL each year), but also due to USFWS' proposed Agency-Barnes Lake reconnection project at the Upper Klamath NWR expected to occur in the fall of 2024. Once Agency-Barnes Lake units are reconnected to UKL, we anticipate that the project area would provide between approximately 34,000 AF of additional storage capacity at minimum lake elevation (4,140.01 feet NAVD88) and 72,330 AF at full pool elevation (4,145.3 feet NAVD88) (Dunsmoor et al. 2022). NMFS anticipates that the additional storage capacity added to UKL by this project will potentially make it more difficult to fill the lake on an annual basis, thereby impacting the frequency and magnitude of flood releases from UKL to the Klamath River.

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 Klamath River natural flow regime. Hardy et al. (2006) concluded that the combined effect of Reclamation's Klamath Project operations and limited storage capacities in the upper Klamath Basin maintained the likelihood of experiencing adequate geomorphic flows that provide riverine restorative function. However, these conclusions were provided in 2006 prior to dam removal, Agency-Barnes Lake reconnection, and recent effects of climate change. Klamath River dam removal reduced overall storage capacity provided by the reservoirs (acknowledging the reservoirs had very limited amounts of storage when at normal operating levels), whereas the Agency-Barnes Lake reconnection will increase the capacity of UKL up to approximately 72,000 AF, thereby reducing probability of filling UKL, spilling water and flooding. Nevertheless, a fair amount of uncertainty remains regarding the magnitude and frequency of geomorphic flows (i.e., flows >15,000 cfs) occurring in the next five years under the proposed action given the changes to the storage capacity of the Klamath Basin, and will largely depend on hydrologic conditions. Regardless, monitoring the effects following dam removal and the Agency-Barnes Lake reconnection project on flood operations and geomorphic flows in the river is critical for future flood and Klamath Project operations.

2.3.3.1.2.4 Summary of Hydrologic Effects

The proposed action results in an annual hydrograph below Keno Dam that resembles the overall shape and timing of the natural flow regime and retains some key elements of the natural flow variability of the upper Klamath Basin (see Reclamation's (2024a) BA Appendix C, Addendum 1). However, largely as a result of operating the Klamath Project, the Klamath River annual flow volume, spring peak magnitude and duration, fall/winter flow variability, and summer base flows are reduced relative to the natural hydrograph (Figure 27). 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 volume, and an earlier return to base flow relative to the natural hydrograph, particularly in below average and dry years (Table 26 and Figure 28). Although reduced relative to the natural hydrograph, spring flows in the mainstem Klamath River are proportionally representative of natural hydrologic conditions in the upper Klamath Basin defined by key hydrologic indicators represented in the Operations Index (average of UKL status and NWI), including UKL storage, UKL net inflow, snowpack and precipitation. The relationship between Keno Release Target flows and the hydrologic indicators via the Operations Index, 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 flow volumes and flow variability are reduced relative to the natural flow regime.

The proposed action employs a formulaic management approach (relying on the daily Operations Index to calculate Keno Release Targets) 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. However, due to Klamath Project deliveries reducing UKL elevations and increasing the amount of inflow required to refill UKL on an inter-annual basis, the proposed action will continue to contribute to diminished daily flow variability, particularly in the FW period (October through February). The spring time period, March through June, is expected to experience the greatest likelihood of flow variability (Table 28 and Table 29). Although NMFS expects the greatest likelihood of flow variability to occur below Keno and Iron Gate during the critical spring period, and the proposed action enhances flow variability relative to some past Klamath Project operations, overall the proposed action will continue to contribute to diminished flow variability relative to the Klamath River natural flow regime, particularly in below average and dry water years.

Sediment maintenance and geomorphic flows are critical for creating and maintaining in-channel and riparian habitat, as well as for disease mitigation. KRM output for the Pulse Flow On, scenario A **(**Figure 6) indicates that some form (magnitude and duration) of a pulse flow would occur in 41 of 42 years of the POR. Releasing the FFA volume as pulse flows on an annual basis has essentially increased the 1.5-yr flood and the 2-yr flood values under the proposed action at both Keno and Iron Gate relative to the observed flood frequency values (Table 30 and Table 31). However, because Klamath Project diversions reduce UKL elevations and decrease the probability of filling UKL on an annual basis, the frequency, magnitude, and duration of larger flood releases (7,000 to 15,000 cfs) are reduced from UKL to the Klamath River relative to past operations and the 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). However, a fair amount of uncertainty exists regarding the magnitude and frequency of geomorphic flows (i.e., flows >15,000 cfs) occurring in the next five years under the proposed action given the changes to the storage capacity of the Klamath Basin. Geomorphic flows are an integral part of the natural flow regime and provide riverine restorative function, but the probability of occurrence in the next five years is largely dependent on future hydrologic conditions.

In conclusion, the Klamath River downstream of Keno Dam is more likely to experience lower flows and drier conditions than it would without the proposed action. As a result of the proposed action storing and delivering Klamath Project water (which consumes a median annual water volume of 260,000 AF) the Klamath River will have reduced annual flow volumes, reduced flow variability, reduced magnitude, frequency and duration of the larger, less frequent flood flows, and more immobile bed conditions relative to the natural flow regime.

2.3.3.1.3 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].

Reclamation proposes to implement the down-ramping rates used in the KRM that includes a ramping rate structure that varies by release rate at Keno Dam. Due to the lack of information on channel geomorphology and floodplain inundation levels in the newly formed river channel from Keno Dam to the former IGD site (post-dam removal), NMFS must rely on ramp rates implemented in past operations at the former IGD until research and monitoring can inform potential adjustments to those rates in the future. Accordingly, the proposed KRM ramp rates at Keno Dam were designed to replicate the ramp rates at the former IGD required under previous biological opinions, including NMFS' 2019 biological opinion (Table 8). NMFS anticipates that Reclamation's proposed ramp-down, and ramp-up rates, when flows at the Iron Gate gage are greater than approximately 3,000 cfs (approximately 2,000 to 2,500 cfs at Keno), will generally reflect natural hydrologic conditions in the Klamath River at flows of this magnitude.

2.3.3.1.4 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) or upstream of the former IGD (64 FR 24049). 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 the former IGD site and Trinity River). Table 9 describes expected flows at Iron Gate based on flows that would be released under the proposed action at Keno Dam.

The proposed action has the greatest hydrologic and water quality effects on the mainstem Klamath River immediately downstream of Keno Dam, and such effects generally diminish further downstream because the proportion of flow contributed by the proposed action diminishes with distance downstream of the flow release point (Keno Dam). Table 26 through Table 29 in Section 2.3.3.1.2 *Hydrologic Effects* demonstrate how flows greater than the Keno Dam minimum flows will be realized more frequently at IGD than at the upstream location of Keno Dam.

In the Section 2.3.3.1.2 *Hydrologic Effects*, NMFS recognizes Reclamation's attempt to incorporate elements of the natural flow regime into the proposed action. Although we expect to see the greatest flow variability occur during the critical spring period, and pulse flows released from the FFA will result in a greater frequency of the 1.5-yr flood and 2-yr flood at both Keno Dam and Iron Gate relative to observed flood frequency, the Project consumes water and thus, reduces the magnitude, duration, and frequency of flows in the mainstem Klamath River.

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

2.3.3.1.4.1 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 the former IGD (RM 190), including Horse and Seiad creeks. Coho salmon spawning was confirmed in the mainstem Klamath River as well as surveyed tributary streams including Horse, Seiad, Grider, West Grider, Beaver, Walker, and O'Neil creeks (Garwood 2012; MKWC 2023) (Magneson et al. 2006). Where spawning habitat exists, gravel quality and fluvial characteristics are likely suitable for successful spawning and egg incubation.

Historically, Klamath Project operations have had minimal reductions to the magnitude, frequency and duration of large, less frequent geomorphic flows (i.e., >15,000 cfs) relative to the natural hydrograph – though there is greater uncertainty in this regard given changes to baseline conditions (e.g., connection of Agency-Barnes Lake and climate change). As described in Section 2.3.3.1.2.3 *Sediment Maintenance and Geomorphic Flows*, a flood frequency analysis shows that the magnitude of 1.5-yr and 2-yr flood frequency flows are expected to increase under the proposed action at Keno and Iron Gate relative to the observed; whereas the magnitude of 5, 10, and 25-yr flood frequency flows have decreased under the proposed action relative to observed values. Figure 29 in Section 2.3.3.1.2 *Hydrologic Effects*, describes immobile bed conditions (daily average flow less than 2,500 cfs) at the former IGD site greater than 90% of the time for the last five years (2018 to 2022).

The Klamath Project will periodically reduce fine sediments through pulse flows released using the FFA, and the benefits of the flushing will likely be sustained for an extended period of the spring. These benefits will occur downstream of Keno Dam and are expected to extend beyond Iron Gate – potentially reaching as far downstream as Seiad, depending on additional runoff and accretion flows. However, in other portions of the year, the Klamath 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 2020 through 2022, the proposed action will contribute to conditions of large concentrations of fines, which degrade the quality of coho salmon spawning gravel.

Model results in the Phase II report (Hardy et al. 2006) for Chinook salmon spawning habitat indicate the former IGD site to Shasta River reach has at least 80% 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. With dams removed, impacts to the hydrograph such as flow variability are moved upstream to the reach immediately downstream of Keno Dam, where flows are released. Much of these impacts are attenuated in a downstream manner through tributary accretion, with baseline conditions seeing significant improvements at the former IGD. 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 and 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 flows are variable and incrementally increase during the late fall and winter. In drier years, spawning habitat will be more limited due to reduced flow variability (particularly in the reach immediately downstream of Keno Dam). However, designated critical habitat downstream of the former IGD is expected to have adequate spawning habitat, even in drier years, in part, due to implementation of minimum flow releases from Keno Dam. Therefore, NMFS expects sufficient quantity of coho salmon spawning habitat will be available under the proposed action.

2.3.3.1.4.2 Adult and Juvenile Migration Corridor

Through the consumption of water by Klamath Project operations, the proposed action would affect water depth and velocity in the mainstem Klamath River. 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 are expected to result in at least 950 cfs at the Iron Gate gage under the proposed action and 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 were less than 1,300 cfs and tributary base flows are at summer low level (Soto et al. 2016). As described below, 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 et al. (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 1,000 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 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, flow increases in the late summer for the Tribal boat dance, which are scheduled to occur every other year, will likely serve as an environmental cue for early returning coho salmon adults and redistributing parr coho salmon.

Although the volume of water released is suitable for migration and fish passage, the reduced flows relative to the natural flow regime in March through June provide less spring discharge volume for smolt outmigration. The reduced volume is likely to impact the amount of time it takes for a smolt to reach the ocean as described further in Section 2.3.3.2.3 *Impacts to Migrating Coho Salmon*.

2.3.3.1.4.3 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. 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, though NMFS recognizes baseline conditions have changed following dam removal. New science is not yet available to better describe the flow-habitat relationship upstream of the former IGD site or how the relationships may have changed downstream of the former IGD site. Although we do not have a model to accurately quantify the habitat availability/discharge relationship, NMFS applies the concept to both the reaches upstream and downstream of the former IGD site.

Using simulated hydrodynamic variables at intensive study sites, Hardy (2012) 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 WUA to characterize the quality and quantity of habitat in terms of usable area per 1,000 linear feet of stream (NRC 2008). 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).

Using the 1991 to 2022 POR, Reclamations (2024a) BA described the effects of reduced flows on habitat availability for coho salmon for three sites, Trees of Heaven (RM 172), Beaver Creek (RM 162), and Community Center (RM 160) as seen in Figure 30. NMFS notes that these sites were not selected for their ability to provide quality coho salmon rearing habitat, but instead were selected solely for annelid worm habitat modeling. These were the only sites available with 2D modeling (Som 2024). Although the models provide some information about habitat availability under different discharge scenarios, there is a wide range of results between sites which makes it difficult to predict average response at a larger reach scale. Ultimately, we understand that as discharge decreases, so does juvenile rearing habitat in the mainstem.

As described in Section 2.3.3.1.2 *Hydrologic Effects*, the reduced flows relative to the natural flow regime in March through June provide less spring discharge volume and likely reduces available rearing and off-channel habitat for juvenile coho salmon. The increased percentage of days with low, 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 2010b).

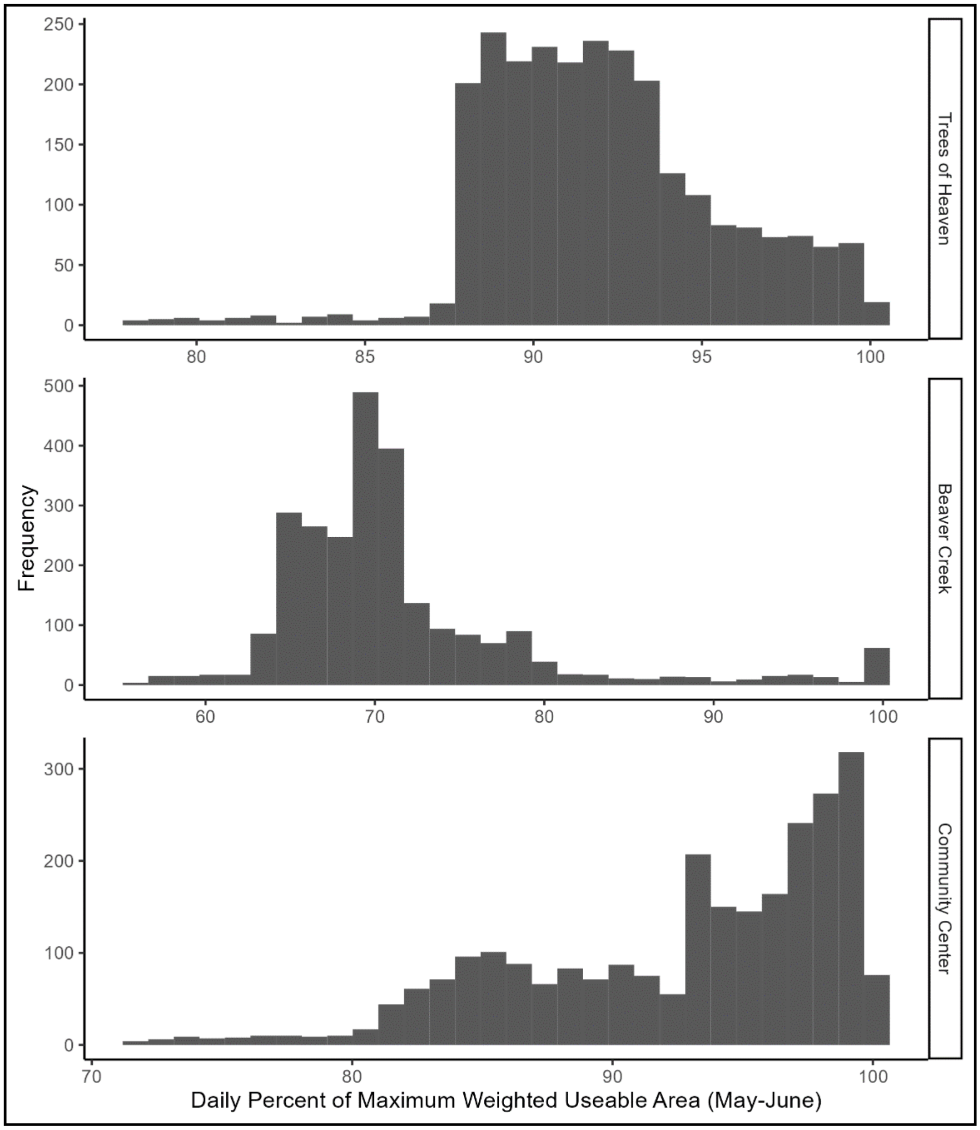

Figure 30. Predicted frequency of daily percent maximum WUA values for coho salmon fry and parr in three reaches downstream of the former IGD during the months of May and June (2024a).

2.3.3.1.4.3.1 Coho Salmon Fry Habitat

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. While NMFS' ability to quantify proposed action effects are limited, NMFS expects the range of proposed action effects on mainstem Klamath River coho salmon habitat variability resulting from flow reductions will vary considerably, from having no effect to levels that NMFS considers adverse.

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% of maximum available. The three sites modeled by Reclamation responded very differently to the proposed action across a broad range of exceedance values. Trees of Heaven and Klamath Community Center sites were relatively unaffected across a broad range of exceedances, while the effects of the proposed action are predicted to occur more frequently and substantially at the Beaver Creek site (Table 32).

Table 32. Number and percentage of days over the period of record at which fry and parr habitat availability is at or above the 80% of maximum WUA for the three reaches for coho salmon during implementation of the proposed action (Reclamation 2024a).

Sites	Number of Days	Percentage of Days
Trees of Heaven	13,861	90%
Beaver Creek	1,452	9%
Community Center	12,465	81%

As described in Section 2.3.3.1.2 *Hydrologic Effects*, mainstem flows will be significantly reduced as a result of the proposed action with river base flows being reached two to three months earlier. While there will be reductions in habitat availability to coho salmon juveniles, we do expect some flow variability under the proposed action 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 Keno. Temporary increases in mainstem flows are expected to result in short-term increases in the amount and quality of habitat in the mainstem for juvenile coho salmon. Therefore, the adverse effects to coho salmon juvenile habitat in the mainstem Klamath River are likely to be somewhat moderated by the flow variability under the proposed action when hydrological conditions in the upper Klamath Basin are wet.

2.3.3.1.4.4 Water Quality

As described in Section 2.3.2.1.1 *Environmental Baseline*, water quality impairments in the Klamath River occur 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 et al. 2008). In this section, NMFS will focus on the water quality effects resulting from controlled flows, which are part of the proposed action. NMFS addresses climate effects in other sections of this Opinion. Water quality analysis conducted by Asarian et al. (2013) indicates flow significantly affects water temperature, DO, and pH in the Klamath River. Multiple, complex, and interacting pathways link flow to water quality effects. In fact, of all the independent variables evaluated, Asarian et al. (2013) found that flow had the strongest effect on water quality. The most relevant of these water quality parameters, water temperature, DO, and pH, are discussed further below.

2.3.3.1.4.5 Water Temperature

After dam removal, Klamath Project operations and Keno water releases have a greater ability to affect water temperatures in the mainstem Klamath River given that the reservoirs, a thermal sink, are no longer present. As discussed previously, the proposed action reduces the volume of water released throughout the year. Water released from Keno 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 Keno Dam, 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 et al. 2007).

The proposed action's effect of reducing mainstem flows in the summer 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 (NRC 2004). Previous water temperature modeling indicates temperatures may increase in the former IGD location to Scott River reach by up 0.5 °C when flows are reduced in this reach (Perry et al. 2011). With dams removed, NMFS assumes the same volume/temperature relationship remains and these impacts will be present downstream of Keno Dam. Below the Scott River, the 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. In conclusion, we find that water temperature is more significantly influenced by air temperature in the sense of its general seasonal and diurnal patterns. However, reduced volume of flow releases in the summer and fall is expected to exacerbate temperature conditions between Keno Dam and Scott River with more extreme responses to climatic conditions.

2.3.3.1.4.6 Nutrients and Dissolved Oxygen

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

Historically, the seasonal (summer/fall) release of nutrients out of Iron Gate Reservoir would stimulate periphyton growth in the mainstem Klamath River (FERC 2022). NMFS expects this same dynamic will occur under the proposed action, when nutrients are released out of Lake Ewauna from Keno Dam. Additionally, return flows may enter the mainstem Klamath from Lost River or F/FF pumps when water is moved off of KDD and Lower Klamath NWR. Return flows, particularly in the spring when water is moved off of fields prior to planting, likely carry large loads of nutrients. The NRC (2004) stated that stimulation of any kind of plant growth from such nutrient loads can affect DO 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 DO and pH conditions.

While the proposed action's increase in nutrients in the mainstem Klamath River between Keno Dam 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 DO 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 DO 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 DO concentration to rise during the day and lower at night during plant respiration. Low DO concentration at night reduces rearing habitat suitability at night. Daily fluctuations of up to 2.0 mg/L of DO in the mainstem Klamath River downstream from the former IGD site have been attributed to daytime algal photosynthesis and nocturnal algal/bacterial respiration (Karuk 2002; Karuk 2003; Hiner 2006; NCRWQCB 2010). NMFS expects similar impacts to be observed downstream of Keno Dam.

In addition, the overall effect of the conceptual linkages between flow and DO 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 DO minimums and narrower daily DO range. Therefore, when the proposed action reduces mainstem flows in the summer, NMFS expects there will likely be a reduction to DO concentrations in the mainstem Klamath River between Keno Dam and Scott River. The proposed action's contribution to DO reduction likely diminishes around Scott River as tributary accretions offset the water temperature and associated DO reductions near this site.

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 DO concentrations fall below 8 mg/L in the mainstem Klamath River during the summer (see Figure 31).

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[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.

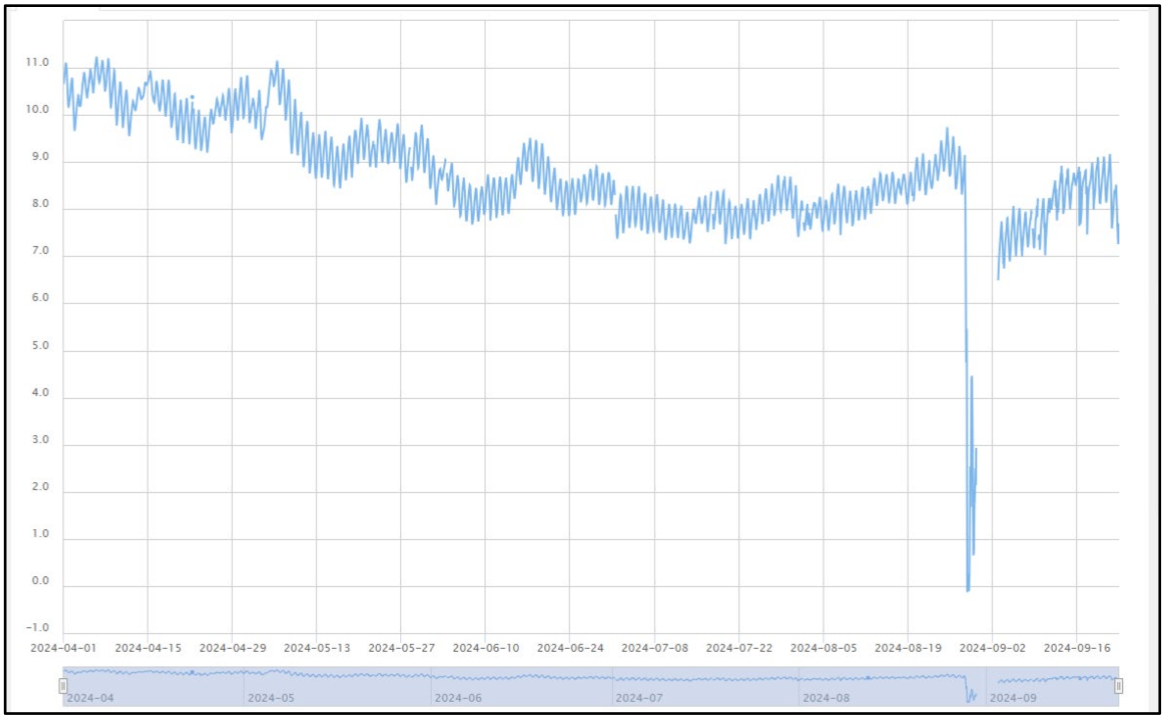

Figure 31. DO (mg/L) in the mainstem Klamath River near the former IGD, April 2023 to September 2024. Anomalous data is a result of dam removal activities (Karuk 2024).

2.3.3.1.4.7 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 annelid intermediate *C. shasta* host. Although overall flow variability is reduced by the proposed action when relative to a natural hydrograph, the spring period has an increased likelihood of flow variability compared to the other seasons. The proposed spring flow regime will aide in the reduction of disease risk for outmigrating coho salmon. However, larger flow events are also a key factor in reducing disease risk, as described below.

Management of UKL under the proposed action is expected to affect mid-winter peak flows, which in turn will affect sediment movement and size distribution. Sediment movement and high flows are known to reduce the density and populations of the annelid worm intermediate host for *C. shasta* (USFWS 2016a). The proposed Klamath Project operations are expected to affect the magnitude and frequency of these high flow events, which is in turn expected to contribute to a higher risk of disease in juvenile coho salmon. As described in Section 2.3.3.1.2 *Hydrologic Effects*, use of the Pulse Flow scenario when managing Keno flows, will help disrupt the river bed, mobilize fine sediment, and reduce disease risks to coho salmon associated with *C. shasta*. Using the Pulse Flow "off" scenario to manage spring flows would rarely provide flow events that could effectively disrupt the river bed and would contribute to greater risk of disease for coho salmon. Even with the FFA volume used to release pulse flows, the proposed action will decrease the 5-yr, 10-yr, and 25-yr flood values at both Keno Dam and IGD compared to their observed flood frequency values. Therefore, the proposed action will likely support minimum benefits to disease risk by providing variable spring flows (though somewhat reduced from the natural flow regime), but contribute to long term bed stability that perpetuates the prevalence of annelid worms.

2.3.3.1.5 Summary of Effects to SONCC Coho Salmon ESU Critical Habitat

Reclamation's proposed action is expected to adversely affect designated critical habitat for SONCC coho salmon. The greatest impacts are associated with reduced juvenile rearing habitat in the spring and summer and increased disease risk for outmigrating smolt. The proposed action may reduce juvenile rearing habitat below 80% of maximum available for as much as 91% of the days when considering the POR (i.e., Beaver Creek). Most locations will not be impacted to that degree and the provision of variable spring flows are expected to moderate these impacts, but the effects overall will be adverse. Decreased survival as a result of increased disease will occur due to a reduction in large sediment mobilization flow events which increases bed immobility. These stable substrate conditions provide a suitable environment for annelid worm populations to thrive. The proposed action will create conditions more representative of the natural flow regime, with flows at or above Reclamation's proposed minimum flows. Additionally, pulse flows from the FFA will provide seasonal disruptions to the *C. Shasta* host. These minimum flows and pulse flows will help lessen the disease risk and rearing habitat impacts of the proposed action. On balance, however, the effects of the proposed action on critical habitat are expected to be adverse given the extent of the effects on juvenile rearing habitat and increased disease.

The proposed action is expected to have minor impacts to spawning habitat from fine sediment deposition and minor impacts to adult and juvenile fish migration from reduced flow volume and velocity in the mainstem. NMFS expects the proposed action will reduce water quality conditions, particularly temperature and DO in the summer due to reduced flow releases from Keno Dam. These impacts will be greatest in the reach immediately below Keno Dam and may reach as far as Scott River. Impacts to water quality within designated habitat downstream of the former IGD are expected to be minor but not insignificant.

2.3.3.2 Effects to SONCC Coho Salmon Individuals

In this section, we describe how the proposed action is expected to impact SONCC coho salmon individuals. Klamath Project operations reduce the overall volume of water released downstream of Keno Dam. However, that volume of water is released in a manner to approximate the shape of a natural hydrograph. As a result of operating the Klamath Project, the Klamath River annual flow volume, spring peak magnitude and duration, fall/winter flow variability, and summer base flows are reduced relative to what we would expect in the absence of the proposed action. As described in Section 2.3.3.1.2 *Hydrologic Effects*, under the proposed action, the median annual Klamath Project delivery of 260,000 AF is approximately 27% of the median annual UKL net inflow (980 TAF) for the 1991 to 2022 POR. Changes to hydrology as a result of the proposed action contribute to a number of stressors. Although these potential stressors could impact coho salmon, coho salmon may not be exposed to them. When coho salmon are likely to be exposed, we move forward with the analysis to determine the risk to individuals. Below is a list of potential stressors associated with the proposed action that may impact individual coho salmon.

Potential stressors include:

- Reduction in spawning habitat.
- Reduction in rearing habitat (e.g., space, food resources, water temperature, and DO).
- Reduction in migration habitat.
- Increased mortality from disease.

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 33). However, different populations of coho salmon will be exposed to varying levels of flow effects under the proposed action. Populations closest to Keno Dam (e.g., Upper Klamath River population) will experience the most pronounced exposure, while populations farthest away, such as the Lower Klamath River and Trinity River populations, are only minimally exposed. Lower Klamath River, Upper Trinity River, South Fork Trinity River, and Lower Trinity River populations may be exposed to impacts of disease as they migrate through the Lower Klamath River. Therefore, impacts to those populations will only be discussed in the context of disease (Section 2.3.3.2.4 *Increased Mortality from Disease*).

Table 33. A summary of the coho salmon life stage exposure period to project-related flow effects.

Life Stage	**Coho Salmon Population(s)**	**General Period of exposure when individuals are in the mainstem**
Adults	Upper Klamath, Shasta, Scott, and Middle Klamath rivers	September to mid-January
Embryos to pre-emergent fry	Upper Klamath River	November to mid-March
Fry	Upper Klamath, Shasta, Scott, and Middle Klamath rivers	March to mid-June
Parr	Upper Klamath, Shasta, Scott, and Middle Klamath rivers	May to February
Smolts	Upper Klamath, Shasta, Scott, Middle Klamath, Upper Trinity, South Fork Trinity, Lower Trinity, and Lower Klamath rivers	March to June

2.3.3.2.1 Effects to Spawning Adults and Egg Incubation

Although most coho salmon are tributary spawners, a small portion of the Upper Klamath River coho salmon population spawns in the mainstem Klamath River downstream of the former IGD. For example, in 2023, 64 redds were observed during Klamath River mainstem surveys between IGD and Seiad Creek (MKWC 2023). We expect at least that many adult coho may spawn between the former IGD and Keno Dam with the dams removed. Therefore, a moderate number of embryos are expected to be present in the mainstem each winter and spring.

As discussed in Section 2.3.3.1.4 *Effects to Physical or Biological Features*, NMFS expects that the proposed action will provide suitable quantity of coho salmon spawning habitat for successful spawning and egg incubation. However, the proposed action is expected to contribute to sedimentation of spawning habitat by reducing the overall flow variability and volume. Despite these impacts, spawning habitat data collected by USFWS indicates adult salmonids successfully construct redds in the mainstem Klamath River annually (USFWS 2022b). With dams removed, flow variability is expected to be improved through tributary inputs in the former hydroelectric reach, particularly in the winter when storm events occur. Therefore, NMFS does not expect the impacts to spawning habitat as a result of sedimentation to rise to the level of adverse impacts to eggs.

While the proposed action will likely reduce mainstem flows from October to January in average and less than average water years, coho salmon eggs in the mainstem are not expected to be dewatered. The naturally increasing flows during the winter from storm events downstream of Keno Dam 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 ramp-down rates proposed by Reclamation. Based on the information we have, NMFS does not expect eggs in the mainstem Klamath River will be adversely affected by flow reductions described in the proposed action where all conditions, such as ramp-rates, are adhered to.

2.3.3.2.2 Effects to Rearing Juveniles

Some juvenile coho salmon likely rear in the mainstem throughout the year or utilize the habitat during key redistribution periods. During the winter, low velocity refugia, such as side channels and alcoves may be used for rearing, while in the summer, cold water, thermal refugias are used for rearing. 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.

Some coho salmon may be present in the mainstem from the time they leave the tributaries to the following winter. However, most juveniles from the tributaries (i.e., ≥ 50%) are assumed to rear in the tributaries. Mainstem rearing habitat quality and quantity are impacted by the proposed action and described in the following three sections.

2.3.3.2.2.1 Impacts on Juveniles from Changes in Water Temperature and DO

Mainstem rearing juvenile coho salmon could be exposed to increased water temperatures as a result of the proposed action. The proposed action reduces the volume of water released from Keno throughout the year. As described in Section 2.3.3.1.4.5 *Water Temperature,* the proposed action's effect of reducing mainstem flows in the summer 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 Keno (NRC 2004).

Increases to water temperature in the spring may have both beneficial and adverse effects to coho salmon. Increasing water temperature in the spring may stimulate faster growth. However, when water temperature chronically exceeds 16.5°C, coho salmon juveniles 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 rearing coho salmon 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 in the mainstem Klamath River between Keno Dam and the Scott River.

As described in Section 2.3.3.1.4 *Effects to Physical and Biological Features*, water temperatures are expected to return to a more normal temperature regime and will heat more quickly in the spring and summer without the presence of the former reservoirs. Warm water temperature in the spring and summer could be further exacerbated by the reduced volume of water released from Keno Dam during that time. However, over the five year term of this proposed action, we expect only small number of juvenile coho to occupy mainstem reaches upstream of the former IGD due to tributary accretions, where flow and temperature related impacts will be greatest. Impacts to water temperature will be largely ameliorated downstream of the former IGD with no impact expected at the Scott River confluence. Downstream of the Scott River confluence water temperature is expected to be more influenced by air temperature and tributary contributions. Therefore, mainstem rearing juvenile coho salmon between Keno Dam and Scott River are expected to be adversely impacted in the late spring and early summer when water temperatures remain above 16.5°C as a result of the proposed action.

Low DO concentrations can impair growth, swimming performance and avoidance behavior (Bjornn et al. 1991). Davis (1975) reported effects of DO levels on salmonids, indicating that at DO 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 DO 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 juveniles that are in the mainstem Klamath River below Keno Dam during the summer and fall.

As discussed in Section 2.3.3.1.4 *Effects to Physical and Biological Features*, when the proposed action reduces mainstem flows in the summer, NMFS expects there will likely be a reduction to DO concentrations in the mainstem Klamath River between Keno Dam and Scott River. Like water temperature impacts, NMFS assumes impacts to DO will be attenuated by tributary flow downstream of Scott River. Coho salmon juveniles in the mainstem Klamath River between Keno Dam and the Scott River will be exposed to the reduced DO concentrations at night and early morning when they are not confined to thermal refugia at tributary confluences. Therefore, the proposed action's contributions to low DO concentrations in the summer will reduce survival of coho salmon by adversely affect swimming performance (at ≤ 8.0 mg/L) and increasing stress (at ≤ 6.0 mg/L) to juveniles in the mainstem between Keno Dam and Scott River during this period.

2.3.3.2.2.2 Impacts to Fry

Flow volume 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 compete with other species for available habitat.

While habitat preferences between coho salmon are not the same as Chinook salmon, and steelhead, 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 et al. 1985). Coho salmon edge 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). Under the proposed action we expect Keno Release Target flows to be above Keno Dam minimums under a wide range of exceedances from March through June (Section 2.3.3.1.2.1 *Proposed Action Flow Regime*, Table 26). Although spring flows are expected to be variable and above proposed minimum releases, the overall volume of water in the mainstem is reduced due to UKL storage objectives (Figure 27). Decreased volume of water in the mainstem can have significant impacts on fry rearing habitat availability as described in Table 32. 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% of maximum available. The three sites modeled by Reclamation responded very differently to the proposed action across a broad range of exceedance values. Trees of Heaven and Klamath Community Center were relatively unaffected across a broad range of exceeds, while the effects of the proposed action are predicted to occur more frequently and substantially at the Beaver Creek site (Table 32).

Table 32, where we see the Beaver Creek site at or above 80% of maximum WUA only 9% of the days under implementation of the proposed action. Therefore, the proposed action is expected to reduce growth and survival of coho salmon fry in portions of the mainstem Klamath River between Keno Dam and Salmon River (RM 66) during mid-June in below average water years (when Fall Creek Hatchery salmonids are also in the mainstem). Downstream of the Salmon River, we expect impacts from reduced flow volume on habitat availability to be attenuated by tributary inflows.

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% of maximum available. The three sites modeled by Reclamation responded very differently to the proposed action across a broad range of exceedance values. Trees of Heaven and Klamath Community Center sites were relatively unaffected across a broad range of exceedances, while the effects of the proposed action are predicted to occur more frequently and substantially at the Beaver Creek site (Table 32).

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.

2.3.3.2.2.3 Impacts to Juveniles from loss of Habitat Availability

Juvenile coho salmon utilize the Klamath River mainstem habitat during key life history stages. Coho salmon express a diversity of rearing strategies across the landscape that provide population resilience. Although most juveniles spawned in tributaries will remain in those tributaries for the entire year of their freshwater rearing period, many will redistribute and rear in the mainstem Klamath River or in non-natal tributaries. In this section, we describe how individuals are impacted by reduced habitat availability in the mainstem Klamath River. The following two sub sections will discuss: (1) habitat availability in the spring for fish utilizing the mainstem as a migratory corridor; and (2) habitat availability in the context of thermal refugia for individuals that rear in the mainstem through the summer.

Impacts to individuals utilizing mainstem habitat in the spring

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 juveniles; (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 FCH salmonids, the onset of elevated water temperatures, and disease prevalence. During the spring, natural-origin coho salmon juveniles 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 three million Chinook salmon smolts from FCH. Therefore, habitat availability during spring is the most essential for coho salmon juveniles.

During the fall (i.e., October and November), coho salmon juveniles 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 juveniles 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. As discussed in Section 2.3.3.1.4 *Effects to Physical or Biological Features*, the Trees of Heaven, Community Center, and Beaver Creek reaches all show reduced habitat availability as a result of the proposed action. These impacts are particularly pronounced in the drier water years.

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 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 2016b).

Habitat availability and quality are essential for coho salmon growth and survival. Habitat quality exerts a significant influence on local salmonid population densities (Bilby et al. 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. 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 et al. (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 et al. 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 et al. 1995; Quinn et al. 1996; Zabel et al. 2004; Ebersole et al. 2006; Roni 2012). Increased growth confers higher over-wintering survival for larger individuals than for smaller individuals (Quinn et al. 1996). Larger smolts also have a greater likelihood of surviving in the ocean than smaller smolts smaller smolts (Bilton et al. 1982; Henderson et al. 1991; Yamamoto et al. 1999; Zabel et al. 2002; Lum 2003; Jokikokko et al. 2006; Muir et al. 2006; Soto et al. 2016). In addition, larger smolts tend to produce larger adults (Henderson et al. 1991; Lum 2003), which have higher fecundity than smaller adults (Weitkamp et al. 1995; Fleming 1996; Heinimaa et al. 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 et al. 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 Keno Dam and Salmon River in March to June. The most significant impacts will occur closest to Keno Dam where relatively few coho salmon juveniles are expected to rear during the term of the proposed action. However, Reclamation (2024a) indicates that locations such as Beaver Creek will be significantly impacted with less habitat available under a wide range of flow conditions. 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 FCH Chinook salmon releases in May or early June).

Impacts to individuals utilizing thermal refugia during summer rearing

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 et al. 2012; Soto et al. 2016). Sutton et al. (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 DO 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 et al. 1999; Ficke et al. 2007; Hamilton et al. 2011).

NMFS can reasonably conclude that the proposed minimum summer flow of approximately 650 cfs from Keno Dam is likely to result in insignificant effects to mainstem thermal refugial size downstream of the Scott River confluence because the effects of flows released from Keno Dam on thermal refugia diminishes with increasing distance downstream due to tributary accretion, larger channel size, and less stable alluvial channels (Sutton 2007). Additionally, NMFS considers juvenile coho salmon use of mainstem thermal refugial habitat (i.e., tributary confluences or cold water plumes at tributary confluences) within the Middle and Lower Klamath River population areas 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 rearing within Middle Klamath River population area.

Although we do not have empirical data to draw conclusions in regards to a reduced flow volume from Keno Dam impacting thermal refugia, we do make some assumptions based on our understanding of how a reduce flow volume increases water temperature and reduces habitat availability. In the reach immediately downstream of Keno Dam which includes the Upper Klamath River population area, size of thermal refugia is likely more sensitive to reductions in flow volume from Keno Dam. However, over the term of this proposed action, very few rearing juvenile coho salmon are expected to enter the habitat upstream of the former IGD. Numerous cold water refugia exist between Keno and the former IGD including tributaries and springs (e.g., Copco Springs, J.C. Boyle Springs). Therefore, a potentially minor reduction in the area of cold water refugia is not expected to be limiting or adversely impact the small number of rearing juvenile coho salmon in the Upper Klamath River population area.

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 et al. (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 flows from the former IGD were 1,000 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.

Given the minimal effect of Keno 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 juveniles accessing tributaries.

2.3.3.2.3 Impacts to Migrating Coho Salmon

Coho salmon adults

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) most adults are observed in tributaries between December 15 and January 1 (Knechtle et al. 2022). 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.

Minimum daily average flows released from Keno Dam under the proposed action are at least 650 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. Prior to dam removal, coho salmon escapement monitoring confirmed successful adult passage in the mainstem Klamath River under a similar flow regime (e.g., USFWS mainstem redd/carcass surveys, CDFW Shasta and Bogus Creek video weir studies, IGH returns). We expect similar or improved spawning conditions downstream of the former IGD under the new proposed action when flows are released from Keno Dam. Some adult coho salmon are expected to repopulate the mainstem upstream of the former IGD during the term of the proposed action. We expect those individuals will experience similarly suitable migration and spawning conditions.

Coho salmon smolt

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 et al. 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 the former IGD site 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 the former 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 et al. 1993; McCormick et al. 1998) or survival (Burns 1971; Mathews et al. 1980; Scarnecchia 1981; Giorgi 1993; Cada et al. 1994; Lawson et al. 2004). Berggren et al. (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 et al. (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 et al. 1966; Mundie 1969), while Burns (1971) found that highest mortality of coho salmon in the summer occurred during periods of lowest flows.

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 et al. (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% of coho smolts were trapped from April 1 through the end of June.

Under the proposed action, delivery of water to the Klamath Project and meeting UKL storage objectives reduces the overall volume of spring flows in the mainstem Klamath River. Therefore, the proposed action decreases survival and outmigration rates in the reach between Keno Dam and the mouth of the Shasta River (RM 177) when flows at the former 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.

2.3.3.2.4 Increased Mortality from Disease

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.

The likelihood of 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). 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 supported 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 et al. 2006; Ray et al. 2012). For coho salmon juveniles, actinospore genotype II density of 5 spores/L was the threshold where 40% 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). Sediment maintenance flows flush fine sediment and provide restorative function and channel maintenance through scouring, which will likely reduce annelid abundance and disturb their fine sediment habitat in the mainstem Klamath River. Fish health researchers (e.g., (Stocking et al. 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 the former IGD site, since infected adult salmon spread the myxospore life history stage of *C. shasta*. In addition, sediment maintenance flows likely disrupt the ability of annelids to extract *C. shasta* spores (Jordan 2012). Bjork et al. (2009) found that higher water velocity resulted in lower *C. shasta* infections to the annelid, 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).

Currently, we do not have information to understand how quickly the system will recover with dams removed and provide benefits that reduce disease risk. Water sampling in 2024, post reservoir drawdown, continued to show high rates of disease (Figure 32) that are comparable to pre-dam removal conditions. We assume the large amount of fine sediment deposited in the channel during drawdown, followed by rapidly warming water temperatures in the spring, and no spring flushing flow, contributed to disease risk in 2024. Over the term of this Opinion, we expect the risk to continue to decrease as baseline conditions improve, at least moderately, post dam removal.

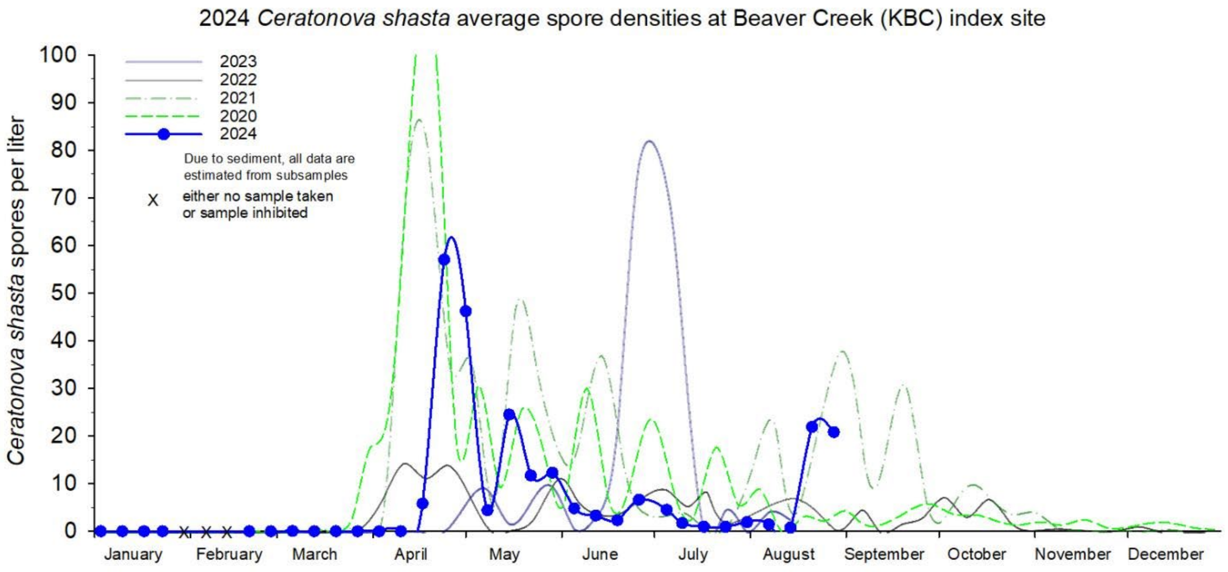

Figure 32. Comparison of spore densities at the Beaver Creek index site for years 2020 to 2024 (OSU 2024).

As previously discussed in Section 2.3.3.1.2 *Hydrologic Effects*, the proposed action generally reduces spring flows in the mainstem Klamath River downstream of Keno Dam relative to the natural hydrograph. 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 in May to mid-June (Foott et al. 2009; Hallett et al. 2012; Ray et al. 2012). This will occur even as the overall risk of disease reduces due to improved channel conditions resulting from dam removal. The proposed action will also likely increase the percentage of coho salmon fry in the mainstem Klamath River 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).

During dry water years, the proposed minimum flows for April, May and June will provide at least 1,000 cfs, 900 cfs, and 750 cfs, respectively, at Keno Dam for diluting actinospores. While these proposed minimum flows are not likely sufficient to dilute actinospore concentrations to below 5 genotype II spores/L when actinospore concentrations are high, these minimum flows provide a limit to the increase in disease risks posed to coho salmon under the proposed action, which may limit impacts from disease-related mortality to coho salmon.

NMFS notes that Reclamation included the use of an FFA that can release a pulse flow in the spring, resulting in a greater frequency of the 1.5-yr flood and 2-yr flood flow frequency downstream of Keno Dam. Use of the FFA to provide a pulse flow is expected to reduce fine sediments which will temporarily reduce disease risk and enhance the survival and fitness of fry and juvenile coho salmon. However, the proposed action will decrease the frequency of higher magnitude, sediment mobilizing flows.

By moving the compliance point to Keno Dam, more variable flows are experienced in downstream reaches through tributary accretions. The variable flows, combined with the use of the FFA, are expected to reduce disease risk for coho salmon. Variable flows, including small variations, provide dynamic fluvial environments in the mainstem Klamath River that may impair annelid fitness, reproductive success, or infection with *C. shasta*. Since annelids appear to prefer stable hydrographs (Jordan 2012), flow variability will likely decrease annelid habitat. In addition, annelids must extract *C. shasta* myxospores from the water to become infected (Strange 2010a; Jordan 2012). Increased flow variability may increase water velocity where annelids may have increased difficulty extracting myxospores or colonizing habitat. If sufficiently large, increased flow variability under the proposed action (e.g., a pulse 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 annelids 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, 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).

NMFS concludes that 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 fitness and survival. Therefore, the proposed action will likely have an overall negative effect by contributing to fine sediment deposition and establishment of annelid worm colonies downstream from Keno Dam, while providing some minimal benefits to reduce disease risk annually through the use of a pulse flow through use of the FFA.

While NMFS cannot quantify the magnitude of the decreased survival as a result of disease infection for coho salmon under the proposed action, particularly in the immediate future while baseline conditions undergo significant changes, NMFS concludes that even though baseline conditions for disease risk are likely improving, the proposed action will continue to heighten the disease risk that remains, reducing the survival of outmigrating coho salmon.

2.3.3.2.5 Impacts of Operation, Maintenance, Fish Screen Investigations, and Fish Passage Improvements

Reclamation proposes various operation, maintenance, and passage improvement activities that may be performed at Klamath Project infrastructure over the course of the proposed action. In addition, they outline various investigations and surveys that may be performed in support of fish screen project planning. These activities include maintenance of gates at various diversion dams, dewatering canals and laterals, work on roads and dikes, application of herbicide and pesticide, and periodic inspections of pumping facilities. Reclamation may also perform site visits, soil testing, and other survey work in support of fish screen construction. However, no instream work is planned during this component of the proposed action.

In addition, Reclamation proposes to improve fish passage at the Keno Dam fish ladder. These activities are described as minor repairs or modifications but may require temporary dewatering of the fish ladder. As proposed, instream work and dewatering activities will only occur outside of fish migration periods. Therefore, coho salmon are not expected to be found in the fish ladder at Keno Dam or upstream, as the extent of their range ends at Spencer Creek. In the rare instance that coho salmon are discovered in the fish ladder or upstream of Keno Dam, we anticipate that would occur during fish migration windows when water quality is suitable. Because Reclamation proposes to perform their work outside of migration windows when water quality is not suitable to support coho salmon and the location is outside the expected range of coho salmon, NMFS does not expect any impacts to individuals as a result of fish passage improvements at Keno Dam.

The activities described in the proposed action occur primarily upstream of Keno Dam and in canals across the Klamath Project service area. NMFS understands these areas fall entirely outside of the expected range of SONCC coho salmon (upstream of Keno Dam) and therefore are not expected to have impacts to coho salmon individuals.

2.3.3.2.6 Summary of Effects to Individuals

All life stages of Klamath River coho salmon are expected to be exposed to proposed action effects during implementation of the proposed action, and populations closest to Keno Dam (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, may only be exposed to a minimal amount of disease risk. Adult coho salmon are present in the mainstem Klamath River only during the upstream migration and spawning period (September to January). Coho salmon eggs and fry associated with a relatively 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 flows under the proposed action are at least 650 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 in the mainstem between Keno Dam 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 (Foott et al. 1999; Sullivan et al. 2000; Ray et al. 2012). High water temperatures are linked to lower DO. Low DO can affect fitness and survival of coho salmon by impairing growth, swimming performance and avoidance behavior (Bjornn et al. 1991). 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.

NMFS believes the high incidence of disease caused by *C. shasta* 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 pulse flows released from the FFA will occur in most years. Pulse flows combined with more variable spring flows are expected to help disrupt the life cycle of *C. shasta.* 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 fitness and survival. Therefore, the proposed action will likely have an overall negative effect by contributing to fine sediment deposition and establishment of annelid worm colonies downstream from Keno Dam, while providing some minimal benefits to reduce disease risk annually through the use of a pulse flow through use of the FFA.

2.3.4 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.

Many activities described in Section 2.3.2 *Environmental Baseline* are reasonably certain to continue within the action area into 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 activities are likely to be similar in the future. 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 Section 2.3.2 *Environmental Baseline Section*.

2.3.4.1 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 Klamath Project to water from the Klamath River and its tributaries, including UKL.

In 2013, the state of Oregon issued the Adjudicator's Findings of Fact and Final Order of Determination (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 Bureau of Indian Affairs on behalf of The Klamath Tribes. 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.

2.3.5 Integration and Synthesis for SONCC coho Salmon

This 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 2.3.3) to the *Environmental Baseline* (Section 2.3.2) and the *Cumulative Effects* (Section 2.3.4), taking into account the *Rangewide Status of the Species and Critical Habitat* (Section 2.3.1), to formulate the agency's 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.

2.3.5.1 Critical Habitat

2.3.5.1.1 Condition of Critical Habitat at the ESU Scale

Section 2.3.2.1 *Status of Critical Habitat in the Action Area* 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 William L. Jess Dam on the Rogue River, 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). Increased prevalence of severe wildfire contributes large amount of sediment to streams and destroys riparian habitat. 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 Section 2.3.2.1 *Status of Critical Habitat in the Action Area*, 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 the removal of four hydroelectric dams on the Klamath River as well as 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).

2.3.5.1.2 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 Klamath Project diversions, decreasing net inflows, and 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, both at the local and landscape level, and in much of the Interior-Klamath diversity stratum have been improving the conservation value of critical habitat in the action area. This is evidenced by the recent removal of the four hydroelectric dams on the mainstem Klamath along with restoration projects planned and underway in the former hydroelectric reach and its tributaries (e.g., floodplain reconnection and spring development). Critical habitat in the Upper and Middle Klamath population areas is currently impacted by the short-term effects of dam removal with large amounts of sediment deposited in the system and reducing water quality. However, NMFS expects that the quality of critical habitat in the mainstem Klamath River portion of the Klamath Diversity Stratum will rapidly improve over the term of the proposed action. NMFS expects baseline condition of the habitat will improve beyond pre-dam removal conditions with reduced disease prevalence, more dynamic hydrograph, enhanced sediment transport, and improved water quality conditions. Additionally, high priority restoration projects that have been funded to provide better access to summer and winter rearing habitat, increase the abundance of rearing habitats, and improve the quality of rearing habitats.

The aggregate benefits from the dam removal and habitat restoration efforts will be integral to the recovery of SONCC coho salmon in the Interior-Klamath diversity stratum. NMFS believes that 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 in the 2020s are predicted to be as high as 0.8° C, and an annual increase in precipitation of approximately 3% (Reclamation 2011a). Projections also suggest that an increase in evapotranspiration will likely offset the increase in precipitation due to warming temperatures.

NMFS expects many of activities discussed in the Section 2.3.2 *Environmental Baseline* will continue (e.g., harvest, predation, restoration activities, and land use/management activities). In addition, future climate change (described above) in the Klamath Basin within the period of the proposed action, may have noticeable additional effects on coho salmon beyond what has been occurring.

2.3.5.1.3 Klamath 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 the former IGD and approximately Orleans is likely to be reduced by Klamath 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, by moving the flow release point to Keno Dam (part of the environmental baseline), critical habitat which begins at the former IGD will benefit from a more natural hydrograph. Additionally, the Klamath Project's use of annual pulse flow events in the spring or use of the FFA to augment flows is expected to reduce the adverse effects from the Klamath Project's storage and use of water in the Klamath basin. When a pulse flow is not released and the FFA volume is used to augment spring flows instead, disease risk will rarely be minimized.

2.3.5.1.3.1 Spawning Habitat

The proposed action includes use of the FFA volume to either release a pulse flow or augment spring flows. When the FFA volume is used to augment flows, we expect reduced mobilization of fines. However, use of the FFA to release a pulse flow is expected to mobilize fines from spawning habitat and improve spawning habitat quality in the Upper Klamath River population area. As Klamath 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 pulse flow events. Generally, NMFS expects the quality and quantity of spawning habitat in the mainstem to be sufficient for the small numbers of adult coho spawners that use the mainstem for spawning.

2.3.5.1.3.2 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 flow released from Keno Dam are expected to commonly remain at minimum levels (see Section 2.3.3.1.2 *Hydrologic Effects*). 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 Keno Dam, which is enhanced by tributary accretions across the action area, including tributaries between Keno Dam and the former IGD.

The juvenile migration corridor within the mainstem Klamath River is also expected to be suitable at flows of at least 700 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.

In summary, the proposed action is not expected to decrease the conservation value of migratory corridors for coho salmon in the action area during the term of the proposed action.

2.3.5.1.3.3 Rearing Habitat

2.3.5.1.3.3.1 Habitat Availability

The proposed action will reduce coho salmon fry and juvenile habitat availability in the mainstem Klamath River downstream of Keno Dam due to the overall reduction in flow volume during the spring and summer. While the amount of habitat reduction is difficult to quantify with the dams removed, NMFS expects some sites (e.g., Beaver Creek) to have significant reductions in habitat availability under a wide range of flows. NMFS cannot quantify the actual extent of habitat reduction; however, the habitat reduction potential is greatest in the most upstream reaches, immediately below Keno Dam because of closer proximity to flow release point.

While there will be reductions in rearing habitat availability, the proposed action will provide spring flow variability and can release a pulse flow through the use of the FFA. Flow variability and pulse flow events 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 Keno Dam. 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. The proposed action's release of Keno Dam minimum flows will help lessen the impacts to coho salmon fry and juvenile habitat in the mainstem. On balance, however, the effect of the proposed action on rearing habitat results in adverse impacts associated with decreased availability.

2.3.5.1.3.3.2 Water Quality

The proposed action is likely to increase water temperature in the mainstem Klamath River between Keno Dam and the Scott River by up to approximately 0.5°C during the spring and summer (Perry et al. 2011). Downstream of the Scott River mouth, the proposed action's effects on water temperature are likely insignificant because cold water accretions and meteorological conditions have a pronounced effect on water temperatures in the mainstem Klamath River. Additionally, the proposed action will likely contribute to adverse effects to coho salmon rearing habitat when DO concentrations fall below 8 mg/L in the mainstem Klamath River during the summer. In summary, the proposed action is likely to adversely affect water quality in the mainstem Klamath River during the period of the proposed action by slightly increasing water temperature and decreasing DO concentrations during the summer.

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

Many of the PBFs of SONCC coho salmon are currently degraded. Although dam removal has significantly altered the landscape toward a more natural condition, the impacts of the removal have temporarily degraded elements of the baseline. NMFS expects that the baseline conditions will rapidly improve as fine sediments, accumulated from dam removal, are transported downstream. Over the term of the proposed action, instream restoration in the former reservoir footprints and tributaries will occur to improve vegetative cover, spawning habitat, rearing habitat, and fish passage. Although the baseline environmental conditions are improving as a result of dam removal and associated restoration projects, implementing the proposed action, will contribute to the ongoing degradation of some of the PBFs.

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, 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 proposed pulse flow and variable spring 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 annelid 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.

Factoring in the status of SONCC coho salmon ESU critical habitat, the improving environmental baseline (i.e., dam removal), and cumulative effects, the effects 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.

2.3.5.2 SONCC coho salmon ESU

In Section 2.3.1.2 *Status of Species and Critical Habitat,* 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 climate change will negatively impact the habitat and status of SONCC coho at the ESU level.

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 be 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 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 (NMFS 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. Individual coho salmon from the three populations (Upper Trinity, South Fork Trinity, and Lower Trinity) in the Interior Trinity River stratum are only exposed to a minor amount of disease risk when they migrate through the lower portion of the mainstem Klamath River. Therefore, these populations are not expected to be adversely affected by the proposed action. Similarly, individual coho salmon in the Lower Klamath River population within the Central Coastal Diversity stratum are only exposed to a minor amount of disease risk when entering the mainstem Klamath River. Therefore, the individuals in the Lower

Klamath River population are not expected to be adversely impacted as a result of 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, former IGH and FCH 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 coho salmon find a mate and successfully reproduce. NMFS expects that the ongoing production of coho salmon at FCH will contribute increased population abundance and spatial diversity, with the dams removed. TRH and FCH 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 et al. 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 Section 2.3.2 *Environmental Baseline*, 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 ongoing activities, such as agricultural water diversions. However, significant improvements to the baseline are expected due to the recent removal of four hydroelectric dams. NMFS expects over the course of the five-year term for this proposed action, a more natural temperature regime will be established in the mainstem Klamath, sediment transport will resume through the former hydroelectric reach, a more dynamic and natural hydrograph will occur, and disease risk will be reduced – all due to the removal of mainstem Klamath dams.

There has been a decline in UKL outflows since the 1960s, which is likely due to increasing Klamath Project diversions, decreasing net inflows, and 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 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.

NMFS expects many of activities discussed in Section 2.3.2 *Environmental Baseline* 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 proposed action may have noticeable additional effects on coho salmon beyond what has been occurring. Specific projections during the term 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.

2.3.5.2.1 Effects of the Proposed Action to the Interior Klamath River Diversity Stratum Populations

As described in the Section 2.3.3.2 *Effects to SONCC Coho Salmon ESU Individuals,* 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 pulse flows and flow variability in the spring. A summary of these adverse effects and minimization measures is presented below. The coho salmon populations closest to Keno Dam are expected to be most adversely affected. The coho salmon populations adversely affected the most to the least are the Upper Klamath (RM 128 to RM 190), Shasta (RM 177), Scott River (RM 144), Middle Klamath (RM 43 to RM 144), whereas coho salmon from the Salmon River (RM 66) population are expected to experience negligible effects from the proposed action.

Adverse effects of the proposed action, resulting in incidental take of coho salmon, include:

- Decreased habitat for coho salmon fry in the mainstem Klamath River from Keno Dam to the Salmon River confluence in June during below average years (≥ 50% exceedance).
- Decreased habitat for coho salmon juveniles in the mainstem Klamath River from Keno Dam to downstream of Scott River confluence 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 Keno Dam 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 Keno Dam and Orleans.
- Increase the likelihood of disease-related mortality for coho salmon fry and juvenile in the mainstem Klamath River 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 and DO drops below 8.0 mg/L in the mainstem Klamath River between Keno Dam and Scott River (RM 144) in May through June.

Similar to the adverse effects described above, the coho salmon populations closest to Keno Dam 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. The Salmon River population is expected to have minimal beneficial 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 pulse flows from the FFA. NMFS anticipates these events will reduce disease risks to juvenile coho salmon that could occur as a result of Klamath 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 Keno Dam and Orleans during March to June.
- 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 the proposed action.
- The minimum 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;

The proposed action's adverse effects and the minimization measures of both the Klamath Project operations and habitat restoration components of the proposed action are integrated and summarized in below Table 34.

Table 34. Summary of the proposed action's adverse effects and minimization measures.

Potential Stressor	Project Effects	Life Stage	General Time	Mainstem Location	Minimization Measures	Proposed Action Effects
Increased Water Temperature	Increased stress	Juvenile	May to mid-June	Keno Dam to Scott River	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.	Coho salmon will continue to have increased stress from slightly elevated water when temperatures exceed 16.5ºC.
Reduced DO	Reduced swimming performance and increased stress	Juvenile	May to mid-June	Keno Dam to Scott River	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.	Coho salmon will continue to have decreased swimming performance or increased stress from decreased DO concentration in the mainstem during the late night and early morning when DO concentrations are below 8.0 mg/L or 6.0 mg/L, respectively.
Reduced Habitat Availability	Reduced growth and survival	Fry	Early to mid-June	Keno Dam to Salmon River	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.	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.
Reduced Habitat Availability	Reduced growth and survival	Juvenile	March through June	Keno Dam to Salmon River	Flow variability incorporated into the proposed action will likely provide increased spring flows when precipitation and	The proposed action will result in habitat reductions in the mainstem Klamath River. However, the minimization measures are likely to

Potential Stressor	Project Effects	Life Stage	General Time	Mainstem Location	Minimization Measures	Proposed Action Effects
					snow melt is occurring in the Upper Klamath Basin, especially during wetter water years.	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.
Reduced Quality of Migration Habitat	Decreased rate of outmigration and reduced survival	Smolt	April through June	Keno Dam to Shasta River	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.	Coho salmon are likely to continue to have a decreased outmigration rate, which will increase likelihood of decreased growth or increased mortality when environmental conditions are conducive to having increased stressors, such as warmer water temperatures and disease proliferation.
Increased Disease	Reduced fitness and survival	Juveniles	April through June	Keno Dam to Orleans	Minimum flows from Keno (April to June) and use of pulse flows will limit the increases of disease risk	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

2.3.5.2.2 Effects of Fitness Consequences on Population Viability Parameters

2.3.5.2.2.1 Abundance

NMFS expects the proposed action will reduce spring rearing habitat availability for fry and juveniles, 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 maintaining elements of spring flow variability and use of pulse flows in the spring will help to reduce these effects of the proposed action.

Of all the adverse effects of the proposed action, NMFS concludes that decreased survival as a result of disease 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 in combination with the future benefits of dam removal, 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. While NMFS cannot quantify the magnitude of the disease impacts to coho salmon as a result of the proposed action, NMFS concludes that the proposed action will result in decreased survival to coho salmon as a result of disease. Populations closest in proximity to Keno Dam and exposed to the infectious zone (i.e., Upper and Middle Klamath, Shasta, and Scott river populations) are expected to experience improvement in survival and abundance during the five-year term of the proposed action, though adverse effects remain. The populations furthest downstream from Keno Dam (Upper Trinity, South Fork Trinity, and Lower Klamath), although exposed to minor risk of disease, are not expected to be adversely impacted. Some coho fry and juveniles will continue to be lost to increased diseased risk caused by the proposed action.

2.3.5.2.2.2 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, relative to current baseline conditions. 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 the proposed action.

2.3.5.2.2.3 Diversity

As described in Section 2.3.2 *Environmental Baseline,* 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 Section 2.3.3.1.2 *Hydrologic Effects*, 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 Section 2.3.3 *Effects of the Action*, Reclamation proposes measures to reduce flow-related effects of the proposed action, including use of a spring pulse flow. 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. 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 maintain thermal refugia and access to tributaries. Therefore, NMFS concludes the proposed action is not likely to result in a level of effects that will reduce diversity of affected populations.

2.3.5.2.2.4 Spatial Structure

As discussed in the Section 2.3.3.2 *Effects to Individuals,* 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 or newly accessible mainstem Klamath River habitat. Therefore, NMFS does not expect the proposed action will reduce the spatial structure of coho salmon.

2.3.5.2.3 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 that are reasonably certain to result in incidental take from the proposed action. Of all the adverse effects of the proposed action, NMFS believes that reduced survival as a result of disease 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 term of the proposed action for the Upper Klamath, Middle Klamath, Shasta, and Scott populations. Though adverse effects due to disease caused by the proposed action will remain, the improved abundance and productivity 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.

2.4 Southern Resident Killer Whale DPS

2.4.1 Rangewide Status of the Species

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

The SRKW DPS, described as killer whales from the J, K and L pods, was listed as endangered under the ESA on November 18, 2005 (50 CFR 224.101(h)). A five-year review under the ESA completed in 2021 concluded that SRKWs should remain listed as endangered and includes recent information on the population, threats, and new research results and (NMFS 2021d). NMFS considers SRKWs to be currently among nine of the most at-risk species as part of NMFS' Species in the Spotlight initiative because of their endangered status, declining population trend, and because they are high priority for recovery based on conflict with human activities and recovery programs in place to address threats (NMFS 2019b). The population has relatively high mortality and low reproduction, unlike other resident killer whale populations, which have generally been increasing since the 1970s (Carretta et al. 2023). Current management priorities are outlined in the 2021 to 2025 Species in the Spotlight Action Plan.[17]

The factors limiting SRKW recovery described in the final recovery plan include reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS 2008c). This section summarizes the status of SRKWs throughout their range and summarizes information taken largely from the recovery plan (NMFS 2008c), most recent five-year review (NMFS 2021d), the PFMC SRKW Ad Hoc Workgroup's report (PFMC 2020), as well as new data that became available more recently.

2.4.1.1 Status of SRKW

2.4.1.1.1 Abundance, Productivity, and Trends

Killer whales, including SRKWs, are a long-lived species and sexual maturity can occur at age 10 (NMFS 2008c). Females produce a low number of surviving calves (n < 10, but generally fewer) over the course of their reproductive lifespan (Bain 1990; Olesiuk et al. 1990). Compared to Northern Resident killer whales (NRKWs), which are a resident killer whale population with a sympatric geographic distribution ranging from coastal waters of Washington State and British Columbia North to Southeast Alaska, SRKWs females appear to have reduced fecundity (Ward et al. 2013; Velez-Espino et al. 2014), and all age classes of SRKWs have reduced survival compared to other fish-eating populations of killer whales in the Northeast Pacific (Ward et al. 2013).

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[17] https://www.fisheries.noaa.gov/resource/document/species-spotlight-priority-actions-2021-2025-southern-resident-killer-whale

Since the early 1970s, annual summer censuses have occurred in the Salish Sea using photo-identification techniques (Bigg et al. 1990; CWR 2019). At present, the SRKW population size has declined to near historically low levels (Figure 33). At the time of the 2024 summer census, the Center for Whale Research reported 73 SRKWs in the population[18] (Figure 33). The previously published historical estimated abundance of SRKWs was 140 animals (NMFS 2008c), which included the number of whales killed or removed for public display in the 1960s and 1970s (summed across all years) added to the remaining population at the time the captures ended.

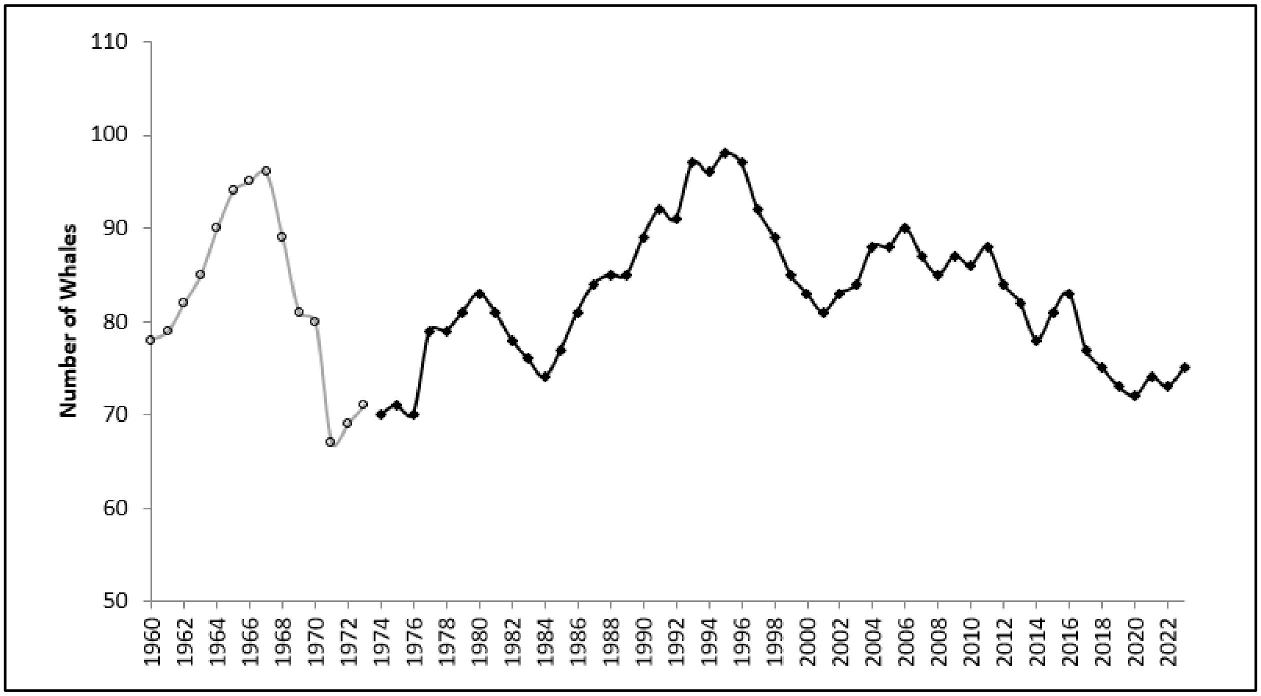

Figure 33. Population size and trend of SRKWs, 1960 to 2023. Data from 1960 to 1973 (open circles, gray line) are number projections from the matrix model of Olesiuk et al. (1990). Data from 1974 to 2023 (diamonds, black line) were obtained through photo-identification surveys of the three pods (J, K, and L) and were provided by the CWR (unpublished data) and (NMFS 2008c).

Seasonal mortality rates among SRKWs and NRKWs may be highest during the winter and early spring, based on stranding data and the number of animals missing from pods returning to inland waters each spring. Olesiuk et al. (2005) reported that high neonate mortality occurred outside of the summer season. Additionally, multiple new calves have been documented in winter months that did not survive to the following summer season (CWR unpublished data). Stranding rates are higher in winter and spring for all killer whale forms in Washington and Oregon (Norman et al. 2004) and a recent review of killer whale strandings in the Northeast Pacific provided insight into health, nutritional status and causes of mortality for all killer whale ecotypes (Raverty et al. 2020).

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[18] See https://www.whaleresearch.com/orca-population for 2024 SRKW census report numbers.

The NMFS Northwest Fisheries Science Center (NWFSC) continues to evaluate changes in fecundity and mortality rates, and has updated the population viability analyses conducted for the 2004 Status Review for SRKWs (Krahn et al. 2004), the 2012 science panel review of the effects of salmon fisheries (Krahn et al. 2004; Hilborn et al. 2012; Ward et al. 2013), and previous five-year status reviews (NMFS 2011a; NMFS 2016c; NMFS 2021d). Subsequently, population estimates, including data from the last five years (2017 to 2021), project a downward trend over the next 25 years (Figure 34). The declining trend is in part due to the changing age and sex structure of the population (the sex ratio at birth was estimated at 55% male and 45% female following current trends), but also related to the relatively low fecundity rate observed over the period from 2017 to 2021 (when the same analyses are applied to Fisheries and Oceans Canada's [DFO's] NRKW data, a similar trend of declining fecundity is also present in that population). Though these fecundity rates are declining, average SRKW survival rates estimated by the NWFSC have been slowly increasing since the late 1990s. The population projection suggests the strongest decline if future fecundity rates are assumed to be similar to 2017 to 2021, and higher but still declining if average fecundity and survival rates over all years (1985 to 2021) (Figure 34). The projection using the highest fecundity and survival rates (1985 to 1989) shows some stability and even a slight increase over the next decade before severely declining. A 25 year projection was selected because as the model projects out over a longer time frame (e.g., 50 years), there is increased uncertainty around the estimates (also see Hilborn et al. (2012)).

The scenario using the most recent (2017 to 2021) survival and fecundity rates may be a more reliable estimation if current levels of survival and poor reproduction continue. This predicted downward trend in the model is driven by the current age and sex structure of young animals in the population, as well as the number of older animals. The range of population trajectories reflects the endangered status of the SRKWs and variable periods of decline experienced over the long and short term and is based on a limited data set for the small population. The analysis does not link population growth or decline to any specific threat, but reflects the combined impacts of all of the threats in the past. As a long-lived species with a low reproductive rate, it will take time for SRKWs to respond to a reduction in threats. It will be difficult to link specific actions to potential future improvements in the population trajectory. One assumption shared across all scenarios presented here is that female reproduction will be similar to average (given the age of animals and time period). As many reproductive aged females have not produced a calf in the last decade, we would expect the SRKW population size to decline even more rapidly if the number of females not reproducing continues to increase, or these females continue to fail to produce calves.

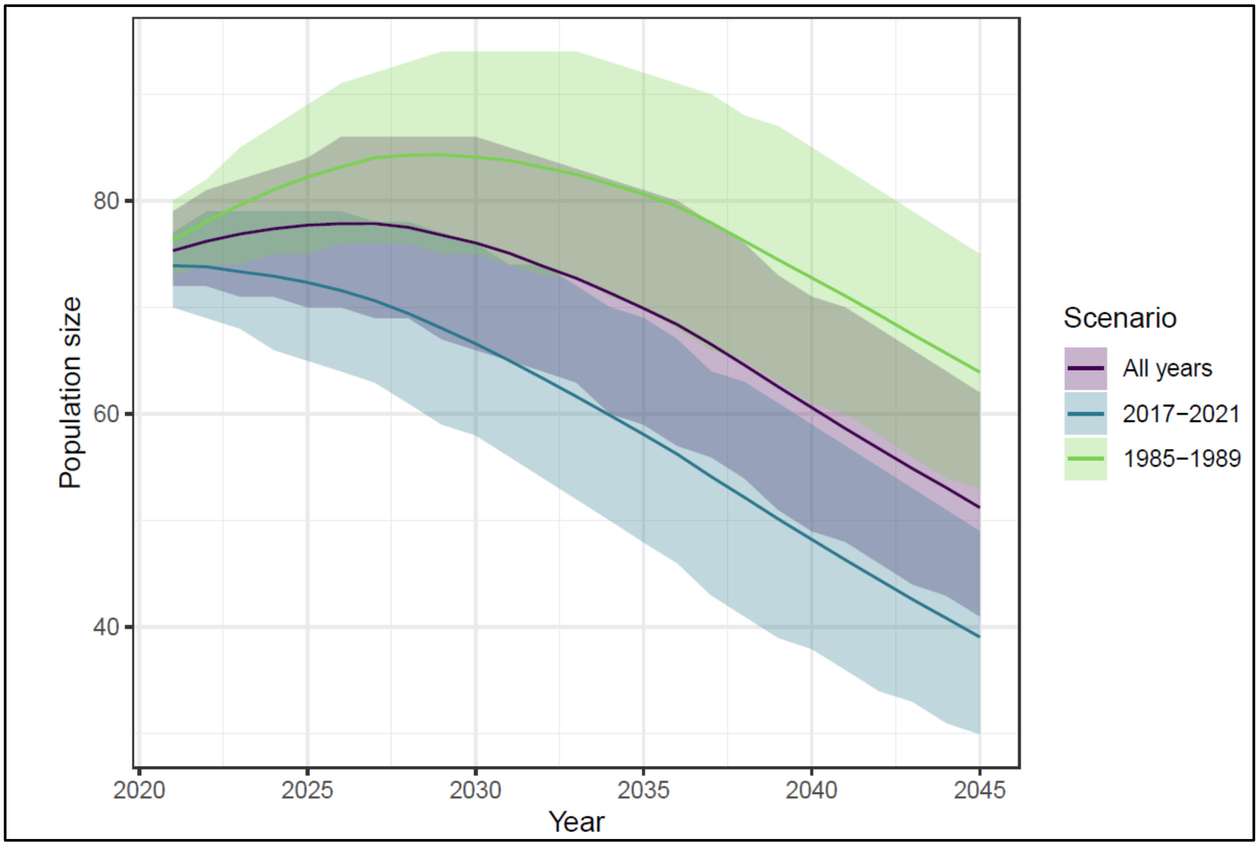


Figure 34. SRKW population size projections from 2020 to 2045 using three scenarios: (1) projections using fecundity and survival rates estimated over the entire time series (1985 to 2021), (2) projections using rates estimated over the last five years (2017 to 2021), and (3) projections using the highest survival and fecundity rates estimated, during the period 1985 to 1989 (NMFS 2021d).

Another factor to consider is the potential effects of inbreeding (generally a risk for any small population). Many 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 (Ford et al. 2011) (Ford et al. 2018). Additionally, several offspring that were tested for paternity resulted from matings between parents and their own offspring (Ford et al. 2018). While these inbreeding effects are estimated to be slightly negative, they are difficult relationships to estimate given the small sample size. Recent genomic analyses indicate that the SRKW population has greater inbreeding and carries a higher load of deleterious mutations than do Alaska resident or transient killer whales, and that inbreeding depression is likely impacting the survival and growth of the population (Kardos et al. 2023). These factors likely contribute to the SRKW's poor status.

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

Individual variation in reproductive success can influence broader population growth or decline, especially for smaller, more isolated populations such as the SRKW (Coulson et al. 2006). Additionally, whether a female produces a female or male offspring may influence her lifetime reproductive success (Weiss et al. 2023). Similarly, the number of reproducing females in a population can signal potential growth or decline. In the SRKW population, the number of reproductive aged females was at its lowest point in the late 1970s, in part because of the prior harvesting that occurred into the early 1970s (Figure 35). Though the overall number of reproductive females has fluctuated between 25 to 35 for most of the last 40 years, there have been contrasting changes by pod, with declines in L pod females and increases in J pod (Ward 2021) (Figure 35). At the start of the survey in 1976, the distribution of females was skewed toward younger ages with few older, post-reproductive females. In recent years, the distribution is more uniform across female ages (in other words, more females in their 30s). Relatedly, female fecundity at age 20 has declined in recent years, while survival for females and males at age 20 has stayed relatively constant (Ward 2021) (Figure 36). This suggests that reduced fecundity may be the driver for the population decline, rather than reduced adult survival. However, given that both high and low fecundity rates have been observed at low total SRKW population sizes (Ward 2021) and that inbreeding depression may be influencing survival (Kardos et al. 2023), there is not a clear relationship between declining fecundity rates and SRKW population size.

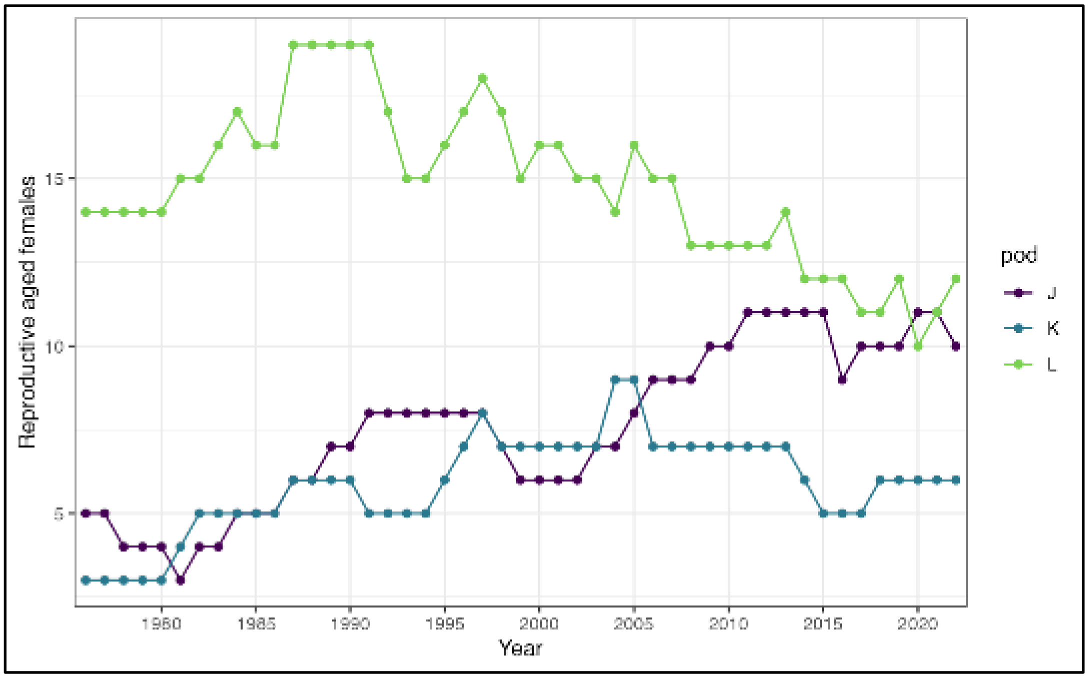


Figure 35 Time series of reproductive age females (10 to 42, inclusive) for SRKWs by year since 1976 (reproduced from Ward 2021).

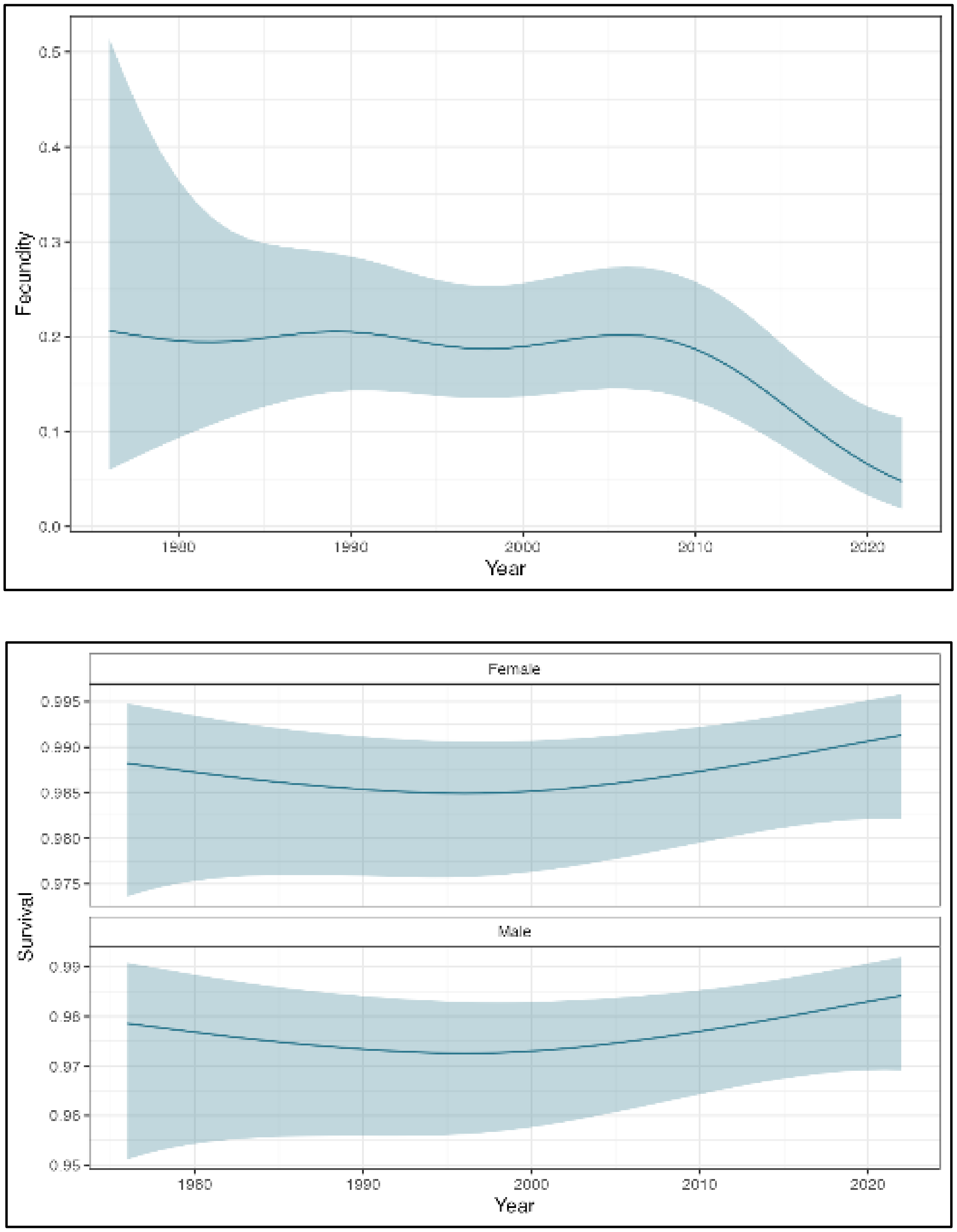
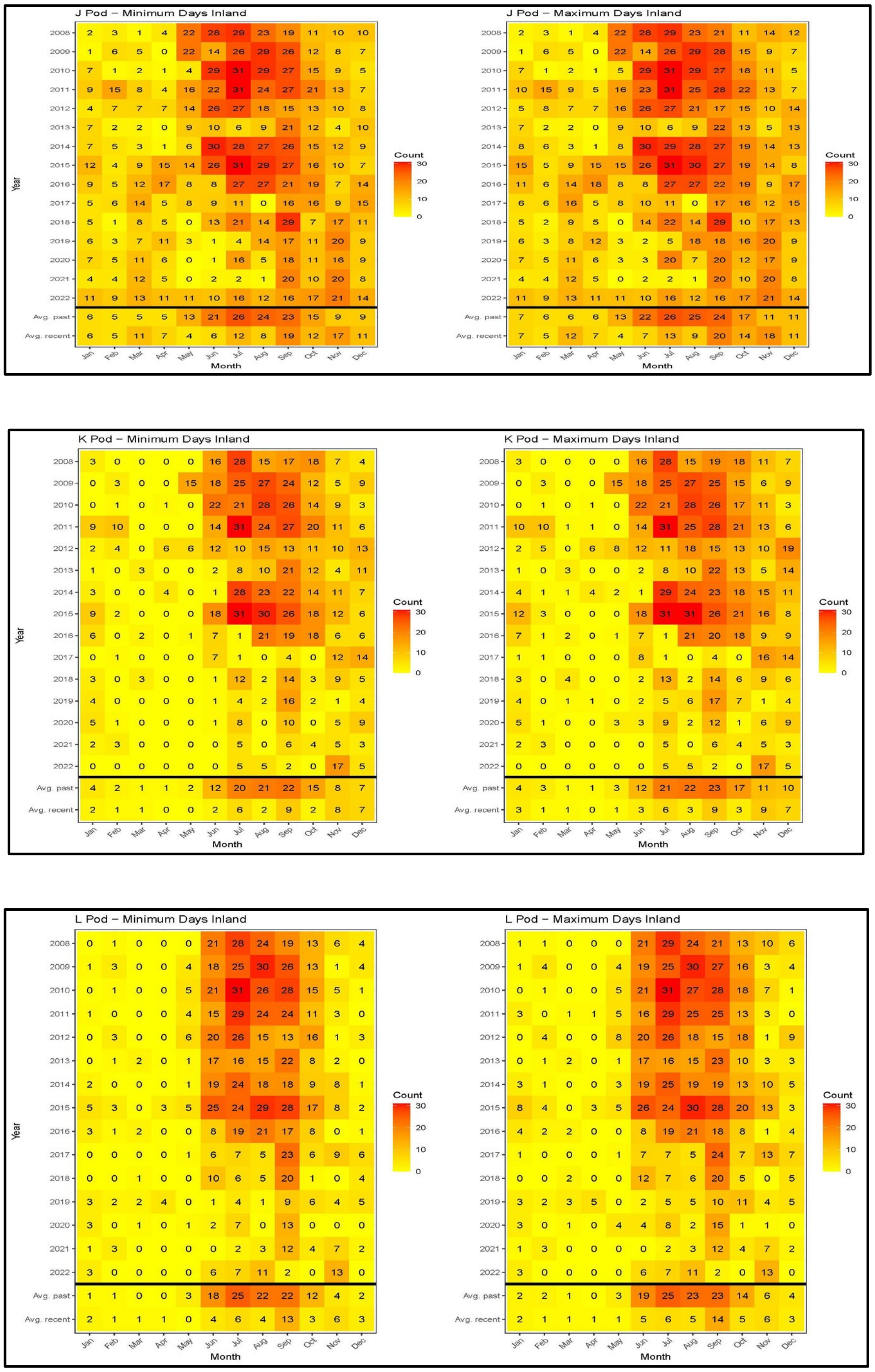


Figure 36. Time series of predicted fecundity rates for a 20-year old SRKW and survival rates for a 20-year old female and male. Estimates are generated from the Bayesian logistic regression models, using priors from the NRKW population. Ribbons represent 95% CIs (reproduced from (reproduced from Ward 2021).

Previous work using fecal hormone data from SRKWs showed that up to 69% of detected pregnancies do not produce a documented calf, and an unprecedented half of those occurred relatively later in the pregnancy when energetic costs and physiological risk to the mother are higher (Wasser et al. 2017). Recent aerial imagery corroborates this high rate of loss (Fearnbach et al. 2021). The congruence between the rate of loss estimates from fecal hormones and aerial photogrammetry suggests the majority of the loss is in the latter half of pregnancy when photogrammetry can detect anomalous shape after several months of gestation (Durban et al. 2016). Although the rates of successful pregnancies in wild killer whale populations is generally unknown, a relatively high level of reproductive failure late in pregnancy is uncommon in mammalian species and suggests there may be cause for concern.

2.4.1.1.2 Geographic Range and Distribution

SRKWs occur throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far North as Southeast Alaska (Figure 18) (Carretta et al. 2023), though there has only been one sighting of a SRKW in Southeast Alaska. SRKWs are highly mobile and can travel up to 86 miles (160 km) in a single day (Erickson 1978; Baird 2000), with seasonal movements likely tied to the migration of their primary prey, salmon. During the spring, summer, and fall months, the whales have typically spent substantial amount of time in the inland waterways of the Strait of Georgia, Strait of Juan de Fuca, and Puget Sound (Olson et al. 2018; NMFS 2021d; Ettinger et al. 2022; Thornton et al. 2022). During fall and early winter, SRKWs, and J pod in particular, expand their routine movements into Puget Sound, likely to take advantage of chum, coho, and Chinook salmon runs (Osborne 1999; Hanson et al. 2010a; Ford et al. 2016; Olson et al. 2018). Although seasonal movements are somewhat predictable, there can be large inter-annual variability in arrival time and days present in inland waters from spring through fall (Hanson et al. 2010b; Olson et al. 2018; NMFS 2021f) (Figure 37), with late arrivals and fewer days present in recent years (NMFS 2021d; Ettinger et al. 2022; Shields 2023)(though see J pod occurrence in 2022). In Figure 37, “Avg past” is the average before 2017 (2008 to 2016) and “Avg recent” is the average from 2017 to 2022. Data are available prior to 2008 but we used the past 15 years to represent more recent history. Minimum Days Inland includes only sightings where pod was specified and known with certainty. Maximum Days Inland include sightings where pod was specified, including when there was uncertainty, and also includes counts of sightings of SRKWs (without pod specified) if no specific pod was listed as sighted any time that day. The area of the Salish Sea included in Figure 37 encompasses both United States and Canadian waters, using the quadrant area defined by The Whale Museum (see Figure 1 in (Olson et al. 2018)) and extending further west into the Strait of Juan de Fuca to the edge of inland SRKW critical habitat at the Cape Flattery-Tattoosh-Bonilla Point line. Similarly, a recent paper by Stewart et al. (2023) showed a decline in visitation to core inland summer habitat (North Puget Sound) for all pods from 2004 to 2020 and that the occurrence of SRKW may be related to annual Fraser Chinook returns.



J Pod – Minimum Days Inland

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	2	3	1	4	22	28	29	23	19	11	10	10
2009	1	6	5	0	22	14	26	29	26	12	8	7
2010	7	1	2	1	4	29	31	29	27	15	9	5
2011	9	15	8	4	16	22	31	24	27	21	13	7
2012	4	7	7	7	14	26	27	18	15	13	10	8
2013	7	2	2	0	9	10	6	9	21	12	4	10
2014	7	5	3	1	6	30	28	27	26	15	12	9
2015	12	4	9	15	14	26	31	29	27	16	10	7
2016	9	5	12	17	8	8	27	27	21	19	7	14
2017	5	6	14	5	8	9	11	0	16	16	9	15
2018	5	1	8	5	0	13	21	14	29	7	17	11
2019	6	3	7	11	3	1	4	14	17	11	20	9
2020	7	5	11	6	0	1	16	5	18	11	16	9
2021	4	4	12	5	0	2	2	1	20	10	20	8
2022	11	9	13	11	11	10	16	12	16	17	21	14
Avg. past	6	5	5	5	13	21	26	24	23	15	9	9
Avg. recent	6	5	11	7	4	6	12	8	19	12	17	11

J Pod – Maximum Days Inland

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	2	3	1	4	22	28	29	23	21	11	14	12
2009	1	6	5	0	22	14	26	29	28	15	9	7
2010	7	1	2	1	5	29	31	29	27	18	11	5
2011	10	15	9	5	16	23	31	25	28	22	13	7
2012	5	8	7	7	16	26	27	21	17	15	10	14
2013	7	2	2	0	9	10	6	9	22	13	5	13
2014	8	6	3	1	8	30	29	28	27	19	14	13
2015	15	5	9	15	15	26	31	30	27	19	14	8
2016	11	6	14	18	8	8	27	27	22	19	9	17
2017	6	6	16	5	8	10	11	0	17	16	12	15
2018	5	2	9	5	0	14	22	14	29	10	17	13
2019	6	3	8	12	3	2	5	18	18	16	20	9
2020	7	5	11	6	3	3	20	7	20	12	17	9
2021	4	4	12	5	0	2	2	1	20	10	20	8
2022	11	9	13	11	11	10	16	12	16	17	21	14
Avg. past	7	6	6	6	13	22	26	25	24	17	11	11
Avg. recent	7	5	12	7	4	7	13	9	20	14	18	11

K Pod – Minimum Days Inland

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	3	0	0	0	0	16	28	15	17	18	7	4
2009	0	3	0	0	15	18	25	27	24	12	5	9
2010	0	1	0	1	0	22	21	28	26	14	9	3
2011	9	10	0	0	0	14	31	24	27	20	11	6
2012	2	4	0	6	6	12	10	15	13	11	10	13
2013	1	0	3	0	0	2	8	10	21	12	4	11
2014	3	0	0	4	0	1	28	23	22	14	11	7
2015	9	2	0	0	0	18	31	30	26	18	12	6
2016	6	0	2	0	1	7	1	21	19	18	6	6
2017	0	1	0	0	0	7	1	0	4	0	12	14
2018	3	0	3	0	0	1	12	2	14	3	9	5
2019	4	0	0	0	0	1	4	2	16	2	1	4
2020	5	1	0	0	0	1	8	0	10	0	5	9
2021	2	3	0	0	0	0	5	0	6	4	5	3
2022	0	0	0	0	0	0	5	5	2	0	17	5
Avg. past	4	2	1	1	2	12	20	21	22	15	8	7
Avg. recent	2	1	1	0	0	2	6	2	9	2	8	7

K Pod – Maximum Days Inland

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	3	0	0	0	0	16	28	15	19	18	11	7
2009	0	3	0	0	15	18	25	27	25	15	6	9
2010	0	1	0	1	0	22	21	28	26	17	11	3
2011	10	10	1	1	0	14	31	25	28	21	13	6
2012	2	5	0	6	8	12	11	18	15	13	10	19
2013	1	0	3	0	0	2	8	10	22	13	5	14
2014	4	1	1	4	2	1	29	24	23	18	15	11
2015	12	3	0	0	0	18	31	31	26	21	16	8
2016	7	1	2	0	1	7	1	21	20	18	9	9
2017	1	1	0	0	0	8	1	0	4	0	16	14
2018	3	0	4	0	0	2	13	2	14	6	9	6
2019	4	0	1	1	0	2	5	6	17	7	1	4
2020	5	1	0	0	3	3	9	2	12	1	6	9
2021	2	3	0	0	0	0	5	0	6	4	5	3
2022	0	0	0	0	0	0	5	5	2	0	17	5
Avg. past	4	3	1	1	3	12	21	22	23	17	11	10
Avg. recent	3	1	1	0	1	3	6	3	9	3	9	7

L Pod – Minimum Days Inland

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	0	1	0	0	0	21	28	24	19	13	6	4
2009	1	3	0	0	4	18	25	30	26	13	1	4
2010	0	1	0	0	5	21	31	26	28	15	5	1
2011	1	0	0	0	4	15	29	24	24	11	3	0
2012	0	3	0	0	6	20	26	15	13	16	1	3
2013	0	1	2	0	1	17	16	15	22	8	2	0
2014	2	0	0	0	1	19	24	18	18	9	8	1
2015	5	3	0	3	5	25	24	29	28	17	8	2
2016	3	1	2	0	0	8	19	21	17	8	0	1
2017	0	0	0	0	1	6	7	5	23	6	9	6
2018	0	0	1	0	0	10	6	5	20	1	0	4
2019	3	2	2	4	0	1	4	1	9	6	4	5
2020	3	0	1	0	1	2	7	0	13	0	0	0
2021	1	3	0	0	0	0	2	3	12	4	7	2
2022	3	0	0	0	0	6	7	11	2	0	13	0
Avg. past	1	1	0	0	3	18	25	22	22	12	4	2
Avg. recent	2	1	1	1	0	4	6	4	13	3	6	3

L Pod – Maximum Days Inland

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2008	1	1	0	0	0	21	29	24	21	13	10	6
2009	1	4	0	0	4	19	25	30	27	16	3	4
2010	0	1	0	0	5	21	31	27	28	18	7	1
2011	3	0	1	1	5	16	29	25	25	13	3	0
2012	0	4	0	0	8	20	26	18	15	18	1	9
2013	0	1	2	0	1	17	16	15	23	10	3	3
2014	3	1	0	0	3	19	25	19	19	13	10	5
2015	8	4	0	3	5	26	24	30	28	20	13	3
2016	4	2	2	0	0	8	19	21	18	8	1	4
2017	1	0	0	0	1	7	7	5	24	7	13	7
2018	0	0	2	0	0	12	7	6	20	5	0	5
2019	3	2	3	5	0	2	5	5	10	11	4	5
2020	3	0	1	0	4	4	8	2	15	1	1	0
2021	1	3	0	0	0	0	2	3	12	4	7	2
2022	3	0	0	0	0	6	7	11	2	0	13	0
Avg. past	2	2	1	0	3	19	25	23	23	14	6	4
Avg. recent	2	1	1	1	1	5	6	5	14	5	6	3

Figure 37. Minimum and maximum number of days that each SRKW pod (J, K, or L) was present in inland waters of the Salish Sea by year and month based on opportunistic sightings (NMFS 2021d) (Whale Museum, unpublished data).

Land- and vessel-based opportunistic and survey-based visual sightings, satellite tracking, and passive acoustic research have provided an updated estimate of the whales' coastal range. Since 1975, confirmed and unconfirmed opportunistic SRKW sightings from the general public or researchers have been collected off British Columbia, Washington, Oregon, and California.

Because of the limitations of not having controlled and dedicated sampling efforts, these confirmed opportunistic sightings have provided only general information on the whales' potential geographic range during this period of time (i.e., there are no data to describe the whales' general geographic range prior to 1975). Together, these SRKW sightings have confirmed their presence as far north as Chatham Strait, SEAK and as far south as Monterey Bay, California (NMFS 2021c). DFO models of SRKW occurrence based on sightings data show hotspots of occurrence off the west side of Vancouver Island at Swiftsure Bank, the west side of San Juan Island, and near the mouth of the Fraser River (Thornton et al. 2022). Additionally, the Pacheedaht First Nation has conducted surveys for SRKW occurrence in the Strait and Swiftsure areas from 2020 to 2022.

As part of a collaborative effort between NWFSC, Cascadia Research Collective, and the University of Alaska, satellite-linked tags were deployed on eight male SRKWs (three tags on J pod members, two on K pod, and three on L pod) from 2012 to 2016 in Puget Sound or in the coastal waters of Washington and Oregon. Over the course of the study, the eight satellite tags deployed were monitored for a range of signal contact durations from 3 days to 96 days depending on the tag, with deployment from late December to mid-May. The winter locations of the tagged whales included inland and coastal waters. The inland waters range occurs across the entire Salish Sea, from the northern end of the Strait of Georgia and Puget Sound, and coastal waters from central West Coast of Vancouver Island, British Columbia to Northern California (Hanson et al. 2017). J pod spends more time during the winter and spring in the inland waters of Washington and British Columbia compared to K and L pods who spend the majority of their time in coastal waters during these seasons (Hanson et al. 2017).

Satellite tagging can also provide details on preferred depths and distances from shore. Approximately 95% of the SRKW locations were within 34 km of the shore and 50% of these were within 10 km of the coast (Hanson et al. 2017). Only 5% of locations were greater than 34 km from the coast, but no locations exceeded 75 km. Almost all (96.5%) outer coastal locations of satellite-tagged SRKWs occurred in continental shelf waters of 200 m (656.2 feet (ft) depth or less, 77.7% were in waters less than 100 m (328.1 ft) depth, and only 5.3% were in waters less than 18 m (59 ft).

Passive acoustic recorders were deployed off the coasts of California, Oregon and Washington in most years since 2006 to assess SRKW seasonal uses of these areas via the recording of stereotypic calls of the SRKWs (Hanson et al. 2013; Emmons et al. 2019). There were acoustic detections off Washington coast in all months of the year, with greater than 2.4 detections per month from January through June and a peak of 4.7 detections per month in both March and April, indicating that the SRKW may be present in Washington coastal waters at nearly any time of year, more often than previously believed (Emmons et al. 2021). Acoustic recorders were deployed off Newport, Fort Bragg, and Port Reyes between 2008 to 2013 and SRKW were detected 28 times (Emmons et al. 2019). Between 2014 to 2017, all three SRKW pods were detected in northern acoustic recorder sites, but only K and L pods were detected in more Southern sites (Emmons et al. 2021). For areas off the coast of Oregon and California, the data available suggest considerable year-to-year variation in SRKW occurrence with their presence (K and L pod primarily) expected to be most likely during the winter and spring (NMFS 2021c).

2.4.1.2 Limiting Factors and Threats

Several factors identified in the final recovery plan for SRKWs may be limiting recovery. The recovery plan identifies three major threats including (1) quantity and quality of prey, (2) toxic chemicals that accumulate in top predators, and (3) impacts from sound and vessels (NMFS 2008c). Oil spills and disease as well as the small population size are also risk factors. It is likely that multiple threats are acting together to impact the whales. Modeling exercises have attempted to identify which threats are most significant to survival and recovery (Murray et al. 2021) and available data suggests that all of the threats are potential limiting factors (Murray et al. 2021).

Recent work by (Williams et al. 2024) supports these assertions. In an updated population viability assessment (PVA) model drawing from work in Lacy et al. (2017) Williams et al. (2024) showed that several factors are affecting the SRKW population growth rate, such as Chinook salmon abundance, polychlorinated biphenyl (PCB) accumulation, noise from vessels, and inbreeding, among others. While this work indicates that Chinook salmon abundance may have the largest influence on population growth rate, it is unclear how inbreeding depression (Kardos et al. 2023) may temper this response found by the authors. There are many limitations to interpreting the specific results, and unquantified uncertainty in the model (see Section 2.4.3.2 *General Effects of Reduced Prey Base for SRKWs* for more detail), but in general, the findings by Williams et al. (2024) support the large body of knowledge (see Section 2.4.1.1.1 *Abundance, Productivity, and Trends*, above) projecting population decline over the long term, and the importance of Chinook salmon prey abundance, as well as the impact of other limiting factors, on the recovery of SRKWs.

2.4.1.2.1 Quantity and Quality of Prey

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

SRKWs are the subject of ongoing research, the majority of which has occurred during summer months in inland waters of Washington State and British Columbia, Canada, and have involved direct observation, scale and tissue sampling of prey remains, and fecal sampling. The diet data suggest that SRKWs are consuming mostly larger (i.e., generally age three and up) Chinook salmon. Chinook salmon is their primary prey despite the much lower abundance in comparison to other salmonids in some areas and during certain time periods. Factors of potential importance include the Chinook salmon's large size, high fat and energy content, and year-round occurrence in the whales' geographic range. Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (kilocalorie/kilogram (kcal/kg)) (O'Neill et al. 2014). For example, in order for a killer whale to obtain the total energy value of one Chinook salmon, they would need to consume on average approximately 2.7 coho, 3.1 chum, 3.1 sockeye, or 6.4 pink salmon (O'Neill et al. 2014). Research suggests that 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). Though SRKW do not only consume Chinook salmon, the degree to which killer whales are able to or willing to switch to non-preferred prey sources (i.e., prey other than Chinook salmon) is also largely unknown, and likely variable depending on the time and location.

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

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

Collection of prey and fecal samples have also occurred in coastal waters in the winter and spring months, as well as observations of SRKWs overlapping with salmon runs (Wiles 2004; Zamon et al. 2007; Krahn et al. 2009). Results indicate that, as is the case in inland waters, Chinook salmon are the primary species detected in diet samples on the outer coast, although steelhead, chum salmon, and Pacific halibut were also detected in samples. Foraging on chum and coho salmon, steelhead, Big skate (*Rana binoculata*) and lingcod was also detected in recent fecal samples (Hanson et al. 2021). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al. 2013). Chinook salmon genetic stock identification from samples collected in winter and spring in coastal waters from California through Washington included 12 United States West Coast stocks, and showed that over half the Chinook salmon consumed originated in the Columbia River (Hanson et al. 2021). Columbia River, Central Valley, Puget Sound, and Fraser River Chinook salmon collectively comprised over 90% of Chinook salmon prey samples for which genetic stock origin was determined for SRKWs in coastal areas. As noted, most of the Chinook salmon prey samples opportunistically collected in coastal waters were determined to have originated from the Columbia River basin, including Lower Columbia Spring, Middle

Columbia Tule, and Upper Columbia Summer/Fall. In general, we would expect to find these stocks given the diet sample locations (Figure 38). However, the Chinook salmon stocks included fish from as far north as the Taku River (Alaska and British Columbia stocks) and as far south as the Central Valley California (Hanson et al. 2021).

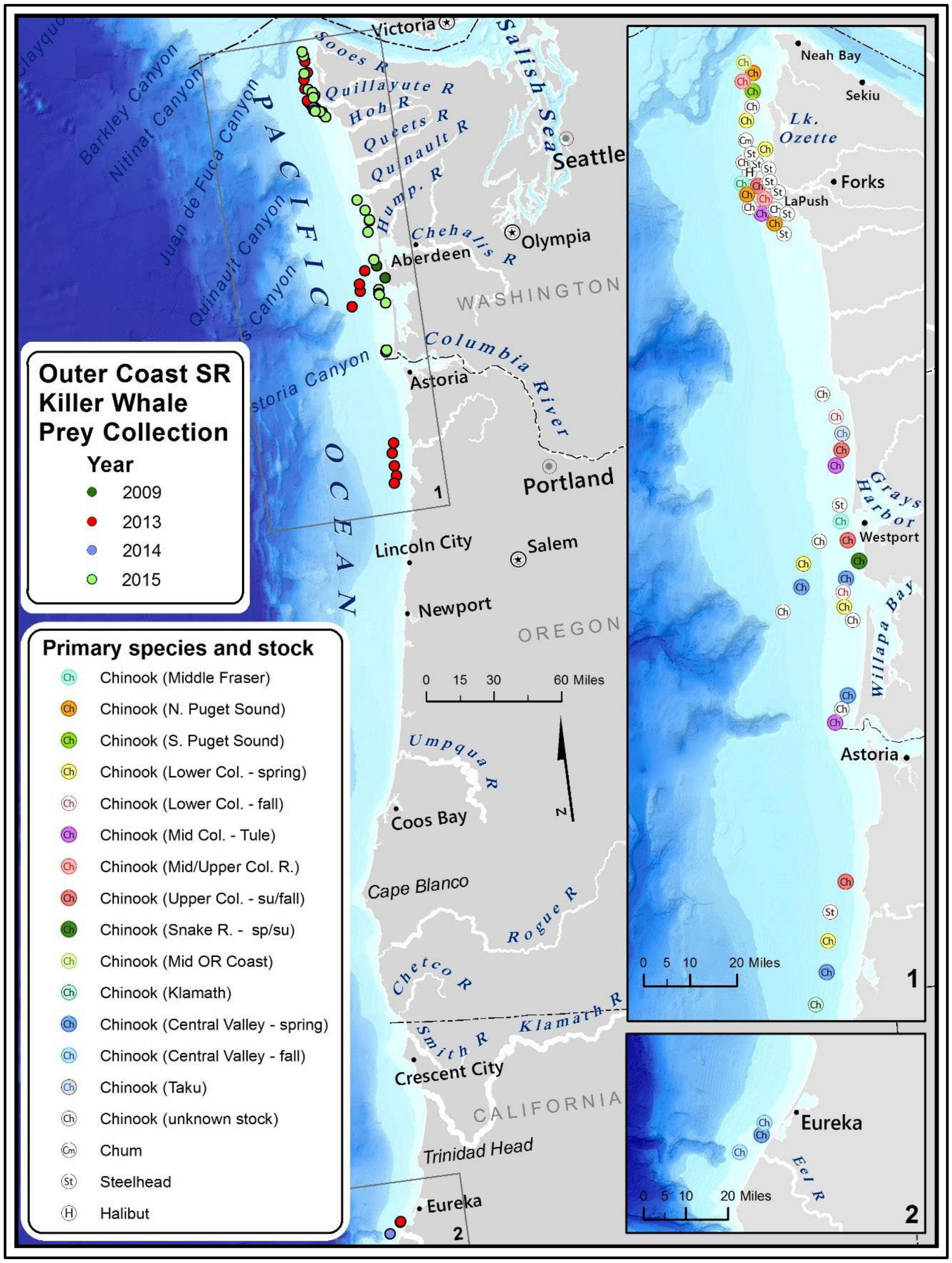


Figure 38. Location and species for scale/tissue samples collected from SRKW predation events in outer coastal waters (stock IDs are considered preliminary)(NMFS 2021c).

A recent study qualitatively analyzed the prey composition of SRKW pods using fecal samples collected between 2011 and 2021 (Van Cise et al. 2024). The study found similar patterns across the pods, with Chinook salmon being the dominant prey species early in the year, and winter diets including a wider variety of species, such as lingcod (Van Cise et al. 2024). First coho, and then chum became a greater proportion of the J pod diet starting in July until January (Van Cise et al. 2024). Although fewer samples were available for K pod, coho was a larger component of their diet in September compared to J pod(Van Cise et al. 2024). L pod's diet was primarily composed of Chinook until September, after which chum and coho contributed in smaller amounts (Van Cise et al. 2024). Notably, L pod also had a relatively high proportion of sablefish in their diet during October (Van Cise et al. 2024).

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

In an effort to prioritize recovery efforts such as habitat restoration and help inform efforts to use fish hatcheries to increase the whales' prey base, NMFS and Washington Department of Fish and Wildlife (WDFW) developed a priority stock report identifying the Chinook salmon stocks along the West Coast (NOAA and WDFW 2018) . The priority stock report was created by using observations of Chinook salmon stocks found in scat and prey scale/tissue samples, observations of the killer whale body condition through aerial photographs, and estimating the spatial and temporal overlap with Chinook salmon stocks ranging from Southeast Alaska to California. Extra weight was given to the salmon runs that support the SRKWs during times of the year when the whales' body condition is more likely reduced and when Chinook salmon may be less available, such as in winter months. Table 35 is a summary of those stock descriptions. However, it important to note, this priority stock report will continue to get updated over time as new data become available. Given this was designed to prioritize recovery actions and there are no abundance estimates for each stock that are factored in, it is currently not designed to assess prey availability within any given area.

Table 35. Summary of the priority Chinook salmon stocks for prioritizing recovery actions (adapted from NOAA and WDFW 2018).

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

Priority	ESU/Stock Group	Run Type	Rivers or Stocks in Group
12	South Puget Sound	Spring	Nisqually, Puyallup, Green, Duwamish, Deschutes, Hood Canal systems
13	Central Valley	Winter	Sacramento and tributaries
14	North/Central Oregon (OR) Coast	Fall	Northern (Siuslaw, Nehalem, Siletz) and Central (Coos, Elk, Coquille, Umpqua)
15	West Vancouver Island	Fall	Robertson Creek, West Coast of Vancouver Island Wild
16	Southern OR & Northern CA Coastal	Fall and Spring	Rogue, Chetco, Smith, Lower Klamath, Mad, Eel, Russian

2.4.1.2.2 Nutritional Limitation and Body Condition

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

Since 2008, NOAA’s Southwest Fisheries Science Center (SWFSC) has used aerial photogrammetry to assess the body condition and health of SRKWs, initially in collaboration with the Center for Whale Research and the Vancouver Aquarium and, more recently, with Sealife Response, Rehabilitation, and Research (SR^3). Aerial photogrammetry studies have provided finer resolution for detecting poor condition, even before malnutrition manifests in “peanut heads” that are observable from boats. Annual aerial surveys of the population from 2013 to 2017 (with exception of 2014) have detected declines in condition before the death of seven SRKWs (L52 and J8 as reported in Fearnbach et al. (2019); J14, J2, J28, J54, and J52 as reported in (Trites et al. 2018)). However, these studies used a body condition metric that is variable across the growth stages and may not accurately represent improving or declining health (Fearnbach et al. 2019). Furthermore, morphometric body condition assessments do not provide information on the cause of reduced body condition. In one study, a hormone analysis from fecal samples suggested that prey availability may be a greater physiological stressor on SRKW than vessel presence due to differences in concentrations of glucocorticoids and a thyroid hormone (Ayres et al. 2012). However, hormone concentrations vary naturally by season, as do vessels and prey availability, which potentially confounds interpretation of these results.

The most recent photogrammetry work by Fearnbach et al. (2023) for pod body conditions in 2023 show that out of five body condition groups, 40% of L pod are in the poorest body condition (an increase in the percent in poorest condition from 13% in 2022) and that 32% of J pod are in the poorest body condition (an slight increase in the percent in poorest condition from 20% in 2022); this is less for K pods at 6% (assuming no change for K pod since they were not measured in 2023). With this and the number of whales in the second lowest body condition group at 27%, J pod has the lowest proportion of individuals above normal body condition (below 35%, vs. ~50% and ~80% for L and K pods).

A recent study utilized seven years of aerial photographs and documented body condition in individual SRKWs over time (99 individuals across all three pods) (Stewart et al. 2021), using the eye patch ratio, which measures the fatness behind the cranium and is robust to variation in surfacing orientation and changes in body proportions with growth (Fearnbach et al. 2019). Importantly, the authors used age- and sex-normalized body condition classes to account for variability in size and nutritive condition. Generally, Stewart et al. (2021) found that whales in poor body condition had mortality probabilities two to three times higher than whales in more robust condition. The authors also examined several variables to estimate the probability that an individual whale's body condition would improve, decline, or remain stable across years, given the estimated Chinook salmon abundance of the previous year. Fraser River and Salish Sea Chinook salmon stocks showed the greatest predictive power with J pod body condition, showing a strong negative relationship between the probability of body condition decline and Chinook salmon abundance (Stewart et al. 2021). L pod body condition was better explained by Puget Sound Chinook salmon abundance, though the relationship was weaker than the relationship between J pod body condition and Fraser Chinook salmon abundance.

The relationship with L pod was difficult to interpret. L pod spends less time in the Salish Sea than J pod (especially in the most recent decade) and Puget Sound Chinook salmon are outnumbered by other Chinook salmon stocks in the North of Falcon[19] (NOF) areas. For K pod, the best model did not include any Chinook salmon abundance covariates, and body condition was relatively constant over time. However, the models including Chinook salmon abundance generally performed only marginally better than the null model, suggesting other factors may contribute to body condition shifts. In another recent paper, the probability of prey capture was reduced for SRKWs when salmon abundance was lower and when the speed of nearby vessels was faster (Holt et al. 2021a), suggesting that there may be multiple pathways to nutritional stress when prey are limited.

A new publication used annual birth and death rates for SRKW to produce an integrated population model to assess the relationship between Chinook salmon abundance, SRKW survival, and SRKW reproduction (Nelson et al. 2024). Nelson et al. (2024) found that the best fit model was one that combined abundance of SRKW and NRKW to make a joint carrying capacity, which suggests that the population of NRKW may be limiting the population growth of SRKW. This model also included Chinook salmon abundance index lagged by one year in the fecundity submodel and no lag in the survival submodel (Nelson et al. 2024). After explicitly accounting for several sources of uncertainty in the population dynamics of SRKWs, the study found modest evidence that Chinook salmon abundance is positively associated with SRKW

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[19] The NOF management area encompasses the Washington coast and Northern Oregon (the coastal waters from United States/Canadian border to Cape Falcon, OR).

survival/mortality rates, and minimal evidence of an association with birth rates (Nelson et al. 2024).

A scientific review investigating nutritional stress as a cause of poor body condition for SRKWs concluded “unless a large fraction of the population experienced poor condition in a particular year, and there was ancillary information suggesting a shortage of prey in that same year, malnutrition remains only one of several possible causes of poor condition” (Hilborn et al. 2012). Recent work has suggested that SRKW condition may deteriorate during the winter months. Aerial photogrammetry analyses from 2015 to 2017 found reduced body condition for J pod whales in May as compared to the previous September, soon after SRKW have foraged on summer salmon runs (Fearnbach et al. 2019). While prey limitation during the winter has been hypothesized as one reason for greater diversity seen in the diet (Hanson et al. 2021), there may be several reasons for seasonal body condition changes (and poor body condition has also been observed in September; Stewart et al. (2021)). Ford and Ellis (2006) report that resident killer whales engage in prey sharing about 76% 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), so that effects of low prey availability may not be seen until prey is extremely low and may be observed in multiple individuals at the same time. Body condition and malnutrition in whales can be influenced by a number of factors, including reduced prey availability, reduced ability to successfully forage, increased energy demands, physiological or life history status, disease, or reduced intestinal absorption of nutrients (Raverty et al. 2020).

It is possible that poor nutrition could contribute to mortality through a variety of mechanisms. To exhibit 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, which have been studied extensively (e.g., adult females: (Daan et al. 1996; Schaefer 1996; Gamel et al. 2005), juveniles: (Trites et al. 2003; Noren et al. 2009)). 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. Malnutrition and persistent or chronic stress can induce changes in immune function in mammals and may be associated with increased bacterial and viral infections (Neale et al. 2005; Mongillo et al. 2016; Maggini et al. 2018).

Reduced body condition and body size has been observed in the NRKW population as well. For example, Groskreutz et al. (2019) used aerial photogrammetry from 2014 to 2017 to measure growth and length in adult NRKWs, which prey on similar runs of Chinook salmon. Given that killer whales physically mature at age 20 and the body stops growing (Noren 2011), we would expect adult male killer whales to all have similar body lengths and all adult female killer whales to have similar body lengths. However, Groskreutz et al. (2019) found that whales aged 20 to 40 years have significantly shorter body lengths than those older than 40 years of age, suggesting the younger mature adults had experienced inhibited growth. Similarly, adult SRKWs under 30 years of age that were measured in 2008 by the same photogrammetric technique were also shorter on average than older individuals, suggesting reduced growth in more recent years (Fearnbach et al. 2011).

High mortality occurred in both resident killer whale populations in the 1990s, which was a time when range-wide abundance of Chinook salmon in multiple subsequent years fell below the

1979 to 2003 average (Figure 39) (Ford et al. 2010). The low Chinook salmon abundance and smaller growth in whale body size coincided with an almost 20% decline from 1995 to 2001 (from 98 whales to 81 whales) in the SRKW population (NMFS 2008c). During this period of decline, multiple deaths occurred in all three SRKW pods and relatively poor survival occurred in nearly all age classes and in both males and females. NRKWs also experienced population declines during the late 1990s and early 2000s. Hilborn et al. (2012) stated that periods of decline across killer whale populations "suggest a likely common causal factor influencing their population demographics" (Hilborn et al. 2012). Overall, evidence of reduced growth and poor survival in SRKW and NRKW populations at a time when Chinook salmon abundance was low suggests that low prey availability may have contributed to nutritional deficiency with serious effects on individual whales.

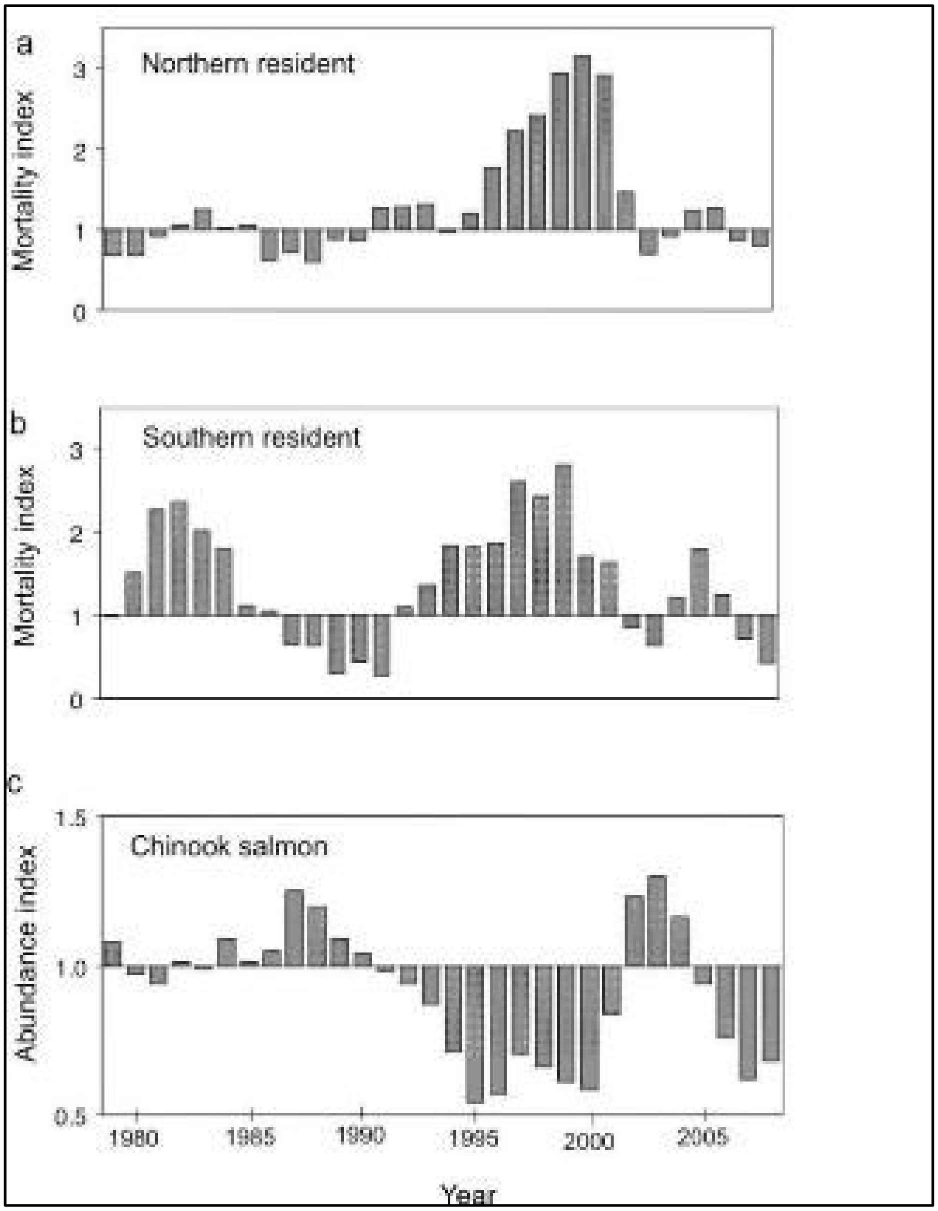

Figure 39. Annual mortality indices for a) NRKW and b) SRKWs and c) abundance index of Chinook salmon from 1979 to 2003 (reprinted from Ford et al. (2010).

During this same general period of time of low Chinook salmon abundance, declining body size in whales, and declining resident killer whale populations, all three SRKW pods experienced substantially low social cohesion (Parsons et al. 2009). This temporal shift in SRKW social cohesion may reflect a response to changes in prey. Similarly, Foster et al. (2012) found that from 1984 to 2007, the SRKW social network was more interconnected in years of higher Chinook salmon abundance. The authors suggest that years with higher Chinook salmon abundance may lead to more opportunities for mating and information transfer between individuals.

For many animals, the distribution and abundance of prey is one of the most important factors influencing social structure (refer to Parsons et al. 2009). In social animals at optimal group size, "group fissioning" could be one response to reduced prey abundance. However, the benefits of cooperative care or food sharing might outweigh the cost of the large group size. Parsons et al. (2009) note that smaller divisions within the pod's matrilines may temporarily occur in SRKWs as opposed to true fission, but this warrants further investigation. Given the highly social nature of SRKWs, socially-mediated fitness outcomes of nutritional limitation could be important.

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

2.4.1.2.3 Contaminants

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 et al. 2003; Viberg et al. 2003; Ylitalo et al. 2005; Fonnum et al. 2006; Viberg et al. 2006; Darnerud 2008; Legler 2008; Noren et al. 2024). SRKWs are exposed to a mixture of pollutants, some of which may interact synergistically and enhance toxicity, influencing their health and reproduction. Relatively high levels of these pollutants have been measured in blubber biopsy samples from SRKWs compared to other resident killer whales in the North Pacific (Ross et al. 2000; Krahn et al. 2004; Krahn et al. 2007; Krahn et al. 2009; Lawson et al. 2020). More recently, these pollutants were measured in fecal samples collected from SRKWs, and fecal toxicants matched those of blubber samples (Lundin et al. 2016a; Lundin et al. 2016b). Recent work by Lee et al. (2023a) quantified the presence of multiple emerging contaminants in the tissues of stranded SRKW and Bigg's (transient) killer whales, including in fetuses and calves of SRKW. Alkylphenols (APs) and polyfluoroalkyl substances (PFAS) were the most prevalent compounds. Concentration of the contaminant 4-nonylphenol (4NP) was significantly higher in SRKW calf samples than in Bigg's, and a major source of 4NP is toilet paper, which could be related to proximity to sewage effluent.

Another publication from Lee et al. (2023b) conducted analysis on polycyclic aromatic hydrocarbons (PAH) composition from stranded SRKW and Bigg's killer whales. On average, SRKW had higher levels of low molecular weight PAHs than Bigg's killer whales (Lee et al. 2023b). Low molecular weight PAHs are generally associated with pyrogenic sources such as petroleum and liquid fossil fuel combustion (Lee et al. 2023b). A new publication analyzed fecal samples of SRKW for the amount and composition of microparticles (Harlacher et al. 2023). Of the 18 SRKW samples analyzed, there was an average of 165 microparticles per gram of feces (Harlacher et al. 2023). They examined 10% of the microparticles to determine their material, and found that 22% of microparticles in SRKW feces were verified synthetic microplastics (Harlacher et al. 2023). Chemical properties of microplastics combine with persistent organic pollutants so that pollutants enter into biological tissues when microplastics are ingested (Harlacher et al. 2023). However, modeling exercises indicate that cetacean microplastic consumption has a limited contribution to the bioaccumulation of toxic contaminants (Alava 2020).

SRKWs 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 et al. 2009; Veldhoen et al. 2010; Mongillo et al. 2016). These harmful pollutants, through consumption of prey species that contain these pollutants, are stored in the blubber and can later be released; when the pollutants are released, they are redistributed to other tissues when the whales metabolize the blubber, for example, in response to food shortages or reduced acquisition of food energy. The release of pollutants can also occur during gestation or lactation, exposing calves to contaminants (and temporarily reducing the burden for lactating females). Recent work by Noren et al. (2024) examined persistent organic pollutant (POP) transfer from mother to calf in bottlenose dolphins and found that maternal milk and blood toxicant levels decreased as calf milk and blood toxicant levels increased, and the rate of transfer varied by class of POP. Once the pollutants mobilize into circulation, they have the potential to cause a toxic response. Fecal samples showed that toxicants were highest in concentration when prey availability was low, and the possibility of toxicity was therefore highest with low prey (Lundin et al. 2016b). Therefore, nutritional stress from reduced prey, including Chinook salmon populations, that may occur or may be occurring, may act synergistically with high pollutant levels in SRKWs and result in adverse health effects.

Disturbance from Vessels and Sound

Killer whales rely on their highly developed acoustic sensory system for navigating, locating prey, and communicating with other individuals. While in inland waters of Washington and British Columbia, SRKWs are a principal target species for the commercial whale watch industry (Hoyt 2001; O’Connor et al. 2009) and encounter a variety of other vessels in their urban environment (e.g., recreational, fishing, ferries, military, shipping). Several main threats from vessels include direct vessel strikes, the masking of echolocation and communication signals by anthropogenic sound, and behavioral changes (NMFS 2008c). There is a growing body of evidence documenting effects from vessels on small cetaceans and other marine mammals (NMFS 2010c; NMFS 2016c; NMFS 2018c; NMFS 2021d). Research has shown that the whales spend more time traveling and performing surface active behaviors and less time foraging in the presence of all vessel types, including kayaks, and that noise from and/or presence of motoring vessels up to 400 meters away has the potential to affect the echolocation abilities of foraging whales and their foraging dives and success (Holt 2008; Lusseau et al. 2009; Noren et al. 2009; Williams et al. 2010; Holt et al. 2021a; Holt et al. 2021b). Models of SRKW behavior states showed that both males and females spent less time in foraging states, with fewer prey-capture dives and shorter dives, when vessels were near (within 400 yards on average) (Holt et al.

2021b). The impact was greater for females, who were more likely to switch from deep and intermediate dive foraging behaviors to travel/respiration when vessels were near (Holt et al. 2021b).

Individual energy balance may be impacted when vessels are present because of the combined increase in energetic costs resulting from (1) changes in whale activity, and (2) 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). Some evidence indicates there is a higher energetic cost of surface, active behaviors and vocal effort resulting from vessel disturbance in the Salish Sea (Williams et al. 2006c; Noren et al. 2012; Noren et al. 2013; Holt et al. 2015). However, reduced prey consumption is likely the more important factor impacted by vessels. In a recent study, SRKWs had a lower predicted probability of capturing prey when vessel speeds were higher nearby (within 1.5 km) (Holt et al. 2021a). Given that vessel speed is one of the strongest predictors of underwater noise (Houghton et al. 2015), faster moving vessels appear to have a greater impact on energy intake in SRKW, including vessels located farther than the closest allowed distance (200 to 400 yards) for viewing the whales, and those beyond the current speed restriction distance (half nautical mile). However, it is difficult to determine the cumulative impacts of the multiple vessel approaches on individual whales and the population. Further, the study found that prey capture dive duration and the speed of descent varied in the presence of echosounders emitted by vessels with received levels of noise, and with vessel distance (Holt et al. 2021a). Importantly, the authors found that the probability of prey capture was positively correlated with prey abundance, suggesting that in years of low prey abundance, vessel impacts may compound the stressor of food availability. In another study, vessel speed did not predict foraging behavior, but estimated levels of sound impacted the probability of foraging (Williams et al. 2018).

Federal vessel regulations were established in 2011 to prohibit vessels from approaching killer whales within 200 yards (182.9 m) and from parking in the path of the whales within 400 yards (365.8 m). These regulations apply to all vessels in inland waters of Washington State with exemptions to maintain safe navigation and for government vessels in the course of official duties, ships in the shipping lanes, research vessels under permit, and vessels lawfully engaged in commercial or treaty Indian fishing that are actively setting, retrieving, or closely tending fishing gear (76 FR 20870, April, 14, 2011). In December 2017, NMFS completed a technical memorandum evaluating the effectiveness of vessel regulations that concluded that the regulations have provided some benefits to SRKWs without causing economic harm to the commercial whale-watching industry or local communities; however, additional measures may be necessary to reduce the impacts of vessels on SRKWs (Ferrara et al. 2017). In 2019, Washington State regulations were updated to increase vessel viewing distances from 200 to 300 yards to the side of the whales and reduce vessel speed within ½ nautical mile of the whales to seven knots over ground (see RCW 77.15.740). In 2021, Washington implemented a Commercial Whale Watch Licensing Program requiring commercial operators to maintain a commercial whale watching license in order to view SRKWs in Washington waters. A Washington State bill was passed in 2023 that expands the buffer distance between vessels and SRKW to 1,000 yards (SB 5371), which goes into effect January 2025.

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 et al. 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 et al. 1996).

2.4.1.2.4 Oil Spills

In the Northwest, SRKWs are the most vulnerable marine mammal population to the risks imposed by an oil spill due to their overall small population size, strong site fidelity to areas with high oil spill risk, large groups of individuals together, late reproductive maturity, low reproductive rate, and specialized diet, among other attributes (Jarvela Rosenberger et al. 2017). Oil spills have occurred in the range of SRKWs in the past, most recently in August 2022 when a commercial fishing vessel sank near San Juan Island. No SRKW were seen near the oil sheen that was spilled. There is potential for spills in the future. Oil can be discharged into the marine environment in any number of ways, including shipping accidents, refineries and associated production facilities, and pipelines. Despite many improvements in spill prevention since the late 1980s, much of the region inhabited by SRKWs remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers.

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

2.4.1.2.5 Climate Change

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

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

2.4.1.3 SRKW Critical Habitat

Critical habitat for the SRKW DPS was first designated on November 29, 2006 (71 FR 69054) in inland waters of Washington State (Figure 40). NMFS published a final rule to revise SRKW critical habitat in 2021 (86 FR 41668; August 2, 2021). This rule, which became effective on September 1, 2021, maintains the previously designated critical habitat in inland waters of Washington (Puget Sound, see 71 FR 69054; November 29, 2006) and expands it to include six additional coastal critical habitat areas off the coast of Washington, Oregon, and California (additional approximately 15,910 square miles[mi^2]) (Figure 41). Critical habitat includes approximately 2,560 $mi^2$of inland waters of Washington in three specific areas: 1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; 2) Puget Sound; and 3) the Strait of Juan de Fuca (Figure 40), as well as 15,910 mi^2 of marine waters along the United States West Coast between the 20 ft (6.1 m) depth contour and the 656.2 ft (200-m) depth contour from the United States international border with Canada south to Point Sur, California. Based on the natural history of SRKWs and their habitat needs, NMFS identified the following physical or biological features essential to conservation for critical habitat: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) passage conditions to allow for migration, resting, and foraging.

Additional information on the physical or biological features essential to conservation can be found in the 2006 critical habitat final rule (71 FR 69054, November 29, 2006) and the recent 2021 critical habitat expansion final rule (86 FR 41668, August 2, 2021), and is incorporated into information provided in the status for the species (Section 2.4.1.1 *Status of SRKW*). We briefly summarize information on each of the three features here; and more detailed descriptions based on recent research findings are also included in the Final Biological Report that supports the 2021 critical habitat rule (NMFS 2021c).

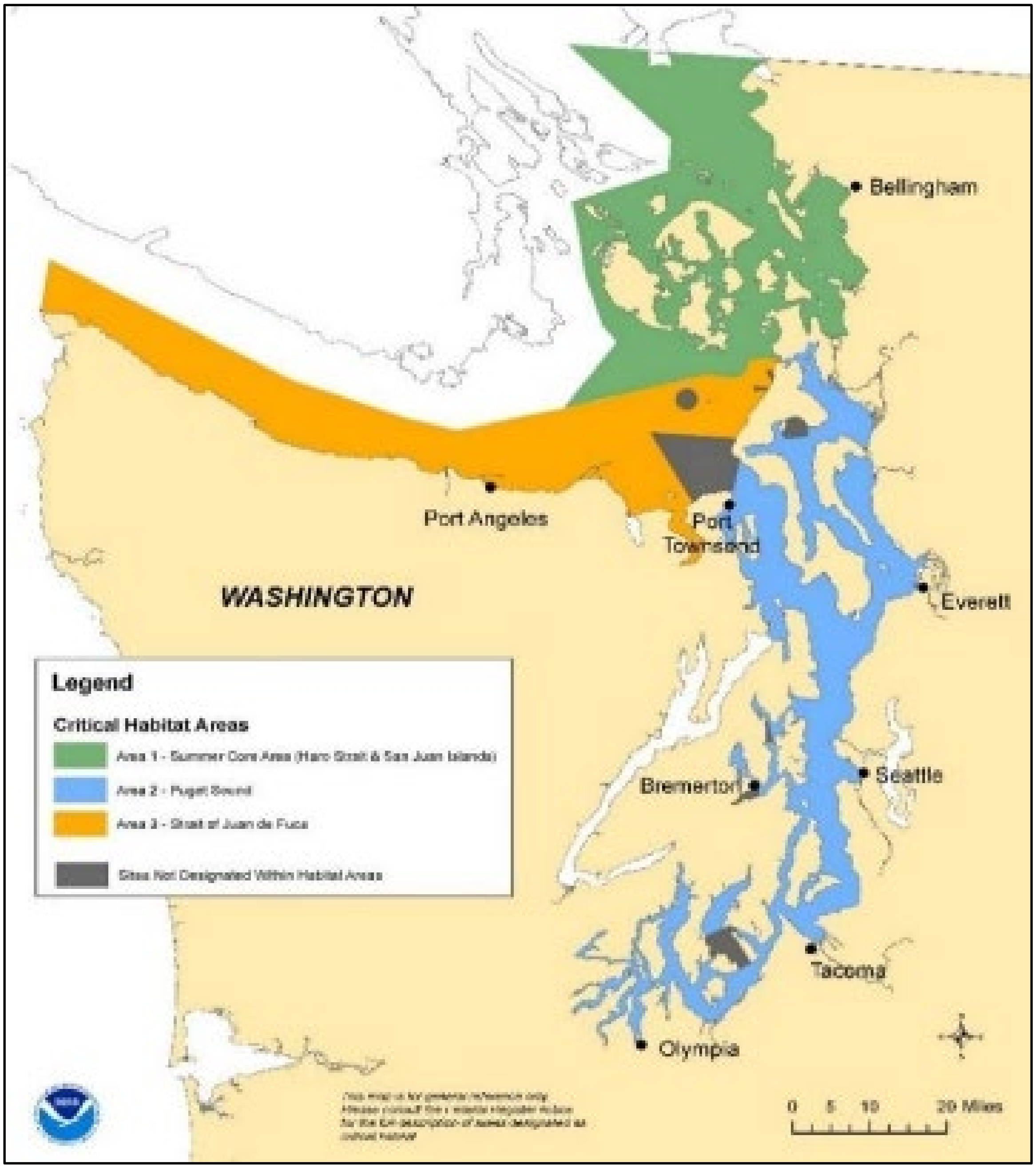

Figure 40. SRKW 2006 critical habitat designation. Note: Areas less than 20 ft deep (relative to extreme high water) are not designated as SRKW critical habitat.

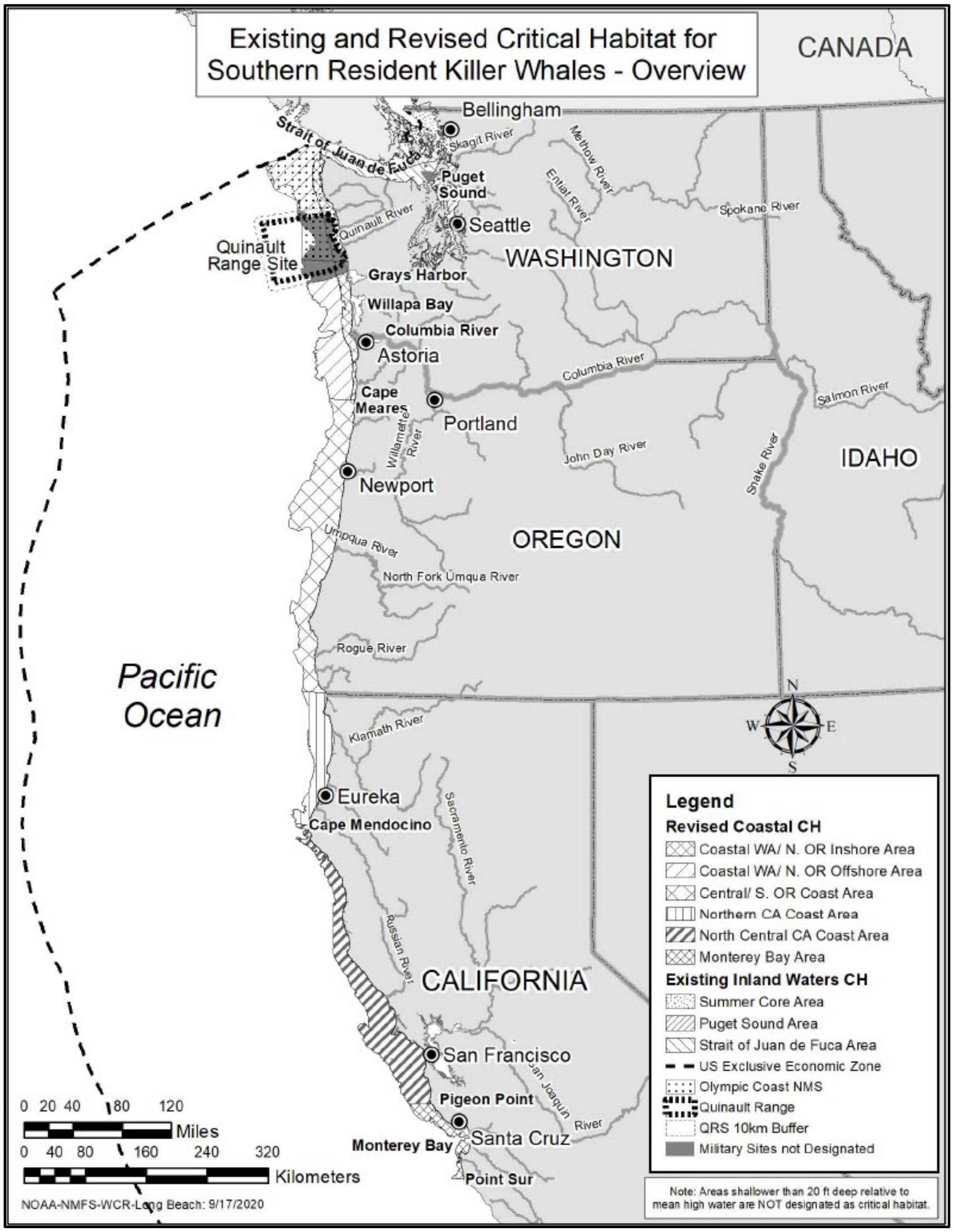

Figure 41. Specific areas of coastal critical habitat containing essential habitat features (86 FR 41668, August 2, 2021).

2.4.1.3.1 Water Quality

Water quality is essential to SRKW conservation, given the population’s present contamination levels, small population numbers, increased extinction risk caused by any additional mortalities, and geographic range (and range of their primary prey) which includes highly populated and industrialized areas. Water quality is especially important in high-use areas where foraging behaviors occur and contaminants can enter the food chain. Water quality in Puget Sound, in general, is degraded as described in the Puget Sound Partnership 2022 to 2026 Action Agenda

(Pugent Sound Partnership (PSP) 2022). For example, toxicants in Puget Sound persist and build up in marine organisms including SRKWs and their prey resources, despite bans in the 1970s of some harmful substances and cleanup efforts. Also, oil spill risk exists throughout the SRKW's coastal and inland range. The USEPA and United States Coast Guard (USCG) oversee the Oil Pollution Prevention regulations promulgated under the authority of the Federal Water Pollution Control Act. There is a Northwest Area Contingency Plan, developed by the Northwest Area Committee, which serves as the primary guidance document for oil spill response in Washington and Oregon. In 2019, the Washington State Department of Ecology published a new Spill Prevention, Preparedness, and Response Program Annual Report describing the Spills Program as well as tracked performance measures from 2009 to 2019 (Washington Department of Ecology (WDOE) 2019). In August 2022, a commercial fishing vessel sank off the west side of San Juan Island and an oil sheen was seen[20]. SRKW were not seen directly near the sheen but existing oil spill response plans were implemented and the Wildlife Branch of the Incident Command activated a Killer Whale Deterrence Team to prevent exposure.

2.4.1.3.2 Prey Quantity, Quality, and Availability

Prey species of sufficient quantity, quality, and availability are essential to conservation as SRKWs need to maintain their energy balance all year long to support daily activities (foraging, traveling, resting, socializing), as well as gestation, lactation, and growth. Most wild salmon stocks throughout the whales' geographic range are at fractions of their historic levels and 28 ESUs and DPSs of salmon and steelhead are listed as threatened or endangered under the ESA. Historically, overfishing, habitat losses, and hatchery practices were major causes of decline. Poor ocean conditions over the past two decades have reduced populations already weakened by the degradation and loss of freshwater and estuary habitat, fishing, hydropower system management, and hatchery practices. In addition to sufficient quantity of prey, fish need to be accessible and available to the whales, which can be related to the density and distribution of salmon, and competition from other predators and fisheries.

Vessels and sound may reduce the effective zone of echolocation and also reduce availability of fish for the whales in their critical habitat (Holt 2008). As mentioned above, contaminants and pollution also affect the quality of SRKW prey in Puget Sound and in coastal waters of Washington, Oregon, and California. The size of Chinook salmon is also an important aspect of prey quality (i.e., SRKWs primarily consume large Chinook), so changes in Chinook salmon size (for instance as shown by (Ohlberger et al. 2018)) may affect the quality of this feature of critical habitat.

2.4.1.3.3 Passage

SRKWs require open waterways that are free from obstruction (e.g., physical, acoustic) to move within and migrate between important habitat areas throughout their range, communicate, find prey, and fulfill other life history requirements. In particular, vessels may present both physical and/or acoustic obstacles to whale passage, causing the whales to swim further and change direction more often, which can increase energy expenditure for whales and impacts foraging behavior (review in (NMFS 2010c) (Ferrara et al. 2017) and see "Disturbance by Vessels and Sound" in Section 2.4.1.1 *Status of SRKW*.

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[20] https://www.fisheries.noaa.gov/feature-story/coordinated-response-protected-southern-residents-sunken-ship-leaking-oil

2.4.2 Environmental Baseline

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

2.4.2.1 SRKW

2.4.2.1.1 Factors Affecting the Prey of SRKWs in the Action Area

As previously discussed, Chinook salmon are prey species for SRKW. In Section 2.3.1 *Rangewide Status of the Species and Critical Habitat* and Section 2.3.2 *Environmental Baseline* for SONCC coho salmon, we discussed the impacts of various activities and factors affecting coho salmon populations in the freshwater environment, including major influences such as water operations in the Klamath River, a rapidly changing baseline resulting from dam removal, and climate change. In general, the factors affecting Chinook salmon in the freshwater environment are very similar to what is discussed for coho salmon in the Klamath River, with an important caveat that Chinook salmon are expecting to repopulate additional habitat upstream of the former IGD and above Keno Dam. Upstream of the dam removal reach, Reclamation's LRD and the Keno Dam currently have fish ladders that will pass anadromous fish. Although coho salmon are only expected to utilize mainstem and tributary habitat up to and including Spencer Creek (ODFW and the Klamath Tribes Hamilton et al. 2005; 2021) for an estimated 76 miles of additional habitat, the additional habitat for Chinook salmon is estimated to be over 300 miles (Huntington 2004; Dunsmoor et al. 2006), and potentially over 420 (USDOI and NMFS Hamilton et al. 2011; 2013). The difference in the amount of habitat that coho salmon and Chinook salmon are expected to utilize post dam removal is due to morphometric and life history differences (e.g., adult run timing) between the two species, and is based on historical studies (Huntington 2004; Hamilton et al. 2005; Dunsmoor et al. 2006; Hamilton et al. 2011; USDOI and NMFS 2013; ODFW and the Klamath Tribes 2021).

All of these important influences on Chinook salmon in the freshwater environment contribute to the health, productivity, and abundance of Chinook salmon that ultimately survive to reach the ocean environment and influence the prey base and health of SRKWs. Given that the factors that affect salmon in the freshwater environment of the Klamath River Basin have already been discussed, and the portion of action area that overlaps with SRKW range does not include the Klamath River Basin, this section focuses on important factors for Chinook salmon and for SRKWs in the marine environment.

As described in Section 2.4.1.1 *Status of SRKW* and assessed in the Final Recovery Plan (NMFS 2008c), the three major threats to SRKW include (1) quantity and quality of prey, (2) toxic chemicals that accumulate in top predators, and (3) impacts from sound and vessels. Other threats identified include oil spills, disease, inbreeding and the small population size, and other ecosystem-level effects (NMFS 2008c). It is likely that multiple threats act together to impact the whales, rather than any one threat being primarily responsible for the status of SRKWs. The five-year review (NMFS 2021d) documents the latest progress made on understanding and addressing threats to SRKW. These threats affect the species' status throughout their geographic range, including the action area, as well as their critical habitat within the action area. As a result, most of the topics addressed in Section 2.4.1.1 *Status of SRKW* and Section 2.4.1.3 *SRKW Critical Habitat* are also relevant to the environmental baseline and we adopt those descriptions or include only brief summaries in this section. NOAA's Species in the Spotlight Priority Action Plan[21] identifies high priority actions for SRKW 2021 to 2025 and ongoing progress towards implementation of recommendations from the Washington State Governor's task force to address all major threats to SRKW can be found here: https://orca.wa.gov/.

2.4.2.1.1.1 Significance of Prey and Prey reductions

As described in Section 2.4.1.1 *Rangewide Status of the Species,* SRKWs, Chinook salmon are the primary prey of SRKW and relationships between various Chinook salmon abundance indices and the vital rates (fecundity and survival) of SRKWs have been outlined in several papers. In addition to examining the linkages between vital rates and prey abundance, many analyses have been aimed at distinguishing which Chinook salmon stocks (or grouping of Chinook salmon stocks) may be the most closely related to these vital rates for SRKWs. Largely, attempts to compare the relative importance of any specific Chinook salmon stock or stock groups using statistical relationships have not produced clear distinctions for which stocks are most influential. One complicating factor is that most Chinook salmon stock indices are highly correlated with each other. It is also possible that different populations may be more important in different years. However, there are still questions about the diet preferences of SRKWs throughout the entire year, as well as the relative exposure of SRKWs to various Chinook salmon or other salmon stocks outside of inland waters during the summer and fall.

Chinook salmon are a very important part of the SRKW diet (Hilborn et al. 2012; Hanson et al. 2013; Hanson et al. 2021; Van Cise et al. 2024) and several studies have found associations between Chinook salmon abundance and vital rates (e.g. fecundity and mortality; (Ford et al. 2005; Ford et al. 2010; Ward et al. 2013; Lacy et al. 2017; PFMC 2020; Murray et al. 2021; Williams et al. 2024).

Not all of the findings in these studies found links with both mortality and fecundity. For example, Nelson et al. (2024) found a stronger link between Chinook salmon abundance and mortality than birth rates, therefore additional work is needed to determine the extent to which Chinook salmon abundance impacts different SRKW vital rates. Recently, several SRKWs have been observed with poor body condition (Fearnbach et al. 2024), which has been associated with higher mortality rates in at least two of the three pods (Stewart et al. 2021). Hilborn et al. (2012) found that, although there may be some support for a cause and effect relationship between salmon abundance and SRKW survival and reproduction, the effect is likely not linear and that predicted improvements in SRKW survival may not be realistic or may diminish at Chinook salmon abundance levels beyond the historical average.

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[21] https://www.fisheries.noaa.gov/resource/document/species-spotlight-priority-actions-2021-2025-southern-resident-killer-whale

In 2019, the PFMC convened an ad-hoc workgroup (PFMC Workgroup) to reassess the effects of PFMC ocean salmon fisheries on SRKWs. As part of their risk assessment, the PFMC Workgroup included conducting updated correlative analyses in the relationships between Chinook salmon abundance and SRKW demography similar to those included in the Panel Report (Hilborn et al. 2012) and described by Ward et al. (2013). These new analyses include more recent data and include a broader range of SRKW demographic indices. Similar to past efforts, the PFMC Workgroup found predicting the relationship between SRKWs and Chinook salmon abundance to be challenging. The relationships between modeled Chinook salmon abundance and SRKW demographics examined by the PFMC Workgroup in this most recent analysis appear weaker than those from prior analyses. For example, although the average coastwide Chinook salmon abundance in this last decade is higher than the average over the entire time series (1992 to 2016), the SRKW population has experienced a decline in their population.

Ultimately, the only significant statistical correlation that was identified was between the winter abundance of Chinook salmon in the NOF coastal area (i.e., off the coast of Washington) and SRKW survival (PFMC 2020). Overall, while not statistically significant, the majority of analyses found the general patterns in the relationship that were expected; namely that the survival and fecundity increased with increasing Chinook salmon abundance while occurrence of peanut-head decreased with increasing Chinook salmon abundance (PFMC 2020). Although the PFMC Workgroup emphasized that caution is warranted when interpreting the results given the limitations of the data, they concluded that these results, coupled with the potential occurrence of SRKWs in the NOF area in all seasons, suggest that Chinook salmon abundance in the NOF area may be more consistently important than Chinook salmon abundance in the South of Falcon (SOF) coastal area (i.e., off the coasts of Oregon and California; PFMC 2020).

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

2.4.2.1.1.2 Link between SRKW and Klamath River Chinook Salmon as Prey

As described in Section 2.4.1.1 *Rangewide Status of the Species*, SRKWs are known to reside in coastal waters along the West Coast of the United States and Canada. K and L pods spend significantly more time in outer coastal waters off of Washington, Oregon, and California than J pod during the winter and spring (Hanson et al. 2013; NMFS 2021c). The BA describes in general some of what is known about the distribution of Klamath River Chinook salmon in the Pacific Ocean in comparison to the distribution of SRKWs. Largely, our knowledge of the distribution of these Chinook salmon in the ocean comes from the data obtained from coded wire tags (CWT) and genetic stock information (GSI) obtained from fish harvested in ocean fisheries that generally occur sometime between April and October.

Unfortunately, the timing of ocean salmon fisheries does not overlap well with the occurrence of SRKWs in coastal waters during the winter and spring, especially in the last few decades. Ocean distribution of Chinook salmon populations based on summer time fishery interactions generally indicates northern movements of Chinook salmon from their spawning origins (Weitkamp 2010). However, we note the range of these movements is quite variable between populations and run timings, and the distribution of Chinook salmon populations in the winter and spring when SRKWs are likely to encounter Klamath River Chinook salmon stocks is not as well known. Shelton et al. (2018; 2021) estimated the seasonal ocean distribution, survivorship, and aggregate abundance of fall run Chinook salmon stocks from California to British Columbia. While no significant seasonal variance in the relative distribution of Chinook salmon stocks from California were detected, Shelton et al. (2018) generally concluded that fall run stocks tended to be more northerly distributed in summer than in winter-spring, and ocean distributions also tend to be spatially less concentrated in the winter-spring (Figure 3 in Shelton et al. 2018).

Without any additional information available that would suggest the distribution of Klamath River Chinook salmon shifts substantially seasonally, we assume the distribution of Klamath Chinook salmon during the winter and spring is similar to what has been documented during the summer and fall. We also assume that data collected from hatchery fish (usually where CWTs are applied) are representative of the distribution of both wild and hatchery populations consistent with the approach used by federal and state agencies to manage salmon fisheries and populations using CWT data for many decades. The limited amount of available information suggests their distributions are similar (Weitkamp 2010).

The available data from CWT and GSI suggest that Chinook salmon from the Klamath River (particularly fall-run) may occur in small numbers as far north as Vancouver Island, 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; Shelton et al. 2021). The coastal area off the Klamath River is likely where the greatest concentration of Klamath origin Chinook salmon occurs. Klamath River Chinook salmon was estimated to make up to 37% of the adult Chinook salmon off of Fort Bragg during the spring and up to about 45% off of the southern Oregon coast in July depending on: (1) the inter-annual variability in strength of salmon runs; (2) the month; and (3) the location (Reclamation 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.[22] Shelton et al. (2018) found that Chinook from Northern California origins (primarily Klamath River) constitutes at least 20% of the Chinook salmon found in coastal areas

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[22] 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 makes 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.

ranging from San Francisco up through central Oregon. Additionally, they found that Chinook originating from Northern California represents a small proportion of age 3+ fall Chinook salmon off the Washington coast year-round and an even smaller proportion in Puget Sound during the spring and summer Shelton et al. (2018).

In total, the available data suggest that Klamath River Chinook salmon can constitute a sizeable percentage of Chinook salmon that would be expected to be encountered by SRKWs in coastal waters off Northern California and south/central Oregon, and smaller proportions of Chinook salmon in the ocean as far south as Point Conception, California as far north as Washington State in coastal waters and possibly very small proportions in Puget Sound and Vancouver Island.

The Final Biological Report supporting the 2021 coastal critical habitat designation found relatively high SRKW use occurred within the Klamath Management Zone (NMFS 2021c), and the Northern California Area (Area 4) was identified as an important feeding habitat for SRKWs and for the prey resources. Chinook salmon originating from rivers adjacent to Area 4 include two of the top ten priority Chinook salmon populations identified as being important to the recovery of SRKWs (National Marine Fisheries Service (NMFS) and Washington Department of Fish and Wildlife (WDFW) 2018), including Klamath fall and spring run Chinook salmon. In addition, ratios of contaminants in blubber biopsies found that the blubber of K and L pod match with similar ratios of contaminants in Chinook salmon from California, which was indicated by the relatively high concentrations of dichlorodiphenyltrichloroethane (DDT). These DDT fingerprints suggest fish from California[23] form a significant component of their diets (Krahn et al. 2007; Krahn et al. 2009; O'Neill et al. 2012). As a result, we conclude that Klamath River Chinook salmon are an important part of the diet for most SRKWs during portions of the year when SRKWs occur in coastal waters off the North American coast and a larger proportion of SRKW diet is Chinook salmon from California and Oregon (Hanson et al. 2021). This is especially true south of the Columbia River, which includes the times of potential reduced body condition and increased diet diversity that received additional weight during the prey prioritization process described above.

2.4.2.1.1.3 Klamath River Chinook Salmon

2.4.2.1.1.3.1 Klamath River Chinook Salmon Life History

Chinook salmon in the Klamath basin are comprised of two separate ESUs; Chinook salmon that spawn downstream of the Trinity River confluence are part of the SONCC Chinook salmon ESU (NMFS 2024a), and Chinook salmon that spawn upstream of the Trinity River confluence comprise the Trinity River (UKTR) Chinook salmon ESU (Williams et al. 2013; NMFS 2018a). Chinook salmon in the Klamath basin 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 (Atlas et al. 2023), although spring-run Chinook salmon in the Klamath basin are only found in the UKTR Chinook salmon ESU. 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

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[23] A study analyzing SRKW diet found that Chinook from the Klamath River made up 2.2+-2.3% of SRKW prey in mid-winter to early spring (Hanson et al. 2021).

"ocean type." However, Williams et al. (2013) states that the large majority of juvenile Chinook salmon in the 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. However, it is possible that the "stream type" life history incidence may increase as Chinook salmon, including especially spring-run Chinook salmon, occupy habitats further upstream following dam removal, and outmigration timing may shift accordingly. Chinook salmon typically mature and return to freshwater between three and six years of age (Snyder 1931).

2.4.2.1.1.3.2 Chinook Salmon Spatial Structure/Distribution

Dam construction has greatly reduced the distribution of Chinook salmon in the Klamath River Basin. Fish passage to the Oregon portion of the Klamath River Basin is believed to have been first blocked by an early phase of the construction of Copco No. 1 Dam at approximately RM 202 in 1912 (Hamilton et al. 2016). Construction of Copco No. 1 Dam was completed in 1918, followed by Copco No. 2 in 1925 and IGD in 1962. IGD at RM 190 represented the upstream limit of access of anadromous fish in the Klamath River. The Lewiston water diversion dam on the Trinity River, completed in 1963, has prevented access of spring-run Chinook salmon to their historical spawning grounds on the East Fork, Stuart Fork, and Upper Trinity River and Coffee Creek (Campbell et al. 1991). Dwinnell Dam on the Shasta River was completed in 1928 and blocks access to the upper Shasta River basin. In addition, spring-run Chinook salmon populations have likely been extirpated from still accessible areas of the basin, such as the Scott and Shasta rivers, in which fall-run Chinook salmon populations still persist (Snyder 1931; Heizer 1972; CDFG 1990; Myers et al. 1998; Thompson et al. 2019).

In addition to the previously available habitat, with the completion of dam removal, Chinook salmon now have access to previously inaccessible habitat upstream beginning initially in the late fall of 2024. Many studies, reports, and publications have analyzed or discussed the quality and extent of Chinook salmon habitat above the former dams. A brief annotation of some of the more important descriptions includes:

- Snyder (1931): large numbers of Chinook salmon historically passed the location of the Copco Dams on an annual basis. Over 7,500 fish were seen spawning in the mainstem river between the current location of the former IGD and Copco Reservoir.
- Fortune et al. (1966): Chinook salmon were present in the upper Klamath during the months of September to November in the early 1900s. There is some evidence there once was a strong run of spring Chinook salmon, but it had declined due to the construction of log dams in the late 1800s. Locations that maintain good spawning gravel include the mainstem in California and Oregon (capacity of 1,350 spawning pairs), Shovel Creek (limited capacity), Spencer Creek (110 spawning pairs), Wood River (520 spawning pairs), Williamson River (240 spawning pairs), and the Sprague River (2,370 spawning pairs). The estimate for the existing suitable rearing habitat above Copco Reservoir was 167 miles.
- Chapman (1981): estimated total Chinook salmon production capacity in areas blocked by the former IGD to be 21,508 returning adult Chinook salmon that could produce 597,437 Chinook salmon smolts.

- Huntington (2004): Huntington used six methods to estimate a potential run capacity of adult Chinook salmon returning to areas above the former IGD that ranged from 9,180 to 32,040, with a mean or "best estimate" value of 21,245 fish. Huntington estimated that historic runs of Chinook salmon to the Wood, Williamson, and Sprague Rivers was over 149,000 fish. Huntington (2006) revised this estimate of historic Chinook salmon potential above Upper Klamath Lake to be 111,230 adult Chinook salmon.

- Hamilton et al. (2005): the purpose of this publication was to report the upstream limit of anadromy prior to dam construction, but the authors do report that significant un-utilized anadromous fish habitat exists upstream of the former IGD.

- Oosterhout (2005): modelling of various management scenarios (e.g., dam removal, volitional passage, trap and haul) showed that abundance was maximized with removal of the four dams. Their estimate for total average spawner capacity was 40,341, with 45% of those being found above LRD.

- Huntington et al. (2006): estimated over 303 miles and 370 miles of spawning or rearing habitat for fall-run Chinook salmon and spring-run Chinook salmon, respectively.

- Dunsmoor et al. (2006): the removal of most or all of the mainstem Klamath Project dams would significantly improve conditions for migration and spawning of adult fall Chinook salmon. Dam removal would provide clear and at times dramatic thermal benefits to migratory salmonids now in, or reintroduced to, the Upper Klamath Basin.

- Hetrick et al. (2009): estimated distances of historical anadromous fish habitat within the Klamath River mainstem, historical side channels, and tributaries that are currently inundated by the Klamath River reservoirs. Described additional benefits to dam removal for fish above and downstream of the former IGD, including that potential increases in food availability, in combination with changes in water temperatures that more closely resemble the historical pre-development thermal regime, are likely to increase the size of smolts at ocean entry, which has been shown to increase estuary/ocean survival.

- Goodman et al. (2011): concluded that a substantial increase in Chinook salmon is possible in the reach between the former IGD and Keno Dam. The term “substantial” should be understood here to mean a number of fish that contributes more than a trivial amount to the population (on the order of 10,000 spawners).

- Hamilton et al. (2011): dam removal would make habitat accessible to both spring-run and fall-run Chinook salmon above the former IGD and likely reestablish Chinook salmon above the former IGD in a short period of time, as observed after barrier removal at Landsburg Dam in Washington (Kiffney et al. 2009). Hamilton et al. (2011) described specific Chinook salmon habitat conditions in reaches above IGD (e.g., Fall Creek, Shovel Creek).

- Hendrix (2011): Median escapements and harvest were higher in the Dam Removal Alternative (DRA) relative to the No Action Alternative (NAA) with a high degree of overlap in 95% confidence intervals due to uncertainty in stock-recruitment dynamics. Still, there was a 0.75 probability of higher annual escapement and a 0.7 probability of higher annual harvest by performing DRA relative to NAA, despite uncertainty in the abundance forecasts. The median increase in escapement in the absence of fishing was 81.4% (95% symmetric probability interval [95%CrI]: -59.9%, 881.4%), the median increase in ocean harvest was 46.5% (95%CrI: -68.7, 1495.2%), and the median increase in tribal harvest was 54.8% (95%CrI: -71.0%, 1841.0%) by performing DRA relative to NAA (estimates provided for model runs after 2033 when portion of the population in the tributaries to UKL are assumed to be established and IGH production has ceased).

- Lindley et al. (2011): predicted expected escapement of Chinook salmon to watersheds above the former IGD. Models based on spring-run Chinook salmon data only predict escapement of about 3,090 spawners per year (90% confidence interval 1,420 to 25,300) to the upper Klamath Basin while models based on the complete dataset predict 3,660 (2,420 to 5,510) spawners per year.
- USDOI and NMFS (2013): “There is a high degree of certainty, based on available science (and the lack of contrary studies), that in the long term dam removal would expand usable habitat for Chinook salmon and would significantly increase their abundance as compared to leaving dams in place”.
- Hamilton et al. (2016): provides significant new information related to the historical abundance and seasonal distribution of salmonids in the Upper Klamath Basin.
- Ramos (2020): Although this study focuses on coho habitat, the study is also useful for identifying and quantifying current Chinook salmon habitat in some of the reaches (Camp Scotch, Jenny, Fall, Shovel, and Spencer creeks) just above the former IGD.
- ODFW and the Klamath Tribes of Oregon (2021) implementation plan for the Reintroduction of Anadromous Fishes into the Oregon Portion of the Upper Klamath Basin (Reintroduction Plan): describes significant habitat for spring-run Chinook salmon and fall-run Chinook salmon in the Upper Klamath Basin, including upstream of Upper Klamath Lake.
- O’Keefe et al. (2022): described habitat conditions and significant, throughout 63 miles of mainstem habitat and 39.4 miles of tributary habitat from the former IGD to LRD.

The summaries of these publications show that while there is variation in the extent and timing of the expected increased productivity of Chinook salmon associated with having access to habitat above the dams, there has been substantial investigation into this question, and there is a high degree of certainty that within the time period of this consultation, Chinook salmon are expected to occupy habitat previously upstream of the dams. These evaluations do take into account, the expected status of physical and environmental conditions above the former IGD, which includes some degraded habitat and seasonal passage concerns associated with the Keno Impoundment and UKL (USDOI and NMFS 2013; CSWRCB 2020). Salmon may be affected downstream of Keno Dam due to flow reductions and at Keno Dam due to fish passage limitations at the ladder and potential entrainment at unscreened Klamath Project facilities within the Keno Impoundment, as salmon return to the Upper Klamath Basin (Reclamation 2024a). As discussed in Section 0, *Element Three–Operation and Maintenance Activities,* Section; 1.3.11, *Fish Passage at Keno Dam*; and Section 1.3.12, *Fish Screen Technical Assistance*, the fish ladder at Keno Dam, fish screens, headgates, and canals owned by Reclamation will now be operated in a way that minimizes impacts to listed species.

NMFS expects salmonids to quickly repopulate habitat upstream of the former IGD. This response has been observed after barrier removal on the Elwha River (Liermann et al. 2017; Duda et al. 2021; Pess et al. 2024), White Salmon River (Allen et al. 2016; Hatten et al. 2016), Cedar River (Burton et al. 2013; Anderson et al. 2015), Rogue River (McDermott 2016), and the Penobscot River (Izzo et al. 2016). Salmon have evolved with mechanisms for populating new habitat when that habitat is suitable and accessible (Bett et al. 2017; Pearsons et al. 2020). However, each dam removal project is different, and the total habitat that is expected to be repopulated by Chinook salmon, which is estimated to be over 303 miles (Huntington 2004; Dunsmoor et al. 2006), and potentially over 420 miles (Hamilton et al. 2011), is substantial. Although some movement past the former IGD by juvenile and adult Chinook salmon is expected in the first year when habitat conditions are suitable, full utilization of this habitat by Chinook salmon, and associated juvenile production, will certainly develop over time.

In addition, the ODFW and the Klamath Tribes of Oregon (2021) Reintroduction Plan recommends species-specific approaches to guide the reintroduction of historically present anadromous fishes. The Reintroduction Plan recommends volitional repopulation for all species except for spring-run Chinook salmon, for which the Reintroduction Plan recommends active reintroduction. The active reintroduction effort for spring-run Chinook Salmon will have two phases; a Reintroduction Study phase (Phase 1), and an Active Reintroduction Phase (Phase 2). The Reintroduction Studies Phase (Phase 1) has already been initiated in 2022 with the annual release of both PIT tagged and radio tagged juvenile spring-run Chinook salmon in tributaries of UKL, and at locations between Keno and Link dams (Hereford 2023; Tallman 2023). Hereford (2023) reports that on April 4, 2022, 3,512 PIT tagged Chinook were released in the Williamson River at Collier State Park, and 3,505 PIT tagged Chinook were released in the Wood River at the USFS Day use area. Subsequently, 231 and 177 PIT tagged Chinook were released on May 20 in each the same locations on the Williamson and Wood Rivers, respectively. A subset of these fish was also acoustic tagged. These studies were replicated in spring 2023, and researchers are currently rearing 10,000 juvenile spring-run Chinook Salmon to be PIT tagged and released in tributaries of UKL in the fall of 2024 and spring of 2025, with plans to repeat in fall of 2025 and spring of 2026 (Hereford 2023). Phase 2 (Repopulation Phase) will build on the results of Phase 1 to use the most effective methods, extent, and intensity of transplantation required to repopulate habitat above UKL. The onset timing of the Repopulation Phase is not yet known, but there is a high likelihood that the spatial structure of spring-run Chinook salmon will expand rapidly during the five-year term of the proposed action.

2.4.2.1.1.3.3 Chinook Salmon Abundance and Productivity

Natural-spawned Chinook salmon abundance has declined dramatically since dams were constructed in the Klamath Basin. Historical levels of Chinook salmon in the Klamath basin are thought to be over 600,000 adult fish returning annually on average (USDOI and NMFS 2013). CDFG (1965) estimated spawning escapement of Chinook salmon at approximately 168,000 adults with the number split about evenly between Klamath and Trinity Rivers. The most recent five-year average (2019 to 2023) for wild spawning fall-run Chinook salmon escapement is 32,454 adults combined for the Klamath and Trinity (CDFW 2024) (Figure 42). The most recent five-year average (2018 to 2022) for wild spawning spring-run Chinook salmon escapement is

5,560 adults combined for the Klamath and Trinity (CDFW 2023c). Hatchery production supplements the overall production of Chinook salmon in the Klamath Basin. The FCH target for annual releases is 3.25 million fall-run Chinook salmon juveniles each year, while TRH aims to release 4.3 million juvenile spring-run and fall-run Chinook salmon combined. However, when adult returns are not sufficient to reach egg production goals the hatcheries are not able to produce their entire target each year. Figure 42 shows the natural spawner abundance of fall-run Chinook salmon in the Klamath Basin from 1978 to 2020, and Figure 43 shows the entire in-river run of fall-run Chinook salmon during the same period, which includes river harvest and hatchery spawners (CDFW 2024). Spring-run Chinook salmon have, on average, about an order of magnitude lower abundance in the Klamath River Basin relative to fall-run Chinook salmon. The majority of the spring-run Chinook salmon in the Klamath return to the Trinity River each year, including the TRH, although the Salmon River does maintain a small wild population of spring-run Chinook salmon.

Figure 44 summarizes the escapement of hatchery and wild spawning adult spring-run Chinook salmon.

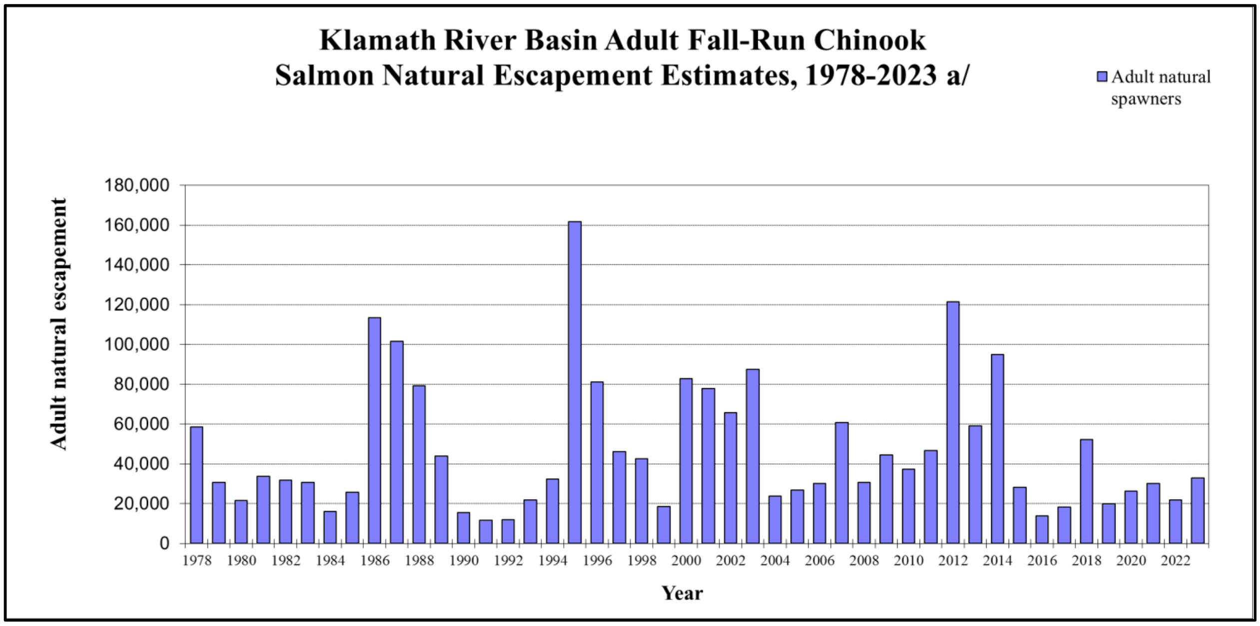

Figure 42. Adult natural escapement of fall-run Chinook salmon in the Klamath Basin, including Trinity River fish (CDFW 2024). "a/" indicates that 2023 data are preliminary and subject to revision.

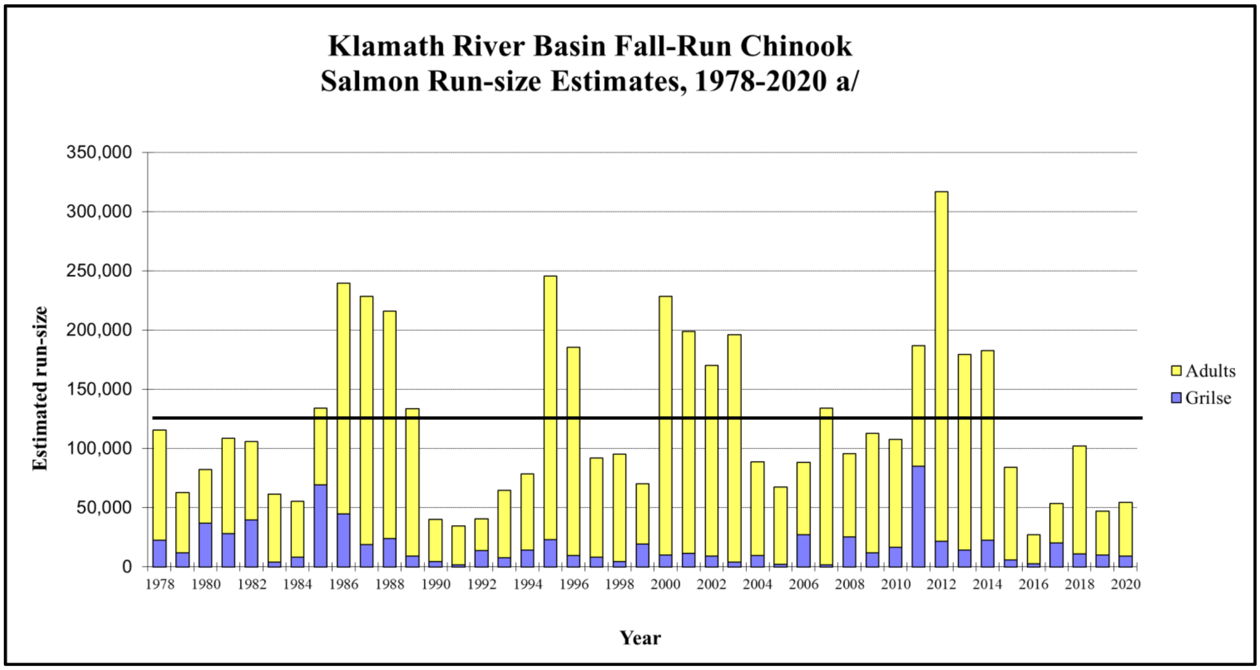

Figure 43. Adult total in-river run of fall-run Chinook in the Klamath Basin, including in-river harvest and hatchery spawning, in the Trinity and Klamath Rivers (CDFW 2024). "a/" indicates that 2023 data are preliminary and subject to revision.

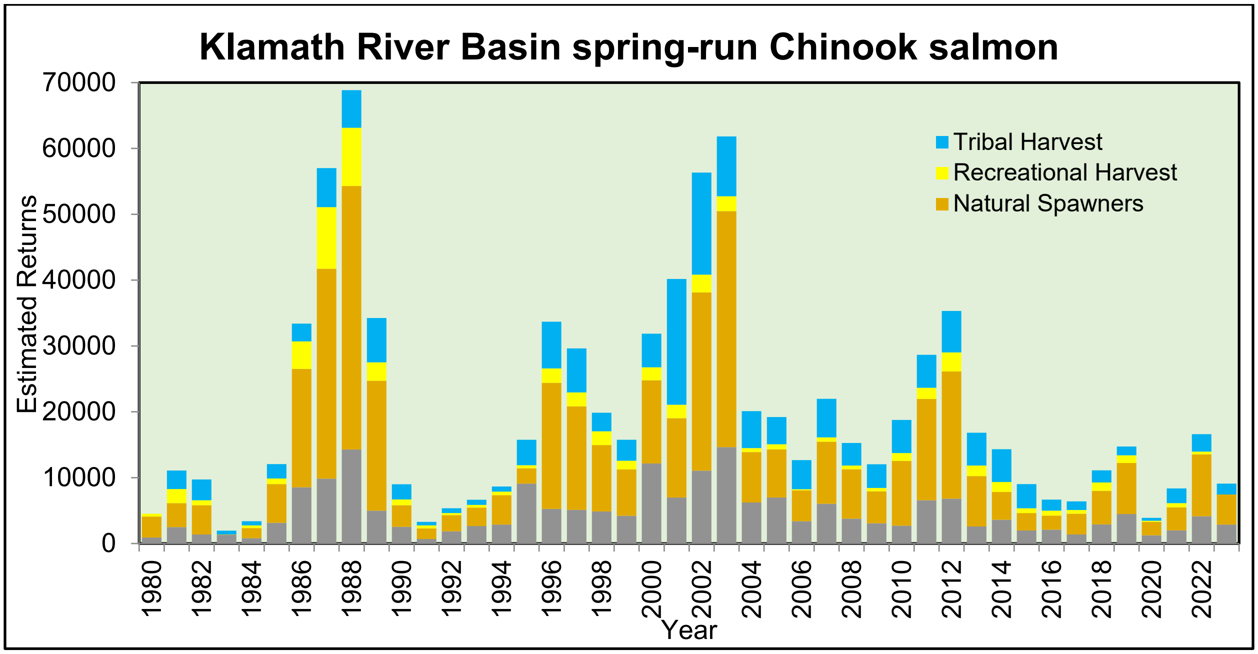

Figure 44. Klamath Basin adult spring-run Chinook salmon abundance estimates (CDFW 2023c). 2023 data is preliminary and subject to revision.

2.4.2.1.1.3.4 Chinook Salmon Diversity

Diversity within the Chinook salmon population is represented by the differing life history strategies. These include spring and fall-run adult migration timing, different timing for freshwater rearing and smolt emigration, and different periods for adult maturation.

Hatcheries can play a role in shifting genetic diversity within populations. Releasing hatchery-origin fish can result in lower productivity of natural-origin salmonids (Davison et al. 2017). Between 1998 and 2019, IGH and TRH released on average roughly 14.4 million hatchery Chinook salmon annually that are part of the UKTR Chinook salmon ESU (CDFW 2021b). Again, FCH/IGH releases only fall-run Chinook salmon, while TRH releases both fall-run and spring-run Chinook salmon. In total, these releases were comprised of approximately 85% fall-run Chinook salmon and 15% spring-run Chinook salmon. Hatchery programs contribute to ocean fisheries and affect natural-area spawning at varying rates (Davison et al. 2017; Shelton et al. 2018). However, the TRH spring Chinook salmon broodstock was founded from endemic stock, and the California Hatchery Scientific Review Group (2012) noted that "No out-of-basin eggs or fish have been used to supplement this program in at least the last 10 years". Both the FCH/IGH and TRH fall run Chinook salmon populations maintain genetic characteristics that align with the geographic locations of the hatcheries in Klamath Basin (Kinziger et al. 2013; Williams et al. 2013). Survey data indicate that straying of hatchery Chinook salmon adults into tributaries is higher for those streams or areas located closest to the two hatcheries in the Klamath Basin (Williams et al. 2013).

2.4.2.1.1.4 Relationship of Klamath River Chinook to Overall Ocean Abundance

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

Ocean abundance estimates for Chinook salmon that originate from United States systems are provided by the PFMC (PFMC 2024b). The forecast estimates for the 2024 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 180,700 fish. This is generally consistent with some of the recent ocean abundances of Klamath Chinook over the last decade, although significantly lower than ocean abundances approaching/exceeding one million fish that have occurred at times in the past (PFMC 2024b). Another significant stock that overlaps with the range of Klamath Chinook salmon off the coast of California and Oregon is Sacramento Fall Chinook salmon. In 2024, the Sacramento Index[24] (SI) is estimated to have an ocean abundance of 213,600 fish (PFMC 2024b). Since the early 1980s, SI values commonly have ranged from 41,000 to 1.6 million fish with an average of 651,000 fish, although recent abundances have been much smaller than historical averages, and SI values have exceeded 500,000 only one times in

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[24] The 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 salmon ocean fishery harvest south of Cape Falcon, OR (2) adult Sacramento River Fall Chinook impacts from non-retention ocean fisheries when they occur, (3) the recreational harvest of adult Sacramento River Fall Chinook in the Sacramento River Basin, and (4) the Sacramento River Fall Chinook adult spawner escapement. The SI forecasting approach uses jack escapement estimates to predict the SI (PFMC 2024b).

the last five years (PFMC 2024b). Since the 2024 SI is estimated to be low compared to the historical ranges, 2024 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. Looking at forecasts for 2024, the PFMC models estimate that the ocean abundance of Klamath Chinook salmon (180,700) would make up about 5.3% of the 3.4 million Chinook salmon predicted to be within the range of SRKWs in 2024 (PFMC 2024d). These estimates are generally consistent with previous analyses by NMFS that suggested Klamath River Chinook salmon contributes 1 to 9% of the total SRKW Chinook salmon prey base when they inhabit outer coastal areas (NMFS 2019b). Within the range of Klamath Chinook salmon (SOF), Klamath Chinook salmon constitute about 11.3% of the Chinook salmon available off the coast of California and Oregon on average.

Previously, there had been limited capabilities to generate specific estimates of the number of Chinook salmon that may be found in the ocean within any defined boundary that would include likely or possible coastal migrations of SRKWs during the winter and spring. There are many different management and monitoring schemes that are employed for Chinook salmon along the Western North American coast that make it difficult to directly relate and compare metrics of Chinook salmon abundance. In 2020, a PFMC Workgroup generated coastwide adult abundance estimates for most Chinook salmon stocks that were used to construct area and season-specific estimates of Chinook salmon abundance for the purposes of exploring the impact of ocean harvest on SRKWs (PFMC 2020). From these efforts, we can characterize the coastwide abundance of Chinook throughout most of their range as well as more localized estimates off the coast of California and Oregon where Klamath Chinook salmon can be found in the range of SRKWs.

The PFMC Workgroup estimated that the ocean abundance of Chinook salmon coastwide within the United States Exclusive Economic Zone (EEZ) has ranged from about 2.1 to 6.0 million Chinook from 1992 to 2016; averaging 3.7 million Chinook salmon over that time period (PFMC 2020). During the most recent 10 years of this time series (2007 to 2016), the range and average number of Chinook salmon in the United States EEZ has been essentially the same (PFMC 2020). In addition, the PFMC Workgroup estimated 1.4 million Chinook salmon were in ocean waters in the range of SRKWs outside the EEZ on average each year during the most recent 10 years (PFMC 2020). While we acknowledge there are additional Chinook salmon available within the full range of SRKWs that are not accounted for in the PFMC Workgroup models, we conclude that the relative magnitude of Chinook salmon in the coastal ocean range of SRKWs is likely at least several million fish each year. The PFMC Workgroup also looked at Chinook salmon abundance at different regional levels, including estimates of Chinook salmon off the coast of California and Oregon. During the most recent 10 years analyzed (2009 to 2018), the average Chinook salmon abundance off the coasts of Oregon and California collectively (i.e., SOF) where Klamath Chinook salmon are expected to occur was 2.1 million Chinook salmon (1.5 million and 0.6 million off Oregon and California, respectively; PFMC 2022a).

Based on the recent ocean abundances of Klamath Chinook salmon and the work done by the PFMC Workgroup, we can characterize the relative contribution of Klamath River Chinook salmon (as represented by the Klamath fall-run) to the total abundance of Chinook salmon in the coastal ocean range of SRKWs in the United States. Using post season estimates from 2009 to 2018 that match with time periods analyzed by the PFMC Workgroup, the average ocean abundance of Klamath Chinook salmon from 2009 to 2018 was about 328,000 (PFMC 2024b).

This equates to nearly 9% of the average ocean abundance of Chinook salmon that may be encountered by SRKWs within the United States EEZ, and about 7% of average abundance of Chinook salmon encountered by SRKW in ocean waters throughout their range. Within the range of Klamath Chinook salmon off the coasts of Oregon and California (SOF), Klamath fall-run Chinook salmon constituted about 16% of the average ocean abundance of Chinook salmon during this time period. Importantly, we recognize this proportion likely varies each year depending on varying strengths in run size (Kope et al. 2011).

In addition to fall-run Chinook salmon, the Klamath Basin contributes spring-run Chinook salmon to ocean abundance. The Klamath spring-run Chinook salmon ocean abundance is typically about an order of magnitude less than the fall-run Chinook salmon ocean abundance, as discussed in Section 2.4.2.1.1.3 *Klamath River Chinook Salmon*. However, Klamath origin spring-run Chinook salmon are known to contribute to SRKW diets in some years (NOAA and WDFW 2018).

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

2.4.2.1.1.5 Climate Change and Environmental Factors in the Ocean

As described in Section 2.4.1.1 *Rangewide Status of the Species*, changing ocean conditions driven by climate change may influence ocean survival and distribution of Chinook salmon and other Pacific salmon further affecting the prey available to SRKWs. Extensive climate change caused by the continuing buildup of human-produced atmospheric carbon dioxide and other greenhouse gases is predicted to have major environmental impacts in the action area during the 21st century and beyond. Warming trends in water and air temperatures are ongoing and are projected to disrupt the region’s annual cycles of rain and snow, alter prevailing patterns of winds and ocean currents, and result in higher sea levels (Mote et al. 2005b; NWF 2005). These changes, together with increased acidification of ocean waters, would likely have profound effects on marine productivity and food webs, including populations of salmon.

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

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

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

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

2.4.2.1.1.6 Salmon Harvest, Hatchery, and Habitat Actions

A more detailed description of the harvest, hatchery, and habitat actions, is available in section 2.4.3 in NMFS (2024b) and is incorporated by reference. Here we briefly summarize the impact of hatchery practices, harvest actions, and habitat actions on prey availability in context of the metabolic needs of SRKWs.

2.4.2.1.1.6.1 Harvest Actions

Salmon fisheries that intercept fish that would otherwise pass through the action area and become available prey for SRKWs occur all along the Pacific Coast, from Alaska to California. Past harvest consultations include the Puget Sound salmon fisheries (NMFS 2010a; NMFS 2014a; NMFS 2015; NMFS 2017c; NMFS 2019a; NMFS 2020b; NMFS 2021f; NMFS 2022a; NMFS 2023a; NMFS 2024b), PFMC-area salmon fisheries (NMFS 2008a; NMFS 2020b; NMFS 2021e), salmon fisheries managed consistent with provisions of the Pacific Salmon Treaty (NMFS 2008c, 2019c, and the *U.S. v. Oregon* Management Agreements NMFS 2008a, (NMFS 2018d)).

Analyses in previous biological opinions discussed here and in NMFS (2024b) have concluded that harvest actions have caused short-term prey reductions and were likely to adversely affect but not likely to jeopardize the continued existence of ESA-listed Chinook salmon or SRKWs. Additionally, Amendment 21 to the FMP for the ocean salmon fisheries addresses SRKW prey needs by limiting prey removal from the fisheries in NOF areas in low abundance years, and could limit reduction of Salish sea prey availability by PFMC fisheries in those years.

2.4.2.1.1.6.2 Hatchery Actions

Hatchery production of salmonids has occurred for over a hundred years. There are over 300 hatchery programs in Washington, Oregon, California, and Idaho that produce and release juvenile salmon that migrate through coastal and inland waters of the action area. Many of these fish contribute to both fisheries and the SRKW prey base in coastal and inland waters of the action area.

NMFS has completed Section 7(a)(2) consultations on more than two hundred hatchery programs (NMFS 2021b). The completed analyses to date have determined that the hatchery programs will not jeopardize listed salmonids. Currently, hatchery production is a significant component of the salmon prey base within the range of SRKWs (Barnett-Johnson et al. 2007; NMFS 2008b). Prey availability has been identified as a threat to SRKW recovery, and we expect the existing hatchery programs to continue benefiting SRKWs by contributing to their prey base. The effects of climate change described in Section 2.4.1 *Rangewide Status of the Species* would be expected to occur in the ocean portion of the action area. The cumulative impacts of hatchery actions in the action area will be one of the factors considered alongside the effects from the proposed action when making a determination for SRKW.

2.4.2.1.1.6.3 Habitat Actions

Habitat-altering activities such as agriculture, forestry, marine construction, levy maintenance, shoreline armoring, dredging, hydropower operations and new development continue to limit the ability of the habitat to produce and support salmon, and thus limit prey available to SRKWs in the action area. Many of these activities have a federal nexus and have undergone Section 7(a)(2) consultation. Independently, those actions have nearly all met the standard of not jeopardizing the continued existence of the listed salmonids or adversely modifying their critical habitat, and when they did not meet that standard, NMFS identified RPAs. The cumulative impacts of habitat actions in the action area will be one of the factors considered alongside the effects from the proposed action when making a determination for SRKW. In addition, the environmental baseline is influenced by many actions that pre-date the salmonid listings and that have substantially degraded salmon habitat and lowered natural production of Chinook salmon. In fact, listed Chinook salmon currently available to the whales are still below their pre-ESA listing levels, largely due to these past activities that pre-date the salmon listings. Since the SRKWs were listed, federal agencies have consulted on impacts to the whales from actions affecting salmon by way of habitat modification.

2.4.2.1.2 Metabolic Needs

We are able to estimate the prey energy requirements for all members of the SRKW population each day, and estimate the prey energy requirements for the entire year, for specific seasons, and/or for geographic areas (inland waters and coastal waters; methodologies described in previous biological opinions; e.g. NMFS 2019a). The daily prey energy requirements (DPERs) for individual females and males range from 41,376 to 269,458 kcal/day and 41,376 to 217,775 kcal/day, respectively, depending on size and age (Noren 2011). The DPERs can be converted to the number of fish required each year if the caloric densities of the fish (kcal/fish) consumed are known. However, caloric density of fish can vary because of multiple factors including differences in species, age and/or size, percent lipid content, geographic region, and season. Noren (2011) estimated that the daily consumption rate of a population with 82 individuals over the age of one year that consumes solely Chinook salmon would consume 289,131 to 347,000 fish/year by assuming the caloric density of Chinook salmon was 16,386 kcal/fish (i.e., the average value for adults from Fraser River). NMFS (2011b) modeled annual SRKW prey requirements and found that the whole population requires approximately 211,000 to 364,100 Chinook salmon per year. Based on dietary/energy needs and 2015 SRKW abundances, Chasco et al. (2017) also modeled SRKW prey requirements and found that in Salish Sea and United States West Coast coastal waters,[25] the population requires approximately 393,109, adult (age 1+) Chinook salmon annually on average across model simulations, including 217,755 in the Salish Sea (discussed in more detail below). These estimates can vary based on several underlying assumptions including the size of the whale population and the caloric density of the salmon, but they provide a general indication of how many Chinook salmon need to be available and consumed to meet the biological needs of the whales.

Due to the lack of available information on the whales' foraging efficiency, it is extremely difficult to precisely estimate how much Chinook salmon or what density of salmon needs to be available to the whales for their survival and successful reproduction. Given the highly mobile nature of these animals, their large ranges with variable seasonal overlap, and the many sources of mortality for salmon, the whales likely need many more fish available throughout their habitat than what is required metabolically to meet their energetic needs.

We have previously estimated the ratio of prey available to SRKW relative to the whales' needs by the magnitude of value or forage ratio in NMFS (2019a). In coastal waters off Washington, Oregon, and California, forage ratios ranged from 10.84 to 33.41 in October to April, from 29.24

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[25] These estimates do not include prey requirements off British Columbia, Canada.

to 88.15 in May to June, and from 42.67 to 154.79 in July to September (assuming a SRKW population size of 75 individuals, using maximum DPER, and using Chinook salmon abundance derived from the FRAM validation scenario based on post season information that approximates what actually occurred; see NMFS (2019a) for further details) (NMFS 2021e). Forage ratios in inland waters ranged from 17.57 to 29.77 in October to April, 16.39 to 30.87 in May to June, and 8.28 to 16.89 in July to September from 1992 to 2016. We have not given much weight to these forage ratios when considering current prey availability because we do not have a known target value that would be adequate to meet SRKW metabolic needs. However, we consider previously estimated ratios as an indicator to help focus our analysis on the time and location where prey availability may be lowest and where the action may have the most significant effect on the whales.

The abundance estimates in Table 18 of NMFS (2024b) are the number of adult Chinook salmon available to SRKWs at the beginning of each time step, prior to natural and fishery mortality and in that time step. Therefore, these are considered maximum estimates of prey available. Similar to other fishery models, the model the PFMC's Ad Hoc SRKW Workgroup used to develop the abundance estimates assumed constant adult mortality throughout the year and from one year to the next; however, natural mortality of salmonids likely varies across years, due in part to variable ocean conditions and their multiple predators. Hilborn et al. (2012) noted that natural mortality rates of Chinook salmon are likely substantially higher than the previous analyses suggest.

Specifically, marine mammal consumption of Chinook salmon in coastal waters has likely increased over the last 40 years as certain marine mammal populations have increased. Chasco et al. (2017) used a spatial, temporal bioenergetics model to estimate Chinook salmon consumption by four marine mammals - harbor seals, California sea lions, Steller sea lions, and fish-eating killer whales - within eight regions of the Northeast Pacific, including areas off the United States West Coast. This model represents a scenario where the predation is an additive effect and there is an adequate supply of salmon available to predators (i.e., there is almost never a deficit of salmon relative predator demands), which may not reflect true prey availability to predators. Chasco et al. (2017) determined that the number of individual salmon, including smolts, consumed annually by marine mammals in the entire Northeast Pacific (including inland waters of Salish Sea) has increased from 5 million to 31.5 million individual salmon from 1975 to 2015 (including juveniles). This includes an increase from 1.5 million to over 3.9 million adult salmon consumed in the Northeast Pacific on average across model parameter uncertainty. Consumption of all salmon ages by pinnipeds annually in the Puget Sound has increased from 68 metric tons to 625 metric tons from 1970 to 2015 (Chasco et al. 2017). There is uncertainty around these specific values, but the modeled increase in predation on salmon from 1975to 2015 does not change with variation in model parameters. With this increase, based on dietary/energy needs and 2015 marine mammal abundances, Chasco et al. (2017)calculated that when species occur in inland waters of the Salish Sea, SRKWs would annually consume approximately 190,215 adult salmon (age 2+), harbor seals would annually consume approximately 346,327 salmon age 2+, and California sea lions and Steller sea lions combined would annually consume approximately 60 adult salmon (sea lions mainly consume smolts). Again, these values represent a model scenario where there is a consistent abundance of salmon for consumption and are only based on the energetic demands and diet preferences of marine mammals, not necessarily true prey availability or consumption. These estimates provide a general indication of how many Chinook salmon need to be consumed to meet the biological needs of these marine mammals.

Recent work by Couture et al. (2022) estimated that annual SRKW consumption of Chinook salmon ranged from 166,000 to 216,300 fish between 1979 to 2020 across the Salish Sea and West Coast of Vancouver Island from April to October each year. While SRKWs were not estimated to be prey limited in most years, Couture et al.'s work suggested that SRKW experienced an energetic deficit (in those months in those locations only) in six of the last 40 years, three of which were the most recent in the time series (2018 to 2020). The authors estimated various parameters that were factored into the novel model they used, including prey species diet proportion as a function of abundance, search efficiency, and prey handling time, which influence prey requirements and may partially explain our different results. Additionally, we note that, compared to our work presented in this Opinion, Couture et al. (2022) used alternative models for estimating SRKW Chinook salmon prey abundance and only modeled prey consumption in two regions (Salish Sea and off the West Coast of Vancouver Island Wild) in part of the year (April to October). The work by Couture et al. (2022) presents an important first step in parameterizing previously unknown variables (such as search efficiency), but further work is needed to refine and validate these metrics.

In summary, though abundance of Chinook salmon available at the beginning of a year (pre-fishing and natural mortality) is substantially greater than the required amount of salmon needed by SRKWs (depending on the model used – see Couture et al. 2022) there is likely competition between SRKWs and other predators, and natural mortality of Chinook salmon may be high, further reducing Chinook salmon availability to SRKWs. Although some of these predators are likely consuming smolts, prey availability to SRKWs in the action area would be reduced in subsequent years based on dietary needs of other marine mammals as well as other predators (e.g. pelagic fish, sharks, and birds). In addition, the available information suggests coastwide prey availability is substantially lower in the winter than summer in coastal waters and opposite in inland waters. Many studies have analyzed the dietary needs of SRKW while in inland waters. Chasco et al. (2017) revealed that marine mammal consumption of Chinook salmon in coastal waters has likely increased over the last 40 years as certain marine mammal populations have increased. With this increase, based on dietary/energy needs and 2015 marine mammal abundances, Chasco et al. (2017) calculated that when species occur in inland waters of the Salish Sea, SRKWs would annually consume approximately 190,215 adult salmon (age 2+), harbor seals would annually consume approximately 346,327 salmon age 2+, and California sea lions and Steller sea lions combined would annually consume approximately 60 adult salmon (sea lions mainly consume smolts). Additionally, recent work by Couture et al. (2022) estimated that annual SRKW consumption of Chinook salmon ranged from 166,000 to 216,300 fish between 1979 to 2020 across the Salish Sea and West Coast of Vancouver Island Wild from April to October each year. While SRKWs were not estimated to be prey limited in most years, Couture et al.'s work suggested that SRKW experienced an energetic deficit (in those months in those locations only) in six of the last 40 years, three of which were the most recent in the time series (2018 to 2020).

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further reducing Chinook salmon availability to SRKWs. Although some of these predators are likely consuming smolts, prey availability to SRKWs in the action area would be reduced in subsequent years based on dietary needs of other marine mammals as well as other predators (e.g., pelagic fish, sharks, and birds). In addition, the available information suggests coastwide prey availability is substantially lower in the winter than summer in coastal waters and opposite in inland waters.

2.4.2.1.3 Prey Quality

Contaminants enter marine waters and sediments from numerous sources, but are typically concentrated near populated areas of high human activity and industrialization. Freshwater contamination is also a concern because it may contaminate salmon that are later consumed by the whales in marine habitats. Chinook salmon contain higher levels of some contaminants than other salmon species, however levels can vary considerably among populations. Mongillo et al. (2016) reported higher concentrations of persistent pollutants in Chinook salmon populations along the West Coast of North America, from Alaska to California that feed in close proximity to land-based sources of contaminants. Contaminant levels of Chinook salmon in inland waters has been documented to be higher than Chinook outside of Puget Sound (i.e., O'Neill et al. 2006; O'Neill et al. 2009; O'Neill et al. 2020). Intermediate levels of PCBs were measured in California and Oregon populations, but Chinook salmon originating from California have been measured to have higher concentrations of DDTs (O'Neill et al. 2006; Mongillo et al. 2016). Therefore, SRKW prey is highly contaminated, causing contamination in the whales themselves. Build-up of pollutants can lead to adverse health effects in mammals (see Toxic Chemical Section 2.2.1.4 in 2024b). Nutritional stress, potentially due to periods of low prey availability or in combination with other factors, could cause SRKW to metabolize blubber, which can redistribute pollutants to other tissues and may cause toxicity. Pollutants are also released during gestation and lactation which can impact calves (Noren et al. 2024).

Size and age structure of Chinook salmon has substantially changed across the Northeast Pacific Ocean (Ohlberger et al. 2018). Since the late 1970s, adult Chinook salmon (ocean ages 4 and 5) along most of the Eastern North Pacific Ocean are becoming smaller, whereas the size of age 2 fish are generally increasing (Ohlberger et al. 2018). Additionally, most of the Chinook salmon populations from Oregon to Alaska have shown declines in the proportions of age 4 and 5-year olds and an increase in the proportion of 2-year olds; the mean age of Chinook salmon in the majority of the populations has declined over time. Populations along the coast from Western Alaska to Northern Oregon had strong declining size trends of ocean-4 fish, including wild and hatchery fish. For Puget Sound Chinook salmon (primarily hatchery origin), there were little or weak trends in size-at-age of 4 year olds and the declining trend in the proportion of older ages in Washington stocks was also observed but slightly weaker than that in Alaska populations (Ohlberger et al. 2018). The authors suggest the reasons for this shift may be largely due to direct effects from size-selective removal by marine mammals and fisheries, followed by evolutionary changes toward these smaller sizes and early maturation (Ohlberger et al. 2019). Smaller fish have a lower total energy value than larger ones (O'Neill et al. 2014). Therefore, SRKWs need to consume more fish salmon in order to meet their caloric needs as a result of a decrease in average size of older Chinook salmon.

2.4.2.1.4 Vessel Activities and Sound

Commercial shipping, cruise ships, and military, recreational, and fishing vessels occur in the inland and coastal range of SRKWs. Additional whale watching, ferry operations, and recreational and fishing vessel traffic occur in their inland range. The overall density of traffic is lower in coastal waters compared to inland waters of the Salish Sea. Several studies in inland waters of Washington State and British Columbia have linked vessel interactions with short-term behavioral changes in NRKW and SRKW (see review in Ferrara et al. 2017), whereas there have been no studies that have examined interactions of vessels and SRKWs with behavioral changes in coastal waters. These studies that occurred in inland waters concluded that vessel traffic may affect foraging efficiency, communication, and/or energy expenditure through the physical presence of the vessels, underwater sound created by the vessels, or both (Holt et al. 2008) (Hanson et al. 2017; Holt et al. 2017; Tennessen et al. 2024). Collisions of killer whales with vessels are rare, but remain a potential source of serious injury and mortality, although the true effect of vessel collisions on mortality is unknown.

Various mitigation actions have been implemented in an attempt to reduce the amount of noise that SRKW are exposed to such as a voluntary vessel slow down trial in Haro Strait in 2007 (Burnham et al. (2021)) and vessel restrictions around SRKW. The Be Whale Wise viewing guidelines and the 2011 federal vessel regulations (www.bewhalewise.org) were designed to reduce behavioral impacts, acoustic masking, and risk of vessel strike to SRKWs in inland waters of Washington State. Since the regulations were codified, there is some evidence that the average distance between vessels and the whales has increased (Houghton et al. 2015; Ferrara et al. 2017).

Vessel sounds in coastal waters are most likely from large ships, tankers and tugs, whereas vessel sounds in inland waters also come from whale watch platforms, ferry operations, and smaller recreational vessels. Commercial sonar systems designed for fish finding, depth sounding, and sub-bottom profiling are widely used on recreational and commercial vessels and are often characterized by high operating frequencies, low power, narrow beam patterns, and short pulse length (NRC 2003). Frequencies fall between 1 and 500 kilohertz, which is within the hearing range of some marine mammals including killer whales and may have masking effects (i.e., sound that precludes or reduces the ability to detect and transmit biological signals used for communication and foraging).

It is currently unclear if SRKWs experience noise loud enough to have more than a short-term behavioral response. Reduced time spent feeding and the resulting potential reduction in prey consumption is likely the most important pathway of effects due to vessels (Ferrara et al. 2017) (Holt et al. 2021a; Holt et al. 2021b). Although the impacts of short-term behavioral changes, including ephemeral feeding disruptions, on population dynamics are unknown, it is likely that because SRKWs are exposed to vessels the majority of daylight hours they are in inland waters, and that the whales in general spend less time foraging in the presence of vessels, there may be biologically relevant effects at the individual or population-level (Ferrara et al. 2017). The extent of vessel impacts in coastal waters of SRKW critical habitat has not been studied and the density of vessels, particularly those targeting and following the whales for whale watching, is much less than inland waters.

2.4.2.1.5 Entrapment and Entanglement in Fishing Gear

Drowning from accidental entanglements in nets and longlines is a minor source of fishing related mortality in killer whales, although not all incidents may be reported. Two killer whales have been recorded entangled in Dungeness crab commercial trap fishery gear off California (a transient in 2015 and unknown ecotype in 2016 (NMFS 2017b)). In 2018, DFO disentangled a transient killer whale entangled in commercial prawn gear near Salt Spring Island, British Columbia (NMFS strandings data, unpublished). In 2013, a NRKW stranded in British Columbia and a fish hook was observed in its colon, but had no evidence of perforation or mucosal ulceration. In 1977, a SRKW (L8) drowned in a net and recreational fishing lures and lines were found in the stomach upon necropsy. Typically, killer whales are able to avoid nets by swimming around or underneath them (Jacobsen 1986; Matkin 1994), and not all entanglements automatically result in death or injury. For example, one killer whale (unknown ecotype) was reported interacting with a salmon gillnet in British Columbia in 1994, but did not get entangled (Guenther et al. 1995). In the summer of 2015, J39, a young male SRKW in J pod, was observed with a salmon flasher hooked in his mouth around the San Juan Islands, which subsequently fell out with no signs of injury or infection.

Entanglements of marine mammals in fishing gear must be reported in accordance with the Marine Mammal Authorization Program (MMAP). MMPA Section 118 established the Marine MMAP in 1994. Under MMPA all fishers are required to report any incidental taking (injuries or mortalities) of marine mammals during fishing operations. Any animal that ingests fishing gear or is released with fishing gear entangled, trailing, or perforating any part of the body is considered injured, and must be reported.[26] No entanglements, injuries or mortalities of SRKW have been reported in recent years.

2.4.2.1.6 Oil Spills

SRKWs are vulnerable to the risks imposed by an oil spill due to their overall small population size, strong site fidelity to areas with high oil spill risk, large groups of individuals together at once, late reproductive maturity, low reproductive rate, and specialized diet, among other attributes (Jarvela Rosenberger et al. 2017). Oil spills have occurred in the range of SRKWs in the past, most recently in August 2022, when a commercial fishing vessel sank off the west side of San Juan Island and an oil sheen was seen (see: https://www.fisheries.noaa.gov/feature-story/coordinated-response-protected-southern-residents-sunken-ship-leaking-oil). Existing oil spill response plans were implemented and emergency ESA consultations were completed to minimize the impacts of response activities, including removing the vessel. The Wildlife Branch of the Incident Command monitored marine mammal sightings and activated a Killer Whale Deterrence Team to prevent exposure to the spill. SRKW were not seen directly in the sheen. Oil can be discharged into the marine environment in any number of ways, including shipping accidents, refineries and associated production facilities, and pipelines. Despite many improvements in spill prevention since the late 1980s, much of the region inhabited by SRKWs remains at risk from serious spills because of the heavy volume of shipping traffic and proximity to petroleum refining centers.

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[26] See reporting requirements and procedures at 50 CFR 229.6 and https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-authorization-program#reporting-a-death-or-injury-of-a-marine-mammal-during-commercial-fishing-operations.

If repeated ingestion of petroleum hydrocarbons by killer whales occurs, it would likely cause adverse effects, though long-term consequences are poorly understood. In marine mammals, acute exposure to petroleum products can cause changes in behavior and reduced activity, inflammation of the mucous membranes, lung congestion and disease, pneumonia, liver disorders, neurological damage, adrenal toxicity, reduced reproductive rates, and changes in immune function (Geraci et al. 1990; Schwacke et al. 2013; Venn-Watson et al. 2015; de Guise et al. 2017; Kellar et al. 2017). Exposure can also result in death and long-term effects on population viability (Matkin et al. 2008; Ziccardi et al. 2015). In addition, oil spills have the potential to adversely impact habitat and prey populations, and, therefore, may adversely affect SRKWs by reducing food availability.

2.4.2.1.7 Scientific Research

Most of the scientific research conducted on SRKW occurs in inland and coastal waters of Washington State. In general, the primary objective of this research is population monitoring or data gathering for behavioral and ecological studies. Research activities are typically conducted between May and October in inland waters and can include aerial surveys, vessel surveys, close approaches, documentation, and biological sampling. Most of the authorized takes occur in inland waters, with a small portion in the coastal range of SRKWs. In light of the number of permits, associated takes, and research vessels and personnel present in the environment, repeated disturbance of individual killer whales is likely to occur in some instances. In recognition of the potential for disturbance and take, NMFS took steps to limit repeated harassment and avoid unnecessary duplication of effort through conditions included in the permits requiring coordination among permit holders, such as restricting the number of research vessels within 200 yards of a SRKW at any given time. The cumulative effects of research activities were considered in a batched biological opinion for four research permits in 2012 (NMFS 2012b). The cumulative effects were also considered in the biological opinion on the renewal of the research permits (NMFS 2018b). The biological opinion concluded the cumulative impacts of the scientific research projects were likely to adversely affect but were not likely to jeopardize the continued existence of SRKWs. The impacts of scientific research in the action area will be one of the factors considered alongside the effects from the proposed action when making a determination for SRKW.

2.4.2.2 Summary of Environmental Baseline for SRKW

SRKWs and their designated critical habitat are exposed to a wide variety of human activities and environmental factors in the action area. All the activities discussed in Section 2.4.1.1 *Rangewide Status of the Species* are likely to have some level of impact on SRKWs and their designated critical habitat when they are in the action area. No single threat has been directly linked to or identified as the cause of the relative lack of growth of the SRKWs population over time, although three primary threats that have been identified are: prey availability, environmental contaminants, and vessel effects and sound (Krahn et al. 2002; NMFS 2016c; NMFS 2021d). There is limited information on how these factors or additional unknown factors may be affecting SRKWs and their designated critical habitat when in coastal waters; however, the small size of the population and projected decline of the population in coming years increases the level of concern about all of these risks (NMFS 2008c; NMFS 2016c; NMFS 2021d). The abundance of their preferred prey (Chinook salmon) throughout the action area is reduced through activities that include ocean harvest, fisheries bycatch, and research. Environmental pressures that include freshwater habitat issues, variable ocean conditions, and predation by other species also contribute to reduced Chinook salmon availability for SRKWs. Overall, the availability of Chinook salmon as prey for SRKWs is constrained and/or affected by numerous factors that make it increasingly challenging for SRKWs to find abundant prey resources.

2.4.3 Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action but that are not part of the action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 CFR 402.02).

The primary potential impact of the proposed action on SRKWs that has been identified 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 SRKWs. Most Klamath Chinook salmon that would be encountered by SRKW are found in coastal Northern California Coast waters north to include the coastal waters of Southern and Central Oregon, but some could be found in the waters of the Washington Coast or Puget Sound.

Section 2.4.1.2.1 *Quantity and Quality of Prey* describes the evaluation by the Science Panel (Hilborn et al. 2012) of the state of the science of the effects of salmon fisheries on SRKWs. While there is uncertainty in the extension of the statistical correlations to precise predictions of the effect of Chinook salmon abundance on the SRKWs 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 SRKWs.

2.4.3.1 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 SRKWs and Klamath River Chinook salmon are potential prey for SRKWs along the coast. Effects of the proposed action that reduce Chinook salmon production could lead to adverse effects to SRKWs. Much like ESA-listed coho salmon, Chinook salmon utilize the Klamath River during all of their life stages and the life history requirements of both Chinook and coho salmon overlap. Therefore, 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.

2.4.3.1.1 Effects of the Proposed Action on Chinook Salmon Individuals

The effects analysis for SRKWs is focused on the potential effects of the proposed action on the ocean abundance of Chinook salmon, their primary food source (Ford et al. 2006; Ohlberger et al. 2019; Hanson et al. 2021). Because SRKWs prefer larger prey, Chinook salmon are typically not considered SRKW prey until they are three years of age or older. Chinook salmon in the

Klamath Basin typically return from the ocean at age 2 to age 5, with the majority of the river run returning at age 3 or age 4 each year (Gough et al. 2018; PFMC 2021). Therefore, Chinook salmon that are affected by the proposed action at age 1 or younger (e.g., eggs, emergent fry, migrating or rearing juveniles) will not impact SRKW prey availability until at least two years later. So, while most Chinook salmon in the Klamath Basin outmigrate within their first year, effects to SRKW prey availability will not occur for two years or more.

As described earlier in the SONCC coho salmon Section 2.3.3 *Effects of the Action,* the proposed action affects salmonid habitat in the action area through the Klamath Project operations. The proposed action's greatest effects to Chinook salmon production are associated with the effects to the Klamath River hydrology. Reclamation's proposed action of storing and delivering Klamath Project water limits the volume of water available to approximate the Klamath River natural flow regime. Based upon our evaluation, under the proposed action, the median annual Klamath Project delivery of 260,000 AF is approximately 27% of the median annual UKL net inflow (980 TAF). In large part as a result of operating the Klamath Project, the Klamath River annual flow volume, spring peak magnitude and duration, and flow variability will be reduced under the proposed action relative to the natural hydrograph. Similar to our conclusion regarding effects of the proposed action on coho salmon, Chinook salmon individuals spawning upstream of and proximal to the previous location of IGD will experience the greatest effects of the proposed action, whereas individuals in the lower Klamath River (e.g., those spawning in the Salmon or Trinity Rivers) will be less likely to be affected.

2.4.3.1.1.1 Exposure and Response

2.4.3.1.1.1.1 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). Spring-run Chinook salmon adults enter the Klamath River from March to July, and will migrate upstream of the mainstem spawning areas, before spawning on average about a month earlier than the fall-run Chinook salmon population (Snyder 1931). Adult Chinook salmon can be susceptible to disease such as Ich and columnaris (caused by *flavobacterium 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). Since that time, Reclamation's Klamath Project operational flows, as analyzed by various NMFS biological opinions (e.g., (NMFS 2010b; NMFS and USFWS 2013; NMFS 2019c), in addition to flow contributions from the Trinity River, have been sufficient to avoid large scale mortality events of adult Chinook salmon downstream of the Trinity River confluence. However, some incidence of disease has been recorded in returning adult salmonids in many years. In low flow years, and under elevated water temperatures, Reclamation's proposed Keno minimum flows are likely to contribute to conditions that increase risks of disease to adult Chinook salmon that enter the Klamath River in late summer and early fall. Chinook salmon may also be affected downstream of Keno Dam due to flow reductions and at Keno Dam due to fish passage limitations at the ladder and potential entrainment at unscreened Klamath Project facilities within the Keno Impoundment, as salmon return to the Upper Klamath Basin following the removal of impassable dams in the Klamath River (Reclamation 2024a).

2.4.3.1.1.1.2 Eggs

Fall-run Chinook salmon are expected to continue to spawn in the mainstem Klamath River in areas affected by the proposed action, and to expand their spawning range upstream of the of the former IGD. Because spring-run Chinook salmon need to hold in suitable summer habitat, Spring-run Chinook salmon, even after active reintroduction and dam removal, are not expected to spawn in the mainstem Klamath River in areas affected by the proposed action. Spawning habitat does not exist in the reach between Keno Dam and UKL. NMFS used the relationships of flow and habitat formulated by Hardy (2012) and Hardy et al. (2006) to quantify how Chinook salmon fry and juvenile habitats vary with water discharge in the mainstem Klamath River below Iron Gate. 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, though NMFS recognizes baseline conditions will change with the dams removed. Therefore, Hardy et al. (2006) instream flow recommendations provide NMFS with a useful reference when analyzing the proposed flows at Keno, and Iron Gate flows produced as a result of Keno releases, 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). In Section 2.3.3.1.2 *Hydrologic Effects*, we describe model results in Hardy et al. (2006) for Chinook salmon spawning that indicate there is an abundance of spawning habitat between Iron Gate and the Shasta River reach. The proposed action will provide Keno Dam minimum flows of at least 650 to 750 cfs during the spawning and incubation period (October to February). NMFS expects this will provide at least 950 to 1,000 cfs in the Iron Gate to Shasta River reach of the Klamath River assuming historical tributary inflows and accretions. In addition, proposed action Keno Release Target flows are at or near Reclamation's proposed Keno Dam minimums between 38 and 66% of days for October through February. 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. 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.

2.4.3.1.1.1.3 Juveniles

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 to 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. Reclamation's (2024a) effects analysis uses a hydrodynamic model developed for the mainstem Klamath River (Hardy et al. 2006; Perry et al. 2023) and WUA curves to simulate habitat availability for Chinook salmon under the proposed action (Figure 45). During this spring freshwater rearing period, habitat availability will be reduced under some hydrological conditions (see Section 2.3.3.1.2 *Hydrologic Effects*), with a decreased amount of essential edge habitat.

As in previous opinions (e.g., (NMFS 2010b; NMFS and USFWS 2013; NMFS 2019c), and similar to our analysis for coho salmon, NMFS expects that at least 80% of maximum available habitat provides for the conservation needs of Chinook salmon. Instream maximum available habitat of 80% has been used to develop minimum flow needs for the conservation of anadromous salmonids (Sale et al. 1981; Hetrick et al. 2009). Therefore, NMFS expects that at least 80% 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% or greater under the proposed action, habitat is not expected to limit individual fitness or population productivity of Chinook salmon. Figure 45 depicts the modeled daily frequency of Chinook salmon habitat availability under the proposed action over the POR without averaging across day (i.e., time dimension) or reach (i.e., spatial dimension). Figure 45 shows daily percent of maximum WUA frequently over 80% for Chinook Salmon fry, parr and spawner/egg habitat availability under the proposed action.

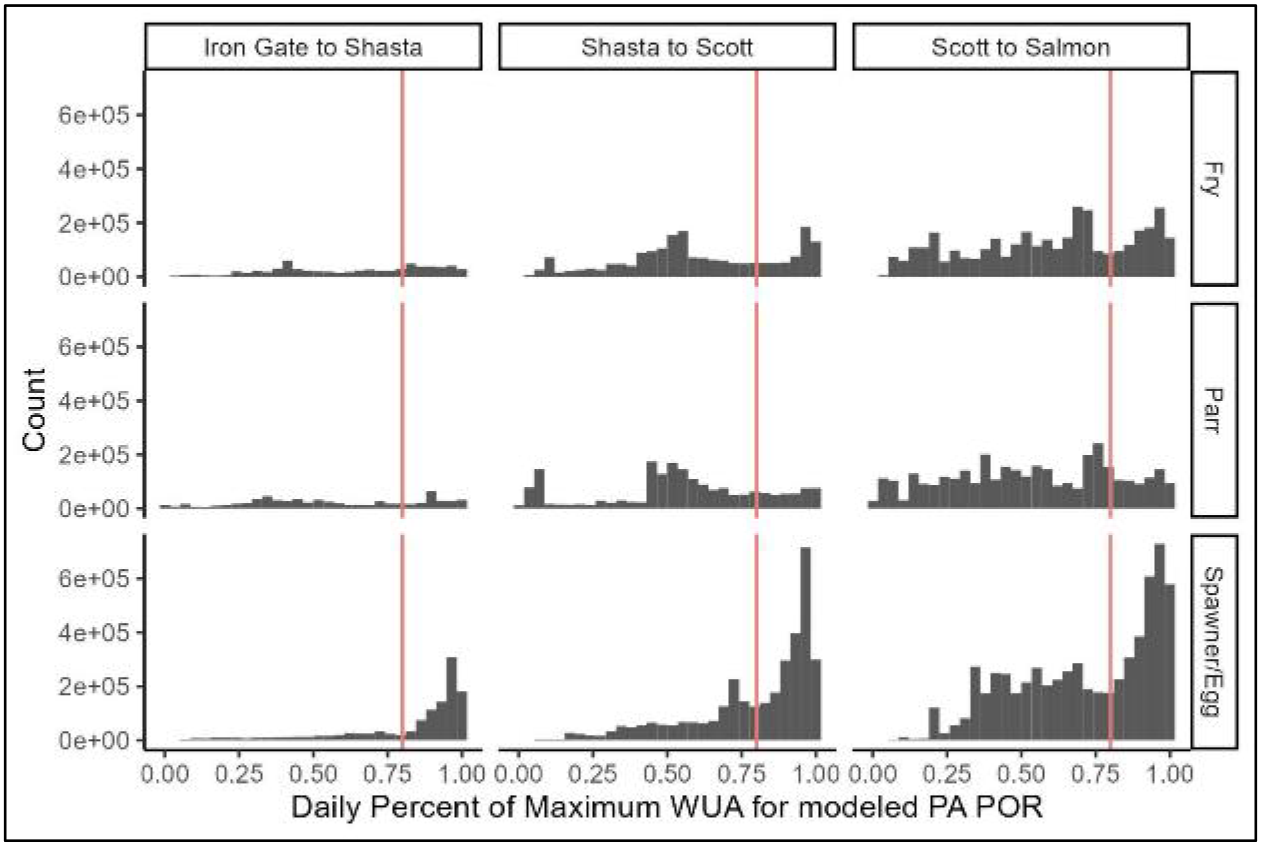

Figure 45. Daily frequency of Chinook Salmon fry, parr and spawner/egg habitat availability under the proposed action (for three reaches downstream of the former location of IGD (Reclamation 2024a)).

Reclamation (2024a) examined the percent of days with greater than 80% habitat available for Chinook Salmon juveniles (fry and parr) under the proposed action (relative to mainstem flows for three reaches and four sites downstream of the former IGD) (Table 36). Although habitat availability for these lifestages is reduced by the proposed action, all three reaches have substantial habitat (i.e., greater than or equal to 80% WUA threshold) available for juvenile life stages over the modeled POR (Table 36). The proposed action may reduce juvenile rearing habitat below 80% of maximum available for as much as 80.6% of the days when considering the POR (i.e., Scott River to Salmon River). Most locations will not be impacted to that degree and the provision of variable spring flows are expected to moderate these impacts, but the effects overall will be adverse. As discussed in the coho salmon effects section, flow volume 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, chinook salmon compete with other species for available habitat. While habitat preferences between coho salmon are not the same as Chinook salmon, and steelhead, some overlap in habitat use is expected. In addition to the reaches below the former location of IGD examined in Figure 45 and Table 36 (i.e. Iron Gate to Salmon River), we also consider the habitat upstream of the former location of IGD, as described by O'Keefe et al. (2022), Ramos (2020), and others, and expect that the expected conditions under the proposed action will be sufficient to provide Chinook salmon access to that tributary habitat, and to the habitat was previously present under the reservoir footprints (NMFS 2021a).

Table 36. Percent of days with greater than 80% habitat available for Chinook Salmon fry, parr, and spawner/egg under the proposed action for the modeled period of record (relative to mainstem flows for three reaches and four sites downstream of the former location of IGD (Reclamation 2024a).

Stage	Reach	Percent of Days Greater Than or Equal to 80% WUA Threshold
Spawner/Egg	Iron Gate to Shasta River	73.5%
	Shasta River to Scott River	61.1%
	Scott River to Salmon River	46.3%
Fry	Iron Gate to Shasta River	36.1%
	Shasta River to Scott River	29.1%
	Scott River to Salmon River	27.8%
Parr	Iron Gate to Shasta River	28.9%
	Shasta River to Scott River	20.2%
	Scott River to Salmon River	19.4%

The overall Project effects of a median 27% reduction in water volume available to the Klamath River will result in lower base flows and smaller incremental increases in flow in the FW period from October through February relative to the natural hydrograph particularly in below average and dry years. To offset some of the potential risks to juvenile salmonids of reduced habitat availability and increased disease risk, the proposed action would implement an FFA for river flow releases from Keno Dam in which a specified proportion of calculated releases during October through March 1 is stored in UKL for use during March 2 through June 30. The FFA can be used to shape flow events to affect fish disease cycles in the river and shape river hydrograph to provide coho salmon habitat, that will also benefit outmigrating Chinook salmon. In addition, as described in Section 2.3.3.1.2 *Hydrologic Effects*, NMFS concludes that releasing the FFA volume as pulse flows on an annual basis will likely provide an adequate magnitude and frequency of sediment maintenance flows that will likely help disrupt the river bed, mobilize fine sediment, and reduce disease risks to salmonids.

For the previous consultation (NMFS 2019c), NMFS relied on the USGS (2019) S3 model to help 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). The S3 model also specifically evaluated the anticipated effects of disease exposure and resultant mortality associated with the proposed action. The USGS model incorporates environmental conditions including 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 allowed 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. The model results predicted that the proposed action for that consultation would improve juvenile survival to ocean entry for fall-run Chinook salmon populations in the Klamath River when compared to past proposed actions, and would result in additional adult Chinook salmon in the ocean as prey for SRKWs (NMFS 2019c). For example, disease conditions are expected to improve as a result of dam removal (NMFS 2021a; Bartholomew et al. 2023; Perry et al. 2023). NMFS considers previous model results as somewhat informative in areas where the proposed actions are similar.

Reclamation's proposed action is expected to reduce the ocean abundance of Klamath basin origin Chinook salmon. This reduction is likely caused by increased disease exposure during the juvenile rearing and outmigration period and reduced fry habitat availability leading to increased competition. These effects would likely reduce growth and survival of some fry and juvenile Chinook Salmon in the Klamath River. Adult Chinook Salmon, when exposed to lower flows in the mainstem Klamath River and, when combined with elevated water temperatures in late summer and early fall, would experience delayed migration, which would reduce reproductive success. While the proposed action is expected to contribute to disease infection, we expect that enhanced flow variability at the former IGD location due to dam removal, and the implementation of pulse flows using the FFA will help to reduce some of the effects of the proposed action in drier years and in periods of elevated water temperatures.

This 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. The effects of the underlying and ongoing impact of Klamath Project operations on juvenile survival under the proposed action cannot generally be quantified, with the notable exception of explicit quantification of the relative amount of adult spawning, egg incubation and juvenile rearing habitat anticipated to result from the proposed action (Figure 45). The relative change of Klamath River Chinook salmon prey abundance that results from effects of the proposed action relative to baseline cannot be fully quantified at this time. This restricts the ability to provide specific quantifiable expectations for the decrease in the abundance of Chinook Salmon in the ocean available as prey for SRKWs. Nevertheless, the analysis in this consultation indicates that prey availability will be lower under the proposed action. Klamath Project related effects will contribute to reductions in the amount of habitat for spawner/egg, fry and parr life stages. This is likely to reduce the abundance of Chinook salmon available as prey for SRKW in the action area.

2.4.3.1.1.2 Summary of Effects on Chinook Salmon Individuals

Section 2.3.3.2 *Effects to Individuals* 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 37 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 Section 2.3.3.2 *Effects to Individuals* for SONCC coho salmon above, but reflects differences in life history between the two species.

Table 37. Adapted from the SONCC coho salmon Section 2.3.3.2 *Effects to Individuals* and modified to represent risks to Chinook salmon.

Potential Stressor	**Project Effects**	**Life Stage**	**General Time**	**Mainstem Location**	**Minimization Measures**	**Proposed Action Effects**
Increased Water Temperature	Increased stress	Juvenile	May to mid-June	Keno Dam to Scott River	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.	Chinook salmon will continue to have increased stress from slightly elevated water when temperatures exceed 16.5ºC
Reduced DO	Reduced swimming performance and increased stress	Juvenile	May to mid-June	Keno Dam to Scott River	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.	Chinook salmon will continue to have decreased swimming performance or increased stress from decreased DO concentration in the mainstem during the late night and early morning when DO concentrations are below 8.0 mg/L or 6.0 mg/L, respectively.
Reduced Habitat Availability	Reduced growth and survival	Fry	March to June	Keno Dam to Salmon River	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.	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.

Potential Stressor	Project Effects	Life Stage	General Time	Mainstem Location	Minimization Measures	Proposed Action Effects
Reduced Habitat Availability	Reduced growth and survival	Juvenile	April through June	Keno Dam to Salmon River	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.	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.
Reduced Quality of Migration Habitat	Decreased rate of outmigration and reduced survival	Smolt	April through June	Keno Dam to Shasta River	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.	Chinook salmon are likely to continue to have a decreased outmigration rate, which will increase likelihood of decreased growth or increased mortality when environmental conditions are conducive to having increased stressors, such as warmer water temperatures and disease proliferation.
Increased Disease	Reduced fitness and survival	Juveniles	April through June	Keno Dam to Orleans	Minimum instream flows from Keno (April-June) and use of pulse flows will limit the increases of disease risk	The proposed action will result in disease risks to Chinook salmon that are lower than observed POR conditions yet higher than under natural flow conditions
Increased Disease	Increased likelihood of disease related mortality	Adults	April to July (spring-run) July to October (fall-run)	Estuary to Keno Dam	Minimum instream flows from Keno (April-June) and use of pulse flows will limit the increases of disease risk	The proposed action will result in disease risks to Chinook salmon that are lower than observed POR conditions yet higher than under natural flow conditions

Considering the analysis provided in the SONCC coho salmon Section 2.3.3.2 *Effects to Individuals*, NMFS expects the proposed action to result in negative impacts to Chinook salmon juveniles and adults. The greatest impacts are associated with reduced fry and juvenile rearing habitat in the spring and increased disease risk for outmigrating smolt. Disease risk is likely to be increased due to a reduction in large sediment mobilization flow events which increases bed immobility. These stable substrate conditions provide a suitable environment for annelid worm populations to thrive. However, the proposed action will use pulse flow events via the FFA to seasonally disrupt the *C. shasta* host so that annual impacts of disease are reduced. The proposed action is expected to have minor impacts to spawning habitat from fine sediment deposition and minor impacts to adult and juvenile fish migration from reduced flow volume and velocity in the mainstem. NMFS expects the proposed action will reduce water quality conditions, particularly temperature and DO in the summer due to reduced flow releases from Keno Dam. While the proposed action is expected to contribute to disease infection over the period of the proposed action, we expect that Reclamation's proposed action flow regime including annual pulse flows using the FFA will help to reduce some of the effects.

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 37). Although NMFS does not anticipate spring-run Chinook spawning to be impacted by the proposed action, impacts to juvenile rearing and juvenile and adult migration are possible. Given the increased migration distance that that will occur for individuals migrating from newly accessible habitat upstream of the former IGD, those individuals may be at higher risk of contracting disease.

In total, various stressors will reduce the fitness and survival of fall-run Chinook salmon as a result of the proposed action, primarily in average and drier water years when environmental stressors are heightened (Table 37). 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 Klamath Project operations on juvenile survival under the proposed action, with the notable exception of explicit quantification of the relative amount of adult spawning, egg incubation, and juvenile rearing habitat 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 SRKWs. 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 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 SRKWs. Thus, as noted above, the SRKW critical habitat PBF of prey will be adversely affected in the action area by the proposed action.

2.4.3.2 General Effects of Reduced Prey Base for SRKWs

Here we review the prey reduction from the proposed action and generally describe the potential effects of prey reduction on SRKWs. The proposed action has the potential to affect SRKWs indirectly by reducing availability of their preferred prey, Chinook salmon, in the ocean. Any proposed action-related effects that decrease the availability of salmon, Chinook salmon in particular, could adversely affect the entire SRKW DPS in their coastal range via reduced prey availability. Reductions in availability of preferred prey (Chinook salmon) may affect the survival and reproductive success of SRKWs. We evaluated effects of the proposed action on the SRKWs qualitatively to determine whether the impacts expected on prey species is also likely to appreciably reduce the likelihood of survival and recovery of SRKW. Our analysis draws extensively from the information described Section 2.4.1 *Rangewide Status of the Species*, and Section 2.4.2.1.1 *Factors Affecting the Prey of SRKWs in the Action Area*.

The best available information indicates that Chinook salmon are the preferred prey of SRKWs year-round (Krahn et al. 2002; Krahn et al. 2007; Hanson et al. 2021) and that SRKW require regular supplies of adult Chinook salmon prey coast-wide, including stocks from California (Hanson et al. 2021). The most current data of the oceanic distribution of fall-run Chinook stocks from Northern California ESUs suggests they may co-occur with the entire SRKW DPS as far south as Point Sur, California through Vancouver Island in the north, with the highest proportion likely in California and Oregon and very rare overlap in Canadian Waters (Shelton et al. 2018; Shelton et al. 2021). Klamath origin Chinook salmon have been identified in the SRKW diet in late winter and early spring along the outer coast (Hanson et al. 2021), during which time body condition declines and whales are increasingly reliant on Chinook stocks from outside of the Salish Sea (Durban et al. 2017; Fearnbach et al. 2018; Hanson et al. 2021). Hanson et al. (2021) found that in fall and early winter 61.9% of Chinook prey collected still originated from Puget Sound. In contrast, in mid-winter through early spring 93% Chinook prey items were from outer coastal water stocks; most originating from the Columbia River (53.6%) followed by 19% from Central Valley Chinook stocks and 6.5% in the Fraser River. The proportion of Klamath origin Chinook salmon detected in the diet during this time frame (2.2%) was similar to stocks originating from the Lower Fraser River (2.3%, close to a third of the total Fraser river contributions) and the spring/summer Snake river stocks (2.2%, 4% of the total Columbia River proportion).

K and L pods, spend significantly more time in outer coastal waters off of Washington, Oregon, and California than J pod (Hanson et al. 2021; NMFS 2021d), where they are more likely to encounter and feed upon Chinook originating from the Klamath River. However, SRKW are also known to consume California origin Chinook salmon far from their stream of origin, such as Central Valley Chinook salmon that were consumed in Puget Sound (Hanson et al. 2021) so it is likely possible for all pods to be impacted by changes in availability of Klamath origin Chinook. SRKWs are further linked to consumption of Chinook salmon from California based on the contaminant signatures discussed above, particularly K and L for reasons described previously (Krahn et al. 2007; Krahn et al. 2009; O'Neill et al. 2012).

Chinook salmon from the Klamath River (especially fall-run Chinook salmon) can constitute a sizeable proportion of the total abundance of Chinook salmon that is available throughout the coastal range of SRKWs (~9% on average from 2009to 2018; but varying substantially between about 1% to 9% during any given year (Kope et al. 2011)). Within the range of Klamath Chinook salmon off the coasts of Oregon and California (SOF), Klamath Chinook salmon constituted about 16% of the average ocean abundance of Chinook salmon during this time period. As previously described in the Section 2.4.2.1.1.3 *Klamath River Chinook Salmon*, Klamath River Chinook salmon become an increasingly significant portion of prey source during any southerly movements of SRKWs along the coast of Oregon and California that may occur during the winter and spring when they are more prey limited and more likely to have poor body condition.

A reduction of Chinook salmon can contribute to nutritional stress in SRKW, which can impact mortality rates and reproductive success directly and indirectly. Previous studies have found correlations between Chinook salmon abundance indices and SRKW demographic rates (e.g. fecundity and mortality; (Ford et al. 2005; Ward et al. 2009; Ford et al. 2010; Lacy et al. 2017) (PFMC 2020; Murray et al. 2021; Nelson et al. 2024; Williams et al. 2024).

Though these studies did not identify the mechanism explaining the relationship, nutritional stress as a result of chronic prey limitation can lead to reduced body size and condition of individuals (e.g., Trites et al. 2003). Whales in poor body condition have a higher likelihood of mortality, some of which has be linked to abundance of specific Chinook salmon stocks in Puget Sound for two of the three pods (Stewart et al. 2021). Evidence of a correlation between nutritional stress and immune function has been detected in other marine mammal species (Brock et al. 2013; Spitz et al. 2015), consistent with mammalian models, though more data are needed to confirm these links. Furthermore, reproduction requires a large amount of energy during gestation and lactation (McHuron et al. 2023) and could increase need for sufficient prey during the reproductive cycle.

The relationship between SRKW demographic parameters (such as fecundity, survival) and specific Chinook stocks is complex. Existing data may be too limited to produce enough statistical power to detect a statistically significant relationship for models, such as regression analyses, that have been used to quantify relationships between SRKW demographic parameters and changes in Chinook salmon abundance, even if a biologically significant difference exists. In most years, SRKWs experience fewer than five births or deaths; these already small sample sizes are exacerbated by the small (and declining) population, as well as the life history of the species (i.e., long lived individuals with a low number of offspring per reproductive female), and the confounding effects of Chinook salmon abundance. Based on simulations and power analysis (Ward et al. 2020) and described in NMFS (2021e), results indicate that the SRKW demographic data alone would not be expected to provide anything more than weak evidence for or against a significant change related to prey abundance (or any other perturbation). Given SRKW increase their consumption of Chinook salmon in California during periods of prey limitation, wider-ranging distribution, and poor body condition, these stocks are likely important sources of nutrition to prevent further nutritional stress and maintain individual and population health.

Though there are estimates of the metabolic needs of the population of SRKWs that we cite throughout this Opinion (such as (Noren 2011; Chasco et al. 2017); see the Environmental Baseline), these estimates can vary based on several underlying assumptions including the size of the whale population and the caloric density of the salmon. As noted in the baseline, there is also a lack of available information on the whales' foraging efficiency and the abundance or density of salmon required to support SRKW survival and successful reproduction. The whales and prey are both highly mobile and have large ranges with variable overlap seasonally. It is uncertain how other factors in their environment, such as vessel presence, further impacts their foraging efficiency and therefore the amount of prey needed throughout their habitat. Analysis by NMFS (2021d) found that the probability of prey capture for SRKWs increased as prey abundance increased (both Chinook and coho), highlighting that the more prey available may allow for higher likelihood of meeting caloric needs. Even with general estimates of how many Chinook salmon need to be consumed to meet the biological needs of the whales, we do not have any quantitative information on the total amount needed in their environment or the density that is needed for the population to be able to consume sufficient prey to support the population.

The effect of reductions in Chinook salmon abundance is likely a more significant risk to SRKWs at relatively low levels of Chinook abundance and this likely also depends on the status of SRKWs at the time. Past efforts have recognized the likely greater risk to SRKW in low Chinook abundance years (PFMC 2020). Large aggregations of modeled Chinook salmon stocks that reflect abundance on a more coastwide scale have previously appeared to be equally or better correlated with SRKW vital rates than smaller aggregations of Chinook salmon stocks, or specific stocks (see Hilborn et al. 2012; Ward et al. 2013), suggesting sufficient coastwide availability of Chinook salmon from different ESUs is critical to maintain population health. A reduction in prey resources present more risk to SRKWs at lower abundance levels and when the whales have a poor status. Because SRKWs are already stressed due to the cumulative effects of multiple stressors, and the stressors can interact additively or synergistically, any additional stress such as reduced Chinook salmon abundance likely has a greater physiological effect than it would for a healthy population, which may have negative implications for SRKW vital rates and population viability (e.g., NMFS 2017a). Intuitively, at some low Chinook abundance level, the prey available to the whales may not be sufficient to allow for successful foraging leading to adverse effects (such as reduced body condition and growth and/or poor reproductive success). This could affect SRKW survival and fecundity, both directly, as discussed above, or indirectly. For example, insufficient prey could cause whales to draw on fat stores. During periods of fasting or other mobilization of fat stores, high levels of endocrine disrupting contaminants that are stored in marine mammal blubber are transferred into serum (Debier et al. 2012; Peterson et al. 2014; Noren et al. 2024), which can affect reproduction and immune function (de Swart et al. 1996; Ross et al. 1996; Schwacke et al. 2002; Mongillo et al. 2016; Wasser et al. 2017).

In response to a decrease in the amount of available Chinook salmon due to the proposed action, SRKWs may have to search farther for more abundant prey, which could result in whales expending more energy in search of depleted prey resources (NMFS 2021e). The potential increase in energy demand would likely have the same effect on an animal's energy budget as reductions in available energy that would expect from reductions in prey. Energetic costs and changes in behavior (more time spent searching for prey and less time for socialization, reproduction) also mean that there is higher risk to the whales when prey is reduced at smaller spatial scales directly where SRKW are foraging. Low abundance across multiple years may have even greater effect because SRKWs likely require more food consumption during certain life stages. Poor female body condition and energy reserves from long-term prey limitation could potentially affect reproduction and/or result in reproductive failure at multiple stages of reproduction (e.g. failure to ovulate, failure to conceive, or miscarriage, successfully nurse calves, etc.). Good fitness and healthy body condition with sufficient energy stores coupled with stable group cohesion and reproductive opportunities are important for reproductive success.

SRKWs are known to consume other species of fish, including other salmon, particularly in their coastal habitat (Hanson et al. 2021), but the relative energetic value of these species is substantially less than that of Chinook salmon (i.e., Chinook salmon are larger and thus have more energy value). Reduced availability of Chinook salmon would likely increase predation activity on other species, increase energy expenditures in search of Chinook salmon, and/or reduce energy intake. Ford et al. (2006) also report that SRKWs engage in prey sharing about 76% of the time during foraging activities. Prey sharing presumably could distribute more evenly any effects of prey limitation across individuals of the population than would otherwise be the case (i.e., if the most successful foragers did not share with other individuals).

The current status of SRKWs and overall Chinook salmon abundance also factors into the potential severity of effects from reduced prey. Populations with healthy individuals may be less affected by changes to prey abundance than populations with less healthy individuals (i.e., there may be a spectrum of risk based on the status of the whale population). We recognize that prey removals present more risk at lower Chinook salmon abundance levels (coastwide) when the whales have a poor status and/or are otherwise already facing other causes of nutritional stress.

Recent photogrammetry work by Fearnbach et al. (2024) found that body condition has continued to decline in the population. In 2023, 32% of J pod and 40% of L pod were in the poorest body condition (out of five body condition groups); 48 and 67% of J and L pod, respectively, had body conditions below normal. K pod was not sighted for body condition measurements during 2023 but has maintained the highest proportion of individuals with above normal body conditions since 2018, though it is also the smallest pod with the lowest birth rate (only one calf within the last decade). It is also notable that this report cited the lowest recorded detection of SRKW presence in core summer habitats in 2023, in line with other studies noting alteration of habitat use by SRKW (e.g. (Olson et al. 2018; NMFS 2021d; Stewart et al. 2023). Thus, current evidence suggests some degree of prey limitation may already be impacting SRKW health and are likely vulnerable to continued reduction in Chinook salmon prey, particularly during winter and spring when they are may be more prey-limited. Because SRKWs are already stressed due to the cumulative effects of multiple stressors, and the stressors can interact additively or synergistically, any additional stress such as reduced Chinook salmon abundance would likely have a greater physiological effect than it would for a healthy population, which may have negative implications for SRKW vital rates and population viability (e.g., NAS 2017).

2.4.3.3 Proposed Klamath Project Operations Related Impacts of Reduced Prey Base for SRKWs

Here we consider the effects of the proposed action on the SRKW by evaluating prey reduction of unlisted Klamath origin Chinook salmon ESUs caused by the proposed action. 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 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 SRKWs in the southern portions of their coastal range. SRKW typically consume larger fish age 3 or older so any effects of the action would not occur immediately. Mortality of juvenile would translate to an effective loss of adult-equivalent Chinook salmon in each ESU or stock 3 to 5 years after the juvenile mortality occurred (i.e., by the time these juveniles would have grown to be adults and available prey of killer whales). Mortality of adults under the proposed action would translate into a lower number of adult-equivalent Chinook salmon in each ESU or stock 4 to 6 years after the adult mortalities occurred (i.e., by the time the offspring of these adults would have grown to be adults and available prey of killer whales).

The season of the runs primarily impacted by the proposed action may also factor into the effect of the proposed action on SRKW. Klamath River Chinook salmon are largely comprised of the fall-run and, to a much lesser degree, spring-run Chinook salmon. Both spring- and fall-run Chinook stocks in the Klamath River are listed on NMFS Priority Chinook Stocks Report, ranked alongside fall-run Chinook salmon from the Central Valley (National Marine Fisheries Service (NMFS) and Washington Department of Fish and Wildlife (WDFW) 2018). However, individuals returning to spawn in spring where they may overlap with SRKW foraging close to natal streams may be of particular importance given the poor body condition and reduced availability of preferred prey experienced by SRKW throughout their range in spring. As mentioned in Section 2.4.3.1.1.1.1 *Adults*, spring-run, Chinook salmon adults enter the Klamath River from March to July and, though it is the smaller of the two runs, could be a particularly important component of the SRKW diet. The proposed action is more likely to impact fall-run Klamath River Chinook salmon than spring run because spring run fish are not expected to spawn in the mainstem Klamath River in areas affected by the proposed action. NMFS does not anticipate spring-run Chinook spawning to be impacted by the proposed action, which may minimize some of the effects expected for SRKW, but impacts to juvenile rearing and juvenile and adult migration are possible.

The reduced abundance of prey could be detected by all SRKWs during foraging throughout the areas they co-occur with Klamath origin Chinook salmon, leading to increased expenditures of energy during foraging. The expected consequences of significant reductions in the abundance of preferred prey for these SRKWs 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 2.4.3.1.1 *Effects of the Proposed Action on Chinook Salmon Individuals*, SRKWs are expected to be adversely affected 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 cannot quantify the impacts due to the operational effects of the proposed action on Chinook salmon or SRKWs. However, the general, overall qualitative assessment indicates that the conditions for Chinook salmon in the Klamath River as a result of proposed Klamath 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. These prey reductions attributed to the proposed action could cause local depletions of prey in designated critical habitat and potentially affect the ability of the whales to meet their bioenergetic needs resulting in the whales leaving areas in search of more abundant prey. In particular, decreased and limited abundances resulting from the proposed action are expected for fall-run Chinook salmon from the Klamath River, although spring-run Chinook salmon juvenile survival and migration may also be impacted. Several effects of the proposed action are expected to consistently decrease Chinook salmon abundance, especially in drier water years throughout the period of the proposed action. These impacts are expected to affect a number of key fall-run Chinook salmon spawning populations, including Bogus Creek, FCH, 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 SRKWs. These reductions in available prey are most likely to be detected by all members of K and L pod, during foraging on the outer coast, but could also impact J pod where Klamath origin Chinook occur in the north in smaller abundances. Reductions in prey could lead to increased expenditures of energy during foraging and reduced body condition, particularly during seasons where other prey sources are also limited (e.g. late winter and early spring). The expected consequences of reduced abundance of preferred prey for SRKWs are reduced fitness of individual SRKWs through increased energy expended to find sufficient prey and nutritional stress. Based on the general relative analyses that have been described above, SRKW are expected to be at risk of reduced fitness due to decreased Chinook salmon abundance in the ocean resulting from proposed action-related operations

2.4.3.4 Overall Effects of Reduced Prey Base for SRKWs 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 Chinook salmon available in the ocean for SRKWs to forage. Reduced abundance, in a range of magnitudes dependent upon other environmental factors, will extend to the potential return of the 2029 cohort (up to 2032). The result of reduced ocean abundance of Klamath River Chinook salmon over this time period is that SRKWs 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 2.4.2.1.1 *Factors Affecting the Prey of SRKWs in the Action Area*, Chinook salmon from the Klamath River are expected to constitute a sizeable component of the diet of SRKWs in coastal waters within the action area where they overlap, particularly in late winter and spring when the whales are more likely to be prey limited. SRKWs are expected to detect and respond to reduced Klamath River Chinook salmon abundance and a reduced prey field during foraging, likely resulting in SRKWs 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, SRKWs 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 2.4.2.1.1 *Factors Affecting the Prey of SRKWs 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 SRKWs but can occur throughout the entire range of the DPS.

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, including flow variability, when considered with the environmental baseline (e.g. removal of four Klamath dams and their associated reservoirs), that will result in improved conditions through lower disease rates for Chinook populations. 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 amount of reduction of Klamath River Chinook salmon expected within the timeframe of this analysis, the improved baseline conditions for Klamath River Chinook salmon due in part to the renewed availability of hundreds of miles of habitat upstream of the former IGD, and the variable contribution of Klamath Chinook to the available prey for SRKWs across their range on an annual basis, we conclude that the relative magnitude of adverse effects to SRKW resulting from the behavioral changes and nutritional stress that is likely to occur in response to reduced abundance of Klamath River Chinook salmon prey in the ocean would likely be limited in extent.

2.4.3.5 Effects on SRKW Designated Critical Habitat

In addition to the effects to SRKWs discussed above, the proposed action affects critical habitat designated for SRKWs off the United States West Coast. Based on the natural history of SRKW and their habitat needs, we identified three PBFs in designating critical habitat for SRKWs:

- Water quality to support growth and development;
- Prey species of sufficient quantity, quality and availability to support individual growth, reproduction, and development, as well as overall population growth; and
- Passage conditions to allow for migration, resting, and foraging (50 CFR 226.206).

There are no impacts to water quality or passage conditions in the ocean that are likely to occur as a result of the proposed action. As described above, impacts to SRKW prey species are likely to occur. The proposed action has the potential to affect the quantity and availability of prey in designated critical habitat, and our analysis of effects on the designated critical habitat focuses on potential impacts on the prey PBF, which have already been analyzed with respect to the whales themselves. The potential reductions in Chinook salmon as a result of the proposed action in the action area is described in detail in Section 2.4.3.1.1 *Effects of Proposed Action to Chinook Salmon Individuals*.

SRKW Critical Habitat is split into six distinct areas, three of which are off the coast of California: Northern California (Area 4), North Central California (Area 5), and the Monterey Bay area where Klamath River Chinook salmon are estimated to be in higher abundance (Area 6, Figure 3; NMFS 2021c). Each of these areas contains all three PBFs mentioned in Section 2.4.1.3 *SRKW Critical Habitat*, including water quality, passage, and prey. Chinook salmon of 3 years or greater are preferred by SRKW and a primary component of the Prey PBF. Areas 4 and 6 are important foraging areas where prey is the primary PBF. Passage is the primary PBF in Area 5, but the prey PBF is still an essential feature throughout their entire habitat. Fall Chinook ESUs from the Central Valley and Klamath make up over 50% of the ESUs in Area 4 and almost all of the Chinook salmon in Areas 5 and 6 (Shelton et al. 2018). Satellite tag data has found K and L pod using Area 4 from January through April and in Area 5 in January and February (NMFS 2021c). Of 49 opportunistic sightings collected between 1982 and 2016, one was in Area 4 in April, seven were present in Area 5 between January and March as well as in October, and seven occurred in Area 6 between January and March (NMFS 2021c). Acoustic recorders have detected whales in Area 5 off of Fort Bragg and Pt. Reyes in January, February, May, and December (Hanson et al. 2013).

As mentioned above, the Klamath Chinook salmon ESUs are also likely a part of critical habitat in Oregon and Washington to some extent, though likely to a lesser degree. Prey is the primary

PBF in Areas 1 and 2 near Washington and Northern Oregon whereas passage is the primary feature in Area 3 near Central and Southern Oregon, though foraging has been observed in Area 3 and still an essential feature. Chinook present in Area 3 are largely from California and Oregon rivers with a smaller contribution coming from the larger Columbia River. Though Klamath Chinook salmon are expected to be present in lower abundance in Area 3 compared to those farther south, it is notable that the only prey sample collected from SRKW in this area was from the Klamath River (Hanson et al. 2013). Satellite tag data has found K and L pod using Area 3 from January through March (NMFS 2021c). Of 49 opportunistic sightings collected between 1982 and 2016, eight occurred in Area 3 between January and May. Areas 1 and 2 are considered high use areas by SRKW and have a mix of Chinook stocks from California to Canada. Shelton et al. (2018) suggest Areas 1 and 2 have a mix of fish originating in California, Oregon, the Columbia Basin, Puget Sound, and the Strait of Georgia with the largest contributions coming from the Columbia Basin and Puget Sound. Hanson et al. (2021)identified prey remains from Columbia River, Puget Sound, the Central Valley, and the Fraser River in Area 1 and Columbia River and Central Valley in Area 2.

It is difficult to assess how reductions in prey abundance may vary throughout designated critical habitat across the coast of Oregon and California, and we have less confidence in our understanding of where reductions could result in localized depletions within specific areas throughout designated critical habitat. Reductions in local abundance of prey from the proposed action may result in the whales leaving certain critical habitat areas in search of more abundant prey in other areas that are designated critical habitat (or potentially in marine waters outside the range of designated critical habitat). However, generalized estimates of prey reductions throughout the range of designated critical habitats, and/or throughout the range of Klamath Chinook salmon specifically, may not accurately predict reductions in prey available in their foraging hot spots.

As described above, the prey reductions attributed to the proposed action could cause local depletions of prey in designated critical habitat and potentially affect the ability of the whales to meet their bioenergetic needs resulting in the whales leaving areas in search of more abundant prey. This circumstance may be most likely to occur when SRKWs spend time foraging off the coast of Oregon and California during the winter and spring, particularly during years of low Chinook salmon abundance. Although we expect improvements in baseline habitat conditions for Chinook salmon as a result of dam removal, the reduction in flow resulting from the proposed action will serve to delay and lessen those improvements. As a result, we conclude the proposed action is likely to adversely affect the quantity and availability of prey resources (prey PBF) within designated critical habitat. This adverse effect may not occur every year and the risk of this effect could be influenced by the relative abundance of other Chinook salmon resources in other coastal marine waters. However, we also assume there could be some years with a reduction in Chinook salmon that enter the ocean and subsequently become potential prey two years later. These years could lead to reduced fitness of individual SRKWs through increased energy expended to find sufficient prey and nutritional stress. As a result, we conclude that adverse effects to the prey PBF of designated critical habitat where Klamath Chinook salmon are found could occur during this time period, although adverse effects to designated critical habitat are not expected throughout the entire period, as during some hydrologic conditions the proposed action will benefit Chinook salmon populations. Thus, the overall effects to the prey PBF of designated critical habitat off the coast of Oregon and California will include adverse effects but not in all years, with likely improvement in the number of Klamath Chinook prey available to SRKW as Chinook repopulate the area upstream of the former IGD.

2.4.4 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 earlier Section 2.4.2 *Environmental Baseline*.

Some pertinent cumulative effects that relate to the proposed action are described above in Section 2.3.4 *Cumulative Effects* for SONCC coho salmon. Cumulative effects on Klamath River basin Chinook salmon in the freshwater environment are likely to be similar to those described for SONCC coho salmon because, as noted earlier, Chinook and coho share similar life histories and are thus likely to be affected by cumulative effects in similar ways. While many of the cumulative effects expected to affect coho salmon will also be relevant to Chinook salmon, there are some important differences between the species that need to be considered. First, Chinook salmon and coho salmon exhibit some differences in life history. For example, coho salmon juveniles almost exclusively spend one or more years in fresh water before emigrating to the ocean, while Klamath Basin Chinook salmon predominantly smoltify and emigrate soon after emergence. The impact of these life history differences between Chinook and coho salmon is minor, as they have similar freshwater habitat requirements for spawning, egg incubation, and rearing, so threats for one species are generally likely to be threats for the other. However, one important difference between the two species that is relevant to the effects of the proposed action is that Chinook salmon are expected to migrate significantly farther upstream coho salmon. Chinook salmon are expected to repopulate over 303 miles of habitat upstream of the former IGD, while coho salmon are expected to repopulate up to Spencer Creek, ~76 river miles of habitat upstream of the former IGD. NMFS coordinated with USFWS regarding activities that were reasonably certain to occur in the areas above Spencer Creek that would impact Chinook salmon future habitat, but not coho salmon, and did not identify activities, including non-federal actions, that were likely to have an impact on Chinook salmon. There may be future activities authorized, funded, or carried out by Federal agencies in the area above Spencer Creek (e.g., restoration actions) that could impact Chinook salmon, but those would require additional ESA Section 7 consultation.

In addition, ODFW and Klamath Tribes (2021) have prepared an Implementation Plan for the Reintroduction of Anadromous Fishes into the Oregon Portion of the Upper Klamath Basin that includes active reintroduction (outplanting of hatchery juveniles into areas above the dams) of spring-run Chinook salmon into the Oregon portion of the basin, which is expected to jumpstart repopulation by Chinook salmon. The Reintroduction Studies Phase (Phase 1) of the active reintroduction effort has already been initiated in 2022 with the annual release of both PIT tagged and radio tagged juvenile spring-run Chinook salmon in tributaries of Upper Klamath Lake, and at locations between Keno and Link dams (Tallman 2023). Phase 2 (Repopulation Phase) will build on the results of Phase 1 to use the most effective methods, extent, and intensity of transplantation required to repopulate habitat above Upper Klamath Lake, and is reasonably certain to occur. The addition of new spring-run Chinook salmon populations in the Klamath Basin would represent an improvement in the availability of Chinook salmon prey resources for SRKWs. In addition to the general increase in the abundance of Chinook salmon that new populations could bring, we recognize the spring-run Chinook salmon that are aggregating to return or distributed along the coast during the winter and spring could provide enhanced resources of prey when SRKWs are most likely to be within the action area. This also coincides with the time of year that prey resources are believed to be most limited (NMFS and WDFW 2018).

Many of effects associated with activities that have occurred in the recent past that have affected the status and environmental baseline of SRKWs as described in Section 2.4.1 *Rangewide Status of the Species* and 2.4.2 *Environmental Baseline*, are expected to continue in the future and contribute to adverse cumulative effects on SRKWs. These are considered reasonably certain to occur in the future because they occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Tribal, Canadian, state and local government actions will likely be in the form of legislation, shoreline growth management, administrative rules, or policy initiatives and fishing permits. These actions may include changes in state ocean policy and increases and decreases in the types of activities currently seen in the action area, including changes in the types of state fishing activities, resource extraction, or state designation of marine protected areas, any of which could impact SRKWs or their designated critical habitat. For example, Washington State will be increasing the buffer distance around SRKWs to 1,000 yards for all vessels as of 2025. Government actions are subject to political, legislative and fiscal uncertainties. Private activities are primarily associated with other commercial and sport fisheries, construction, dredging and dredge material disposal, vessel traffic and sound, alternative energy development, offshore aquaculture/mariculture, and marine pollution. Although these factors are ongoing and reasonably certain to continue in the future to some extent, the extent that these factors will continue and the magnitude of their effects depends on whether there are economic, administrative, and legal impediments (or in the case of contaminants, safeguards). Therefore, while it is difficult to precisely assess the cumulative impacts and the relative importance of these effects, and given the types of effects, NMFS assumes the environmental baseline provides the best available information characterizing the type and magnitude of the effects these activities may be expected to have in the action area in the future during this proposed action. Most of these factors represent long running and/or ongoing human activities actions or natural processes that do not have expected or known timelines for when changes will occur.

Numerous non-federal NMFS partners will continue to implement targeted management actions identified in the SRKW recovery plan (NMFS 2008c) informed by research. Actions by non-federal activities surrounding implementation of the SRKW recovery plan that are ongoing or expected to occur are described in the most recent five-year review (NMFS 2021d).

Additional activities that may occur in the coastal waters off Vancouver Island, Washington, Oregon, and California will likely consist of state or local government actions related to ocean use policy and management of public resources, such as changes to or additional fishing or energy development projects. Changes in ocean use policies as a result of non-federal government action are highly uncertain and may be subject to sudden changes as political and financial situations develop. Examples of changes to or additional actions that may occur include: development of aquaculture projects; changes to state fisheries which may alter fishing patterns; installation of hydrokinetic projects near areas where SRKWs are known to occur; designation or modification of marine protected areas that include habitat or resources that are known to affect marine mammals in general; and coastal development which may alter patterns of shipping or boating traffic. However, none of these potential state, local, or private actions, can be anticipated with any reasonable certainty in the action area at this time, and most of those described as examples would likely involve federal involvement of some type given the federal government's role in regulating activity in the ocean across numerous agencies and activities.

In summary, 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 SRKW, or have other effects on their survival and recovery. It is likely that Section 2.4.1 *Rangewide Status of the Species* and Section 2.4.2 *Environmental Baseline* characterize the type and magnitude of the effects these factors may be expected to have in the future during this proposed action.

2.4.5 Integration and Synthesis for SRKWs

This section is the final step in assessing the risk that the proposed action poses to species and critical habitat. In this section, we add the *Effects of the Action* (Section 2.4.3) to the *Environmental Baseline* (Section 2.4.2) and the *Cumulative Effects* (Section 2.4.4), taking into account the *Rangewide status of the Species* (Section 2.4.1) and *SRKW Critical Habitat* (Section 2.4.1.3), to formulate the agency's Opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

As described in Section 2.4.3 *Effects of the Action*, our analysis of effects to SRKWs 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 SRKWs and ultimately the survival and reproduction of SRKWs.

The SRKW population is made up of three pods (J, K, and L); two of which (K and L) are more likely to occur in coastal waters off California and Oregon times during the winter and spring. Over the last five decades, the SRKW population has generally remained at a similarly low population size of about 80 to 90 individuals, and currently consists of 73 individuals. According to the most recent data available, J pod has about 25 members, K pod has 15 members, and L pod has 33 members. Chinook salmon have been confirmed to be the preferred prey of SRKWs, and both the survival and fecundity of SRKWs have previously been linked to the abundance of Chinook salmon that may be available for them as prey. The exact relationship between prey availability and vital rates in a multiple stressor context is still unclear given it is also possible for stressors that are a part of the *Environmental Baseline* (Section 2.4.2) to impact survival and reproduction in mammals. For example, it is likely that the accumulation of pollutants in SRKWs through consuming Chinook salmon presents a significant risk of decreased fitness, and nutritional stress may increase the impact of contaminant load on SRKW health though mobilization of compounds stored in blubber. 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, though the link between Chinook salmon and reproductive success has become less clear over time. Other signs of poor health (peanut head) have been observed in a number of individuals as well. Recent observations of poor body condition throughout much of the population, along with limited reproductive success in recent years, are possible indications that nutritional stress may already be occurring in the population. Whales in poor body condition have a higher likelihood of mortality, some of which has be linked to abundance of specific Chinook salmon stocks in Puget Sound for two of the three pods.

Currently, the abundance of Chinook salmon in the action area is limited by numerous major influences on the fresh water environment, including ongoing Klamath Project operations and climate change. The harvest of Chinook salmon in the ocean also reduces the abundance of prey for SRKWs. It is also likely that the accumulation of pollutants in SRKWs 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 SRKW population over time, but the relatively small SRKW population size and limited reproductive success in recent years remains the primary source of concern for this species.

Based on the analysis in Section 2.4.3 *Effects of the Action,* NMFS expects that the proposed action will reduce the amount of Klamath River Chinook salmon available in the ocean for SRKWs to forage throughout the duration of the effects of the proposed action, extending as far as 2033[27] by the time most of the juvenile Chinook production five 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. 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 this will likely result in 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, SRKWs 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 SRKWs. More recent annual aerial surveys of the population have provided evidence of a general decline in SRKW body condition since 2008, and documented members of J pod being in poorer body condition in May compared to September. 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 2.4.3 *Effects of the Action,* the overlap in distribution of SRKWs and Klamath Chinook salmon occurs throughout the SRKW range but are most likely when SRKW

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[27] Effects for SRKW extending up to 2033 are based on a five-year action beginning in 2024, with most Chinook salmon leaving the ocean by age 4.

are 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, SRKWs 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 Klamath 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. It is also important to consider that any Chinook reductions resulting from this action would likely be small relative to the amount of total Chinook available to SRKW in the ocean. In addition, as discussed in Section 2.4.2 *Environmental Baseline*, conditions for Chinook salmon in the Klamath Basin are expected to improve as a result of Klamath dam removal and other habitat restoration efforts. Further, active reintroduction of spring-run Chinook salmon is expected to increase the abundance of Klamath origin spring-run Chinook salmon in the ocean to be prey for SRKW. Factoring in the status of the species, environmental baseline, and cumulative effects, NMFS concludes the proposed action would not be expected to jeopardize the continued existence of the SRKW DPS or destroy or adversely modify their designated critical habitat.

2.5 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, and the cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of the SRKW DPS, or destroy or adversely modify their designated critical habitat.

2.6 Incidental Take Statement

Section 9 of the ESA and federal regulations pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Harass" is further defined by interim guidance as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and Section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

2.6.1 Amount or Extent of Take

In this 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 DO concentrations, and decreased smolt outmigration rates due to the reduced overall volume of spring flows in the mainstem Klamath River. Also, NMFS anticipates the proposed action will result in incidental take in the form of harm to SRKW individuals through reduction in prey availability and impairment of foraging behavior as described in Section 2.6.1.2 *Incidental Take Summary for SRKW.*

Quantifying the amount or extent of incidental take of coho salmon in the mainstem Klamath River is difficult since the Klamath Project's primary mechanism for affecting coho salmon is through hydrologic changes to the Klamath River discharge at Keno Dam due to the proposed action storing and delivering Klamath 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 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. The proposed action's reduction of spring flows in the mainstem Klamath River is likely to increase water temperatures in the spring in the mainstem between Keno Dam and the Scott River. 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. As a result of the proposed action, coho salmon are likely to continue to have a decreased outmigration rate, which will increase likelihood of decreased growth or increased mortality when environmental conditions are conducive to having increased stressors, such as warmer water temperatures and disease proliferation.

Because habitat reductions, elevated water temperatures, reductions to DO 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. Given that Keno Dam is the new compliance point for Klamath

River flows under the proposed action, NMFS uses the calculated daily average Keno Release Target flows as surrogates for the amount or extent of incidental take to coho salmon as a result of the effects. As described in the proposed action Section 1.3.2.1.4 *Releases from Keno Dam to the Klamath River*, this includes periods when the daily RBFS (i.e., Keno Dam minimum flows) (Figure 46) are being released, when calculated daily average Keno Release Targets above the Keno Base (Keno base x Keno Release Multiplier) are prescribed/required, and when the entire FFA volume is being released as pulse flows or augmentation, above the calculated daily average Keno Release Target flows.

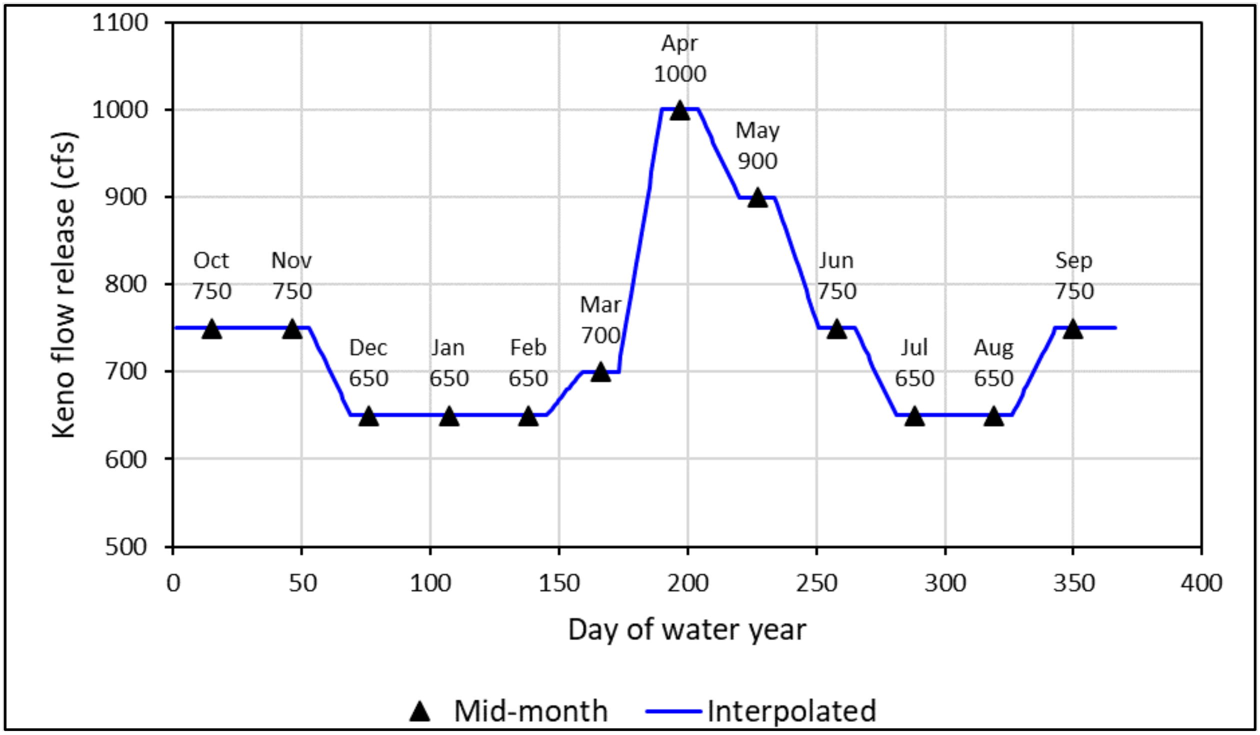

Figure 46. RBFs specified for 15 days centered on the fifteenth day of each month, with daily flows linearly interpolated between these periods

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 daily average RBFs (i.e. Keno Dam minimum flows) as shown in Figure 46[28] shall be met or exceeded; (2) the calculated daily average Keno Release Target flows (above the daily average Keno River Base Flows shall be met or exceeded; and (3) the entire FFA volume is released as a pulse flow or augmentation, above the calculated daily average Keno Release Target flows. If any of these thresholds are not met, beyond the previously-described maximum reduction of 5% below the daily required Keno Release Target flows, which are not to exceed 48 hours in duration, and the noted minor variations in ramp rates, the amount or extent of incidental take of coho salmon will be considered exceeded.

In this Opinion, NMFS identifies the proposed action's contribution to increasing disease-related harm and mortality to coho fry and juveniles from *C. shasta* infection through impaired growth,

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[28] NMFS recognizes that minor variations in ramp rates (within 10% of targets) may occur for short durations.

swimming performance, and body condition, and increased stress and susceptibility to secondary infections. Limited data exist or are expected to be available on juvenile coho salmon fitness in relation to this disease-related harm and mortality, and NMFS cannot specifically quantify the amount or extent of incidental take associated with disease related impediments to fitness. Therefore, NMFS is using the prevalence of mortality (POM) of coho salmon as a surrogate for disease related mortality from *C. shasta* infection (Som et al. 2019).

The Arcata USFWS office (AFWO) has developed a model (USFWS POM model) that estimates the POM, defined as the predicted proportion of a spring/early summer outmigrating population of juvenile fish that suffer *C. shasta* induced mortality (Som et al. 2019). NMFS considers this to be the best scientific data available regarding disease related mortality of coho salmon in the Klamath River. Based on the results of this model (Table 38), and as discussed in the SONCC coho salmon Section 2.3.3 *Effects of the Action*, NMFS concluded that the proposed action will likely result in disease related harm and mortality to coho salmon fry and juveniles that are lower than those observed during recent POR conditions, and as such, we conclude that the incidental take of coho salmon fry and juveniles will be not be higher than those observed during the most recent 10 years. Results from the preliminary USFWS POM model indicate 2014 as the year of highest POM during the recent period, with a Shasta River coho salmon POM of 0.41 (Som et al. 2019) (Table 38). Therefore, the amount or extent of incidental take of coho salmon as a result of the proposed action's contribution to *C. shasta* related harm and mortality will be considered exceeded if annual Shasta River coho salmon POM exceeds 0.41 (41%, see Table 38). 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 POM of age-0 and age-1 coho salmon in the mainstem Klamath River emigrating from the Shasta River.

Year	POM	Reference
2014	0.413	(Som et al. 2019)
2015	0.263	
2016	0.092	
2017*	NA	-
2018*	NA	-
2019	0	(Som 2019)
2020	0.118	(USFWS 2021)
2021	0.12	(USFWS 2022a)
2022	0.03	(USFWS 2023)
2023**	0.01	(USFWS 2024)

Notes:
*Model runs for 2017 and 2018 are not currently available, but factors influence disease conditions (i.e. temperature, spore concentration) during these years were relatively low.

** 2023 model runs were only for age-1 coho because CDFW was unable to generate abundance estimates for age-0 fish via trap efficiency trials due to low anticipated overall abundances. Relative to historic years, the overall concentration of infectious spores specific to coho Salmon (commonly called Type-II) was relatively low in 2023, but detectable levels of infectious spores reached 7 spores/liter during the observed peak in age-0 emigration timing. Hence, it would be expected that the true POM for age-0 fish was higher in 2023 than that estimated for age-1 fish (USFWS 2024).

2.6.1.1 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	Juvenile	March to June	Keno Dam to Salmon River	Harm	Flow surrogate*
Increased risk of disease (*C. shasta*)	Juvenile	April through June	Keno Dam to Orleans	Harm	In addition to the flow surrogates described above, measured by a surrogate of up to 49 percent (via AFWO evaluation of POM) of the total annual juvenile coho salmon outmigrating from the Shasta River.
Elevated water temperature	Juvenile	May to mid-June	Keno Dam to Scott River	Harm	Flow surrogate*
DO reduction	Juvenile	May to mid- June	Keno Dam to Scott River	Harm	
Decreased outmigration rates	Smolts	April to June	Keno Dam to Shasta River	Harm	

Notes:
*Measured by flow surrogates described above as: 1) the daily average Keno RBFs (i.e. Keno Dam minimum flows) as shown in Figure 46 shall be met or exceeded; 2) the calculated daily average Keno Release Target flows (above the daily average Keno River Base Flows shall be met or exceeded; and 3) the entire FFA volume is released as a pulse flow or augmentation, above the calculated daily average Keno Release Target flows.

2.6.1.2 Incidental Take Summary for SRKW

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 a limited level of harm to SRKW, particularly members of K and L pod (currently 48 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 direct relationships between the effects of the proposed action and individual SRKW health. Because we cannot express the amount or extent of anticipated take or monitor take-related impacts in terms of individual SRKWs, we will rely on surrogates of the amount or extent of incidental take of SRKW as a result of the proposed action as follows: 1) the flow surrogates used in Section 2.6.1.1 *Incidental Take Summary for Coho Salmon*, and 2) the impact of infection rates and disease mortality on juvenile survival of Klamath River Chinook salmon.

Although Chinook salmon and coho salmon exhibit some differences in life history, the impact of these life history differences is minor with regard to how these species are affected by changes in flows. Recognizing that Chinook salmon are expected to migrate upstream of Keno Dam, the two species have similar freshwater habitat requirements for spawning, egg incubation, and rearing, so threats for one species generally to be threats for the other. As we cannot quantify the total extent of Klamath River Chinook salmon productivity that is lost or is limited by the proposed action, we use the same measures of flow already used as surrogates of incidental take to coho salmon to describe the extent of impacts to Chinook salmon that have been analyzed in this Opinion. Therefore, these flow thresholds also serve as the extent of impacts to Chinook salmon (and ultimately extent of take to SRKW) 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 SRKW as a result of the proposed action. This threshold is quantifiable, 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.

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 Sections 2.4.3.1.1 *Effects of the Proposed Action on Chinook Salmon Individuals*, that relied upon results anticipated by the S3 models. The benefits of the flow variability incorporated into the proposed action 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.

For juvenile Chinook salmon, we use an estimated prevalence of *C. shasta* infection rate at the Kinsman trapping location in the Klamath River as an indicator for monitoring the disease related effects of the proposed action on Chinook salmon, and ultimately on SRKW. We apply the conservative assumption described in USGS (2019) that defines all infected juveniles will subsequently die. Therefore, prevalence of infection for these model results is equivalent to POM. S3 model results indicated that the POM for naturally produced juvenile Chinook salmon surviving to the Kinsman trap location that originate from spawning in the mainstem and utilize upper Klamath tributaries (i.e., Klamath River, Bogus Creek, Shasta River) have not exceeded a POM of 0.45 (45%; see Table 40) during the most recent 10 years. By extension from these results, we expect that the POM for naturally produced juvenile Chinook salmon surviving to the Kinsman trap location that originate from spawning in the mainstem and upper Klamath tributaries will not exceed 45 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 SRKW 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. Modeled prevalence of infection/POM of natural-origin juvenile Chinook salmon (Klamath River, Bogus Creek, Shasta River) at Kinsman trap location.

Migration year	**POI**	**Reference**
2014	0.41	(USGS 2019)
2015	0.15	
2016	0.20	
2017*	NA	
2018*	NA	-
2019	0.23	(USGS 2020)
2020	0.35	(USGS 2021)
2021	0.45	(USGS 2022a)
2022	0.31	(USGS 2023)
2023	0.17	(USGS 2024)

Notes:
*Model runs for 2017 and 2018 are not currently available, but factors influence disease conditions (i.e. temperature, spore concentration) during these years were relatively low.

2.6.2 Effect of the Take

In this 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.

2.6.3 Reasonable and Prudent Measures

"Reasonable and prudent measures" refer to those actions the Director considers necessary or appropriate to minimize the impact of the incidental take on the species (50 CFR 402.02).

RPM 1. Reclamation shall take necessary and appropriate actions within its authorities to minimize take of coho salmon and SRKW 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 Klamath 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, including monitoring to track our assumptions regarding the impacts of the proposed action under recently changed conditions (i.e. connection of Agency-Barnes Lake, species range expansion and habitat changes following dam removal).

2.6.4 Terms and Conditions

In order to be exempt from the prohibitions of Section 9 of the ESA, the federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. 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.

2.6.4.1 The Following Terms and Conditions Implement RPM 1:

1A. Monitor and ensure Klamath Project operations do not deviate from the Klamath Basin Planning Model (KRM version)

Reclamation shall monitor and ensure that Klamath Project operations do not deviate from the rules and parameter settings from the PA's KRM run titled, "Viewer_v11d for MST11b_Draft PA_Jan26." This includes, but is not limited to, ensuring operational adherence to the following specific model outputs**:**

1. Daily River Base Flow (RBF) for Keno Dam releases (Keno Dam minimum flows)
2. Daily Upper Klamath Lake (UKL) Status;
3. Daily and Seasonal Normalized Wetness Index (NWI);
4. Daily Operations Index;
5. Daily Keno Release Target calculations;
6. Project Supply calculations; and
7. Tule Lake and Lower Klamath National Wildlife Refuge water supply.

Reclamation will monitor compliance with these key model outputs, ensuring that operations remain within the modeled parameters and commensurate with observed previous years' and current year hydrologic conditions in any given water year consistent with the proposed action. Reclamation will provide documentation of such compliance to the USFWS and NMFS as requested, but not less than annually. If Reclamation anticipates that operations will deviate or if operations have deviated from any of these model outputs, Reclamation will notify the USFWS and NMFS immediately. The incidental take expected and analyzed in this Opinion reflects the Keno Release Model operations; thus, operations that result in deviations from the model's rules, parameter settings, or outputs could result in changes to flows, lake elevations, or other physical conditions and cause more take than has been analyzed. If the USFWS and NMFS determine that these deviations change the Project operations analyzed in our effects analysis, Reclamation shall reinitiate consultation. Until consultation is complete, Reclamation will take any necessary interim measures, as recommended by the USFWS and NMFS, to minimize incidental take.

1B. Release of the FFA volume to minimize the impact of take to SONCC coho salmon

In all years, Reclamation shall release to the Klamath River the entire FFA volume (determined by the proposed action and modeling results) as a pulse flow unless NMFS determines that a pulse flow is not needed to minimize the impact of take in a given year. In the event that the entire FFA volume is not released during implementation of a pulse flow, Reclamation will follow NMFS' advice regarding release of the remaining FFA volume to augment Klamath River flows in a manner that minimizes the impact of take. This will ensure that the entire FFA is used in a manner that minimizes the impact of take.

1C. Implement target ramp down rates

Reclamation will implement the proposed target ramp down rates at Keno at all times unless Reclamation is physically unable to do so due to an extraordinary hydrologic event (i.e., flooding). Additionally, Reclamation will coordinate with NMFS regarding any flexibility regarding ramp down rates.

1D. Minimize the impact of take associated with Deferred Project Supply

When determining the availability of Deferred Project Supply and before making any allocations of such supply, Reclamation shall coordinate with NMFS to ensure that the determination appropriately considers Section 7 statutory requirements have been satisfied so that the impacts of take will be minimized. Reclamation will provide a description (including monitoring and reporting) of how taking measures to maximize Deferred Project Supply ensures the modeled outcomes in the Klamath River and UKL are realized.

1E. Minimize the impact of take associated with Annual Drought Planning

The Annual Drought Plan will not re-allocate water to UKL, NWRs, or the Klamath River contrary to the KRM proposed action run; the Annual Drought Plan only applies to how Reclamation intends to allocate the Project Supply, calculated according to the proposed action, among the various entities and Klamath Project water users with different contractual priorities.

1F. 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 and coho salmon emigration period to estimate the abundance of outmigrant juvenile salmon at three locations on the Klamath River. These sites include from upstream-most to downstream-most, 1) a location to be determined upstream of the former IGD site, near the former location of Copco 1 dam, 2) Former IGD site, 3) Kinsman site located just upstream of the Scott River confluence, and 4) Mainstem Klamath River at Weitchpec above the confluence with the Trinity River. Mark-recapture experiments are 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 for both Chinook and coho salmon.

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 Klamath River, with emphasis on determining the effects of pulse flow releases under the proposed action and updating data. This includes funding the rotary screw traps and frame nets described above. 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.

1G. In the event of funding lapses, fund the monitoring and reporting requirements of CDFW Shasta River Rotary Screw Trap

The Shasta Rotary Screw Trap is an essential monitoring component of the 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 ITS for this Opinion. Similarly, additional traps are needed to evaluate impacts in the Keno Dam to Iron Gate reach post dam removal. ODFW will operate a Rotary Screw Trap at Spencer Creek that will fulfill this need and allow weekly estimates of coho salmon leaving which can be used in the S3 model to estimate impacts to smolt in the Keno Dam to Iron Gate reach. CDFW currently funds and operates the Shasta River Rotary Screw Trap while ODFW funds and operates the Spencer Creek trap. However, funding is not secured in future years and may lapse. Therefore, Reclamation shall coordinate with CDFW and ODFW to determine whether they will continue to fund and operate the trap after 2024. In the event that CDFW or ODFW will not continue to fund and operate the trap from 2025 through 2030, 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.

1H. 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 is very sensitive to spore concentrations and includes a spore concentration model that can be used to evaluate how different management or environmental conditions might lead to altered spore concentrations. This model included IGH infections rates and should be updated with similar measures from the FCH produced fish. 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.* Therefore, Reclamation shall coordinate with USGS and ensure funding is available for the necessary S3 model updates.

Reclamation's Klamath Project water management in the Klamath River has included water releases in the form of a pulse flow from Keno Dam intended to mobilize and transport sediment and 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 reductions in disease risk as a response to flow releases from Keno as well as the relative effect of pulse flow releases. 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) scenario model runs to evaluate the effect of in-season disease triggers on simulated prevalence of infection and mortality and (2) updated monitoring data (post dam removal) to provide new and support existing inputs to the S3 model. These data include:

- Spawner escapement estimates and distribution data collected at mainstem Klamath River locations below Keno Dam by USFWS.
- Spawner escapement estimates upstream of LRD estimated through use of a counting facility installed at LRD (e.g., video or sonar) and consistent with that described in the Implementation Plan for the Reintroduction of Anadromous Fishes Into the Upper Klamath Basin (ODFW and Klamath Tribes 2021).
- POM estimates. Specifically, juvenile coho and Chinook salmon collection and processing for *C. shasta* infection at juvenile monitoring sites completed by USFWS that are completed by Karuk and Yurok Tribes and Oregon State University.
- Juvenile productivity estimates by reach. These data will be collected by USFWS using outmigrant traps at key locations such as Copco, Interstate 5, Kinsman, and Weitchpec.
- 2-D hydrodynamic modeling for three sites under development by USFWS identified as J.C Boyle, Copco No. 1, and Copco No. 2, and remodeling downstream sites identified as Community Center, Beaver Creek, and Trees of Heaven that were completed over ten years prior to dam removal.

1I. 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 outmigrating coho salmon in the Klamath River will increase the understanding of the level of disease-related mortality of coho salmon as a result of the proposed action. This model estimates coho mortality as a function of exposure duration, water temperature, and spore concentration (Type II spores). Using appropriate statistical models (e.g., Bayesian hierarchical Cormack-Jolley-Seber model) can account for the impacts of physical variables on fish survival and migration rates, account for imperfect detection that is afforded via the multiple telemetry stations implemented in survival studies, and integrate those data that are missing for non-detected fish to provide population-levels estimates of disease risk.

Additional methods are needed to update the model. An analysis of tagging data will provide new information about disease mortality for free-ranging fish instead of sentinel lab experiments. The analysis would help confirm or modify models based on sentinel studies and lead to new insights about in-situ mortality in the wild. Similarly, additional analysis of telemetry data, inclusive of new sites established in Oregon by ODFW, will refine and update the model. Therefore, Reclamation shall fund appropriate analysis of PIT tag and telemetry data to refine and update models that estimate coho salmon mortality. These efforts will better assess the effects of *C. shasta* spore concentrations on the survival of actively migrating coho salmon in the Klamath River. Reclamation shall provide results of that modeling to NMFS.

2.6.4.2 The Following Terms and Conditions Implement RPM 2:

2A. Annual identification and installation of needed water-level and flow- measurement gages in the Klamath Project

Reclamation shall continue to consult annually with Service hydrologists, biologists, and other appropriate agencies (e.g., USGS, OWRD, and irrigation districts) to assess the need for additional or replacement gages in the Klamath Project area. If additional or replacement gages are deemed necessary, Reclamation shall take appropriate actions to acquire and install the gages and incorporate them into the QA/QC network as quickly as possible. An annual summary of progress on identification and installation of necessary gages shall be included in the *Annual Monitoring Report* due every March 1, beginning March 1, 2026.

2B. Klamath Project operations updates

Reclamation shall maintain the operations spreadsheets used to implement the proposed action. The spreadsheet(s) translate the code in the KRM and the detailed written description of the proposed action provided in Appendix C of Reclamation's BA (Reclamation 2024a) into an operations spreadsheet(s). The operations spreadsheet(s) bring together the input data (e.g., UKL net inflow, UKL elevations, Operation Indices), equations (e.g., seasonal water supply allocations, NWI), and forecasts (e.g., UKL lake elevation, expected flow volumes) that Reclamation uses on a daily basis to implement the proposed action. Reclamation shall provide the Services with the proposed action implementation and operation spreadsheet(s) upon request by the Services. Reclamation shall provide updates to the Service within two weeks of Reclamation's acceptance and use of an updated operations spreadsheet(s). Reclamation shall support the Services' use of the spreadsheet. Any deviation from the NWI-based forecasts used in the proposed action KRM run must be consistent with the effects analyzed in this Opinion, and approved by the Services.

2C. Klamath Project implementation and hydrologic monitoring

Reclamation shall undertake appropriate hydrologic monitoring in Klamath Project reservoirs and canals because accurate monitoring of water levels in Klamath Project reservoirs and flows through Klamath Project facilities is fundamental to our understanding of the effects of the proposed action and amount of take of SONCC coho salmon.

Required hydrologic monitoring includes the following:

Klamath Basin Planning Model

Reclamation shall use the WRIMS 2.0 software platform for the annual updates during the duration of this Opinion. Reclamation may update the software to new versions as they are published and verified, and Reclamation shall inform the Services prior to doing so. The potential use of software other than WRIMS will be evaluated in coordination with the Services.

Monitor and Maintain Water-Level and Flow-Measurement Gages throughout the Project

Water level and flow measurement gages shall be maintained throughout the Klamath Project. All hydrologic data, including water levels in Klamath Project reservoirs shall be monitored at frequent intervals, at least daily, and Reclamation shall make all collected data available to the Services via a secure website or other appropriate means. An annual summary of reservoir water level and flow-monitoring compliance shall be included in the Annual Monitoring Report due March 1 every year.

Accurate hydrologic data are needed to calculate Klamath Project water use and effects on SONCC coho salmon and ensure compliance with this ITS. Monitoring shall be conducted at the following locations, and the list shall be evaluated annually and could include additional monitoring if needed.

Flow Measurement:

- A Canal
- Lost River to LRDC at Lost River Diversion
- 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)
- North Canal
- KSD at State Line and at pumps F/FF
- LRD
- Keno Dam
- West Side Power Canal at LRD
- Station 48
- Miller Hill Pumping Plant, including spill from the pumping plant
- Anderson Rose Dam
- J Canal Diversions
- D Plant
- Klamath River below the former J.C Powerplant, near Keno

- Klamath River above Fall Creek near Copco
- Iron Gate

Water Level:

- UKL, Clear Lake, Gerber Reservoir
- Tule Lake Sump 1A and 1B
- Lower Klamath Unit 2

2D. Monitor Keno Impoundment and UKL Klamath Project-related diversions

Reclamation shall monitor Klamath 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 Klamath Project-related diversions helps ensure that the diversion volumes are consistent with what was modeled in the KRM for the POR and will provide NMFS with more certainty regarding KRM output, specifically Keno Dam flows, Klamath Project deliveries and UKL elevations. More certainty in water allocations will help improve the KRM 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.

2E. 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 March 1, 2025, provide the Services a final Implementation Plan that addresses the Services’ comments by June 1, 2025, 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.

2F. 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. The first Annual Monitoring Report shall be due March 1, 2026. Development of an annual monitoring report will ensure collection and dissemination of Project operations information and report on compliance with incidental take surrogates for listed species described in the Incidental Take Statement. 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 (LRD to Keno Dam) and all measured and estimated accretion data (Keno Dam to former IGD) in addition to all of the Keno Release Target flows, FFA volumes and releases, Project Supply and Refuge delivery information.
2. Reclamation shall provide rolling monthly and annual graphs of the observed Keno Release Target flows versus what the modeled Keno Release Target flows would have been for the given time period.
3. Reclamation will provide an annual report on any instream construction work that occurs at Keno Dam or points of diversion (e.g., fish screen monitoring, maintenance, or investigations). The monitoring report shall include available information on the total number of coho and Chinook salmon captured, relocated, injured, or killed during such work, 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 and Chinook 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.

4. Reclamation shall fund an updated habitat availability study to determine the flow/habitat relationship, post dam removal. This updated study should include the reach between Keno Dam and the former IGD site so that it's inclusive of the newly occupied reaches.
5. Reclamation shall fund an updated sediment transport study to determine the relationship between flows and sediment mobilization and transport, post-dam removal in the mainstem Klamath River from Keno Dam to the confluence of the Scott River. The relationship between flows and streambed mobility/transport is important to identify flow rate thresholds necessary to reduce annelid worm prevalence and minimize disease risk.

6. Reclamation shall provide an annual report that records the frequency and duration of geomorphic flow events at Keno Dam and the former IGD under the new baseline condition. This report will better determine the impacts of the proposed action under changed conditions such as ABL connection and dam removal.
7. Reclamation shall provide an annual report summarizing water temperature and dissolved oxygen downstream of Keno Dam to Orleans and utilizes the updated RBM10 model to determine the influence of Keno Dam flow releases on these parameters.
8. Reclamation shall provide an annual report summarizing water quality monitoring data downstream of Keno Dam. The report shall include monitoring data collected for temperature, dissolved oxygen, and pH, and nutrients during implementation of return flows from KSD (F/FF pumps on). The monitoring and reporting should identify and distinguish when and where the return flows are coming from (i.e., KDD Ag lands, Lower Klamath NWR, Lost River, etc.).
9. Reclamation shall provide an annual report or reports describing the results of S3 model runs for POM (coho salmon) and POI (Chinook salmon) as described in Section 2.6.1 *Amount or Extent of Take*.

2G. Adaptive Management and Monitoring

Reclamation shall commit to technical and financial support of the Services' priority Adaptive Management and Monitoring (AMM) actions, in coordination with the Services and under Service personnel oversight and leadership, where determined appropriate. NMFS' priority AMM actions include monitoring of salmonid repopulation and habitat utilization in the Klamath River, including newly reconnected Klamath River and tributary reaches, and in the upper Klamath Basin, including entrainment into Klamath Project facilities. Detailed descriptions of these monitoring priorities can be found in Terms and Conditions 1F, 1G, 1H, 1I, and 1J.

These AMM priorities will inform Reclamation's SDM process and will be undertaken in addition to other ongoing fish species and habitat monitoring activities and where necessary, may supersede those other activities. Reclamation will coordinate closely with the Services and other federal, state, and Tribal partners to prioritize these actions.

2H. Monitor Klamath Project facilities for entrainment

Reclamation describes O&M activities at their facilities, using the assumption that coho and Chinook salmon exposure will be rare. Given mainstem Klamath River dams were recently removed and the range of SONCC coho salmon is expected to extend only to Spencer Creek, NMFS relied on the same assumption in Section 2.3.3.2 *Effects to SONCC Coho Individuals*. Chinook salmon are expected to re-occupy reaches upstream of Keno Dam and are likely to have greater exposure to Reclamation facilities. Therefore, Reclamation shall have qualified fish biologists on site at unscreened diversions, canals, and other facilities such as Keno Dam and fish ladder, when any maintenance or investigative work is performed at the facilities (e.g., dewatering). Any encounters with salmon during the work shall be reported to NMFS. Additional studies to understand risk of entrainment at unscreened diversions should be prioritized and developed in coordination with NMFS.

2.7 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 pulse flows releases to create habitat conditions conducive to salmonid fitness, and detrimental to the disease pathogen *C. shasta*. For example, release of a pulse flow during a spring runoff event could increase the benefit of the disturbance to downstream reaches near Iron Gate and Scott River through the added volume of accretion flows. Sediment maintenance and geomorphic flows are critical in creating and maintaining in-channel and riparian habitat, remove accumulated fine sediment, maintain sediment balance, scour vegetation and remobilize gravels to form bars, and for disease mitigation.

Reclamation is evaluating fish screen needs and deterrent or avoidance measures for Klamath Project diversions to reduce or alleviate fish entrainment in irrigation canals, and addressing items related to fish passage at Keno Dam via a multi-agency and stakeholder working group. In doing so, Reclamation should rely on Klamath Reservoir Reach Restoration Prioritization Plan (O'Keefe et al. 2022), and CDFW's California Salmonid Stream Habitat Restoration Manual (Flosi et al. 2010), to utilize best available information and adhere to best management practices to reduce effects to salmonids and their habitat.

2.8 Reinitiation of Consultation

This concludes formal consultation for Klamath Project Operations from October 1, 2024 through September 30, 2029.

Under 50 CFR 402.16(a): "Reinitiation of consultation is required and shall be requested by the federal agency where discretionary federal agency involvement or control over the action has been retained or is authorized by law and: (1) If the amount or extent of taking specified in the incidental take statement is exceeded; (2) If new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) If the identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion or written concurrence; or (4) If a new species is listed or critical habitat designated that may be affected by the identified action."

2.9 "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.

2.9.1 Southern DPS North American Green Sturgeon

Reclamation has determined the proposed action may affect, but is not likely to adversely affect, Southern DPS green sturgeon (Reclamation 2024a). Reclamation determined the action area is not within areas designated as critical habitat for the Southern DPS green sturgeon; thus, Reclamation essentially determined the proposed action is expected to have no effect on critical habitat for this DPS.

The Southern DPS green sturgeon is listed as a threatened species, and includes all green sturgeon originating from the Sacramento River basin and from coastal rivers south of the Eel River (exclusive) (50 CFR 223.102(e)). The only known spawning population is in the Sacramento River (71 FR 17757; April 7, 2006). Sub-adult and adult Southern DPS green sturgeon enter coastal bays and estuaries north of San Francisco Bay, California, during the summer months to forage (Lindley et al. 2008). As such, individuals of the Southern DPS green sturgeon's potential occurrence in the lower Klamath River is limited to only the sub-adult and adult life stages, only during summer months, and only in the Klamath River estuary (NMFS 2018e).

The proposed action, depending on hydrological conditions in a given year, may reduce the 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. Klamath 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.

Southern DPS green sturgeon Critical Habitat

In 2009, NMFS designated critical habitat for the Southern DPS green sturgeon (74 FR 52300; October 9, 2009). The area identified as critical habitat includes: (1) all United States coastal marine waters out to the 60 fathom depth bathymetry line (relative to mean lower low water) from Monterey Bay, California north and east to include waters in the Strait of Juan de Fuca, Washington; (2) the following freshwater riverine areas in California: the Sacramento River, Lower Feather River, and Lower Yuba River; (3) the Sacramento-San Joaquin Delta; and (4) Suisun, San Pablo, San Francisco, and Humboldt bays in California (50 CFR 226.219(a)). The Klamath River and estuary is not designated as critical habitat for Southern DPS green sturgeon. Although SRKW in the ocean may be indirectly affected by the proposed action through impacts to their prey, Chinook salmon, there is no known mechanism by which the proposed action would be expected to effect Southern DPS green sturgeon in coastal marine waters.

2.9.2 Southern DPS Pacific Eulachon

Reclamation has determined that the proposed action may affect, but is not likely to adversely affect, Southern DPS eulachon and its designated critical habitat (Reclamation 2024a).

The Southern DPS eulachon was listed as threatened species in 2010 (75 FR 13012 (March 19, 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 to 5 years in 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 3 to 5 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). In the Klamath River, Eulachon abundance has likely decreased below the minimum viable population size. Yurok tribal fisheries seine/dip net survey data over a 4-year period show a large variation, from seven Eulachon in 2011 to 1,000 in 2014 (NMFS 2017e).

The proposed action, depending on hydrological conditions in a given year, may reduce the flows in the lower Klamath River when Southern DPS eulachon may be present in the 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. Klamath 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 eulachon 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 MSA directs federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 CFR 600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects to EFH may result from actions occurring within EFH or outside of it and may include site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH [CFR 600.905(b)].

This analysis is based, in part, on: 1) the EFH assessment provided by Reclamation as an amendment to their BA (Reclamation 2024b); 2) Reclamation's (2024a) BA; 3) descriptions of EFH for Pacific Coast Salmon in the Pacific Coast Salmon Fishery Management Plan (PFMC 2024a) developed by the PFMC and approved by the Secretary of Commerce; and 4) the NMFS (2019c) 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' Opinion. The proposed action is Reclamation's continued operation of the Klamath Project to store, divert, and convey water to meet authorized Klamath 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 Klamath Project and ensure its proper long-term function and operation. The period covered by this proposed action is October 1, 2024, through September 30, 2029.

The proposed action consists of the following three major elements:

1. Store waters of the Upper Klamath Basin and Lost River
2. Operate the Klamath Project, or direct the operation of the Klamath Project, for the delivery of water for irrigation purposes, subject to water availability, 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 O&M activities necessary to maintain Klamath Project facilities to ensure proper long-term function and operation.

3.2 Essential Fish Habitat Affected by the Project

The action area for the proposed action in this Opinion includes all areas where Klamath Project water is diverted from, locations where water is diverted to, and downstream of diversion points until effects of the diversions become undifferentiable from background conditions. The action area extends from UKL, in South Central Oregon, and Gerber Reservoir and Clear Lake Reservoir in the Lost River drainage in Southern Oregon and Northern California, approximately 254 miles downstream to the mouth of the Klamath River, and then out into the Pacific Ocean Therefore, the action area includes areas designated as EFH for various life-history stages of Pacific Coast groundfish (PFMC 2023), coastal pelagics (PFMC 2024c), and Pacific salmon (PFMC 2024a).

EFH for Pacific Coast groundfish (PFMC 2023) includes the following Designated Habitat Areas of Particular Concern (HAPC): Estuaries, Canopy Kelp, Seagrass, Rocky Reefs, and Areas of Interest. The HAPC for Pacific Coast groundfish that could be adversely affected is estuaries. EFH for coastal pelagic species (PFMC 2024c) includes prey species. Although Pacific Coast groundfish and coastal pelagic EFH occurs in the Klamath River estuary and marine environments, the proposed action, as it relates to Pacific Coast groundfish and coastal pelagics, is expected to have only minimal effects to the physical, chemical, and biological resources in the Klamath River estuary and the marine environment. Pacific salmon marine EFH are (1) estuarine rearing; (2) ocean rearing; and (3) juvenile and adult migration; however, the proposed action is expected to have only minimal effects to the physical, chemical, and biological resources in the marine environment. Therefore, this EFH analysis will focus primarily on Pacific salmon freshwater EFH, which is described and identified in PFMC (2024a), and further described below.

EFH for Chinook salmon and coho salmon (PFMC 2024a) 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. EFH for, and life history of, managed Pacific salmon species is discussed at length in Appendix A to the Pacific Coast Salmon Fishery Management Plan, as Modified by Amendment 18 to the Pacific Coast Salmon Plan (PFMC 2014), which is summarized here for coho salmon and Chinook salmon with specific life history information for the Klamath River summarized from the attached biological opinion.

3.2.1 Coho Salmon

Coho salmon in the Klamath Basin, including their general life history, are described in Section 2.3.1.1 *Species Description and General Life History*. Coho salmon freshwater EFH consists of four major components related to the species' life cycle: (1) spawning and incubation; (2) juvenile rearing; (3) juvenile migration corridors; and (4) adult migration corridors and holding habitat.

Freshwater EFH depends on lateral (e.g., floodplain, riparian), vertical (e.g., hyporheic) and longitudinal connectivity to create habitat conditions for spawning, rearing, and migration including: (1) water quality (e.g., DO, nutrients, temperature, etc.); (2) water quantity, depth, and velocity; (3 composition.

3.2.2 Chinook Salmon

Chinook salmon in the Klamath Basin, including their general life history, are described in Section 2.4.2.1.1.3, *Klamath River Chinook Salmon*. Chinook 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., DO, 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;) riparian-stream-marine energy exchanges (4) channel gradient and stability; (5) prey availability; (6) cover and habitat complexity (e.g., large woody debris (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 and (10) substrate composition.

3.3 Adverse Effects on Pacific Salmon Essential Fish Habitat

3.3.1 Hydrological Effects of the Proposed Action

As part of the proposed action, Reclamation proposes to manage flows in the Klamath River in a manner that approximates the natural flow regime, represented by real-time hydrologic conditions as defined by the UKL status, NWI, and resulting Operations Index (Section 1.3 *Proposed Federal Action*). Under the proposed action, the average annual hydrograph at Keno, Oregon for the 1991 to 2022 POR would resemble the natural hydrograph (shape, timing, variability); however, the peak discharge magnitude is substantially reduced and the timing is shifted approximately one month earlier, from early May to early April, relative to the historic average annual hydrograph at Keno for the 1905 TO 1913 period. Additionally, fall/winter, spring and summer discharge is considerably reduced. Historically, Klamath River discharge did not reach base flows until September. After factoring in the anticipated effects of implementation of the proposed action in addition to other factors described above, base flows now typically occur in early June in dry years and at the beginning of July in average and wet years, a shift in base flow timing of approximately two to three months earlier

The overall Klamath Project effects of a median 27% reduction in water volume will result in lower base flows and relatively smaller incremental increases in flow in the FW period from October through February compared to the natural hydrograph. Absent the proposed Klamath Project operations effects, Keno Release Target flows generally would be higher with more variability during this period. However, during the March through June period, proposed action Keno Release Target flows are at or near (plus 5%) Reclamation’s proposed Keno Dam minimums between 4 and 6% of days; similar to what NMFS would expect under a natural flow regime, where minimum flows would likely only occur approximately 5% of the time in the Klamath River (95% exceedance flows). The months of March (4%), April (4%), May (5%) and June (6%) have the lowest percentage of days at or near Reclamation's proposed Keno Dam minimum flows. The March through June results are more representative (than the rest of the year) of a natural flow regime during the critical period of coho salmon’s life history in the spring. 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 Klamath River natural flow regime.

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 Keno Dam and reduce downstream due to the ameliorating effects of key tributaries (e.g., Scott River, Salmon River, Trinity River).

3.3.1.1 Hydrological Effects on fish disease

Disease risk is likely to be increased due to a reduction in large sediment mobilization flow events which increases bed immobility. These stable substrate conditions provide a suitable environment for annelid worm populations to thrive. However, the proposed action will create conditions more representative of the natural flow regime with flows at or near Reclamation’s proposed Keno Dam minimum flows for a small percentage of time. Spring flow variability and use of pulse flow events to seasonally disrupt to the *C. shasta* host so that annual impacts of disease, combined with environmental effects of dam removal, are reduced in comparison to the 1991 to 2024 POR.

3.3.2 Coho Salmon Habitat

The effects of the proposed action on coho salmon habitat are described at length in the Section 2.3.3.1 *Effects to SONCC Coho Salmon ESU Critical Habitat* of the attached Opinion.

The proposed action is expected to have minor impacts to spawning habitat from fine sediment deposition and minor impacts to adult and juvenile fish migration from reduced flow volume and velocity in the mainstem. NMFS expects the proposed action will reduce water quality conditions, particularly temperature and DO in the summer due to reduced flow releases from Keno Dam. However, the level of significance of the impact is not entirely certain considering the rapidly changing baseline conditions post dam removal, and lack of updated modeling.

3.3.3 Chinook Salmon Habitat

The overall proposed action effect of an approximate 27% reduction in water volume to median annual UKL net inflow (980 TAF), resulting in lower base flows, and relatively smaller incremental increases in flow in the FW period from October through February compared to the natural hydrograph, would likely be most influential during average to dry years. 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.

Reclamation’s proposed action is expected to adversely affect the ocean abundance of Klamath basin origin Chinook salmon. These adverse effects could include increased disease exposure during the juvenile rearing and outmigration period and reduced fry habitat availability leading to increased competition. These effects could reduce growth and survival of fry and juvenile Chinook salmon. Adult Chinook salmon could be exposed to lower flows in the mainstem Klamath River and, when combined with elevated water temperatures in late summer and early fall, may delay migration, which would reduce reproductive success. While the proposed action is expected to contribute to disease infection, we expect that enhanced flow variability due to dam removal, and the implementation of pulse flows using the FFA will help to reduce some of the effects of the proposed action in drier years and in periods of elevated water temperatures.

3.3.3.1 Chinook Spawning Habitat

Fall-run Chinook salmon are expected to continue to spawn in the mainstem Klamath River in areas affected by the proposed action, and to expand their spawning range upstream of the former IGD. Spring-run Chinook salmon, even after active reintroduction and dam removal, are not expected to spawn in the mainstem Klamath River in areas affected by the proposed action. The proposed action will provide at least 950 cfs during the spawning and incubation period (October to February). In addition, proposed action Keno Release Target flows are at or near Reclamation’s proposed Keno Dam minimums between 38 and 66% for October through February. 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. 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.

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, DO, and pH in the Klamath River.

3.3.5 Water Temperature

As new baseline conditions develop post dam removal, Klamath Project operations and Keno water releases will have a greater ability to affect water temperatures in the mainstem Klamath River given that the reservoirs, a thermal sink, are no longer present. The proposed action reduces the volume of water released throughout the year. Water released from Keno Dam 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 Keno Dam, 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 et al. 2007). The proposed action’s effect of reducing mainstem flows in the summer 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 (NRC 2004). Previous water temperature modeling indicates temperatures may increase in the IGD to Scott River reach by up 0.5 °C when flows are reduced in this reach (Perry et al. 2011). Below the Scott River, the 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. However, reduced volume of flow releases in the summer and fall is expected to exacerbate temperature conditions in the former IGD to Scott River reach with more extreme responses to climatic conditions.

3.3.6 Nutrients and DO

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

Historically, the seasonal (summer/fall) release of nutrients out of Iron Gate Reservoir would stimulate periphyton growth in the mainstem Klamath River (USDOI and CDFW 2012). NMFS expects this same dynamic will occur under the proposed action, when nutrients are released out of Lake Ewauna from Keno Dam. Additionally, return flows may enter the mainstem Klamath from Lost River or F/FF pumps when water is moved off of KDD and Lower Klamath NWR. Return flows, particularly in the spring when water is moved off of fields prior to planting, likely carry large loads of nutrients. The NRC (2004) stated that stimulation of any kind of plant growth from such nutrient loads can affect DO 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 DO and pH conditions.

While the proposed action's increase in nutrients in the mainstem Klamath River between the former 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 DO 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 DO 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[29] would have greater water quality effect on the reduced water column.

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 pulse flows releases to create habitat conditions conducive to salmonid fitness, and detrimental to the disease pathogen *C. shasta*. For example, release of a pulse flow during a spring runoff event could increase the benefit of the disturbance to downstream reaches near Iron Gate and Scott River through the added volume of accretion flows. Sediment maintenance and geomorphic flows are critical in creating and maintaining in-channel and riparian habitat, remove accumulated fine sediment, maintain sediment balance, scour vegetation and remobilize gravels to form bars, and for disease mitigation.

2. Reclamation is evaluating fish screen needs and deterrent or avoidance measures for Klamath Project diversions to reduce or alleviate fish entrainment in irrigation canals, and addressing items related to fish passage at Keno Dam via a multi-agency and stakeholder working group. In doing so, Reclamation should rely on Klamath Reservoir

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[29] 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.

Reach Restoration Prioritization Plan (O'Keefe et al. 2022), and CDFW's California Salmonid Stream Habitat Restoration Manual (Flosi et al. 2010), to utilize best available information and adhere to best management practices to help to ensure that any short-term adverse effects to the streambed, hydrology, water quality, and associated EFH are minimized.

3.5 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 of the Opinion addresses these DQA components, documents compliance with the DQA, and certifies that this Opinion has undergone pre-dissemination review.

4.1 Utility

Utility principally refers to ensuring that the information contained in this consultation is helpful, serviceable, and beneficial to the intended users. The intended user of this Opinion is Reclamation. Other interested users could include Klamath Project water users, Klamath Basin tribes, and other stakeholders. Individual copies of this Opinion were provided to Reclamation. The document will be available within two weeks at the NOAA Library Institutional Repository [https://repository.library.noaa.gov/welcome]. The format and naming adhere to conventional standards for style.

4.2 Integrity

This consultation was completed on a computer system managed by NMFS in accordance with relevant information technology security policies and standards set out in Appendix III, 'Security of Automated Information Resources,' Office of Management and Budget Circular A-130; the Computer Security Act; and the Government Information Security Reform Act.

4.3 Objectivity

Information Product Category: Natural Resource Plan

Standards: This consultation and supporting documents are clear, concise, complete, and unbiased; and were developed using commonly accepted scientific research methods. They adhere to published standards including the NMFS ESA Consultation Handbook, ESA regulations, 50 CFR 402.01 et seq., and the MSA implementing regulations regarding EFH, 50 CFR part 600.

Best Available Information: This consultation and supporting documents use the best available information, as referenced in the References section. The analyses in this Opinion and EFH consultation contain more background on information sources and quality.

Referencing: All supporting materials, information, data and analyses are properly referenced, consistent with standard scientific referencing style.

Review Process: This consultation was drafted by NMFS staff with training in ESA and MSA implementation and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5 REFERENCES

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6 APPENDICES

Appendix A – Reclamation (2024a) BA

Appendix C, Description of the Klamath Basin Planning Model, Keno Release Version

APPENDIX C

Description of the Klamath Basin Planning Model, Keno Release Version

As in the previous Section 7 Endangered Species Act (ESA) consultations on U.S. Bureau of Reclamation (Reclamation) Project operations, the Klamath Basin Planning Model (KBPM) was used to simulate operations under the Proposed Action. Various versions of the KBPM have been used since 2009, each based in the Water Resources Integrated Modeling System (WRIMS). This highly flexible modeling system enables implementation of operational alternatives in simulations. In the current re-consultation effort, removal of dams in the Klamath Hydroelectric Project required that the downstream-most compliance point be moved from the U.S. Geological Survey (USGS) gage below Iron Gate Dam to the USGS gage below Keno Dam. As a result, the version of the KBPM developed in support of this re-consultation has been named the Keno Release Model (KRM). The operational strategy embodied in the Proposed Action as simulated by the KRM is described in this Appendix.

Some aspects of the KRM that were described previously are not discussed in detail herein. Agricultural deliveries in the KRM are simulated using the Agricultural Water Delivery Sub-model described in Section A.4.4.4 of Appendix A to Reclamation's 2018 Biological Assessment (Reclamation, 2018), which is fully incorporated into the KRM. Also, the modifications to the KBPM used in the KRM to simulate reconnection to Upper Klamath Lake (UKL) of the reclaimed former wetland area within the Upper Klamath National Wildlife Refuge were documented in Dunsmoor (2022).

Key Structural Variables

The KRM implements a consistent year-round operational strategy for making water management decisions focused on continuous tracking of the hydrologic conditions in the Upper Klamath Basin using the Normalized Wetness Index (NWI) and water storage conditions in UKL using the UKL Status Index (UKL Status). These two indices are combined into a single Operations Index (Ops Index) that is used to distribute water among the various uses relative to conditions of basin hydrology and UKL storage.

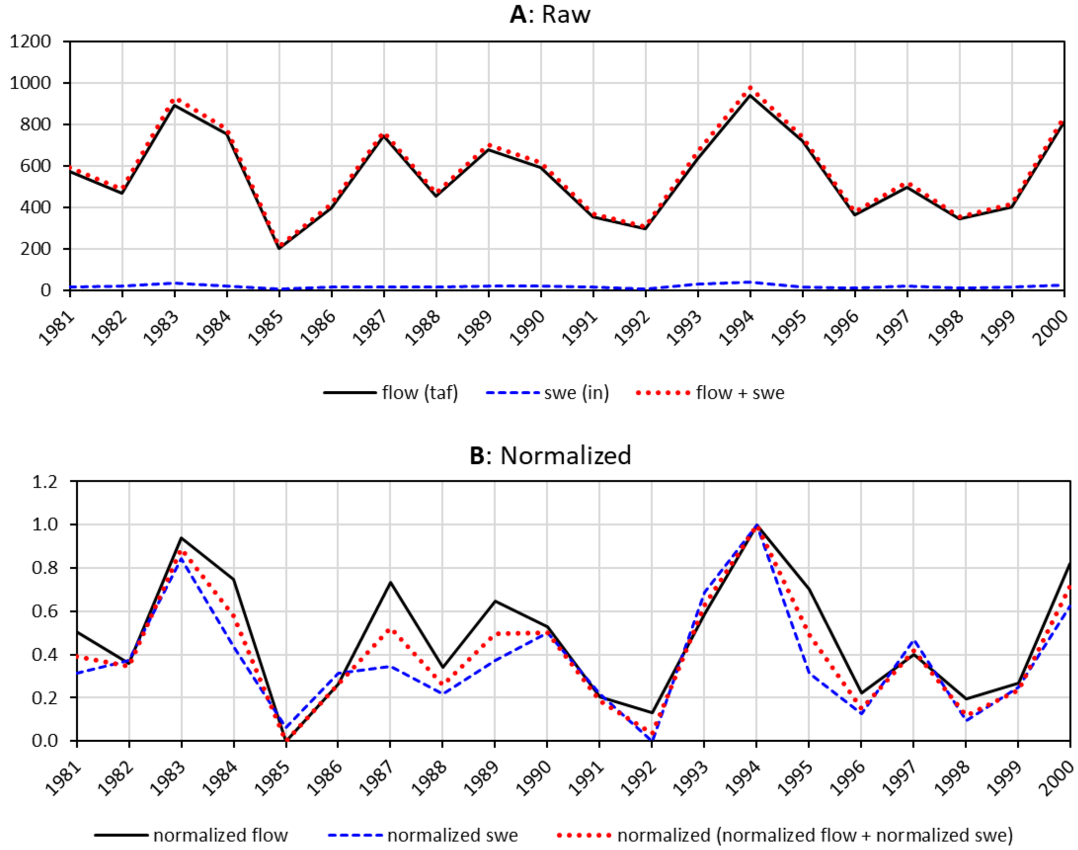
Normalizing Variables

All three indices use normalized variables. Normalized variables are rescaled to the minimum and maximum values for water years 1991-2022 using this equation:

$$Normalized_i = \left(\frac{X_i - X_{min}}{X_{max} - X_{min}}\right) \tag{1}$$

Where i is day (or month for climate index variables) and min/max are the daily (monthly) minima/maxima over the 1991-2022 period. This simple rescaling of variables with different units retains the relative patterns within each variable while ensuring that the normalized variable is zero when the raw variable is at the minimum, and 1 when the raw variable is at the maximum. When applying this formula to time frames outside of the 1991-2022 period that may contain more extreme minima or maxima, the calculation is constrained to a minimum of 0 and a maximum of 1.

In addition, normalized variables can be meaningfully combined in ways that the raw variables cannot. To illustrate, consider two made-up time series consisting of flow volumes measured in thousands of acre-feet (TAF) and snowpack water content measured in inches of snow-water equivalents (SWE) on Appendix Figure C-1A. Because the units of the two raw variables are so different, combining them as a sum retains nearly all the information from the variable with the largest units (flow, TAF) and nearly none of the information from the variable with the smallest units (SWE, inches). However, if the two variables are normalized to their respective maxima and minima (Appendix Figure C-1B) the scale difference is eliminated because each is now unitless, scaled from 0 (when at the raw minimum) to 1 (when at the raw maximum). Rescaling the variables in this way also retains the patterns within each variable in that the relative position of each normalized data point is unchanged from the raw data. If the two normalized variables are summed, and the sum is subsequently normalized, then the information from each variable is retained equally despite the different units of the raw variables.



Notes: In A, raw variables with different units (TAF of flow, and inches of SWE of the snowpack) do not retain equivalent information from each variable when summed because of the large difference in magnitudes of the units. In B, the normalized variables are now on the same scale (0 to 1), each retains the relative patterns of the raw variables, and the normalized sum retains equal amounts of information from each variable.

Appendix Figure C-1. An illustrative example of normalization using made-up variables

Normalized Wetness Index

Within the KRM, the hydrologic status of the Upper Klamath Basin is estimated using two versions of the NWI. The daily version of the NWI tracks hydrologic conditions throughout the year, and as a component of the Ops Index is a key variable governing the distribution of water. The seasonal version of the NWI generates seasonal forecasts of UKL net inflow that are used by the KRM to determine water allocations from UKL to the Project irrigators.

Daily Version of the Normalized Wetness Index

The NWI is a daily index expressing the hydrologic status of the Upper Klamath Basin that is used by the KRM in two ways. The continuous daily NWI is one component of the Ops Index, the main structural variable governing the movement of water in the KRM. Because the NWI was designed to track with UKL net inflow, with some modification from its daily form, it can be used to forecast seasonal UKL net inflow volumes that are used in the KRM to allocate water to Project irrigation. This seasonal forecasting application of the NWI is described in the *Seasonal Version of the Normalized Wetness Index* section below.

The daily version of the NWI is a daily index expressing the hydrologic status of the Upper Klamath Basin, calculated as

$$WI_d = q_d Q_d + s_d S_d + pn_d PN_d + pl_d PL_d + c_d C, \tag{2}$$

where:

q_d is the daily weight for UKL net inflow.

Q_d is the normalized 30-day trailing sum of UKL net inflow volume.

s_d is the overall daily weight for the SWE of the snowpack.

S_d is the normalized weighted mean SWE of the three 8-digit hydrologic unit code (HUC8) catchments upstream of Link River Dam, where the weights are the proportion of each catchment area exceeding 1,500 m (4,839 ft) in elevation to the total area exceeding 1,500 m in all three catchments. Mean SWE of each HUC8 catchment is computed using the Natural Resources Conservation Service (NRCS) Snow Telemetry (SNOTEL) stations listed in Appendix Table C-1 and mapped on Appendix Figure C-2.

pn_d is the overall daily weight for the 30-day trailing sum of precipitation.

PN_d is the normalized weighted mean 30-day trailing sum of precipitation of the three HUC8 catchments upstream of Link River Dam, where the weights are the proportion of each catchment area to the total area of all three catchments. Daily precipitation time series were acquired from Parameter-elevation Regressions on Independent Slopes Model (PRISM) outputs for ten randomly selected 4-km grids within each HUC8 catchment, from which a daily mean was calculated for each HUC8 catchment. PRISM precipitation data were obtained July 6, 2023, from the PRISM Climate Group at Oregon State University (https://prism.oregonstate.edu).

pl_d is the overall daily weight for the 31- (1 month) to 1,095-day (36 months or 3 years) trailing sum of precipitation.

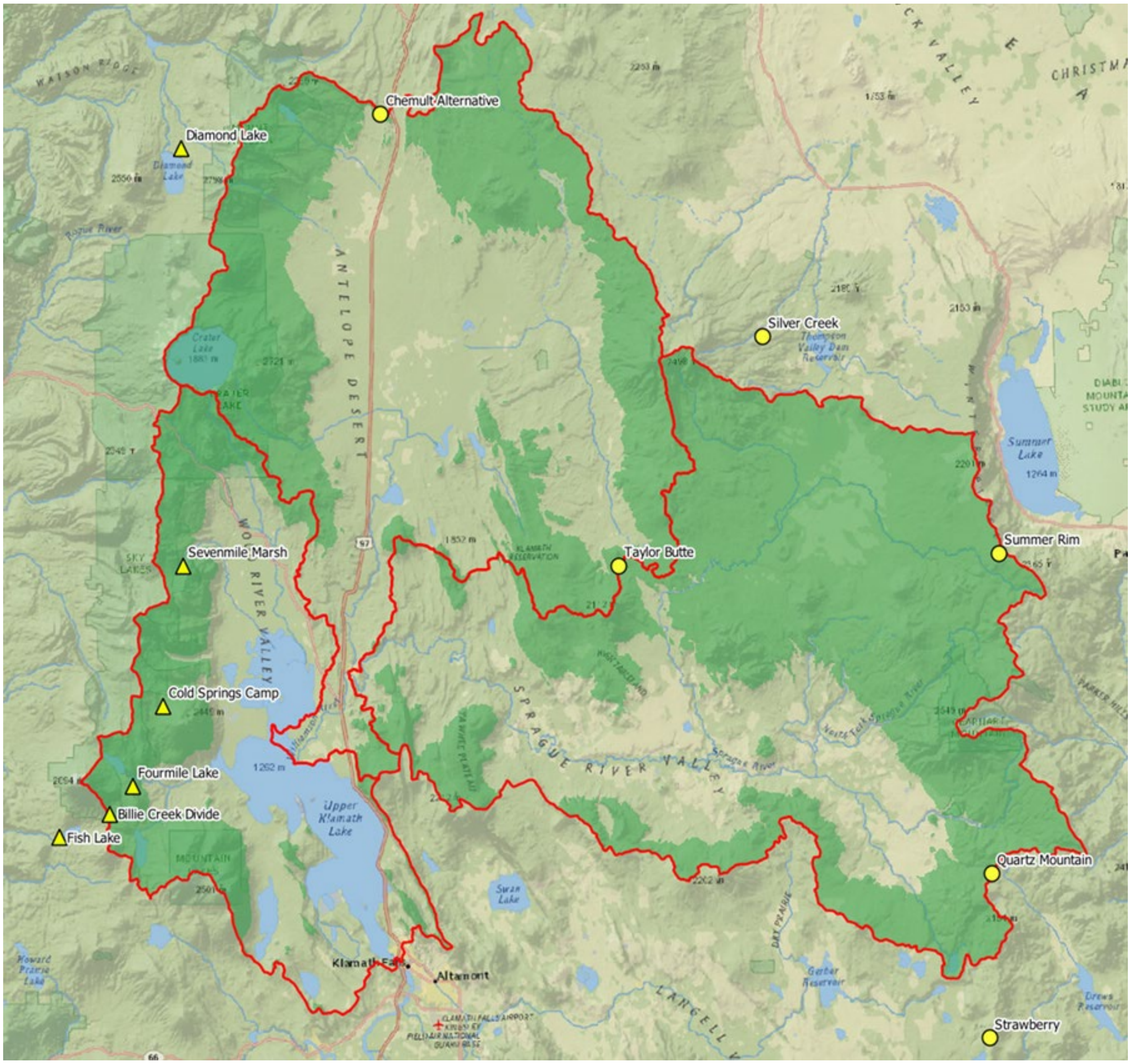
PL_d is the normalized weighted mean 31- to 1,095-day trailing sum of precipitation of the three HUC8 catchments upstream of Link River Dam, otherwise computed similarly to PN_d. Precipitation conditions over the prior 3 years is intended to capture effects, for example, of extended periods of dry or wet conditions on processes that may influence inflow (e.g., soil moisture conditions, flow of springs from responsive aquifers, etc.).

c_d is the daily weight for the climate index.

C is, from December 1 to April 14, the 3-month trailing mean of the normalized Pacific Decadal Oscillation index (PDO; Mantua et al., 1997) for the prior month. From April 15 to November 30, C captures the interaction of the monthly PDO index and the monthly Niño 3.4 sea surface temperature anomalies index (N34; https://psl.noaa.gov/data/correlation/nina34.anom.data), computed as follows. First, the complement of the normalized N34 is calculated (1 – normalized N34). Second, the normalized PDO and the complement of the normalized N34 are summed by month and normalized again. Finally, the 3-month trailing mean is computed, and the value from the prior month is used. Each index is computed from the Extended Reconstructed Sea Surface Temperature (ERSST) version 5 data set (Huang et al., 2017).

Appendix Table C-1. Natural Resources Conservation Service Snow Telemetry sites used to calculate mean snow-water equivalents for the 8-digit hydrologic unit code catchments above Link River Dam

Upper Klamath Lake HUC8 18010203	Williamson HUC8 18010201	Sprague HUC8 18010202
Fish Lake	Diamond Lake	Silver Creek
Billie Creek Divide	Chemult Alternate	Taylor Butte
Fourmile Lake	Silver Creek	Summer Rim
Cold Springs Camp	Taylor Butte	Quartz Mountain
Sevenmile Marsh		Strawberry



Notes: HUC8 catchments are outlined in red. Yellow symbols denote SNOTEL sites in the Cascade Mountains (triangles) and east of the Cascade Mountains (circles). Green-shaded areas are above 1,500 m in elevation.

Appendix Figure C-2. Natural Resources Conservation Service Snow Telemetry sites used to calculate mean snow-water equivalents for the daily and seasonal versions of the Normalized Wetness Index

Variables were normalized to the period-of-record for water years 1991-2022 using Equation 1. The last step in computing the NWI is to normalize the WI_d values so that the driest condition yields an NWI of zero, and the wettest condition an NWI of 1. The daily NWI time series is smoothed using a 14-day trailing mean for use in the KRM.

On the first and fifteenth day of each month (or the day before in leap years), an iterative process was used to assign values to the daily weights q_d, s_d, pn_d, pl_d, and c_d. For each of these days, 7,776 combinations of weights (0-1 by 0.2 increments) were used to compute 7,776 versions of the NWI, each of which was then regressed on the square root of the 91-day forward sum of UKL net inflow volume. Mean absolute error (MAE) was computed for each regression. For each variable, the weight to be used in the final NWI calculation was then calculated as the mean weight of the 10 weight combinations yielding the lowest regression MAE, and this mean was weighted by the MAE values reflected on the mean MAE (that is, the smallest MAE values are assigned the largest weights, and the largest MAE values are assigned the lowest weights). Using these daily weights (Appendix Table C-1) to compute the NWI produces the relationships between NWI and future UKL net inflows on Appendix Figure C-3. After the daily weights were established by this iterative process, the weights for the remaining days were linearly interpolated. The daily NWI relationship to UKL net inflows holds up over longer periods as compared to the 91-day forward sum of UKL net inflow used to optimize the NWI. For example, means of the NWI and UKL net inflow volumes by water year for October through March and April through September retain clear relationships (Appendix Figure C-4).

Appendix Table C-2. Daily weights for computing the daily Normalized Wetness Index

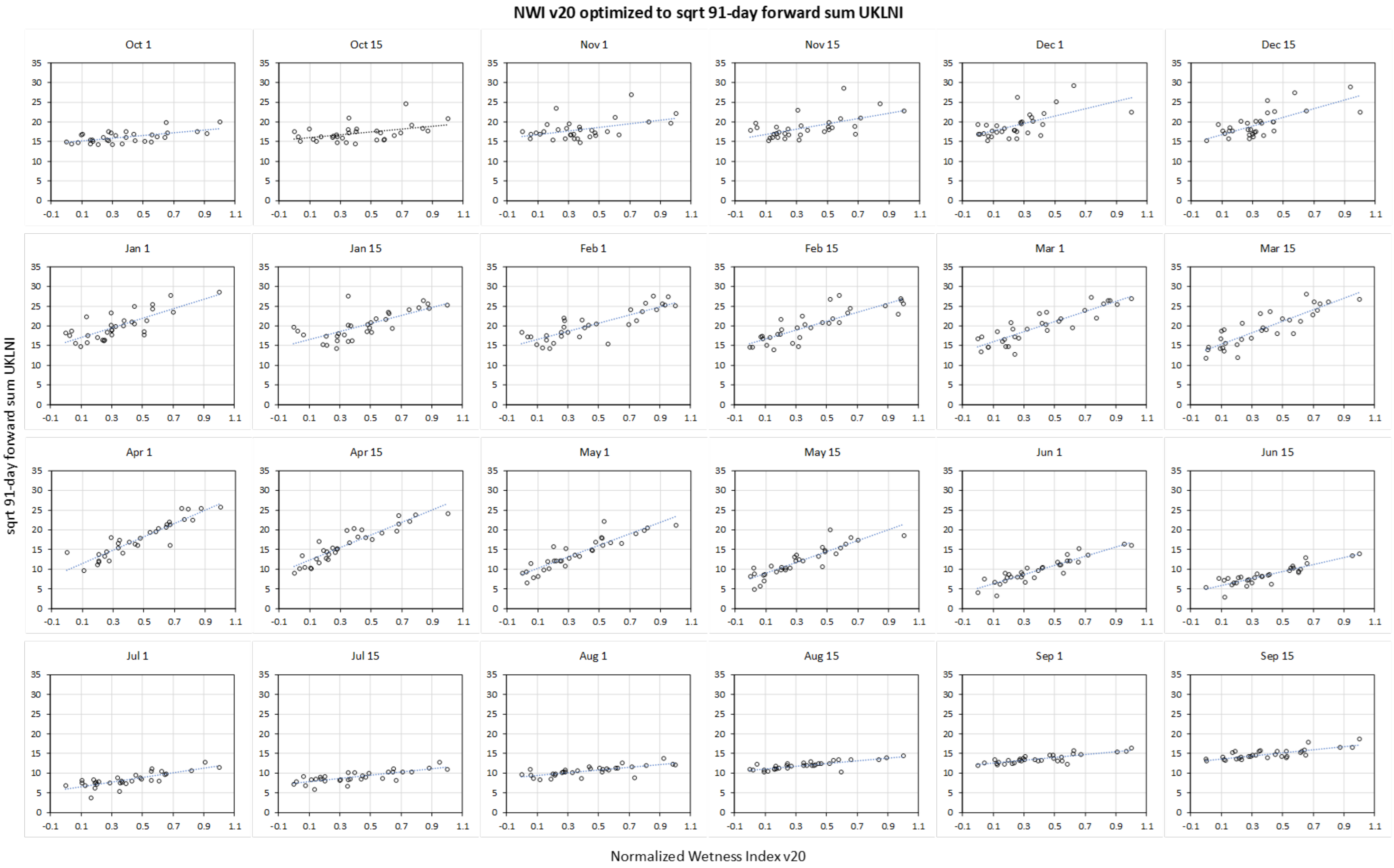
Day of Water Year	Date	q_d	s_d	pn_d	pl_d	c_d	Climate Index Used	MAE	MSE	MAPE
1	Oct 1	0.06	-	0.00	0.86	0.51	3 mta PDO_CN34	0.92	1.26	5.6%
15	Oct 15	0.10	-	0.00	0.76	0.78	3 mta PDO_CN34	1.27	3.19	7.2%
32	Nov 1	0.00	0.22	0.00	0.71	0.21	3 mta PDO_CN34	1.50	4.76	8.0%
46	Nov 15	0.32	0.96	0.50	0.90	0.34	3 mta PDO_CN34	1.58	5.12	8.1%
62	Dec 1	0.94	0.12	0.56	0.06	0.46	3 mta PDO	1.65	5.85	8.3%
76	Dec 15	0.76	0.16	0.76	0.74	0.40	3 mta PDO	1.78	5.16	9.0%
93	Jan 1	0.56	0.28	0.82	0.88	0.42	3 mta PDO	1.75	4.74	8.9%
107	Jan 15	0.12	0.84	0.22	0.74	0.24	3 mta PDO	1.68	5.30	8.6%
124	Feb 1	0.12	0.94	0.88	0.50	0.16	3 mta PDO	1.55	3.91	8.2%
138	Feb 15	0.88	0.55	0.65	0.02	0.00	3 mta PDO	1.52	4.47	7.9%
152	Mar 1	0.65	0.88	0.08	0.02	0.00	3 mta PDO	1.55	3.85	8.5%
166	Mar 15	0.41	0.86	0.00	0.08	0.04	3 mta PDO	1.75	5.04	9.6%
183	Apr 1	0.44	0.92	0.20	0.24	0.18	3 mta PDO	1.36	3.19	8.6%
197	Apr 15	0.52	0.94	0.14	0.22	0.02	3 mta PDO_CN34	1.19	2.40	7.7%
213	May 1	0.44	0.92	0.20	0.26	0.06	3 mta PDO_CN34	1.23	2.65	9.7%
227	May 15	0.98	0.88	0.20	0.06	0.16	3 mta PDO_CN34	1.17	2.66	11.6%
244	Jun 1	0.80	0.76	0.31	0.41	0.00	3 mta PDO_CN34	0.89	1.53	11.9%
258	Jun 15	0.70	0.80	0.00	0.49	0.00	3 mta PDO_CN34	0.77	1.20	12.1%
274	Jul 1	0.52	-	0.00	0.94	0.20	3 mta PDO_CN34	0.78	1.14	11.0%
288	Jul 15	0.41	-	0.00	0.82	0.43	3 mta PDO_CN34	0.73	0.86	8.6%
305	Aug 1	0.22	-	0.00	0.88	0.49	3 mta PDO_CN34	0.59	0.75	5.9%
319	Aug 15	0.06	-	0.33	0.84	0.39	3 mta PDO_CN34	0.44	0.43	3.7%
336	Sep 1	0.08	-	0.00	0.80	0.23	3 mta PDO_CN34	0.47	0.40	3.5%
350	Sep 15	0.00	-	0.06	0.86	0.45	3 mta PDO_CN34	0.62	0.62	4.1%

Notes:
Date is the day corresponding to the specified day of water year in non-leap years. q_d is the weight for the normalized 30-day trailing sum of UKL net inflow volume. s_d is the weight for normalized weighted mean SWE. pn_d is the weight for the normalized weighted mean 30-day trailing sum of precipitation. pl_d is the weight for the normalized weighted mean 31- to 1,095-day trailing sum of precipitation. c_d is the weight for the 3-month trailing mean of the normalized climate index. PDO_CN34 indicates use of the PDO combined with the complement of the N34 as described in the text, and 3-month trailing average is denoted by 3 mta. For each date, errors from the best performing (lowest MAE) NWI regression on the square root of the 91-day forward sum of the UKL net inflow volume are summarized as MAE, mean squared error (MSE), and mean absolute percentage error (MAPE).

Singh et. al (2021) found streamflow changes were responsive to interactions among the ENSO (N34) and PDO climate indices in the Pacific Northwest but not in the West (California and Nevada). Because the Klamath Basin is in the transition area between these two regions and may respond differently than the much larger regions used in that study, interactions among the PDO and N34 indices were explored. These indices were normalized and considered separately and combined in various ways. Because the NWI is formulated to have a positive correlation with future UKL net inflow, and at times climate indices may be negatively correlated with future inflows, the complement of the normalized index was calculated as 1 - normalized index. If the climate index was negatively correlated with inflow, then it would be positively correlated with its complement, which could then be used in the NWI.

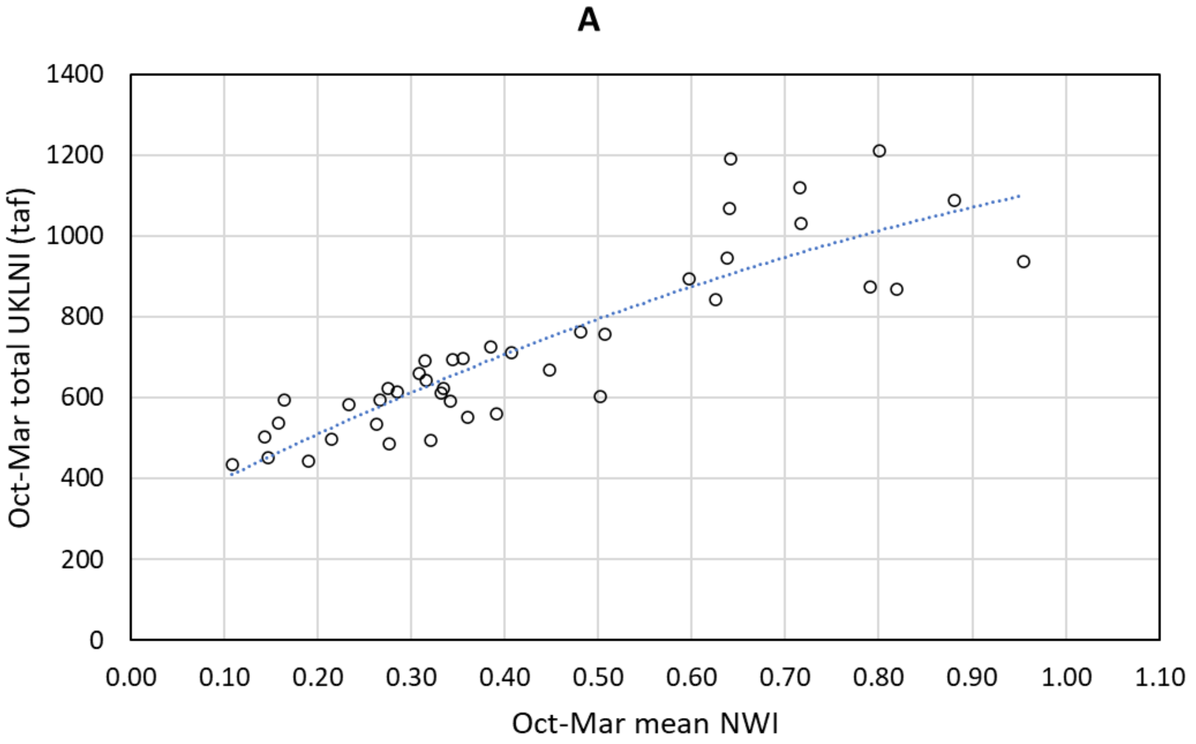
Eight potential formulations were considered for incorporating normalized climate indices into the daily NWI: PDO, N34, CPDO, CN34, PDO_N34, PDO_CN34, CPDO_N34, and CPDO_CN34 (C indicates use of the complement of the normalized index). Combined indices were produced by first normalizing each individual index and computing its complement, if necessary, adding them together, and normalizing again. A version of the NWI without a climate index variable was also evaluated.

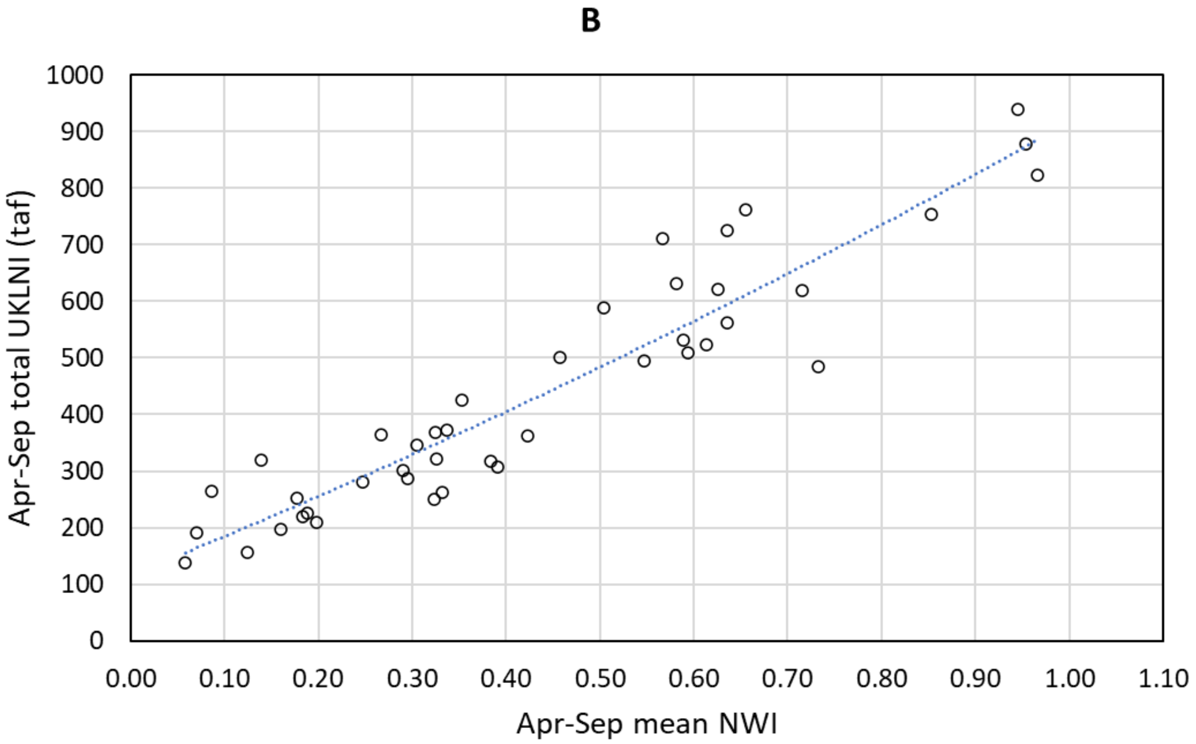
In each of these cases, the iterative process for determining optimal weights for variables was completed, the optimal weights were used to compute the NWI, and errors from the regression of NWI on the square root of the 91-day forward sum of UKL net inflow were calculated. For each NWI associated with the alternative formulations of the climate indices, these errors were compared to those for the NWI without a climate index variable (base case) and the best performing (largest error reduction from the base case) formulations over contiguous periods of time were selected. In the end, two formulations of the climate indices were chosen for use in the daily NWI: the PDO for December 1 to April 1, and the PDO_CN34 for the rest of the year.



Notes: The regression with the lowest MAE is shown for each date.

Appendix Figure C-3. Normalized Wetness Index regressed on the square root of the 91-day forward sum of Upper Klamath Lake net inflow volume on the days for which daily weights were iterated for use in the Normalized Wetness Index





Note: Fitted lines are included to help visualize the relationships.

Appendix Figure C-4. Daily Normalized Wetness Index averaged over fall-winter (A) and spring-summer (B) periods relative to the actual Upper Klamath Lake net inflow volumes for the same periods (TAF)

Seasonal Version of the Normalized Wetness Index

The seasonal version of the NWI relies upon the same variables as the daily version except for the treatment of climate indices. However, the process used to determine the weights for each variable regressed each of the date-specific 7,776 iterations of the NWI (calculated using each unique combination of weights) on the square root of the seasonal UKL net inflow volume being forecasted instead of the square root of the 91-day forward sum of the UKL net inflow volume that was used for the daily NWI. Quantile regression models (Koenker et al., 2018) for seasonal forecasts were developed for each of the forecast periods listed in Appendix Table C-3 from the specified day of the water year through September, which resulted in leap years including one more day in each forecast period than in non-leap years. Future revisions of the NWI-based forecasts should ensure that the number of days in each forecast period is consistent across years.

Appendix Table C-3. Date-specific weights for computing the seasonal Normalized Wetness Index

Day of Water Year	Date	Forecast Period	q_d	s_d	pn_d	pl_d	c_d	MAPE
152	Mar 1	Apr-Sep	0.33	0.84	0.00	0.10	0.04	10.0%
183	Apr 1	Apr-Sep	0.50	0.92	0.24	0.40	0.00	7.6%
197	Apr 15	Apr 15-Sep	0.52	0.90	0.20	0.30	0.00	7.1%
213	May 1	May-Sep	0.54	0.96	0.26	0.48	0.00	7.8%
227	May 15	May 15-Sep	0.98	0.68	0.18	0.32	0.08	8.7%
244	Jun 1	Jun-Sep	0.92	0.68	0.36	0.84	0.20	7.7%

Notes:
Date is the day when a forecast will be issued in non-leap years. q_d is the weight for the normalized 30-day trailing sum of UKL net inflow volume. s_d is the weight for normalized weighted mean SWE. pn_d is the weight for the normalized weighted mean 30-day trailing sum of precipitation. pl_d is the weight for the normalized weighted mean 31- to 1,095-day trailing sum of precipitation. c_d is the weight for the 3-month trailing mean of the normalized climate index. For each date, errors from the best performing (lowest MAE) NWI regression on the square root of the forecast period sum of the UKL net inflow volume are summarized as MAPE.

Climate variables were evaluated for use in the seasonal NWI in the same manner as for the daily NWI. The complement of the normalized PDO is the only climate index used in the seasonal NWI. The influence of the climate index variable is considerably less on the seasonal NWI than on the daily NWI (compare c_d values in Appendix Table C-2 to those in Appendix Table C-3), presumably because of the longer period over which UKL net inflow is accumulated in the seasonal NWI. Note that the climate index variable has a substantial effect for only the June 1 forecast date (Appendix Table C-3).

A leave-one-out cross-validation approach (James et al., 2021) was used to select the final forecasting model from among four candidate forms: $y = b_1x + \varepsilon$, $y = b_1x^2 + b_2x + \varepsilon$, $\sqrt{y} = b_1x + \varepsilon$, or $\sqrt{y} = b_1x^2 + b_2x + \varepsilon$, where x is the seasonal NWI, y is the seasonal volume of UKL net inflow being forecasted, and ε is error. This process involved omitting 1 year, fitting each candidate quantile regression model and then using it to forecast the year that was omitted, and then computing the cross-validation forecast error for that year. After repeating this process until all the years (1991-2022) had been omitted and forecasted with attendant errors computed, the forecast model with the lowest MAE was used to directly estimate the 50% and 95% exceedance forecasts for each of the forecast dates (Appendix Table C-4 through Appendix Table C-9, and Appendix Figure C-5).

Forecasts were made for the period-of-record used to calibrate the forecast models (1991-2022), but also for the years not involved in the calibration (1981-1990). The KRM uses all the 50% exceedance forecasts, and the 95% exceedance forecasts for Apr 1 and 15, to compute the water allocations for Project irrigation (see the *Project Irrigation Allocation* section below).

Appendix Table C-4. March 1 percent-exceedance forecasts of April through September Upper Klamath Lake net inflow volumes (TAF) based on the seasonal Normalized Wetness Index

Year	95%	70%	50%	30%	5%		Year	95%	70%	50%	30%	5%
1981	117	179	238	266	345		2002	253	382	429	463	575
1982	357	538	569	605	739		2003	139	211	270	299	383
1983	482	724	729	768	926		2004	314	474	512	547	672
1984	385	579	605	642	781		2005	140	214	272	302	386
1985	313	472	510	545	670		2006	434	653	668	707	856
1986	349	526	557	594	726		2007	228	345	395	428	535
1987	228	344	395	428	534		2008	308	465	504	539	663
1988	174	265	321	352	445		2009	211	320	372	405	507
1989	301	454	494	529	652		2010	180	273	329	360	455
1990	161	245	302	332	422		2011	234	354	404	437	545
1991	98	150	209	236	308		2012	170	258	315	346	438
1992	101	155	214	241	315		2013	190	287	342	374	471
1993	414	622	642	679	824		2014	115	175	234	262	340
1994	161	245	302	333	423		2015	90	138	197	224	294
1995	219	332	383	416	520		2016	239	361	410	443	552
1996	371	559	587	624	760		2017	396	595	618	656	797
1997	365	549	578	615	751		2018	111	169	228	256	332
1998	401	603	625	663	806		2019	283	427	470	505	623
1999	552	829	819	859	1030		2020	162	246	303	333	424
2000	354	534	564	601	734		2021	173	263	319	350	443
2001	151	229	287	317	405		2022	131	199	258	287	369

Appendix Table C-5. April 1 percent-exceedance forecasts of April through September Upper Klamath Lake net inflow volumes (TAF) based on the seasonal Normalized Wetness Index

Year	95%	70%	50%	30%	5%		Year	95%	70%	50%	30%	5%
1981	196	232	260	282	400		2002	254	325	351	386	501
1982	455	663	678	760	843		2003	193	228	256	277	395
1983	551	829	836	942	1002		2004	258	331	358	393	508
1984	503	745	757	850	922		2005	187	219	247	267	385
1985	409	583	602	672	765		2006	441	639	655	734	820
1986	368	513	534	595	696		2007	255	326	353	387	503
1987	275	359	385	424	538		2008	363	505	527	586	687
1988	193	227	255	276	394		2009	285	376	402	443	556
1989	461	673	688	771	853		2010	206	249	276	300	419
1990	209	252	280	304	422		2011	410	585	603	674	767
1991	236	296	323	353	470		2012	314	423	448	495	605
1992	132	135	161	171	285		2013	204	245	272	296	414

Year	95%	70%	50%	30%	5%		Year	95%	70%	50%	30%	5%
1993	376	528	549	611	710		2014	194	230	257	279	397
1994	161	179	207	222	339		2015	155	170	197	211	328
1995	346	477	500	555	659		2016	335	458	482	534	640
1996	346	476	499	554	659		2017	436	629	646	723	810
1997	326	444	467	518	626		2018	222	273	300	328	446
1998	411	587	606	677	769		2019	319	432	456	505	613
1999	551	829	836	942	1002		2020	180	208	236	255	373
2000	379	532	553	616	715		2021	170	193	220	237	355
2001	183	212	240	259	377		2022	118	116	142	149	261

Appendix Table C-6. April 15 percent-exceedance forecasts of April 15 through September Upper Klamath Lake net inflow volumes (TAF) based on the seasonal Normalized Wetness Index

Year	95%	70%	50%	30%	5%		Year	95%	70%	50%	30%	5%
1981	171	208	226	265	338		2002	168	204	223	261	334
1982	481	556	575	643	779		2003	206	247	266	308	388
1983	604	694	712	792	952		2004	178	216	235	274	349
1984	556	641	659	735	885		2005	159	194	213	250	321
1985	333	390	409	463	569		2006	484	559	577	646	782
1986	313	367	385	438	539		2007	225	269	287	331	415
1987	199	239	258	299	377		2008	375	437	455	513	627
1988	120	151	170	204	266		2009	264	312	330	378	470
1989	376	438	456	515	629		2010	222	265	284	327	411
1990	129	161	180	215	279		2011	436	506	524	588	714
1991	187	226	244	285	361		2012	354	413	431	488	597
1992	71	96	115	144	197		2013	197	237	255	296	374
1993	473	547	565	633	766		2014	133	165	183	218	284
1994	124	155	174	208	272		2015	109	139	157	190	250
1995	316	371	390	442	544		2016	217	259	278	321	403
1996	280	331	349	398	493		2017	443	513	531	596	723
1997	302	355	373	425	524		2018	203	244	263	305	384
1998	454	526	544	610	740		2019	329	386	404	458	562
1999	604	694	712	792	952		2020	150	185	203	240	309
2000	259	307	326	373	464		2021	83	109	128	158	213
2001	160	196	214	252	323		2022	95	122	141	172	230

Appendix Table C-7. May 1 percent-exceedance forecasts of May 1 through September Upper Klamath Lake net inflow volumes (TAF) based on the seasonal Normalized Wetness Index

Year	95%	70%	50%	30%	5%		Year	95%	70%	50%	30%	5%
1981	106	146	159	187	244		2002	129	169	183	212	284
1982	317	348	362	394	593		2003	175	214	228	259	362
1983	560	564	576	606	970		2004	137	177	191	220	298
1984	480	493	507	538	847		2005	120	160	174	202	269

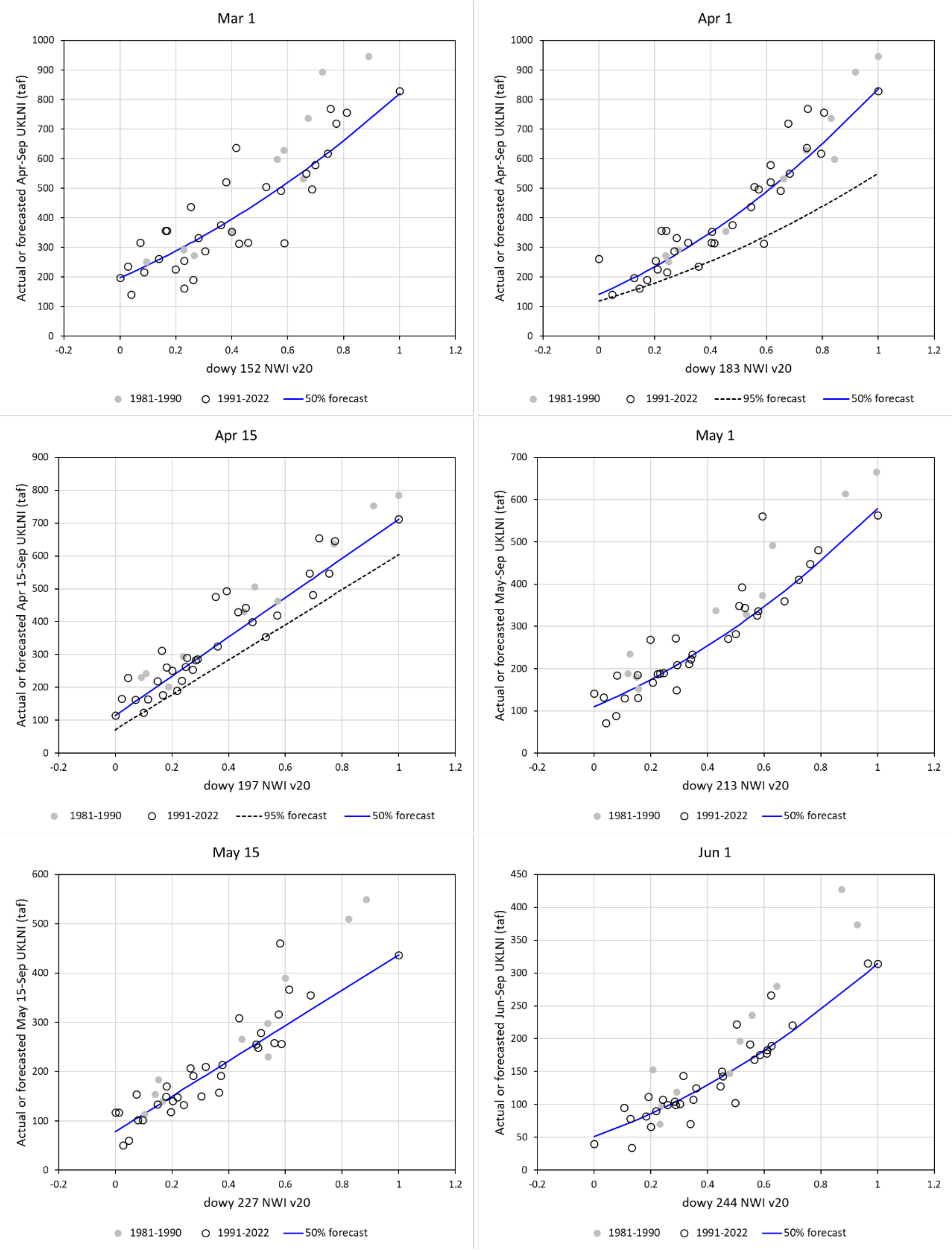
Year	95%	70%	50%	30%	5%		Year	95%	70%	50%	30%	5%
1985	297	329	343	375	561		2006	415	436	450	481	747
1986	214	252	266	297	426		2007	172	211	226	256	357
1987	96	136	149	176	226		2008	287	320	334	366	545
1988	104	144	157	185	240		2009	153	193	207	237	325
1989	267	301	316	347	513		2010	177	216	231	261	365
1990	94	134	147	174	223		2011	397	419	433	465	718
1991	154	194	208	238	327		2012	235	271	285	316	460
1992	72	110	122	148	182		2013	123	163	177	205	274
1993	372	397	411	443	679		2014	90	130	143	170	216
1994	81	120	133	160	200		2015	69	107	120	145	177
1995	264	299	313	344	508		2016	132	172	186	215	289
1996	259	294	308	340	500		2017	342	370	384	416	631
1997	289	322	336	368	548		2018	155	195	209	238	328
1998	297	329	343	375	561		2019	248	283	298	329	481
1999	563	566	579	609	974		2020	82	122	134	161	202
2000	254	289	303	335	491		2021	61	98	110	135	162
2001	105	145	159	186	243		2022	105	145	158	186	242

Appendix Table C-8. May 15 percent-exceedance forecasts of May 15 through September Upper Klamath Lake net inflow volumes (TAF) based on the seasonal Normalized Wetness Index

Year	95%	70%	50%	30%	5%		Year	95%	70%	50%	30%	5%
1981	77	98	115	142	178		2002	127	150	165	192	260
1982	256	285	293	322	472		2003	172	197	209	237	333
1983	358	393	395	426	640		2004	119	141	157	184	247
1984	336	369	373	403	603		2005	135	158	173	200	273
1985	233	262	271	299	435		2006	288	319	325	355	524
1986	201	228	238	267	381		2007	150	174	187	215	297
1987	95	116	133	159	207		2008	219	246	256	284	410
1988	100	121	137	164	215		2009	155	179	193	220	306
1989	234	262	271	300	435		2010	139	162	176	204	279
1990	91	112	128	155	200		2011	260	290	298	327	479
1991	111	132	148	175	233		2012	174	200	212	240	338
1992	50	69	88	114	133		2013	94	115	132	158	205
1993	247	276	285	314	458		2014	69	89	107	133	164
1994	58	77	95	122	146		2015	40	59	78	104	117
1995	242	270	279	308	448		2016	113	135	151	178	237
1996	197	224	235	263	375		2017	225	253	262	291	420
1997	221	249	259	287	414		2018	105	127	143	170	224
1998	249	278	286	315	461		2019	176	202	214	242	341
1999	400	437	437	468	708		2020	67	87	105	131	161
2000	251	280	288	317	463		2021	45	64	83	109	125
2001	75	95	113	139	175		2022	104	126	142	169	223

Appendix Table C-9. June 1 percent-exceedance forecasts of June 1 through September U Upper Klamath Lake net inflow volumes (TAF) based on the seasonal Normalized Wetness Index

Year	95%	70%	50%	30%	5%		Year	95%	70%	50%	30%	5%
1981	50	82	92	99	129		2002	48	79	90	96	125
1982	147	194	195	204	274		2003	63	98	107	115	150
1983	222	275	268	278	378		2004	60	94	104	111	145
1984	242	298	288	298	406		2005	107	148	154	162	216
1985	122	166	170	178	239		2006	163	212	212	221	298
1986	111	154	159	167	223		2007	73	109	118	125	165
1987	46	77	87	94	122		2008	137	182	185	194	260
1988	52	84	94	101	131		2009	96	136	143	151	200
1989	102	143	149	157	209		2010	66	101	110	117	154
1990	61	95	105	112	146		2011	141	187	189	198	266
1991	71	107	116	123	162		2012	94	134	141	149	198
1992	18	40	51	57	71		2013	60	94	103	110	144
1993	108	150	155	164	218		2014	34	61	72	79	100
1994	35	62	73	79	102		2015	42	72	83	89	115
1995	124	169	173	181	242		2016	55	88	98	105	136
1996	141	188	190	199	267		2017	120	164	168	176	236
1997	137	183	186	194	261		2018	75	112	120	128	168
1998	257	313	301	311	426		2019	95	135	142	150	199
1999	271	328	314	324	444		2020	52	84	95	101	132
2000	130	175	178	187	250		2021	31	57	68	74	95
2001	45	76	86	93	120		2022	44	74	84	91	117



Notes: 50% (blue solid lines) and 95% (black dashed lines) exceedance forecasts were directly estimated using quantile regression for the 1991-2022 period of record (open circles). The same equations were used to forecast net inflows over the 1981-1990 period (solid grey circles). Note that the KRM uses the 95% exceedance forecasts only for April 1 and 15.

Appendix Figure C-5. Seasonal Upper Klamath Lake net inflow forecasts based on the seasonal Normalized Wetness Index that are used in the Keno Release Model

In the Proposed Action, seasonal forecasts of net inflow into UKL are used only to determine allocations to Project irrigation. Because of the very recent change in the UKL net inflow time series, the seasonal NWI-based forecast models are the only available models that have been calibrated using the new net inflow time series. Therefore, the KRM presently uses only the seasonal NWI to forecast UKL net inflows and calculate the seasonal progression of water volumes available for irrigation use. However, the KRM is structured to use the NRCS, California Nevade River Forecast Center (CNRFC), and NWI models for forecasting either individually or in combination. Combined forecasts consist of an average weighted by the reflection of the MAE associated with each forecast model. The reflection is a simple transformation that flips the model-specific MAE relative to the mean of all the models so that the reflected MAE for the best performing model (i.e., the smallest MAE) will be the largest weight when combining the forecasts. Combined forecasts among some or all of the three main forecasting models frequently outperformed the individual models when this KRM component was built prior to the change in the UKL net inflow time series, and this will likely also be true using the recalibrated models.

Appendix Table C-10 and Appendix Table C-11 compare the absolute values of the errors (actual - forecast) from the three forecast models. This is not yet an “apples-to-apples" comparison because the NRCS and CNRFC forecasts are made for, and errors are computed from, the UKL net inflow time series used before the recent revision, whereas the seasonal NWI-based forecasts and errors use the revised UKL net inflow time series. Nonetheless these comparisons illustrate the kind of evaluation that should be performed before finalizing the selection of forecast model products for use in the Proposed Action. Note that in this imperfect comparison, the NWI-based forecasts out-perform the other two models for the May 1 and June 1 forecasts and are intermediate for the April 1 forecast (Appendix Table C-10 and Appendix Table C-11), but on each date a combination of forecasts performs the best.

Appendix Table C-10. Mean absolute errors of seasonal 50% exceedance forecasts of Upper Klamath Lake net inflow among the three forecast models and the best performing combination of the three models

Source	**Mar 1 Apr-Sep**	**Apr 1 Apr-Sep**	**Apr 15 Apr 15-Sep**	**May 1 May-Sep**	**May 15 May 15-Sep**	**Jun 1 Jun-Sep**
NRCS		47		38		20
CNRFC		54		41		27
NWI	72	50	40	32	31	16
Best combined		39		30		15

Appendix Table C-11. Mean absolute percentage errors of seasonal 50% exceedance forecasts of Upper Klamath Lake net inflow among the three forecast models and the best performing combination of the three models

Source	**Mar 1 Apr-Sep**	**Apr 1 Apr-Sep**	**Apr 15 Apr 15-Sep**	**May 1 May-Sep**	**May 15 May 15-Sep**	**Jun 1 Jun-Sep**
NRCS		12.0%		15.7%		15.6%
CNRFC		14.1%		16.3%		19.9%
NWI	21.7%	13.3%	12.4%	14.4%	17.9%	15.7%
Best combined		10.6%		12.2%		12.3%

When the NRCS and CNRFC have finished reconstructing their forecasts, Reclamation and U.S. Fish and Wildlife Service and National Marine Fisheries Service (Services) will evaluate the forecast characteristics and the effects on the Proposed Action outcomes of using the best performing model or combination of models in the KRM. Reclamation and the Services will seek agreement on the specific forecast model or combination of models to be used for updating forecasts every 2 weeks from April 1 to June 1. Until then the Proposed Action will use the seasonal NWI-based forecasts.

Upper Klamath Lake Status

In addition to tracking the hydrologic condition of the Upper Klamath Basin using the NWI, the storage condition of UKL is another important consideration for water management. Before describing it, however, it is important to understand the use of shadow UKL levels in the KRM. As will be described later in this document, the KRM implements a deferred use operation (Flexible Flow Account) for river flow releases from Keno Dam in which a specified proportion of calculated releases during October through March 1 is stored in UKL for use during March 2 through June. A similar deferred use operation is employed for Project irrigation (deferred Project Supply Account) in which inflows or return flows from the Lost River and F/FF pumps that are allowed to move out of the Project to contribute to targeted releases from Keno Dam (when neither Link River Dam nor Keno Dam is spilling) are accounted for as an accrual to the deferred Project Supply Account in UKL that can be used by irrigators during the irrigation season. Deferred Project Supply Account accruals also occur when UKL water that is set aside for maintaining Sump 1A in Tule Lake National Wildlife Refuge (TLNWR) and Unit 2 in Lower Klamath National Wildlife Refuge (LKNWR) is replaced by inflows or return flows from the Lost River and F/FF pumps when neither dam is spilling.

Each of these deferred use operations is intended to provide flexibility to those using the water and is designed to have no or minimal impact on how water is used by other system components at any point in time. To achieve that end, a water accounting structure keeps daily track of what UKL levels would be if the deferred use operations were not occurring—this is called the UKL shadow level. By using the UKL shadow level to determine the UKL Status (and hence the Ops Index), the deferred use operations can proceed in a flexible manner without affecting the Ops Index, which is a key component in the computation of River releases, Project irrigation allocation, and other variables. UKL shadow levels on day d are determined from UKL shadow storage (SS) computed as:

$$SS_d = S1_{d-1} - FFA_d - DPSA_d, \tag{3}$$

where $S1$ is UKL storage volume, FFA is the Flexible Flow Account volume, and $DPSA$ is the accumulated deferred Project Supply Account volume. Both FFA and $DPSA$ are described in the *Releases from Keno Dam to the Klamath River* and *Deferred Project Supply Accounting* sections of this Appendix, respectively. UKL shadow storage is translated into UKL shadow level using the elevation-capacity relationship for Upper Klamath Lake that includes the Upper Klamath National Wildlife Refuge (UKNWR) wetland reconnection via interpolation when needed (Appendix Table C-12).

Appendix Table C-12. Elevation-capacity relationship for Upper Klamath Lake including the Upper Klamath National Wildlife Refuge wetland reconnection

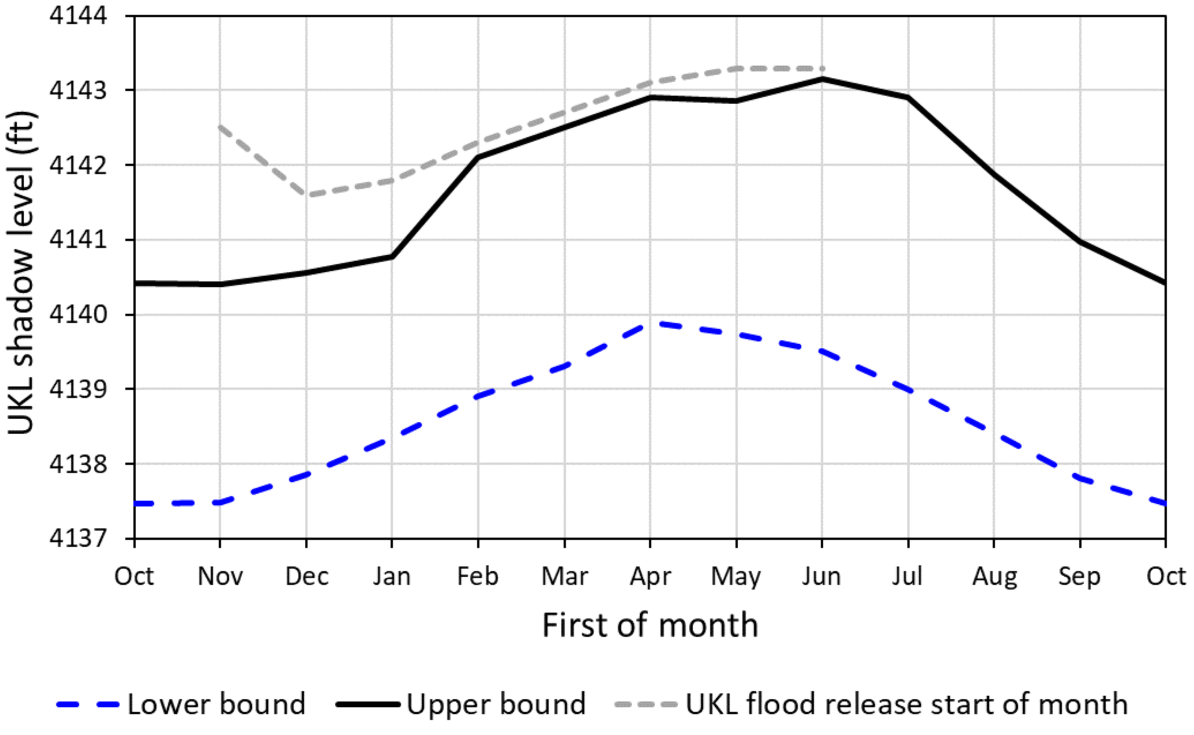
Elevation (ft, Reclamation datum)	Active Storage (TAF)		Elevation (ft, Reclamation datum)	Active Storage (TAF)
4,136	0.000		4,139.8	294.841
4,136.1	6.557		4,139.9	303.924
4,136.2	13.220		4,140	313.118
4,136.3	19.983		4,140.1	322.432
4,136.4	26.843		4,140.2	331.839
4,136.5	33.797		4,140.3	341.326
4,136.6	40.841		4,140.4	350.886
4,136.7	47.970		4,140.5	360.513
4,136.8	55.180		4,140.6	370.206
4,136.9	62.464		4,140.7	379.960
4,137	69.817		4,140.8	389.775
4,137.1	77.226		4,140.9	399.649
4,137.2	84.678		4,141	409.581
4,137.3	92.165		4,141.1	419.582
4,137.4	99.687		4,141.2	429.623
4,137.5	107.242		4,141.3	439.696
4,137.6	114.831		4,141.4	449.798
4,137.7	122.454		4,141.5	459.928
4,137.8	130.112		4,141.6	470.083
4,137.9	137.802		4,141.7	480.264
4,138	145.526		4,141.8	490.470
4,138.1	153.283		4,141.9	500.699
4,138.2	161.083		4,142	510.949
4,138.3	168.935		4,142.1	521.221
4,138.4	176.843		4,142.2	531.509
4,138.5	184.812		4,142.3	541.813
4,138.6	192.845		4,142.4	552.132
4,138.7	200.944		4,142.5	562.465
4,138.8	209.111		4,142.6	572.812
4,138.9	217.347		4,142.7	583.175
4,139	225.651		4,142.8	593.552
4,139.1	234.014		4,142.9	603.943
4,139.2	242.443		4,143	614.345
4,139.3	250.949		4,143.1	624.761
4,139.4	259.539		4,143.2	635.189
4,139.5	268.218		4,143.3	645.627
4,139.6	276.991		4,143.4	656.076
4,139.7	285.864		4,143.5	666.535

In the KRM, lower and upper bounds are set on UKL shadow levels, and daily UKL Status is calculated as the relative position of UKL shadow level (L) on day d between the specified lower (low) and upper (up) bounds for water years 1991-2022:

$$UKL\ Status_d = min\left(1, \left(max\left(0, \frac{L_d - L_{low}}{L_{up} - L_{low}}\right)\right)\right). \tag{4}$$

When L_d is at or above the upper bound, UKL Status will be 1; UKL Status will be zero when L_d is at or below the lower bound. The lower bound is established as the 95% exceedance UKL shadow level on the first day of each month (interpolated for other days) as computed from the output of a particular simulation. Similarly, on the first day of each month (interpolated for other days), the upper bound is the flood release curve minus 0.2 ft during December through March but is otherwise the highest simulated UKL shadow level. The upper and lower bounds are determined iteratively by repeatedly running the KRM, recalculating the lower and upper bounds for each iteration using the results from the prior simulation. After several iterations, the upper and lower bounds stop changing significantly and the bounds are finalized.

UKL bounds do not prevent UKL levels from moving above or below them; they are not lake level requirements. Rather, they specify the UKL shadow level at which and below the UKL Status will be zero, or at which and above the UKL Status will be 1. The upper and lower bounds used in the KRM for the Proposed Action are shown on Appendix Figure C-6.

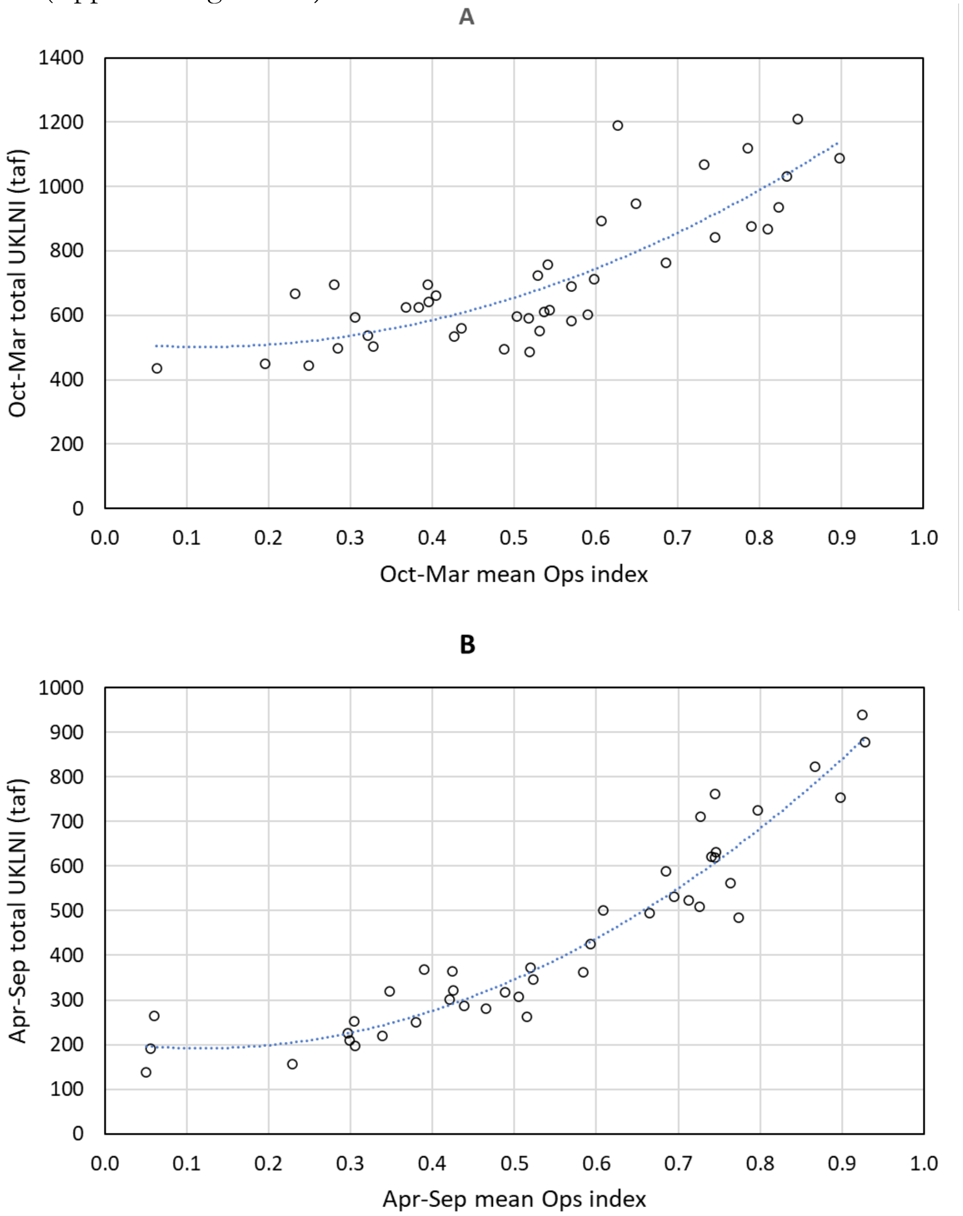


Appendix Figure C-6. Lower and upper bounds for Upper Klamath Lake shadow levels used for computing UKL Status and the winter/spring flood release curve for Upper Klamath Lake

Operations Index

The Ops Index is the main structural variable governing the movement of water in the KRM. It is calculated as the average of the 14-day trailing mean of the daily NWI and the UKL Status, thereby including measurement of the basin hydrologic status and the storage status of UKL. Ops Index values range from 0 (driest, lowest storage) to 1 (wettest, highest storage).

The Ops Index tracks consistently with UKL net inflow. For example, October to March and April to September average Ops Index values show clear relationships to similarly averaged UKL net inflow volumes (Appendix Figure C-7).



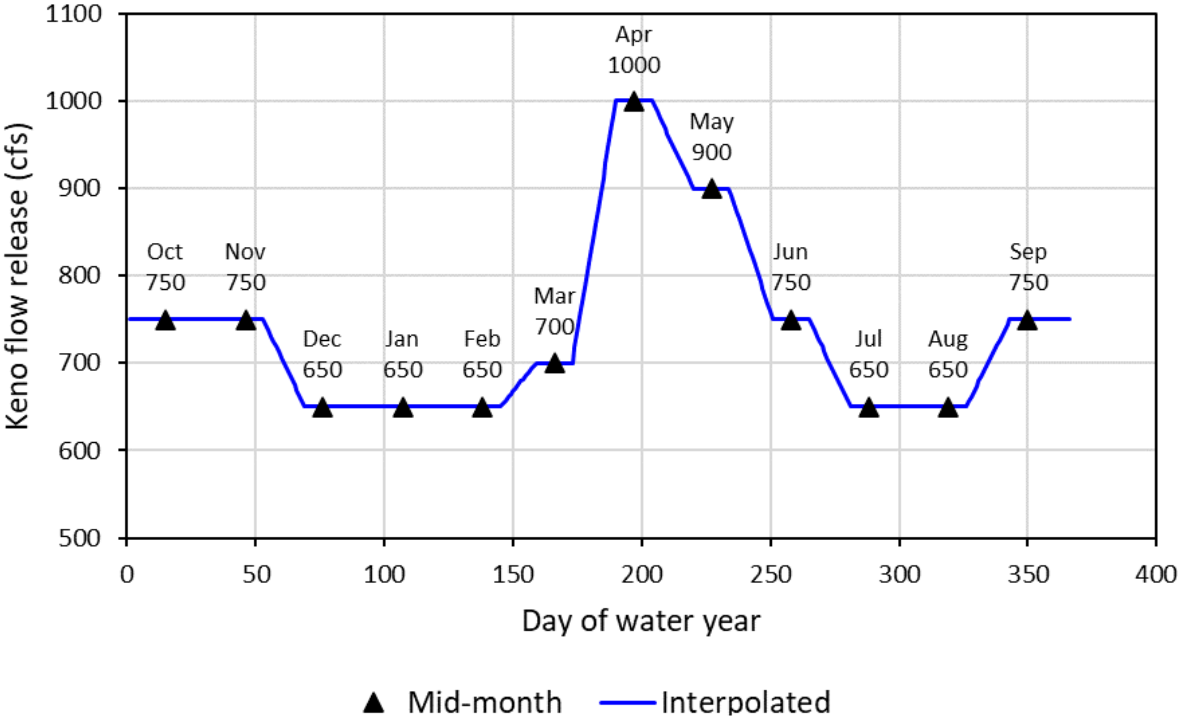
Note: Fitted lines are included to help visualize the relationships.

Appendix Figure C-7 Seasonal relationship between the mean Ops Index and Upper Klamath Lake net inflow volume for October through March (A), and April through September (B) in the Proposed Action

Releases from Keno Dam to the Klamath River

A daily River Base Flow regime for Keno Dam releases was established by specifying base flows for the center 15 days of each month and interpolating flows for the remaining days (Appendix Figure C-8). The River Base Flow (RBF) is the lowest flow that will ever be targeted for release from Keno Dam on a specific day of the year, which would occur only when the Ops Index or the Keno Release Multiplier ($KRmult$) is 0. On each day (d), a $KRmult$ is selected based on the Ops Index and the current month (Appendix Table C-13), and the targeted release (in cfs) from Keno Dam (KRT) is computed:

$$KRT_d = max(RBF_d, RBF_d + (RBF_d \times KRmult_d) - FFAinc_d + FFAuse_d). \tag{5}$$



Appendix Figure C-8. River Base Flows specified for 15 days centered on the fifteenth day of each month, with daily flows interpolated between these periods

Appendix Table C-13. Keno Release Multiplier lookup table used by the Keno Release Model

Ops Index	Oct	Nov	Dec-Feb	Mar	Apr	May	Jun	Jul-Sep
0	0	0	0	0	0	0	0	0
0.2	0.06	0.06	0.07	0.17	0.14	0.11	0.14	0
0.4	0.09	0.09	0.16	0.35	0.27	0.4	0.17	0.01
0.6	0.14	0.16	0.6	0.93	0.62	0.74	0.33	0.05
0.8	0.34	0.6	2.05	2.49	2.19	1.73	0.72	0.23
1	1.08	2.43	4.78	6.28	5.3	4.18	2.5	0.68

Notes:
Each day the Ops Index is computed and used to look up the associated multiplier values (interpolated as necessary).

A Flexible Flow Account (FFA) operation is used in the KRM that defers use of some water targeted for release to the river during fall-winter ($FFAinc_d$), storing the accumulating volume in UKL during the October to March 1 accrual period. During March 2 through June, the stored FFA water ($FFAuse_d$) is used in a manner that can vary each year.

Key elements of this operation include the FFA reserve proportion (RP_d) determined by the value of the Ops Index (Appendix Table C-14), and the expectation that the river will fully use the FFA volume each year. Computation of the daily addition of deferred volume to the FFA begins with

$$FFAinc_d = (RBF_d \times KRmult_d) \times RP_d. \tag{6}$$

As the Ops Index approaches 0.7, the FFA reserve proportion declines to zero because with wetter conditions comes less need to augment flows or to shape a discrete event like a pulse flow.

Appendix Table C-14. Flexible Flow Account reserve proportion lookup table for the Keno Release Model

Ops Index	FFA Reserve Proportion
0	0.9
0.6	0.7
0.7	0
1	0

Notes:
Reserve proportions are interpolated to correspond with the computed Ops Index.

However, the full amount of the $FFAinc_d$ is not always stored for later use (i.e., added to the FFA) because of interactions with spill and ramping operations. The amount of yesterday's daily accrual volume (TAF) to the FFA is calculated as

$$Yest\_FFA\_savings_d = max\big(0, FFAinc_{d-1} - max(0, C13\_exc_{d-1} - Yest\_DPS\_spill_d - I91\_IG_{d-1} - C131\_IG_{d-1} - C13\_ramp_{d-1})\big), \tag{7}$$

where $C13\_exc_{d-1}$ is yesterday's spill from Keno Dam, $I91\_IG_{d-1}$ and $C131\_IG_{d-1}$ are yesterday's flows from the Lost River and returns from KDD, respectively, that contributed to Klamath River flows below Keno Dam, and $C13\_ramp_{d-1}$ is yesterday's down-ramping flow at Keno Dam. Yesterday's spill of the deferred Project Supply volume ($Yest\_DPS\_spill_d$) is explained later in the *Deferred Project Supply Accounting* section below.

Spills from Link River or Keno dams will stop the accrual of FFA volume. Spills from Link River Dam will spill the stored FFA volume after the accumulated deferred Project Supply volume has been spilled.

Use of the FFA volume ($FFAuse_d$) may take different forms year to year. Pulse flows may be implemented from the FFA volume, or the volume may be used to augment flows, or both. Two simulations of the Proposed Action have been prepared to illustrate the flexibility intended for the use of the FFA. In one (run name MST11b_DraftPA_Jan26) a Pulse Flow operation is implemented annually based upon a set of criteria intended to provide a realistic (but not prescriptive) representation of how Pulse Flows could be implemented. In the other (run name MST11b_DraftPA_PFoff_Jan26) no Pulse Flows are implemented and the FFA volume is added to the Keno Release Targets according to one of many possible distribution shapes.

The conditions governing Pulse Flow operations in the KRM were not intended to constrain real-time operations. Operationally, sizing the peak release based on ramping rates (which typically govern the recession limb of the Pulse Flow) and release targets immediately before the Pulse Flow must be done in a manner that prevents using more volume for the Pulse Flow event than is available in the FFA. The KRM determined the magnitude of the first day's Pulse Flow release to be 30% of the FFA volume, a conservative approach that ensured subsequent ramping did not overspend the FFA in the POR simulated. In addition, the KRM limited the size of the FFA to approximately 35 TAF, which appeared to adequately balance the cost of deferrals to winter flows with the benefit of providing sufficient pulse flows and/or augmented flows in the spring. Finally, the KRM did not simulate a Pulse Flow if a daily release from Keno Dam exceeded 4,500 cfs after January.

The variable $Yest\_FFA\_use_d$ (TAF) is used to account for the interaction of yesterday's $FFAuse$ and yesterday's spill from Link River Dam ($C1\_exc_{d-1}$):

$$Yest\_FFA\_use_d = \min(FFAuse_{d-1}, C1\_exc_{d-1}). \tag{8}$$

Spills from the FFA can occur after all of the accumulated deferred Project Supply volume has been spilled and are quantified by:

$$Yest\_FFA\_spill_d = max\big(0, \big(min(C1\_exc_{d-1}, C13\_exc_{d-1} - I91\_IG_{d-1} - C131\_IG_{d-1})\big) - Yest\_DPS\_spill_d\big). \tag{9}$$

The FFA (FFA_d) tracks the accrual, storage, and use of deferred flow volumes as of day d using:

$$FFA_d = max(0, FFA_{d-1} + Yest\_FFA\_savings_d - Yest\_FFA\_use_d - Yest\_FFA\_spill_d). \tag{10}$$

Down-ramping rates used in the KRM have been translated from those used for Iron Gate Dam releases to approximate ramp rates for releases from Keno Dam that would produce flow changes at the Iron Gate gage like those required under previous Biological Opinions (Appendix Table C-15).

Appendix Table C-15. Ramp rates for releases from Keno Dam under the Proposed Action compared to those for releases from Iron Gate Dam under the Interim Operations Plan

Keno Release Threshold (cfs)	Keno Ramp Rate (cfs/day)	IGD Release Threshold from IOP (cfs)	IGD Ramp Rate (cfs/day)
<1,400	150	<1,900	150
<2,800	300	<3,300	300
<3,100	600	<3,600	600
<3,500	$C13_{-1}$ - 2,500	<4,000	$C15_{-1}$ - 3,000
<4,100	1,000	<4,600	1,000
≥4,100	min(2,000, $C13_{-1}$ - 3,100)	≥4,100	min(2,000, $C15_{-1}$ - 3,600)

Notes:
$C13_{-1}$ and $C15_{-1}$ are the prior day releases from Keno and Iron Gate dams, respectively.

Simulated Proposed Action outcomes for the river expressed as percent exceedance, maximum and minimum of daily flows computed by month for water years 1991-2022 are in Appendix Table C-16 and Appendix Table C-17 for the Keno gage, and Appendix Table C-18 and Appendix Table C-19 for the Iron Gate gage. Note that tables are provided for each of the Proposed Action simulations (Pulse Flows on and off). Simulated flow at the Iron Gate gage is the sum of the Keno Release Target, Keno ramping and spills, and the Keno to Iron Gate accretions.

Appendix Table C-16. Simulated Proposed Action outcomes (cfs) for the river at the Keno gage with Pulse Flows on

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,418	2,281	3,335	6,705	7,772	6,046	6,878	5,759	4,654	1,658	1,370	1,189
5%	1,161	1,475	2,088	2,164	3,381	3,978	4,612	3,307	1,851	893	1,220	1,072
10%	975	1,104	1,428	1,628	2,510	2,877	3,796	2,549	1,368	839	1,034	897
15%	948	1,041	1,165	1,271	1,787	2,604	3,128	2,264	1,294	797	920	872
20%	937	907	785	992	1,224	2,427	2,855	2,141	1,219	776	846	848
25%	869	860	758	764	1,074	2,233	2,500	2,039	1,176	757	790	831
30%	840	803	746	751	909	1,717	2,237	1,932	1,148	748	768	823
35%	794	784	736	737	758	1,470	2,070	1,714	1,098	737	745	815
40%	779	777	726	725	735	1,375	1,947	1,563	1,052	698	727	791
45%	773	773	719	717	713	1,224	1,841	1,484	1,026	681	708	777
50%	771	770	710	708	699	1,182	1,651	1,446	1,001	677	690	771
55%	770	765	701	697	691	1,123	1,545	1,405	990	673	678	766
60%	767	763	689	687	686	1,049	1,472	1,345	978	669	673	757
65%	764	760	679	679	681	982	1,417	1,304	969	665	666	755
70%	762	759	673	674	677	943	1,363	1,235	956	659	662	754
75%	762	758	669	671	673	921	1,300	1,188	930	655	656	753
80%	760	755	665	665	669	904	1,260	1,140	913	654	654	751
85%	758	752	663	660	662	881	1,210	1,107	874	653	653	750
90%	757	742	661	658	658	821	1,138	1,030	831	651	651	745
95%	752	726	656	656	655	756	1,043	948	783	650	650	730
Min	751	706	650	650	650	675	877	840	708	650	650	709

Notes:
Statistics (minimum, maximum, and percent exceedance) are computed from daily flows for water years 1991-2022 for the specified months.

Appendix Table C-17. Simulated Proposed Action outcomes (cfs) for the river at the Keno gage with Pulse Flows off

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,418	2,281	3,335	6,705	7,772	6,046	6,878	5,759	4,654	1,658	1,370	1,189
5%	1,161	1,475	2,087	2,164	3,381	3,656	4,504	3,307	1,851	893	1,220	1,072
10%	976	1,104	1,429	1,626	2,510	2,712	3,531	2,672	1,366	839	1,034	897
15%	948	1,045	1,165	1,271	1,787	2,474	3,141	2,366	1,297	797	920	872
20%	937	910	785	993	1,227	2,313	2,728	2,250	1,231	776	846	849
25%	869	861	759	764	1,079	1,531	2,378	2,140	1,183	758	790	832
30%	842	804	747	751	908	1,362	2,202	2,037	1,150	748	768	823
35%	796	784	736	737	754	1,281	2,044	1,913	1,111	737	745	816
40%	779	777	726	725	734	1,202	1,900	1,784	1,068	698	727	791

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
45%	773	773	720	717	712	1,171	1,774	1,698	1,043	681	708	777
50%	771	770	710	708	699	1,119	1,638	1,649	1,009	677	689	771
55%	770	765	701	697	691	1,066	1,571	1,593	985	673	678	766
60%	767	763	689	687	685	996	1,522	1,527	967	669	673	757
65%	764	760	679	679	681	952	1,490	1,463	957	665	666	755
70%	762	759	673	674	677	930	1,434	1,407	943	659	662	754
75%	762	758	669	671	673	915	1,370	1,343	926	655	656	753
80%	760	755	665	665	669	897	1,317	1,287	906	654	654	751
85%	758	752	663	660	662	869	1,237	1,239	879	653	653	750
90%	757	741	661	658	658	821	1,148	1,115	825	651	651	745
95%	752	726	656	656	655	755	1,097	1,015	798	650	650	730
Min	751	706	650	650	650	675	877	884	703	650	650	709

Notes:
Statistics (minimum, maximum, and percent exceedance) are computed from daily flows for water years 1991-2022 for the specified months.

Appendix Table C-18. Simulated Proposed Action outcomes (cfs) for the river at the Iron Gate gage with Pulse Flows on

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,902	3,231	6,609	12,735	10,344	8,341	7,855	6,251	5,406	2,163	1,768	1,555
5%	1,549	1,887	3,043	3,799	4,721	5,042	5,546	4,235	2,449	1,336	1,568	1,444
10%	1,446	1,553	1,981	2,338	3,329	3,977	4,718	3,330	1,981	1,254	1,363	1,291
15%	1,333	1,450	1,756	1,997	2,692	3,509	4,120	3,000	1,803	1,200	1,306	1,233
20%	1,301	1,339	1,527	1,783	2,243	3,295	3,591	2,762	1,669	1,160	1,230	1,204
25%	1,259	1,281	1,351	1,541	1,797	3,079	3,251	2,642	1,608	1,134	1,166	1,182
30%	1,207	1,227	1,262	1,406	1,557	2,895	3,005	2,527	1,572	1,096	1,115	1,166
35%	1,171	1,191	1,205	1,317	1,472	2,559	2,864	2,306	1,502	1,077	1,080	1,146
40%	1,152	1,167	1,172	1,258	1,374	2,307	2,691	2,141	1,442	1,040	1,062	1,133
45%	1,140	1,147	1,143	1,223	1,292	2,050	2,524	2,027	1,398	1,023	1,041	1,122
50%	1,133	1,134	1,119	1,187	1,230	1,866	2,296	1,932	1,360	1,009	1,019	1,109
55%	1,122	1,125	1,100	1,151	1,195	1,724	2,203	1,877	1,338	999	1,005	1,096
60%	1,110	1,117	1,079	1,121	1,160	1,584	2,090	1,815	1,319	990	988	1,081
65%	1,096	1,109	1,065	1,097	1,131	1,503	1,980	1,754	1,301	980	975	1,069
70%	1,084	1,100	1,052	1,081	1,105	1,424	1,881	1,675	1,275	972	967	1,059
75%	1,072	1,088	1,039	1,061	1,087	1,361	1,741	1,612	1,259	958	955	1,049
80%	1,054	1,078	1,022	1,041	1,069	1,310	1,669	1,532	1,235	948	945	1,038
85%	1,036	1,066	1,003	1,021	1,048	1,276	1,637	1,483	1,207	940	934	1,027
90%	1,024	1,051	984	992	1,019	1,236	1,564	1,369	1,149	927	924	1,010
95%	1,015	1,026	961	969	996	1,129	1,421	1,264	1,070	917	913	998
Min	986	978	918	912	930	1,024	1,250	1,102	1,001	898	883	958

Notes:
Statistics (minimum, maximum, and percent exceedance) are computed from daily flows for water years 1991-2022 for the specified months.

Appendix Table C-19. Simulated Proposed Action outcomes (cfs) for the river at the Iron Gate gage with Pulse Flows off

Statistic	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Max	1,902	3,231	6,609	12,735	10,344	8,341	7,855	6,251	5,406	2,163	1,768	1,555
5%	1,549	1,887	3,043	3,799	4,721	4,719	5,517	4,235	2,465	1,337	1,568	1,444
10%	1,446	1,553	1,980	2,338	3,329	3,693	4,555	3,423	1,997	1,254	1,363	1,291
15%	1,333	1,455	1,750	2,002	2,692	3,347	4,105	3,167	1,794	1,200	1,306	1,233
20%	1,301	1,343	1,530	1,783	2,243	3,094	3,534	2,852	1,674	1,160	1,230	1,204
25%	1,260	1,281	1,346	1,541	1,798	2,848	3,166	2,757	1,616	1,134	1,166	1,182
30%	1,209	1,228	1,262	1,406	1,556	2,478	3,009	2,634	1,569	1,096	1,115	1,166
35%	1,171	1,192	1,205	1,317	1,475	2,272	2,867	2,499	1,519	1,077	1,080	1,147
40%	1,152	1,168	1,172	1,260	1,373	2,069	2,576	2,332	1,456	1,040	1,062	1,133
45%	1,140	1,147	1,143	1,225	1,290	1,946	2,434	2,217	1,409	1,023	1,041	1,122
50%	1,133	1,134	1,118	1,187	1,230	1,779	2,265	2,134	1,371	1,009	1,019	1,109
55%	1,123	1,125	1,100	1,151	1,196	1,703	2,191	2,058	1,351	999	1,005	1,096
60%	1,110	1,117	1,079	1,121	1,160	1,565	2,124	1,993	1,320	990	988	1,081
65%	1,096	1,109	1,065	1,097	1,131	1,494	2,029	1,911	1,292	980	975	1,069
70%	1,084	1,100	1,052	1,080	1,105	1,417	1,853	1,842	1,267	972	967	1,059
75%	1,072	1,088	1,039	1,061	1,087	1,358	1,800	1,768	1,247	958	955	1,049
80%	1,054	1,078	1,022	1,041	1,069	1,310	1,758	1,706	1,223	948	945	1,038
85%	1,036	1,066	1,003	1,021	1,048	1,275	1,667	1,629	1,190	940	934	1,027
90%	1,024	1,051	984	992	1,019	1,236	1,562	1,447	1,139	927	924	1,010
95%	1,015	1,026	961	969	996	1,128	1,472	1,360	1,081	917	913	998
Min	986	978	918	912	930	1,024	1,250	1,159	993	898	883	958

Notes:
Statistics (minimum, maximum, and percent exceedance) are computed from daily flows for water years 1991-2022 for the specified months.

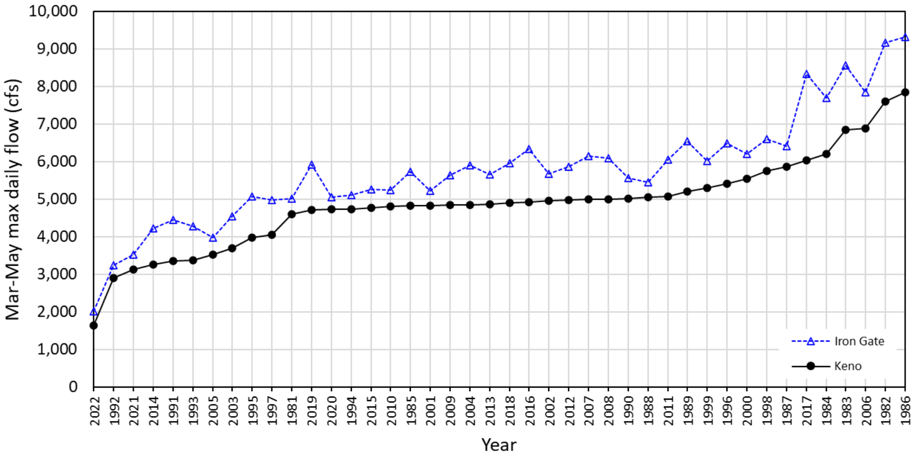
The volume used from the FFA each year for each of the Proposed Action simulations is almost always very similar (Appendix Table C-20). In 1989, less FFA water was used when the Pulse Flow was off because in that scenario some of the FFA volume spilled (after all the accumulated deferred Project Supply volume spilled). Maximum daily flows at Keno and Iron Gate with Pulse Flows on and off are shown on Appendix Figure C-9.

Appendix Table C-20. Flexible Flow Account volumes used by the river each year for each of the Proposed Action simulations (Pulse Flows on and off)

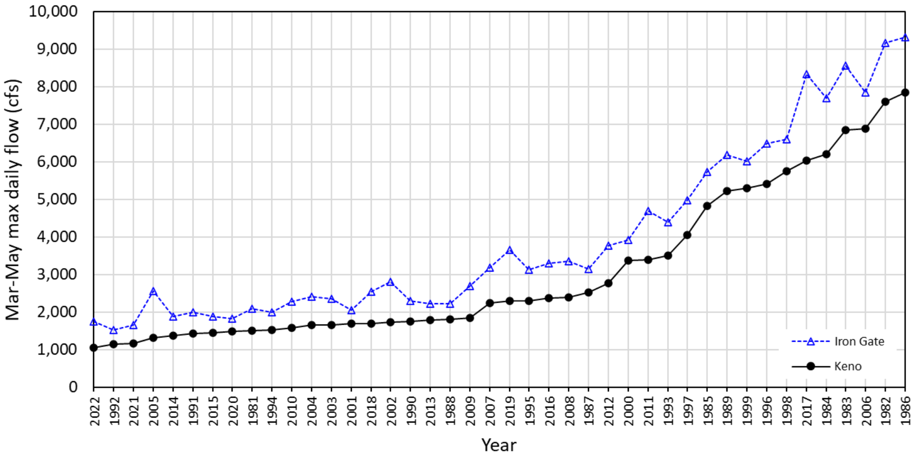
Year	FFA Used with PF On (TAF)	FFA Used with PF Off (TAF)		Year	FFA Used with PF On (TAF)	FFA Used with PF Off (TAF)
1981	22	22		2002	34	34
1982	0	0		2003	18	18
1983	0	0		2004	24	25
1984	7	7		2005	16	16
1985	15	15		2006	22	22
1986	0	0		2007	35	35
1987	35	35		2008	36	36
1988	36	36		2009	36	36
1989	36	30		2010	25	25
1990	36	36		2011	36	36

Year	FFA Used with PF On (TAF)	FFA Used with PF Off (TAF)		Year	FFA Used with PF On (TAF)	FFA Used with PF Off (TAF)
1991	17	17		2012	36	36
1992	12	12		2013	35	35
1993	12	12		2014	16	16
1994	34	34		2015	25	25
1995	20	20		2016	34	34
1996	0	0		2017	11	11
1997	0	0		2018	27	27
1998	8	8		2019	24	24
1999	5	5		2020	34	34
2000	20	20		2021	14	14
2001	35	35		2022	4	4

A: Pulse Flow On



B: Pulse Flow Off



Note: ears are sorted based on the magnitude of the March through May max daily flow at Keno.

Appendix Figure C-9. Maximum daily flow for March through May in each year for the Pulse Flow on (A) and Pulse Flow off (B) scenarios of the Proposed Action

Project Irrigation Allocation

In past operations of the Project, allocations from UKL were made to various uses based on the volume of UKL net inflow forecasted to appear from some specified date in the spring through September. The only forecast-based allocation in the current Proposed Action is made for Project irrigation. Portions of this allocation can change when the net inflow forecasts change (see Appendix Table C-3 for the forecast dates), but the allocation is firm and unchanging from June 1 through the rest of the year. Water available for irrigation use from UKL during the spring-summer period is divided into forecast-based firm and variable components from UKL storage and inflow.

The process for allocating water for irrigation begins with looking up the Project Share (PS) of storage or inflow components, which is determined by the Ops Index (Appendix Table C-21). On March 1 and then again on April 1, a Project Supply from Storage (PSS, in TAF) is computed as

$$PSS_d = (SS_d - 209.111\ taf) \times PS_d, \tag{11}$$

where d is either March 1 or April 1, SS_d is UKL Shadow Storage, and 209.111 TAF is the UKL active storage at an elevation of 4,138.8 ft (Reclamation datum, see Appendix Table C-21). The $PSS_{Apr\ 1}$ is the Firm Project Supply from Storage, which does not change again that year.

Appendix Table C-21. Project Share of storage and inflow components of the Klamath Project allocation

Ops Index	Project Share
0	0.12
0.2	0.17
0.4	0.26
0.6	0.26
0.8	0.25
1	0.24

Note:
Project Share values are interpolated based on the value of the Ops Index.

Estimates of UKL net inflow volume for April through September are made on each forecast date and are used to calculate the Project Supply from inflow (PSI). Such estimates are comprised of the actual UKL net inflow volume since April 1 plus the forecasted UKL net inflow volume from the forecast date through September. On April 1, the variable Apr95vol is the 95% exceedance forecast on April 1 of April-September UKL net inflow. On April 15, Apr95vol is the actual UKL net inflow from April 1-14 plus the 95% exceedance forecast of April 15-September UKL net inflow. Apr50vol is computed in the same manner as Apr95vol using the 50% exceedance forecast instead of the 95% exceedance forecast. So, for example, the Apr50vol on March 1 and April 1 is the 50% exceedance forecast of April-September UKL net inflow, and on May 15 is the actual UKL net inflow from April 1-May 14 plus the 50% exceedance forecast of May 15-September UKL net inflow.

In March there is no distinction between firm and variable allocations from UKL net inflow for irrigation, so on March 1 the Project Supply from inflow (PSI, in TAF) is calculated as:

$$PSI_{Mar\ 1} = Apr50vol_{Mar\ 1} \times PS_{Mar\ 1}. \tag{12}$$

Starting on April 1, the Project Supply from inflow is divided into firm and variable components. The Firm Project Supply from inflow ($FPSI$, in TAF) is computed provisionally on April 1 and then finally on April 15 as:

$$FPSI_d = min\big(350\ taf - PSS_{Apr\ 1}, Apr95vol_d \times PS_d\big), \tag{13}$$

where d is either April 1 or 15, and 350 TAF is the maximum Project Supply from UKL. $FPSI_d$ is constrained so that when added to the Project Supply from Storage the sum does not exceed the maximum Project Supply from UKL. The $FPSI_{Apr\ 15}$ remains constant through the rest of the year.

By April 15, the firm supplies from storage and inflow are known, and the Firm Project Supply (FPS, in TAF) is calculated as:

$$FPS_{Apr\ 15} = \min\big(350\ taf, PSS_{Apr\ 1} + FPSI_{Apr\ 15}\big), \tag{14}$$

but note that this is also computed provisionally on Apr 1 using the provisional $FPSI_{Apr\ 1}$.

On April 1, the variable component (which can increase or decrease) of Project Supply from inflow ($VPSI$, in TAF) is computed for the first time, and then is recomputed on every subsequent forecast date until becoming firm on June 1. On forecast date d this supply is computed as:

$$VPSI_d = min\big(350\ taf - FPS_d, (Apr50vol_d \times PS_d - FPSI_d)\big) \times PSM_d, \tag{15}$$

where FPS_d is held constant at $FPS_{Apr\ 15}$ for forecast dates later than April 15, and PSM_d is the Project Supply Multiplier that is determined by the exceedance quantile of the cumulative actual UKL net inflow volume since April 1 (Appendix Table C-22). As actual UKL net inflow after April 1 increases above the median (the exceedance quantile declines from 0.5), the Project Supply Multiplier increases above 1 and increases the Variable Project Supply. The opposite occurs when the inflows decline below the median (the exceedance quantile increases from 0.5). The annual progression of the Variable Project Supply from inflow is shown in Appendix Table C-23 for the Proposed Action run with Pulse Flows on.

Appendix Table C-22. The Project Supply Multiplier is determined by the exceedance quantile for cumulative Upper Klamath Lake net inflow volume since Apr 1

Inflow Exceedance Since Apr 1	Project Supply Multiplier
0.05	1.5
0.5	1
0.95	0.5

Note:
Exceedance is computed for water years 1991-2022.

Appendix Table C-23. Keno Release Model output showing the various computed components of Project Supply from Upper Klamath Lake (TAF) for the Proposed Action run with Pulse Flows on

Year	Storage Mar 1	Provisional Inflow Mar 1	Firm Storage Apr 1	Provisional Inflow Apr 1	Firm Inflow Apr 15	Variable Apr 1	Variable Apr 15	Variable May 1	Variable May 15	Firm Variable Jun 1	Firm Supply Apr 15	Firm Supply Jun 1
1981	48	120	63	49	58	13	12	6	2	6	121	127
1982	88	142	95	112	143	76	31	10	26	29	238	267
1983	81	178	89	134	185	103	40	37	14	14	274	288
1984	73	153	96	122	167	91	37	37	25	45	263	307
1985	60	133	76	105	115	69	28	51	53	41	191	232
1986	92	137	101	91	103	58	24	19	31	29	204	232
1987	79	101	93	70	67	27	15	3	12	7	160	167
1988	78	83	93	50	41	10	9	17	22	20	134	155
1989	51	128	92	114	126	83	29	32	50	36	218	255
1990	70	79	87	54	46	15	10	16	17	19	133	152
1991	31	39	53	56	58	14	10	9	1	5	111	116
1992	15	32	18	19	14	3	3	7	6	3	32	35
1993	11	139	58	98	162	68	35	26	15	7	220	227
1994	52	73	59	38	38	6	8	3	0	0	97	97
1995	44	100	76	90	102	54	23	29	44	38	177	216
1996	90	142	95	86	91	41	22	41	44	71	186	257
1997	87	140	89	83	95	40	20	37	40	39	183	222
1998	75	155	90	103	141	70	32	0	11	62	231	293
1999	57	204	70	137	179	101	39	43	37	39	248	287
2000	79	142	87	95	84	53	20	57	83	70	171	241
2001	55	71	72	48	54	14	10	9	2	1	126	127
2002	55	112	69	66	58	23	13	24	33	25	127	152
2003	54	70	68	50	71	19	16	24	37	25	139	164
2004	52	133	72	67	61	33	14	19	21	20	133	153
2005	21	46	26	31	38	8	7	7	25	73	63	136
2006	68	166	72	111	149	68	32	45	49	58	221	279
2007	68	103	90	66	76	30	17	21	28	19	165	185
2008	55	131	72	94	114	56	24	15	13	16	186	202

Year	Storage Mar 1	Provisional Inflow Mar 1	Firm Storage Apr 1	Provisional Inflow Apr 1	Firm Inflow Apr 15	Variable Apr 1	Variable Apr 15	Variable May 1	Variable May 15	Firm Variable Jun 1	Firm Supply Apr 15	Firm Supply Jun 1
2009	60	97	79	74	83	27	14	0	11	15	161	177
2010	53	86	60	52	70	15	13	12	9	5	130	135
2011	71	105	89	104	131	68	29	30	13	13	220	233
2012	75	82	89	81	110	35	25	4	6	5	199	203
2013	60	89	73	53	68	14	15	9	5	1	141	143
2014	44	58	56	45	47	9	10	3	0	0	104	104
2015	59	51	66	37	36	7	7	2	0	2	102	104
2016	52	107	82	86	70	37	15	9	12	8	152	161
2017	73	156	97	108	143	77	32	24	14	15	240	255
2018	48	50	71	58	67	15	14	14	7	12	138	150
2019	49	122	63	83	112	38	26	29	25	21	175	196
2020	54	79	50	40	42	7	7	0	0	4	92	96
2021	20	58	20	28	16	4	3	2	2	2	36	39
2022	3	31	5	14	15	1	3	10	14	12	20	32

The Project Supply from UKL ($PSup$) sums the storage and inflow components and becomes firm on June 1, after which it does not change. On March 1, it is calculated as:

$$PSup_{Mar\ 1} = min(350\ taf, PSS_{Mar\ 1} + PSI_{Mar\ 1}). \tag{16}$$

On and after April 1 it is calculated as:

$$PSup_{d} = min(350\ taf, FPS_{d} + VPSI_{d}), \tag{17}$$

Note that d is either April 1 or 15 for FPS. At the end of this process, $PSup_{Jun\ 1}$ is the final, firm Project Supply from UKL for the rest of the year. Appendix Table C-23 reports the values computed for each component of Project Supply for the Proposed Action run with Pulse Flows on, and the temporal sequence of computed Project Supply from UKL within each year is in Appendix Table C-24.

Appendix Table C-24. Keno Release Model output showing the computed values of Project Supply from Upper Klamath Lake (TAF) within each year for the Proposed Action run with Pulse Flows on

Year	Mar 1	Apr 1	Apr 15	May 1	May 15	Jun 1		Year	Mar 1	Apr 1	Apr 15	May 1	May 15	Jun 1
1981	168	125	132	127	122	127		2002	167	158	140	150	160	152
1982	230	282	269	247	263	267		2003	124	137	155	163	176	164
1983	258	325	313	311	288	288		2004	185	172	147	152	153	153
1984	226	310	300	299	287	307		2005	67	65	70	71	89	136
1985	192	250	219	242	244	232		2006	234	251	254	266	270	279
1986	228	249	228	223	235	232		2007	170	186	183	187	193	185
1987	180	191	175	163	172	167		2008	186	223	210	201	199	202
1988	162	153	143	151	156	155		2009	157	179	176	161	172	177
1989	180	289	248	250	268	255		2010	138	127	143	142	139	135
1990	149	156	143	149	150	152		2011	176	261	249	250	233	233
1991	69	122	121	120	111	116		2012	157	205	223	203	205	203
1992	47	40	35	39	38	35		2013	149	140	157	150	146	143
1993	150	224	255	246	235	227		2014	101	111	114	107	104	104
1994	124	103	105	100	97	97		2015	110	111	109	104	102	104
1995	143	219	201	207	221	216		2016	159	205	167	162	165	161
1996	231	222	208	227	230	257		2017	229	282	272	264	254	255
1997	227	211	204	220	224	222		2018	98	144	151	152	145	150
1998	230	263	263	231	243	293		2019	171	183	201	205	200	196
1999	262	308	287	291	285	287		2020	133	97	99	92	92	96
2000	221	236	191	228	254	241		2021	78	52	40	39	39	39
2001	126	133	136	135	127	127		2022	34	21	23	30	34	32

Project Irrigation Diversions

The KRM represents Klamath Project Ag diversions at A Canal (D1), Station 48 and Miller Hill (aggregated into D91), North Canal (D11), and Ady Canal (D12A). In the KRM accounting, three sources of water are tracked for Project Ag diversions: UKL, Lost River water diverted into the LRDC (LRDC accretions), and F/FF pumping. During the irrigation season, UKL source diversions are divided into a Project Supply component (described above) and a Deferred Project Supply component (described in the *Deferred Project Supply Accounting* section). Ag diversion accounting rules vary by point of diversion, season of diversion, and the flood control status of UKL. The following priority schedule is used to determine how much Project Supply and deferred Project Supply were diverted the previous day.

9. A Canal
    - Irrigation season (March-October)
        - No flood control.
            - All diversions are from UKL.
                - Division between Project Supply and Deferred Project Supply is described below.
        - Flood control operations declared (imminent or occurring).
            - All diversions are from UKL.
                - Divert Deferred Project Supply first.
                - Divert Project Supply second.
    - Winter season (November-February).
        - No A Canal Ag diversions.
10. Station 48 and Miller Hill.
    - Irrigation season (March – November 15).
        - No flood control.
            - Divert LRDC accretions first.
            - Divert from UKL second.
                - Division between Project Supply and Deferred Project Supply is described below.
            - Divert from F/FF pumping last.

    - · Flood control operations declared (imminent or occurring).
        - Divert LRDC accretions first.
        - Divert F/FF pumping second.
        - Divert UKL last.
            - Divert Deferred Project Supply first.
            - Divert Project Supply second.
  - – Winter season (November 16 – February).
    - · No Station 48 or Miller Hill Ag diversions.

11. North and Ady Canals (Ag).
    - – Irrigation season (March-September).
        - · No flood control.
            - Divert from UKL first.
                - Division between Project Supply and Deferred Project Supply is described below.
            - Divert LRDC accretions second.
            - Divert F/FF pumping last.
        - · Flood control operations declared (imminent or occurring).
            - Divert LRDC accretions first.
            - Divert F/FF pumping second.
            - Divert UKL last.
                - Divert Deferred Project Supply first.
                - Divert Project Supply second.
    - – Winter Season (October-February).
        - · Flood control or No Flood Control.
            - KDD winter water right diversions are from UKL.
                - None are from Deferred Project Supply.
                - Winter water right is limited to 28,910 acre-feet.

Note that when there are no flood control operations during the irrigation season, Station 48 diverts LRDC accretions first when available, whereas North and Ady Canals divert water from UKL. The purpose of this is to keep as much Lost River water in the Lost River basin as possible. Beyond that, if flood control is not imminent or occurring, the LRDC accretions are allowed to support river flows and accumulate as Deferred Project Supply in UKL (accounting described in next section). The UKL water then being diverted by North and Ady Canals is a combination of Project Supply and Deferred Project Supply. Similarly, diversion of F/FF pumping occurs last during the irrigation season when there is no flood control. It is not lost to the Project. The F/FF pumping supports Keno flows and generates deferred Project Supply in UKL as described in the *Deferred Project Supply Accounting* section of this Appendix.

In the Proposed Action simulation, Project diversions during the irrigation season (SS for Spring-Summer) by source and year are listed in Appendix Table C-25. The diversion from UKL includes both Project Supply and Deferred Project Supply. As indicated in the priority diversion outline above, the A Canal irrigation season is March through October, Station 48 and Miller Hill is March through November 15, and North and Ady Canals is March through September.

Appendix Table C-25. Simulated irrigation season (SS) Klamath Project diversions (TAF) by year and source

Year	From UKL	From LRDC Accretions	From F/FF Pumping	SS Total		Year	From UKL	From LRDC Accretions	From F/FF Pumping	SS Total
1981	176	10	0	187		2002	199	26	0	226
1982	297	41	1	339		2003	200	26	0	226
1983	292	47	2	341		2004	230	28	0	258
1984	315	51	2	368		2005	181	17	0	198
1985	315	46	2	362		2006	355	48	2	405
1986	274	35	4	313		2007	264	21	1	285
1987	206	19	1	226		2008	248	18	0	266
1988	191	13	2	205		2009	220	11	0	231
1989	282	27	2	311		2010	160	15	0	175
1990	212	15	0	227		2011	274	17	0	291
1991	156	5	0	161		2012	238	14	0	252
1992	56	0	0	56		2013	176	10	0	186
1993	293	15	0	308		2014	127	3	0	130
1994	129	3	0	132		2015	129	5	0	134
1995	293	19	0	313		2016	193	10	0	203
1996	315	21	2	338		2017	290	29	4	323
1997	288	23	0	311		2018	190	19	0	209
1998	313	35	5	353		2019	275	25	0	300
1999	380	52	5	437		2020	133	20	0	152
2000	309	42	4	355		2021	63	10	0	72
2001	203	27	0	230		2022	49	4	0	53

Deferred Project Supply Accounting

Deferred Project Supply accumulates in UKL through two accounting mechanisms. The first is Project contributions to targeted flows at Keno Dam that replaces river releases at Link River Dam, and the second is Project contributions to TLNWR and LKNWR that replace refuge supply from UKL.

The amount of Lost River water or F/FF pumping that goes to Keno Releases can be calculated using the diversion priority schedule outlined in the previous section. First, determine the amount of Lost River accretions and/or F/FF pumping that is diverted at Station 48, Miller Hill, and North or Ady Canals using the diversion priorities. The remainder is the Project contribution to flows at Keno.

Project contributions to targeted flows at Keno Dam must occur under the following conditions to result in an increase in the Deferred Project Supply Account (DPSA).

12. The Keno impoundment is balanced.
    a. Releases at Link Dam are in balance with Project deliveries out of the Keno impoundment, targeted flow releases from Keno Dam, and operational storage levels within the Keno impoundment.
    b. Keno impoundment is not in flood control operations.
13. UKL is not in flood control operations.
14. The date is on or between November 1 and September 30. No Deferred Project Supply is accumulated in October.

If these three conditions are met while Lost River accretions or F/FF pumping are contributing to Keno flows, there will be an equivalent decrease in Link Dam releases and increase in the DPSA. If there is flow exceeding the targeted flow due to a Keno impoundment imbalance, the increase in DPSA is the Project contribution to Keno flows minus the Keno excess flow:

$$Yest\_Flow\_Savings_d = max(0, Yest\_Prj\_Keno\_Contribution_d - C13\_exc_{d-1}), \qquad (18)$$

where, $Yest\_flow\_savings_d$ is the amount (TAF) Link release was reduced due to Project contributions to Keno flow, $Yest\_Prj\_Keno\_Contribution_d$ is yesterday's LRDC accretion and F/FF pumping contribution to flow at Keno (TAF), and $C13\_exc_{d-1}$ is flow (TAF) at Keno in excess of targeted and ramping flows (i.e., spill).

On April 1, it is assumed that Reclamation and FWS will formulate a plan for meeting LKNWR and TLNWR needs over the irrigation season. Needs will be met through a combination of water already in the refuges, water provided by the Project through reuse of Ag drainage, and, finally, the 43,000 acre-feet dedicated supply from UKL. If it is determined that none or part of the UKL refuge supply is needed, it will be added to the DPSA uniformly from April 2 to October 31. $Yest\_Ref\_Savings$ is the variable name for the daily uniform distribution of foregone UKL refuge supply to the DPSA in acre-feet. It is assumed that if the quantity of foregone UKL refuge supply is adjusted over the course of the irrigation season that the $Yest\_Ref\_Savings$ calculation will be adjusted such that the cumulative savings to the DPSA is the correct amount by the end of October.

Project use of Deferred Project Supply is calculated based on the Ag diversion priorities set in the previous section. First, the quantity of UKL Ag diversion is calculated. These diversions only occur during the irrigation season. If flood control operations were not imminent or occurring yesterday, the Project diversion of DSP is calculated as

$$Yest\_Prj\_Div\_DPS_d = Frac\_Div\_DPS_d \times Yest\_Prj\_Div\_UKL_d, \tag{19}$$

where, $Yest\_Prj\_Div\_DPS_d$ is yesterday's Project diversion of deferred Project Supply (TAF), $Frac\_Div\_DPS_d$ is the proportion of Deferred Project Supply diversion to the total Project diversion from UKL (Equation 20), and $Yest\_Prj\_Div\_UKL_d$ is the total Project diversion from UKL (TAF) as of yesterday.

When UKL is not in flood control, the variable $Frac\_Div\_DPS_d$ is calculated as:

$$Frac\_Div\_DPS_d = \frac{DPSA_{d-1}}{\max(0, PSup_d - PSup\_used_{d-1}) + DPSA_{d-1}}, \tag{20}$$

where, $DPSA_{d-1}$ is the deferred Project Supply Account balance at the beginning of yesterday, $PSup_d$ is the Project Supply, and $PSup\_used_{d-1}$ is the total quantity of Project Supply used at the beginning of yesterday.

If flood control operations are occurring or declared to be imminent, the fraction of the UKL diversion that comes from Deferred Project Supply is 1 and any remaining UKL diversion after Deferred Project Supply is exhausted comes from Project Supply.

In the event of flood control releases (actual or imminent), Deferred Project Supply can be diverted by the TLNWR and LKNWR. For Deferred Project Supply accounting, the refuge diversion variable is $Yest\_Ref\_Div\_DPS_d$ and is an aggregate account of yesterday's refuge diversion of Deferred Project Supply in acre-feet.

During UKL flood control operations, Deferred Project Supply spills before the Flexible Flow Account. The calculation of yesterday's Deferred Project Supply spill to the river is:

$$\begin{gathered} Yest\_DPS\_Spill_d = \\ max(0, min(C1\_exc_{d-1}, C13\_exc_{d-1} - Yest\_Prj\_Keno\_Contribution_d, \\ DPSA_{d-1} - Yest\_Prj\_Div\_DPS_d - Yest\_Ref\_Div\_DPS_d)), \end{gathered} \tag{21}$$

where, $Yest\_DPS\_Spill_d$ is the UKL flood control spill of Deferred Project Supply that is not diverted by the Project or Refuge (TAF), and $C1\_exc_{d-1}$ is flow at Link River Dam that exceeds the minimum required Link release (TAF).

Now that the mechanisms for accumulating, diverting, and spilling Deferred Project Supply have been defined, the final calculation is the balance of the deferred Project Supply Account (DPSA) for the end of yesterday:

$$\begin{aligned} DPSA_d = \max\,(0, DPSA_{d-1} &+ Yest\_Flow\_Savings_d + Yest\_Ref\_Savings_d \\ &- Yest\_Prj\_Div\_DPS_d - Yest\_Ref\_Div\_DPS_d - Yest\_DPS\_Spill_d), \end{aligned} \tag{22}$$

where, $DPSA_d$ is the deferred Project Supply account in UKL at the end of yesterday. The $DPSA$ is reset to zero on November 1 (there is no carryover into the next year), and accumulation of water in the account begins on the same day.

Table E-26 reports cumulative values by water year for key parameters in Equation 22. Column Flow/Ref Savings is the combined accumulation of variables $Yest\_Flow\_Savings_d$ and $Yest\_Ref\_Savings_d$. DPS Prj Delivery reports the cumulative $Yest\_Prj\_Div\_DPS_d$. DPS Ref Delivery column reports the cumulative $Yest\_Ref\_Div\_DPS_d$, and Deferred Project Supply Spill to the River reports the cumulative $Yest\_DPS\_Spill_d$. When savings is greater than the sum of the expenditures, the remainder is converted to general UKL storage on November 1.

Appendix Table C-26. Simulated accumulation of Deferred Project Supply through Flow and Refuge Savings and expenditure of Deferred Project Supply through Project Delivery, Refuge Delivery, and Spill to River (TAF)

Year	Flow/Ref Savings	DPS Prj Delivery	DPS Ref Delivery	DPS Spill to River
1981	52	52	0	0
1982	165	91	5	69
1983	222	92	21	90
1984	216	77	24	111
1985	124	87	0	37
1986	88	54	3	31
1987	61	46	15	0
1988	60	43	17	0
1989	75	31	4	40
1990	71	66	4	0
1991	42	42	0	0
1992	22	22	0	0
1993	81	70	0	11
1994	34	34	0	0
1995	89	89	0	0
1996	127	71	15	41
1997	103	77	5	20
1998	214	27	10	171
1999	262	133	9	102
2000	101	77	18	5
2001	84	84	0	0
2002	53	53	0	0
2003	39	39	0	0
2004	83	83	0	0
2005	52	52	0	0
2006	185	108	17	60
2007	92	89	4	0
2008	51	51	0	0
2009	45	45	0	0
2010	26	26	0	0
2011	44	44	0	0
2012	37	37	0	0
2013	35	35	0	0
2014	24	24	0	0
2015	25	25	0	0
2016	33	33	0	0
2017	71	45	10	16
2018	45	45	0	0
2019	96	96	0	0
2020	39	39	0	0
2021	25	25	0	0
2022	18	18	0	0

Refuge Diversions

TLNWR and LKNWR have four sources of water: dedicated UKL storage, Lost River water, Deferred Project Supply flood spill, and UKL flood spill. Refuges cannot divert flood-released FFA.

Each irrigation season, 43,000 acre-feet of UKL water was modeled as diversions to the LKNWR and TLNWR. This water is delivered over the April through October period. The point of diversion for the LKNWR is Ady Canal. The modeled point of diversion for TLNWR is Station 48. To the extent that the Project can maintain the needed elevations of Sump 1A and Unit 2 by other means, the dedicated UKL refuge supply can be accrued to the Deferred Project Supply for delivery to the Project.

Lost River water, if allowed, will flow directly to the TLNWR. If the TLNWR reaches capacity, Lost River water can also be pumped from the Tule Basin to LKNWR through D Plant. When the Tule Basin is at capacity and UKL is approaching flood control, Lost River water can be diverted into the LRDC and re-diverted to the LKNWR through Ady Canal.

If the Deferred Project Supply spills, the refuges can divert the spilled water at Station 48 or Ady Canal before it flows over Keno Dam. During the irrigation season, Project Ag diversions of spilled Deferred Project Supply take priority over refuge diversions. If UKL continues to spill in flood control operations after the DPSA and FFA are empty, the LKNWR can divert flood waters from UKL at Ady Canal.

Appendix Table C-27 lists simulated deliveries to TLNWR and LKNWR combined by source and water year. In years when the diversion of dedicated UKL supply does not equal 43,000 acre-feet, the remainder was credited to Deferred Project Supply and delivered to the Project. This was accounted for in the Flow/Ref Savings column of Appendix Table C-26. The quantity of Lost River water delivered to TLNWR and LKNWR listed in Appendix Table C-27 includes Lost River water that flows directly to TLNWR, D Plant diversion out of the Tule Basin to LKNWR, and Ady diversion to LKNWR of LRDC accretions.

Appendix Table C-27. Combined Tule Lake National Wildlife Refuge and Lower Klamath National Wildlife Refuge deliveries (TAF) by source and water year

Year	Dedicated UKL	Lost River	DPS Spill	UKL Spill		Year	Dedicated UKL	Lost River	DPS Spill	UKL Spill
1981	31	46	0	0		2002	20	58	0	0
1982	2	117	5	11		2003	26	71	0	0
1983	0	95	21	0		2004	19	56	0	0
1984	0	109	24	0		2005	22	64	0	0
1985	0	62	0	0		2006	0	114	17	0
1986	0	94	3	4		2007	4	55	4	0
1987	6	52	15	0		2008	17	68	0	0
1988	12	52	17	0		2009	29	36	0	0
1989	15	77	4	0		2010	38	25	0	0
1990	17	56	4	0		2011	26	72	0	0
1991	32	31	0	0		2012	27	42	0	0

Year	Dedicated UKL	Lost River	DPS Spill	UKL Spill		Year	Dedicated UKL	Lost River	DPS Spill	UKL Spill
1992	41	15	0	0		2013	30	42	0	0
1993	21	71	0	0		2014	39	18	0	0
1994	30	28	0	0		2015	40	20	0	0
1995	22	72	0	0		2016	31	42	0	0
1996	0	102	15	3		2017	11	82	10	0
1997	0	97	5	2		2018	22	57	0	0
1998	0	131	10	2		2019	21	68	0	0
1999	0	98	9	0		2020	26	38	0	0
2000	0	97	18	0		2021	37	27	0	0
2001	6	28	0	0		2022	43	12	0	0

Inflow and Accretion Inputs to the Keno Release Model

The KRM inputs some inflow and accretion time series. Details of their development are provided in this section. An inflow/accretion time series representing the historic inputs from the Lost River ($I91hist$) was not filtered or smoothed. It is, however, dynamically adjusted within the KRM either up or down depending on the difference in simulated daily A Canal deliveries from the historic deliveries as documented in Section A.4.4.5 of Appendix 4 to the 2018 Biological Assessment (Reclamation, 2018).

Upper Klamath Lake Net Inflow

Daily UKL net inflow accounts for the net amount of water entering or leaving UKL above Link River Dam. There is no reliable measurement of actual daily inflow into UKL because of the many ungaged surface water and groundwater inflows. In addition, the ungaged activities of agricultural operations around the periphery of the lake, many of which are within the footprint of diked and drained wetlands that were once part of UKL, frequently pump water that accumulated behind dikes over the winter back into UKL during the spring and divert water for irrigation during the summer. Evaporation from open-water areas, and evapotranspiration from wetland areas, are continuous phenomena that vary with meteorological conditions and the areal extent of inundation.

Despite these conditions, it is essential to estimate the balance of water for each day in the period of record to be simulated (water years 1981-2022) entering or leaving the primary storage reservoir for the Klamath Reclamation Project, and this is done by measuring the daily net inflow to UKL. This is a two-step process. In the first step, the daily (d) raw UKL net inflow ($I1raw$, in TAF) is calculated as:

$$I1raw_d = \Delta\, storage_d + outflow_d, \tag{23}$$

where $\Delta\, storage_d$ is the change in UKL storage from the previous day, and $outflow_d$ is the sum gaged diversions (and at times inflows, which enter the summation as negative numbers). A more detailed depiction of this calculation is:

$$I1raw_d = (UKLS_d - UKLS_{d-1}) + (Link\ River_d + ACan_d + PStor_d + Cal_d), \tag{24}$$

where $UKLS_d$ is the volume held in active storage within UKL, $Link\ River_d$ is the gaged flow of the Link River below Link River Dam adjusted for diversions at the dam into the Westside (Keno) Canal, and $ACan_d$ is the diversion into the A Canal. $PStor_d$ accounts for the pumped-storage operations using the Agency Lake Ranch lands on the west side of Agency Lake that occurred from 1998 through 2013 and occasional short-term actions by the UKNWR after 2013. $PStor_d$ is the daily net movement of water into or out of this area (diversion minus return), which will be negative when returns exceed diversions. Finally, Cal_d accounts for the breached dike that inundated the former Caledonia Marsh area from July 8 through December 31, 2006, and the subsequent pump-off that lasted until April 30, 2008. More detailed information is available from Dunsmoor (2017), although after that report the bathymetry of UKL was re-measured and the relationship between storage and lake surface elevation was re-defined (Hollenback et al., 2023). This revised elevation-capacity relationship (Table E-12) was used to compute daily UKL storage from the weighted mean elevation (Reclamation datum) of multiple gages reported by USGS gage 11507001.

This measurement of the raw UKL net inflow is affected by windy conditions and associated seiches in UKL that affect lake level measurements. Therefore, a smoothed UKL net inflow time series ($I1$) is used both operationally and for the KRM simulations. A single exponential smoother (alpha = 0.182) was applied to generate $I1$.

Keno Impoundment Accretions

In the reach between the USGS gage Link River at Klamath Falls, Oregon (11507500) and the USGS gage Klamath River at Keno, Oregon (11509500) there are many diversions from and inputs to the Keno impoundment from domestic, industrial, municipal, agricultural, and other sources. Over the 1981-2022 period of record, daily accretions (which can be, and frequently are, negative) have been highly variable, reflecting the many uncoordinated inputs and outputs to this reach, a few of which are gaged.

The first step in calculating the Keno impoundment accretions ($I10$, in TAF) involves calculating what the flow would be at the Keno gage based on the daily (d) gaged inputs to and outputs from the Keno impoundment:

$$Computed\ Keno\ flow_d = Link\ River_d + LRDC\ input_d + FFF_d - LRDC\ diversion_d - North\ Canal_d - Ady\ Canal_d, \tag{25}$$

where $Link\ River_d$ is the same combination of gaged Link River flow and Westside Canal diversion as that used in the UKL net inflow calculation, $LRDC\ input_d$ is inflow from the Lost River Diversion Channel, FFF_d is inflow from the F and FF pumps, and $LRDC\ diversion_d$, $North\ Canal_d$, and $Ady\ Canal_d$ are diversions from the Keno impoundment into the LRDC or into the footprint of the former Lower Klamath Lake for irrigation or refuge uses.

Next, the raw Keno impoundment accretion ($I10raw$, in TAF) is calculated as:

$$I10raw_d = Measured\ Keno\ flow_d + Computed\ Keno\ flow_d, \tag{26}$$

where $Measured\ Keno\ flow_d$ is the mean daily flow for the Klamath River at Keno gage reported by USGS. $I10raw_d$ may be positive or negative.

Intermittent (once every few years) signatures of the PacifiCorp hydropower operation are present in this time series in the form of very large, sudden positive $I10raw_d$ values on one day followed by very large negative $I10raw_d$ values on the next day. According to PacifiCorp, these result from maintenance activities within the hydropower project. Daily accretions associated with these events have been identified and replaced by the 5-day trailing average of $I10raw_d$. Finally, the $I10$ time series used in operations and modeling is produced by applying a single exponential smoother (alpha = 0.3) to the $I10raw_d$ time series.

Keno to Iron Gate Accretions

Estimating daily accretions into the Keno-to-Iron Gate (KIG) reach between the USGS gage Klamath River at Keno, Oregon (11509500) and the USGS gage Klamath River below Iron Gate Dam, California (11516530) has long been difficult because of the operations of PacifiCorp's hydroelectric project. To optimize the power peaking operations at this series of facilities, PacifiCorp required frequent, rapid changes in releases from the dams above Iron Gate. Details and data for these operations have always been confidential, making it very difficult to estimate daily accretions.

PacifiCorp and Reclamation entered into a non-disclosure agreement allowing the use of daily time-step reservoir storage data, which resulted in improved KIG accretion estimates in the last consultation. Nonetheless, issues remained with the accretion time series. For instance, operations within the hydropower project can result in lower releases from Iron Gate Dam than are occurring from Keno Dam, causing accretion estimates to be erroneously negative. For the current consultation, the KIG accretion time series was revisited to remove artifacts of the hydropower operations and improve the accuracy of the daily accretion estimates.

Step one of this process was the calculation of the daily raw accretion, $I15hist\_raw_d$ (TAF):

$$I15hist\_raw_d = (avgIGQ_d - avgKQ_d) + (avgTS_d - avgTS_{d-1}), \tag{27}$$

where $avgIGQ_d$ and $avgKQ_d$ are the average flow volumes for days d and $d-1$ at the Iron Gate and Keno gages, respectively, $avgTS_d$ is the average combined storage of JC Boyle, Copco, and Iron Gate reservoirs for days d and $d-1$, and $avgTS_{d-1}$ is the average combined reservoir storage for days $d-1$ and $d-2$. Averaging the flow and storage components of the accretion calculation in this way reduces the incidence of wild swings in the time series but does not eliminate them.

Step two begins the first filtering pass by computing the daily accretion change ($\Delta I15hist\_raw_d$) as a proportion of the 7-day trailing median accretion ($\mathrm{7dtmI15hist\_raw}_d$, median of $d-1$ through $d-7$) accretion:

$$\Delta I15hist\_raw_d = \frac{I15hist\_raw_d - I15hist\_raw_{d-1}}{\mathrm{7dtmI15hist\_raw}_d}. \tag{28}$$

Then $I15hist\_raw_d$ values are evaluated by a first-pass filter for the following conditions:

1. $\Delta I15hist\_raw_d < -0.25$;

2. $|\Delta I15hist\_raw_d| \leq 0.25$;

3. $|\Delta I15hist\_raw_d| > 0.25$ and air temperature exceeds 34° F on day d or $d-1$ and SWE at the Fish Lake SNOTEL exceeds 0.2 inches;

4. $|\Delta I15hist\_raw_d| > 0.25$ and precipitation over days d through $d-6$ equals or exceeds 0.4 inches.

If condition 1 is true, or if none of the conditions are true, then the raw accretion for that day is flagged as an operational outlier. If condition 2, 3, or 4 is true then the raw accretion for that day is not flagged. Values flagged as operational outliers are replaced by the 5-day trailing median (median of days $d-1$ through $d-5$) in the new variable $I15hist\_p1_d$.

Step three applies the second-pass filter, which repeats step two using $I15hist\_p1_d$ instead of $I15hist\_raw_d$. After the operational outliers have been replaced by the 5-day trailing median (median of days $d-1$ through $d-5$), any value less than 225 cfs is replaced by the 70% exceedance flow of the prior 30 days in the new variable $I15hist\_p2_d$.

Step four applies the third-pass filter, which repeats step three using $I15hist\_p2_d$ instead of $I15hist\_p1_d$. After the operational outliers have been replaced by the 5-day trailing median (median of days $d-1$ through $d-5$), any value less than 225 cfs is replaced by the 70% exceedance flow of the prior 30 days. The last step in the filtering process was manually identifying any remaining operational outliers (20 were found), and then replacing them with the 70% exceedance flow of the prior 30 days in the new variable $I15hist\_p3_d$.

After the filtering steps were completed, $I15hist\_p3$ was smoothed with a single exponential smoother (alpha = 0.5) to produce the $I15hist$ daily time series that is a direct input into the KRM. This time series represents the accretions estimated with all the hydropower dams in place and operating normally.

The KRM ingests as input the $I15hist$ time series as well as another, $I15evap$, that estimates the daily evaporative losses from the reservoirs above JC Boyle, Copco 1, and Iron Gate dams. Evaporation estimates were generated using the Daily Lake Evaporation Model by Reclamation Technical Service Center scientists for use in the Natural Flow Study and were graciously shared for use in the KRM. An earlier version of these estimates was documented in a draft report on open-water evaporation for the Natural Flow Study that was released for comment in late 2023 (Mikkelson, 2023). The data shared for use in KRM included some changes that were made in response to reviewer comments since the release of Mikkelson (2023), and it is possible that additional changes may be made to the evaporation estimates before they are finalized (Kristin Mikkelson, personal communication, January 3, 2024). Because the dams downstream from Keno Dam have been removed, the KRM uses the daily sum of $I15hist$ and $I15evap$ to generate $I15$, the accretions to the KIG reach of the Klamath River.

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