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

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April 29, 2025 **Refer to NMFS No:** WCRO-2023-02169

Tessa Eve Beach, Ph.D.
Deputy to the Deputy District Engineer for Programs, Planning and Project Management
Acting Environmental Services Branch Chief
Department of the Army
San Francisco District, Corps of Engineers
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Grant Davis
General Manager
Sonoma Water
404 Aviation Boulevard
Santa Rosa, California 95403

Re: Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson–Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Russian River Watershed Water Supply and Channel Maintenance Project

Dear Dr. Beach and Mr. Davis:

Thank you for your letter of August 23, 2023 and your September 5, 2023 email requesting initiation of formal 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*.) on the U.S. Army Corps of Engineers' (USACE) and Sonoma Water's Proposed Actions in the Biological Assessment and Essential Fish Habitat Assessment for the Russian River Watershed Water Supply and Channel Maintenance Project.

This Biological Assessment was revised and clarified by subsequent letters and information provided by the USACE and Sonoma Water and in a February 21, 2024 letter, we informed you that we had sufficient information to reinitiate consultation as of February 12, 2024. On January 6, 2025, the USACE supplemented the Biological Assessment with additional Proposed Actions pursuant to a November 7, 2024 settlement agreement in *White v. United States Army Corps of Engineers*, 3:22-cv-06143-JSC (N.D. Cal.). USACE and Sonoma Water provided additional details regarding aspects of the action in subsequent communications with NMFS. The "Proposed Action" analyzed in our Biological Opinion includes and considers all of these communications.

In this Biological Opinion, we conclude that the Proposed Action is not likely to jeopardize the continued existence of the federally endangered Central California Coast (CCC) coho salmon

(*Oncorhynchus kisutch*) and Killer whale, Southern Resident DPS (*Orcinus orca*), or the threatened CCC steelhead (*O. mykiss*) and California Coastal (CC) Chinook salmon (*O. tshawytscha*). We also conclude that the Proposed Action is not likely to result in the destruction or adverse modification of designated critical habitat for these listed species. However, NMFS anticipates that incidental take of all of these species is reasonably certain to occur as a result of the Proposed Action. Therefore, an incidental take statement with non-discretionary terms and conditions to minimize the impact of such take is included with the enclosed Biological Opinion.

Thank you also for your request for essential fish habitat (EFH) consultation. NMFS reviewed the Proposed Action for potential effects on EFH pursuant to Section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA), implementing regulations at 50 CFR 600.920, and agency guidance for use of the ESA consultation process to complete EFH consultation. After reviewing the Proposed Action, we have concluded that the action would adversely affect EFH designated under the Pacific Coast Salmon, Pacific Coast Groundfish, and Coastal Pelagic Species Fishery Management Plans (FMP). Therefore, pursuant to section 305(b)(4)(A) of the MSA, NMFS has provided EFH conservation recommendations (Section 3) to avoid, minimize, mitigate, or otherwise offset those adverse effects. As required by section 305(b)(4)(B) of the MSA, the USACE and Sonoma Water must provide a detailed response in writing to NMFS within 30 days after receiving EFH conservation recommendations. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH conservation recommendations unless NMFS and the federal agency have agreed to use alternative time frames for the federal agency response.

Please contact Joshua Fuller at 707-575-6096 or Joshua.Fuller@noaa.gov should you have any questions regarding this consultation.

Sincerely,

Alecia Van Atta
Assistant Regional Administrator
California Coastal Office

Enclosure

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copy to efile: ARN 151422WCR2023SR00271

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

The Russian River Watershed Water Supply and Channel Maintenance Project

NMFS Consultation Number: WCRO-2023-02169

Action Agencies: U.S. Army Corps of Engineers, Sonoma Water, and The Mendocino County Russian River Flood Control and Water Conservation Improvement District

Affected Species and NMFS' Determinations:

ESA-Listed Species	Status	Is Action Likely to Adversely Affect Species?	If likely to adversely affect, Is Action Likely to Jeopardize the Species?	Is Action Likely to Adversely Affect Critical Habitat?	If likely to adversely affect, is Action Likely to Destroy or Adversely Modify Critical Habitat?
California Coastal (CC) Chinook (*Oncorhynchus tshawytscha*)	Threatened	Yes	No	Yes	No
Central California Coast (CCC) coho salmon (*O. kisutch)*	Endangered	Yes	No	Yes	No
CCC steelhead (*O. mykiss*)	Threatened	Yes	No	Yes	No
Killer whale, Southern Resident DPS (*Orcinus orca*)	Endangered	Yes	No	No	NA

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

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

Issued By:

Alecia Van Atta
Assistant Regional Administrator
California Coastal Office

Date: April 29, 2025

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List of Acronyms

ACRONYM	WORD
ac-ft	Acre-Feet
AMP	Adaptive Management Plan
AR	Atmospheric River
BA	Biological Assessment
BMP	Best Management Practices
CAP	Continuing Authorities Program
CC	California Coastal
CCC	Central California Coast
CDFW	California Department of Fish and Wildlife
CFR	Code of Federal Regulations
cfs	Cubic Feet Per Second
CMP	Coastal Salmonid Population Monitoring Plan
CPS	Coastal Pelagic Species
CSG	California Sea Grant
CSWP	Central Sonoma Watershed Project
CVD	Coyote Valley Dam
CVFF	Coyote Valley Fish Facility
D1610	Decision 1610
DCFH	Don Clausen Fish Hatchery
DO	Dissolved Oxygen
DPS	Distinct Population Segment
DSMT	Downstream Migrant Traps
EFH	Essential Fish Habitat
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FIRO	Forecast Informed Reservoir Operations
FRAM	Fishery Regulation Assessment Model
ft	Feet
FY	Fiscal Year
HGMP	Hatchery Genetics Management Plan
HOR	Hatchery Origin
ITS	Incidental Take Statement
JMT	Joint Monitoring Team
LCM	Life Cycle Monitoring
LWD	Large Woody Debris
MCRRFCD	Mendocino County Russian River Flood Control and Water Conservation Improvement District
MDN	Marine-Derived Nutrients
mi^2	Square Miles
MOU	Memorandum of Understanding
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NCRWQCB	North Coast Regional Water Quality Control Board
NGVD	National Geodetic Vertical Datum

ACRONYM	WORD
NMFS	National Marine Fisheries Service
NOF	North of Falcon Coastal Area
NOR	Natural Origin
NRKW	Northern Resident Killer Whales
NTU	Nephelometric Turbidity Units
NWFSC	Northwest Fisheries Science Center
PACR	Post-Authorization Change Report
PBF	Physical and Biological Features
PCB	Polychlorinated Biphenyls
PCE	Primary Constituent Element
PFMC	Pacific Fishery Management Council
PG&E	Pacific Gas & Electric
PIT	Passive Integrated Transponder
ppm	Parts per million
ppt	Parts per thousand
PVP	Potter Valley Project
RPA	Reasonable and Prudent Alternative
RPM	Reasonable and Prudent Measures
RRCSCBP	Russian River Coho Salmon Captive Broodstock Program
RREITF	Russian River Estuary Study
RRHFA	Russian River Habitat Focus Area
RRTA	Russian River Turbidity Assessment
SRKW	Southern Resident Killer Whales
SWFSC	Southwest Fisheries Science Center
SWRCB	State Water Resources Control Board
TAC	Technical Advisory Committee
TDC	Thiamine Deficiency Complex
TUCO	Temporary Urgency Change Order
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WCM	Water Control Manual
WDFW	Washington Department of Fish and Wildlife
WUA	Weighted Usable Area
WY	Water Year
YOY	Young of Year

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 Code of Federal Regulations (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 (Section 515 of the Treasury and General Government Appropriations Act for Fiscal Year (FY) 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 NMFS California Coastal Office.

This Opinion is based on information provided in the final *Biological Assessment and Essential Fish Habitat Assessment for the Russian River Watershed Water Supply and Channel Maintenance Project prepared by the U.S. Army Corps of Engineers (USACE) and Sonoma Water* (BA, ESA, Inc. 2023), including appendices. This BA was revised and clarified by subsequent letters and information from the USACE and Sonoma Water. On January 6, 2025, the USACE supplemented the BA with additional Proposed Actions pursuant to a November 7, 2024 settlement agreement in *White v. United States Army Corps of Engineers*, 3:22-cv-06143-JSC (N.D. Cal.). USACE and Sonoma Water provided additional details regarding aspects of the action in subsequent communications with NMFS. The "Proposed Action" analyzed herein includes and considers all of these communications (see Section 1.2). Our Opinion covers a term of 10 years and is based on this information and other sources of the best scientific and commercial data available. Text in several sections of this Opinion were taken directly from the BA and from NMFS' 2008 Opinion and incorporated as written.

On September 24, 2008, NMFS issued a 15-year *Biological Opinion for water supply, flood control operations, and channel maintenance conducted by the USACE, Sonoma Water, and Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFCD) in the Russian River watershed* (2008 Opinion; NMFS 2008a) (See Figure 1). The 2008 Opinion analyzed the effects of the agencies' Proposed Actions on listed species, including the threatened California Coastal (CC) Chinook salmon evolutionarily significant unit (ESU) (*Oncorhynchus tshawytscha*) and Central California Coast (CCC) steelhead distinct population segment (DPS) (*O. mykiss*), and endangered CCC coho salmon ESU (*O. kisutch*).

The 2008 Opinion concluded that the Proposed Action was likely to jeopardize the survival and recovery of CCC steelhead and CCC coho salmon and adversely modify their designated critical habitat. CC Chinook salmon would not be jeopardized by the Proposed Action, nor would its critical habitat be adversely modified or destroyed. NMFS worked with the USACE, Sonoma Water, and MCRRFCD to develop a Reasonable and Prudent Alternative (RPA) to the Proposed Action that would avoid jeopardy and included it in the 2008 Opinion.

Like the previous consultation, this Opinion addresses the USACE and Sonoma Water's proposed management of reservoir releases, minimum instream flows, habitat conditions, and facilities in portions of the mainstem Russian River, Santa Rosa Creek watershed, Dry Creek, and the Russian River Estuary (Estuary). Hydroelectric project operations, hatchery management, and Stream Maintenance Program activities were included as part of the Proposed Action consulted over in the 2008 Opinion; however, the action agencies did not consult over these activities as part of this ongoing consultation, concluding they were addressed through separate ESA processes and consultations or that coverage is no longer needed. As a result, they are not included in this consultation.

As part of the Proposed Action analyzed in the 2008 Opinion, Sonoma Water consulted over its flow management plan at CVD and WSD (i.e., conformance with D1610, water supply releases, and water elevation management in the estuary). The flood control elements of the project involved the regulation of flood flows by the USACE to control flooding in properties adjacent to the Russian River and the storage of water in two reservoirs to be released for water supply in Sonoma, Mendocino, and Marin counties during the spring, summer, and fall. The water supply released from the reservoirs flows down the mainstem Russian River and Dry Creek to diversion points downstream of the dams. Part of the water stays in the river channel and flows to the Pacific Ocean at the river's mouth near Jenner. The diverted water is delivered to end-users for municipal, industrial, agricultural, and domestic uses.

CVD is on the East Fork (commonly also referred to as East Branch) headwaters of the Russian River, and WSD is on Dry Creek, a main tributary of the Russian. Russian River water is released from Lake Mendocino (the reservoir formed by CVD) for flood control, and, under the requirements of the State Water Resources Control Board's (SWRCB) Decision 1610 (D1610), for water supply (SWRCB 1986). Minimum stream flows under D1610 are specified for four reaches in the Russian River watershed: the East Fork Russian River from CVD to the confluence with the mainstem, the mainstem Russian River between the East Fork confluence and Dry Creek, Dry Creek downstream of WSD to the confluence with the Russian River, and the mainstem Russian River between Dry Creek and the mouth (see Figure 2).

In the 2008 Opinion, NMFS concluded that the minimum instream flow requirements established in D1610 were adversely affecting listed salmonids and their critical habitat. Specifically, NMFS determined that artificially elevated summertime minimum flows resulted in high water velocities. These elevated velocities led to reductions in the quality and quantity of rearing habitat for steelhead in the Upper Russian River mainstem (below CVD) and in Dry Creek (Lower Russian River) for juvenile coho salmon and steelhead. Additionally, NMFS concluded that maintaining these flows disrupts lagoon formation in the estuary and, therefore, impairs juvenile rearing habitat for steelhead and to lesser a degree coho salmon in the estuary.

To address these concerns, the 2008 Opinion provided an RPA that included options to pursue changes to D1610 to reduce minimum flows in the Russian River and Dry Creek between late spring and early fall via Sonoma Water filing Temporary Urgency Change Petitions with the SWRCB. Under state processes, this type of interim petition can be used to temporarily modify a post-1914 permit or license, such as changing the point of diversion, purpose of use, place of use, or other terms or conditions, or to transfer water and can provide approval of changes lasting up to 180 days, though the changes may be renewed. After review and approval of these interim petitions, the SWRCB then issues Temporary Urgency Change Orders (TUCOs). Sonoma Water has annually filed Temporary Urgency Change Petitions with the SWRCB as an interim measure to implement the flow objectives of the 2008 Opinion RPA (while pursuing permanent changes to D1610 flows) and/or in response to prevailing stream flow and reservoir water storage conditions. The proposed Russian River hydrologic index change (flow storage and release regime), is summarized below. Sonoma Water has previously and proposes to continue to include this hydrologic index change in both its longer-term petitions and shorter-term Temporary Urgency Change Petitions (interim petitions) going forward. While both types of petitions include the same hydrologic index thresholds for defining water year classifications, the shorter-term petitions may be necessary while the longer-term petitions are under review by the SWRCB. This proposed hydrologic index would also establish minimum instream flow requirements for the Upper Russian River, Dry Creek, and Lower Russian River based on reservoir storage levels.

Changes in operations of Pacific Gas & Electric's (PG&E's) Potter Valley Project (PVP), and their impact on water supply reliability in Lake Mendocino and thus the Russian River watershed, have led to ongoing uncertainty regarding future transfers of water from the Eel River watershed through the PVP. The PVP is located on the East Fork of the Russian River and Eel River in Mendocino and Lake County, respectively. PG&E's Lake Pillsbury is impounded by Scott Dam on the Eel River. Natural flow of the Eel River water and water released from Lake Pillsbury are diverted 12 miles downstream from Scott Dam at Cape Horn Dam on the Eel River, and then are conveyed through a diversion tunnel and penstocks to the Potter Valley Powerhouse on the East Fork. Some of the water discharged from the powerhouse is diverted into canals from which the Potter Valley Irrigation District receives water under a water supply agreement with PG&E and its own appropriative state water rights license. The remaining water discharged from the powerhouse not consumptively used by Potter Valley Irrigation District flows down the East Fork into Lake Mendocino.

The average annual transfer through the PVP between 1922 and 2006 was approximately 150,000 acre-feet (ac-ft). Since 2007, the average annual transfer through the PVP has been approximately 60,000 ac-ft. This significant reduction in transferred Eel River water from PVP is the result of an Order issued by the Federal Energy Regulatory Commission in January 2004 that amended PG&E's operating license. In 2021 the transformer bank at the power house failed, resulting in the inability for the project to produce power and make discretionary power production releases through the penstocks. In April 2022 the Federal Energy Regulatory Commission license expired and in July 2022, PG&E filed a license surrender plan for the PVP. In March 2023 PG&E made the decision to not close the radial gates due to seismic risk concerns, reducing the potential maximum storage capacity from approximately 77,000 ac-ft to approximately 56,000 ac-ft. The reduction in storage capacity going into the summer season has required PG&E to request flow variances to reduce releases from Scott Dam in order to manage the reservoir's cold-water pool.

In the Proposed Action for this consultation, Sonoma Water proposes several actions to address these uncertainties and improve water supply reliability in the Russian River watershed, which would be carried out as part of amending Sonoma Water's future interim petitions. The proposed hydrologic index (described in the Proposed Action section below; Tables 1a and 2) was designed to meet three objectives: 1) more accurately describe hydrologic conditions in the Russian River watershed than previous indexes; 2) use threshold evaluation dates similar to D1610 hydrologic index evaluation dates; and 3) avoid depleting Lake Mendocino storage during a 1 in 100-year design drought. As proposed, this interim change would move the hydrologic index from Lake Pillsbury in the Eel River watershed to Lake Mendocino in the Russian River watershed, account for operational changes at PG&E's PVP, and request, via interim petitions, changes to D1610 minimum flows consistent with the RPA from the 2008 Opinion that called for adjustments to the minimum flows for Normal and Dry hydrologic conditions.

In addition to CCC coho salmon, CCC steelhead, and CC Chinook salmon, this Opinion also analyses the effects of the Proposed Action on Southern Resident Killer Whales (SRKW) because Chinook salmon are a primary prey for SRKW in the Pacific Ocean.

1.1.1 Additional Relevant ESA Consultations, Permits, and MOU

1997 Memorandum of Understanding (MOU) - NMFS, USACE, Sonoma Water, and the MCRRFCD entered into an MOU on December 31, 1997. The purpose of the MOU was to establish a framework for a Section 7 consultation under the ESA for existing operations and actions implemented by USACE, Sonoma Water, and MCRRFCD.

2008 Russian River Biological Opinion - NMFS transmitted a draft Opinion to the USACE and Sonoma Water on June 11, 2007 that concluded the Proposed Action was likely to jeopardize CCC steelhead and CCC coho salmon and adversely modify designated critical habitat for these species. NMFS, USACE, and Sonoma Water worked collaboratively on the development of changes to the Proposed Action that would avoid jeopardy and adverse modification of critical habitat. NMFS provided a working draft Opinion to USACE on August 1, 2008, and a final draft on September 17, 2008. A final Opinion was issued by NMFS on September 24, 2008.

Stream Maintenance Program Biological Opinion - On April 15, 2022, NMFS issued a Biological Opinion for Sonoma Water's Stream Maintenance Program in Sonoma County that combines and supersedes routine stream maintenance activities previously covered in the 2008 Opinion. In 2010, NMFS issued an Opinion for Sonoma County's Stream Maintenance Program in the Petaluma River and Sonoma Creek Watersheds (NMFS 2022a).

Mirabel Fish Screen/Ladder Project Biological Opinion – On June 16, 2014, NMFS issued a Biological Opinion to the USACE and Sonoma Water over their proposed Mirabel Fish Screen and Fish Ladder Replacement Project, following a 2009 feasibility study that identified a preferred project.

Hatchery Genetics Management Plans (HGMPs)
In July 2021, the California Department of Fish and Wildlife (CDFW) and USACE finalized an HGMP for the Russian River Steelhead Integrated Harvest Hatchery Program in support of their application for ESA Section 10(a)(1)(A) permit coverage. The ESA Section 10 permit was issued and Section 7 consultation was completed by NMFS in 2024.

In September 2017, CDFW and USACE finalized an HGMP for the Don Clausen Fish Hatchery Russian River Coho Salmon Captive Broodstock Program (RRCSCBP) in support of their application for ESA Section 10(a)(1)(A) permit coverage. The ESA Section 10 permit was issued and Section 7 consultation was completed by NMFS in 2021.

Figure 1. Overview map of the Russian River watershed (ESA, Inc. 2023).

1.2. Consultation History

Discussions on reinitiating consultation over the 2008 Opinion (which was set to expire in 2023) began in 2021 with a meeting hosted by Sonoma Water. Sonoma Water and the USACE began working on a BA, and provided several drafts to NMFS for feedback during 2022. Several meetings were held to discuss the BA in 2023, and NMFS determined it had sufficient information to officially reinitiate consultation as of February 12, 2024.

We provide a list of activities and communications related to this consultation below. We also note that completion of this consultation has been delayed by ongoing litigation. On August 1, 2022, Sean White sent a 60-day Notice of Intent to Sue to USACE and NMFS regarding aspects of the 2008 Opinion, primarily focused on the USACE's completion of RPM elements related to turbidity. On October 17, 2022, Plaintiff filed a complaint in *White v. United States Army Corps of Engineers et al.*, No. 3:22-cv-06143-JSC (N.D. Cal.). raising two claims: (1) that the USACE's failure to comply with the terms and conditions of RPM No. 4 in the Incidental Take Statement resulted in unauthorized take under Section 9 of the ESA; and (2) that the agencies were required to reinitiate consultation under Section 7 of the ESA. While case filings are not detailed in the timeline below, significant agency time and resources were required to respond to this litigation, within the same timeline and by the same agency staff involved in completing this consultation.

The following items describe important activities that are relevant to, and include, initiation of consultation over the Proposed Action:

April 28, 2021 - Sonoma Water hosted an inter-agency meeting to re-initiate consultation on operations within the Russian River watershed. In addition to Sonoma Water and USACE staff, the meeting was attended by staff from NMFS and CDFW.

2022 - Sonoma Water and the USACE began working on a BA, and provided several preliminary drafts to NMFS for feedback during 2022.

June 16, 2022 - Sonoma Water hosted an inter-agency (Executive Committee) meeting to discuss implementation of the 2008 Opinion and describe the process and schedule for review of the BA. In addition to Sonoma Water and USACE staff, the meeting was attended by staff from NMFS and CDFW.

August 3, 2022 - USACE and Sonoma Water met with representatives from NMFS and CDFW to discuss initial agency feedback on the Environmental Baseline section of a draft BA.

November 2, 2022 - Sonoma Water and Environmental Science Associates (ESA, Inc.), a consultant that assisted with BA development, provided an overview of how they desired to receive feedback on the draft BA to agency representatives from NMFS and CDFW.

December 12, 2022 - NMFS received an agency draft of the BA from the USACE.

December 14, 2022 - Sonoma Water and ESA, Inc., met with agency representatives from NMFS and CDFW to receive initial feedback on the agency draft BA.

Multiple resource agency meetings and two half-day workshops were held to discuss the various elements of the Proposed Action contained in the draft BA. Attendees included representatives from NMFS, CDFW, and USACE. Specific meetings and the dates they occurred are listed below:

- January 4, 2023 - Meeting to discuss flood control operations.
- January 11, 2023 - Meeting to discuss water supply operations.
- January 18, 2023 - Meeting to discuss estuary management.
- January 25, 2023 - Meeting to discuss Dry Creek enhancement measures.
- February 2, 2023 - Sonoma Water hosted a workshop on Dry Creek enhancement past actions and future proposed work.
- February 1, 2023 - Meeting to discuss the monitoring program in the Russian River watershed.
- February 8, 2023 - Meeting to discuss channel maintenance and Mirabel Dam operations.
- February 21, 2023 - Sonoma Water hosted a workshop on Mirabel operations and Wohler pool operations, including presenting information on outmigrant survival and predation.

January 24 through February 24, 2023 - NMFS provided the USACE and Sonoma Water with five comment letters on the December, 2022 draft BA.

February 14, 2023 - USACE emailed NMFS stating that they now considered aspects of their flood control operations and dam inspections to be non-discretionary actions not subject to ESA consultation requirements. A revised Draft BA was attached in the email.

On February 28, 2023 - USACE sent a letter requesting initiation of formal consultation with NMFS pursuant to Section 7 of the ESA over Proposed Actions for USACE's and Sonoma Water's Russian River Watershed Water Supply and Channel Maintenance Project. The letter included a revised BA dated February 28, 2023 (ESA, Inc. 2023).

April 3, 2023 - NMFS sent a letter to USACE stating that the materials included in the consultation request did not provide all of the information necessary to initiate formal consultation under the ESA, as described in the regulations governing interagency consultations, or to complete EFH consultation under the MSA. The letter identified the additional information needed to initiate formal ESA consultation and to complete MSA consultation with NMFS.

August 27, 2023 - USACE sent NMFS a transmittal memorandum requesting reinitiation of consultation under Section 7(a)(2) of the ESA.

September 5, 2023 - USACE sent an email to NMFS that included the final *Biological Assessment and Essential Fish Habitat Assessment for the Russian River Watershed Water Supply and Channel Maintenance Project prepared by the U.S. Army Corps of Engineers (USACE) and Sonoma Water* (BA, ESA, Inc. 2023).

September 20, 2023 - USACE provided the *Russian River Turbidity Assessment and Proposed Plan for Sonoma County and Mendocino County, California. Final Report with Addendum* to NMFS (USACE 2023).

February 1, 2024 - USACE emailed NMFS a January 18, 2024 BA Coordination Letter, identifying the USACE's and Sonoma Water's commitment to provide certain information and to work with NMFS on "12 items" of concern to facilitate the consultation process once initiated, with the commitment to complete them no later than 90 days from the date of reinitiation.

February 9, 2024 - Sonoma Water and the USACE provided an email to NMFS further clarifying aspects of the Proposed Action related to estuary management and the scope of estuary habitat enhancement projects.

February 12, 2024 - USACE emailed NMFS clarifying the duration of the Proposed Action to be 10 years and to also exclude the Fish Flow Project as a Proposed Action in the BA.

February 21, 2024 - NMFS provided a response letter to USACE stating NMFS had sufficient information to reinitiate consultation as of February 12, 2024, and noting that that we were continuing to evaluate the scope of the USACE's discretion over components of the Proposed Actions as described in the Biological Assessment. NMFS requested additional commitments specifically related to 12 proposed actions to be completed by the USACE and Sonoma Water during the 90-day consultation period.

April 12, 2024 - Sonoma Water provided a memo to NMFS documenting the correspondence, deliverables, and workshops that occurred or were scheduled to occur during the anticipated 90-day consultation period.

April 18 - May 11, 2024 - NMFS coordinated with USACE and Sonoma Water via numerous emails and phone calls to review and finalize the following memos related to the 12 proposed actions.

May 6, 2024, Sonoma Water provided *the Study Plan: Migration Survival and Travel Time of Salmon and Steelhead Smolts in the Mainstem Russian River* (Sonoma Water 2024a) to NMFS.

May 7, 2024 - Sonoma Water provided a *Memo on Reservoir Water Supply Pool Operation Adaptive Management Action* (Sonoma Water 2024b) to NMFS.

May 10, 2024 - Sonoma Water provided a *Memo on Dry Creek Habitat Enhancement Alternatives Action* (Sonoma Water 2024c) to NMFS.

May 10, 2024 - Sonoma Water provided a *Memo on Beach Management and Estuary Metric Development* (Sonoma Water 2024d) to NMFS.

May 28, 2024 - NMFS emailed MCRRFCD to inquire about their participation in the Section 7 process as a participating agency and their obligations to conduct channel maintenance in the Upper River as agreed to under a 1997 MOU with the USACE.

June 20, 2024 - MCRRFCD replied to NMFS via email confirming their participation. They indicated their activities would remain the same as described in the 2008 Opinion.

November 7, 2024 - The U.S. District Court (N.D. Cal.) granted a stipulation entering the settlement agreement and dismissing the complaint in *White v. United States Army Corps of Engineers et al.*, No. 3:22-cv-06143-JSC (N.D. Cal.). The agreement required that USACE provide NMFS with a supplement to the BA containing certain measures within 60 days of the court's approval of the agreement (i.e., by January 6, 2025).

January 6, 2025 - NMFS received the USACE's *White v. United States Army Corps of Engineers', 3:22-cv-06143-JSC (N.D. Cal.) settlement - Supplement to U.S. Army Corps of Engineers' and Sonoma Water's Biological Assessment for the Russian River Watershed Water Supply and Channel Maintenance Project* (USACE 2025), which included provisions from the settlement agreement in relation to the Proposed Action and provided turbidity-related updates to the Proposed Action.

April 6, 2025 - NMFS received additional information via email from ESA, Inc. on behalf of Sonoma Water regarding the implementation timeline for conservation commitments outlined in the BA.

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 (RPMs)), 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.

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). Under the MSA, "federal action" means any action authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken by a federal agency (see 50 CFR 600.910). We considered, under the ESA, whether or not the Proposed Action would cause any other activities and determined that the Proposed Action would cause several other activities. These activities are discussed in Section 1.3.8 and in subsequent sections of this Opinion as appropriate.

The USACE and Sonoma Water propose to continue to carry out water supply and flood control operations at WSD and CVD as set out in the 2023 BA and supplemental communications. These dams provide flood control and water supply storage for the Russian River basin via Lake Mendocino and Lake Sonoma. The USACE and Sonoma Water are the federal and local sponsors, respectively, for both CVD at Lake Mendocino and WSD at Lake Sonoma. Related activities include: flow releases into the Russian River and Dry Creek, water diversions and storage (Wohler Pool and Santa Rosa Creek), estuary management, channel and facility maintenance, managing Dry Creek habitat enhancements, monitoring, and conservation measures (Table 1). This Opinion considers the effects of these activities as proposed by USACE and Sonoma Water for a 10-year period.

Table 1. Summary of Proposed Actions. This table appeared in the BA at Section 3.1, Description of the Proposed Action. NMFS has made minor, non-substantive edits for clarity.

Proposed action/Project Element	**Summary Description and Status**
Reservoir Flood Control and Water Supply Pool Operations at CVD and WSD	USACE is proposing flood control operations at CVD associated with the *Planned Major Deviation* to the 1986 Lake Mendocino Water Control Manual (WCM), pending updates to the Lake Mendocino WCM, and application of Forecast Informed Reservoir Operations (FIRO) procedures. FIRO procedures will be incorporated into the revised Lake Mendocino WCM through an ongoing process. USACE is also proposing flood control operations at WSD consistent with the 1984 Lake Sonoma WCM, with future proposed modifications associated with application of FIRO procedures, which are currently in development. Sonoma Water proposes a change to its interim petitions to the SWCRB in order to modify the hydrologic index to reflect conditions in the Russian River watershed as opposed to the current D1610 index located in the Eel River watershed, and implement changes to D1610 minimum flows consistent with the 2008 Opinion that calls for adjustments to the minimum flows for Normal and Dry hydrologic conditions, pending completion of permanent changes to Sonoma Water's interim petitions. Changes to Sonoma Water's interim petitions are intended to address current uncertainties associated with changes in operations of PG&E's PVP and its impact on water supply reliability in Lake Mendocino and the Russian River watershed.
Russian River Estuary Management and Habitat Enhancement	Sonoma Water is proposing modified management of the Estuary with the objectives of enhancing salmonid habitat in the Estuary while minimizing flood risk to low-lying properties adjacent to the Estuary.
Dry Creek	Sonoma Water proposes to conduct maintenance activities, including sediment and debris removal, vegetation management, and streambank stabilization at existing habitat enhancement sites. Sonoma Water and the USACE propose restoration alternatives to completing Phase III construction. Sonoma Water and the USACE propose including additional best management practices (BMPs) to achieve the goals and objectives of the activities included above.

Proposed action/Project Element	Summary Description and Status
Channel Maintenance	The Mendocino County Russian River Flood Control and Water Conservation and Improvement District (MCRRFCD) proposes to continue to perform stream bank maintenance over a 58-kilometer (km) reach of the Russian River from the Mendocino County line north of Cloverdale, upstream to the town of Calpella and in the East Fork Russian below CVD, downstream to the confluence with the Russian River, a 1.6 km reach. Sonoma Water proposes limited channel maintenance on portions of Dry Creek, specifically maintenance of facilities associated with WSD operations.
Santa Rosa Creek Diversion	Sonoma Water proposes ongoing operation and maintenance of the recently constructed bypass pipe at the Santa Rosa Creek diversion structure (Vortex tube).
Conservation Measures	Sonoma Water and the USACE propose implementing additional measures designed to further avoid and minimize impacts to listed species and designated critical habitats.
Monitoring	Sonoma Water proposes to continue monitoring related to the Proposed Action such as: 1) monitoring of salmonid populations, 2) physical and biological components in the estuary, 3) turbidity and flow, stranding during ramping events, and 4) efficacy of habitat enhancement reaches in Dry Creek and at other locations where additional habitat restoration may occur.

1.3.1 Reservoir Operations - Flood Control and Water Supply at CVD and WSD

This section discusses the proposed reservoir management by USACE and Sonoma Water including proposed changes to flood control and water supply operations. The USACE owns and operates the dams and has responsibility for reservoir operations when the reservoirs are within their flood pool, a period referred to as flood control operations. Flood control operations typically occur during the flood season, between November 1 and February 15, and the February 15 through May 1 adaptive management period. Sonoma Water has responsibility for reservoir operations when the reservoirs are below the flood pool elevation; a period referred to as water supply operations. Water supply operations typically occur during late winter/spring (February 15 through May 1), but can also occur during Dry and Critically Dry Water Years during fall (October through December) adaptive management periods. The rate at which water is released from the reservoirs, either for flood control or for water supply, has implications for both physical and biological resources downstream of the dams.

Flood control involves the regulation of flows to control flooding in properties adjacent to the Russian River. Water supply includes the storage of water in two reservoirs which includes transport and release or use of water in Sonoma, Mendocino, and Marin counties. The water supply is released from the reservoirs and flows down the mainstem Russian River and Dry Creek to diversion points downstream of the dams. These diversions collect water which is then transported via pipelines. Some water remains in the river channel and flows to the Pacific Ocean at the river's mouth near Jenner. The diverted water is delivered to end-users for municipal, industrial, agricultural, and domestic uses.

Within the flood control pool, and if conditions downstream permit, water is required to be released from both reservoirs to restore storage space for the next precipitation event. Forecast Informed Reservoir Operations (FIRO) is a flexible water management approach that uses data from watershed monitoring and improved weather forecasting to help reservoir operators selectively retain or release water from reservoirs for increased resilience to droughts and floods. FIRO applies emerging science and technology to optimize water resources and adapt to climate change without costly infrastructure. Without FIRO, reservoir operators are forced to evacuate flood control space when downstream conditions permit, regardless of future weather forecasts. In the portion of the flood control pool used for FIRO, ramping rates can be considered while formulating a decision based on FIRO principles. For all flood control releases from water elevations in the reservoirs above the FIRO flood control pool, USACE proposes to accommodate desired ramping rates for the protection of ESA-listed salmonids to the extent possible without impacting flood risk management obligations.

Because flooding and water supply in the Russian River basin are driven almost entirely by atmospheric rivers (ARs), the success of FIRO at Lake Mendocino depends on research to improve AR forecasts. A large body of work, led by the Center for Western Weather and Water Extremes (CW3E) at Scripps Institution of Oceanography, has enabled FIRO at Lake Mendocino. CW3E's work includes the AR Reconnaissance program, which fills major gaps in observations over the ocean to improve the accuracy of forecast models. USACE utilized the FIRO tools with planned major deviations from the Lake Mendocino Water Control Manual during water years 2019 and 2020. In both years, FIRO increased water supply benefits and managed flood risks. In 2020, FIRO increased water storage by nearly 20 percent, roughly equivalent to the water used by 22,000 households.

The proposed change to the hydrologic index incorporates reservoir storage levels at Lake Mendocino and is designed to more accurately reflect hydrologic conditions in the Russian River watershed, thereby improving water supply reliability (Table 1a; Sonoma Water 2025). This revised index evaluates Lake Mendocino storage against specified thresholds to determine the water supply condition, which in turn establishes the minimum instream flow requirement for the Russian River.

Table 1a. Storage thresholds in Lake Mendocino and evaluation dates for the proposed hydrological index (in acre-feet). Note: the information provided in the table and below has been updated since the publication of the BA and provided to NMFS via email from Sonoma Water (Sonoma Water 2025, unpublished data).

Water Year	1/1	2/1	3/1	3/16	4/1	4/16	5/1	5/16	6/1	10/1	11/1	12/1
Dry	68,400	68,400	68,400	77,000	86,000	91,000	93,000	94,000	94,000	58,000	51,000	49,000
Critical	42,000	49,000	57,000	67,000	73,000	74,000	75,000	76,000	76,000	46,000	41,000	40,000

1. “Dry” water supply condition exist when storage in Lake Mendocino is less than:

58,000 acre-feet as of October 1
51,000 acre-feet as of November 1
49,000 acre-feet as of December 1
68,400 acre-feet as of January 1
68,400 acre-feet as of February 1
68,400 acre-feet as of March 1
77,000 acre-feet as of March 16
86,000 acre-feet as of April 1
91,000 acre-feet as of April 16
93,000 acre-feet as of May 1
94,000 acre-feet as of May 16
94,000 acre-feet as of June 1

2. “Critical” water supply conditions exist when storage in Lake Mendocino is less than:

46,000 acre-feet as of October 1
41,000 acre-feet as of November 1
40,000 acre-feet as of December 1
42,000 acre-feet as of January 1
49,000 acre-feet as of February 1
57,000 acre-feet as of March 1
67,000 acre-feet as of March 16
73,000 acre-feet as of April 1
74,000 acre-feet as of April 16
75,000 acre-feet as of May 1
76,000 acre-feet as of May 16
76,000 acre-feet as of June 1

3. “Normal” water supply conditions exist in the absence of defined “Dry” or “Critical” water supply conditions.

Many reservoir operational procedures are proposed to continue in a manner consistent with those prescribed in the Warm Springs Dam and Lake Sonoma WCM (USACE 1984) and the Coyote Valley Dam and Lake Mendocino WCM (USACE 1986) as described in the 2008 Opinion, however, modifications to those flood control and water supply operations are also proposed. Specifically, implementation of FIRO at Lake Mendocino, and in the future, Lake Sonoma, will result in revisions to flood control operations at those facilities.

Sonoma Water proposes to petition for the following changes to D1610 minimum flows, intended to be consistent with the 2008 Opinion, as part of the interim petitions (Table 2):

Normal Years:

- Reduce the minimum flow requirement between the mouth of Dry Creek and the mouth of the Russian River from 125 cubic feet per second (cfs) to 70 cfs.

- Reduce the minimum flow requirement in the Russian River from the East Fork to Dry Creek (Upper River) from 185 cfs to 125 cfs between June 1 and August 31; and from 150 cfs to 125 cfs between September 1 and October 31.

- Reduce the minimum flow requirement in Dry Creek from Warm Springs Dam to the Russian River from 80 cfs to 40 cfs from May 1 to October 31.

Dry Years:

- Reduce the minimum flow requirement between the mouth of Dry Creek and the mouth of the Russian River (Lower River) from 85 cfs to 70 cfs.

Although D1610 provides minimum flow standards for the mainstem Russian River and the lower 14 miles of Dry Creek, it does not provide standards for an upper limit to the amount of stream flow that may be discharged down these rivers. Sonoma Water's use of the Russian River and Dry Creek as conduits for transmitting water supply from Lake Sonoma and Lake Mendocino during the low flow season has resulted in stream flows that are often more than 40 cfs higher than minimum flows under D1610. With respect to the water supply operations, under the Proposed Action, there will be no change to ramping rates that will continue to be at a maximum of 12 cfs/hour and no more than 24 cfs/day to minimize effects on adult and juvenile salmonids downstream of WSD and CVD. All other minimum flows set by D1610 (Figure 2) will remain unchanged.

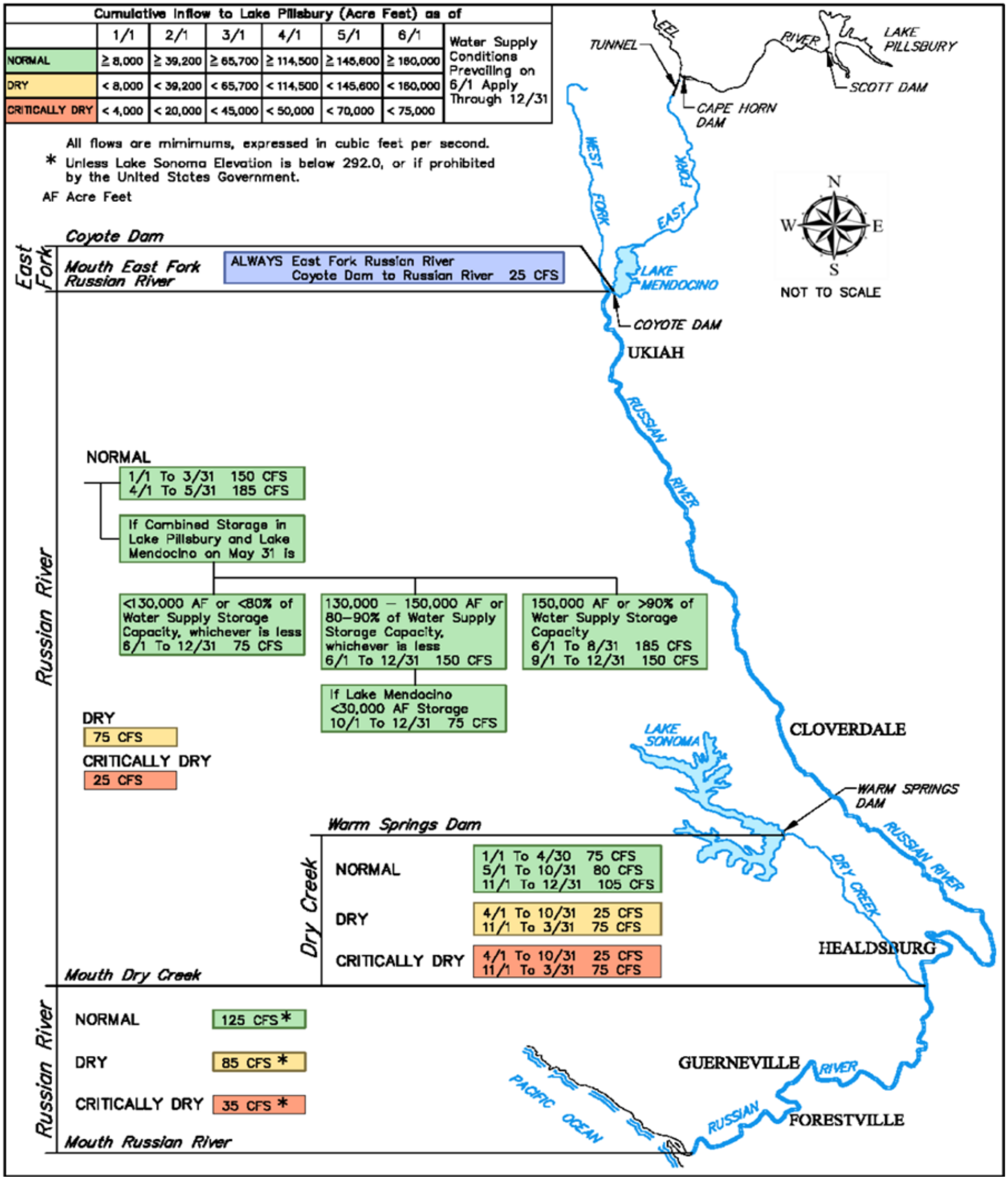

Figure 2. Decision 1610 Minimum Instream Flows (ESA, Inc. 2023).

Table 2. Current and Proposed Minimum Flows for Three Reaches in the Russian River Watershed (ESA, Inc. 2023).

Mainstem Russian River from the East Fork to the mouth of Dry Creek (Upper River)	Normal	185	125	June 1 to August 31
	Normal	150	125	September 1 to October 31
	Dry	75	105-110[1]	October through December
	Dry	75	150[1]	February 15 to May 31
Mainstem Dry Creek	Normal	80	40	May 1 to October 31
	All	See Figure 2 Above	Adaptively Managed Blockwater[2]	Fall and Late Winter/Early Spring
Between the Mouth of Dry Creek and the Mouth of the Russian River (Lower River)	Normal	125	70	All
	Dry	85	70	All
	All	See Figure 2 Above	Adaptively Managed Blockwater[2]	Fall and Late Winter/Early Spring

[1] See Sections 1.3.1.1.4 and 1.3.1.2.4 below for more details on Adaptively Managed Pulse Flows. During the adaptive management periods, the USACE and Sonoma Water will provide flow augmentation to assist with the spring outmigration of smolts (105 cfs) and adult passage flows for Chinook salmon (110 cfs) released from the CVFF should a target flow release strategy be selected for implementation by the Reservoir Operations Group.

[2] See Section 1.3.1.5.2 below for more details on adaptively managed blockwater. Sonoma Water, in coordination with USACE, will commit up to 2,500 ac-ft of water (blockwater) on an annual basis (reset each year) to be used to augment releases from Lake Sonoma into Dry Creek and the Lower River to aid in salmonid migration and survival.

In a May 7, 2024 memo to NMFS entitled “Reservoir Water Supply Pool Operations Adaptive Management Action” (Sonoma Water 2024b), Sonoma Water describes proposed adaptive management strategies at Lake Mendocino and Lake Sonoma, specifically the proposed Reservoir Water Supply Pool Operations Adaptive Management Action. These strategies are intended to augment the Proposed Action presented in the BA to aid in migration and survival of salmonids. Sonoma Water, in coordination with the USACE, will convene a Reservoir Operations Group consisting of personnel from Sonoma Water, USACE, NMFS, CDFW, and SWRCB (coordinating agencies). The first meeting of this group will occur within four months of issuance of this Opinion, with additional meetings proceeding quarterly. The Reservoir Operations Group will develop projections for Lake Mendocino and Lake Sonoma storage based on existing conditions and hydrologic forecasts to assess water supply that could be made available for a pulse release or a blockwater release action (see proceeding sections for more detail) without leading to a significant decline in Lake Mendocino and/or Lake Sonoma storage resulting in a significant risk to water supply reliability at the two reservoirs (e.g., substantial decreased storage, depletion of cold water pools, inadequate storage for subsequent year reservoir operations management objectives, including minimum flows for fish habitat).

Sonoma Water will make water supply projections and forecasts on a monthly basis during the late winter/spring (February 15 through May 1) and fall (October through December) adaptive management periods. Based on projections and forecasts, the Reservoir Operations Group will determine the appropriate target blockwater/pulse flow release strategy and develop an operations plan including flow schedules (specific timing, magnitude, and duration of flows). A draft of the plan will be provided to the Reservoir Operations Group within one year of publication of this Opinion.

During winter/spring and fall Reservoir Operations Adaptive Management periods, the Reservoir Operations Group will communicate via regular conference calls and will share current information and forecasts via e-mail and/or an internet website. All adaptive management actions will be recorded and reported in annual reports, including information on estimated outcomes of effectiveness, consequences to water supply (e.g., impacts on carryover or in-season supplies), and recommendations for consideration in subsequent years. If agreement on the Lake Mendocino Water Supply Pulse Flow Adaptive Management or the Lake Sonoma Water Supply Blockwater Release Adaptive Management actions cannot be reached among all designees from the coordinating agencies (Reservoir Operations Group), Sonoma Water proposes to defer to NMFS' recommendations, in coordination with the SWRCB and CDFW, on the actions that will be taken regarding blockwater releases.

1.3.1.1 Flood Control Operations at CVD

CVD was built in 1959 and impounds water coming from the East Fork through Potter Valley into Lake Mendocino. Lake Mendocino has a flood storage capacity of 122,400 ac-ft and a total surface area of 1,822 acres. This section of the East Fork also receives water from PG&E's Potter Valley Project (PVP), which transfers water from the Eel River through a tunnel and penstocks at the watershed divide between the Eel and the Russian Rivers.

Operation of CVD by the USACE provides flood protection for areas below the dam and supplies water for domestic and agricultural uses. The USACE limits releases from CVD to prevent flooding at Hopland that can occur when flows exceed 8,000 cfs. Specific criteria for flood control operations are described in the Lake Mendocino WCM (USACE 1986).

1.3.1.1.1 Flood Control Operations at CVD - FIRO

Flood control releases under the Proposed Action will be made in accordance with the Planned Major Deviation (Deviation) to the Lake Mendocino WCM (USACE 1986). USACE approved the Deviation and has developed an update to the Lake Mendocino WCM to reflect the operations that are allowed by the Deviation. Under the Proposed Action, storage at Lake Mendocino would reach a maximum of 80,050 ac-ft during the flood season, between November 1 and February 15, which represents an increase of 11,650 ac-ft compared to the amount prescribed in the current WCM. After February 15, the FIRO pool would increase by approximately 355 ac-ft per day (an increase of approximately 19 percent compared to pre-FIRO reservoir management) until May 12 when it intersects the guide curve for a maximum storage of 111,000 ac-ft (Figure 3 as an example from 2019 and 2020). Storage in the flood control space up to 80,050 ac-ft would be guided by procedures identified as part of FIRO during flood control season between November 1 through February 15.

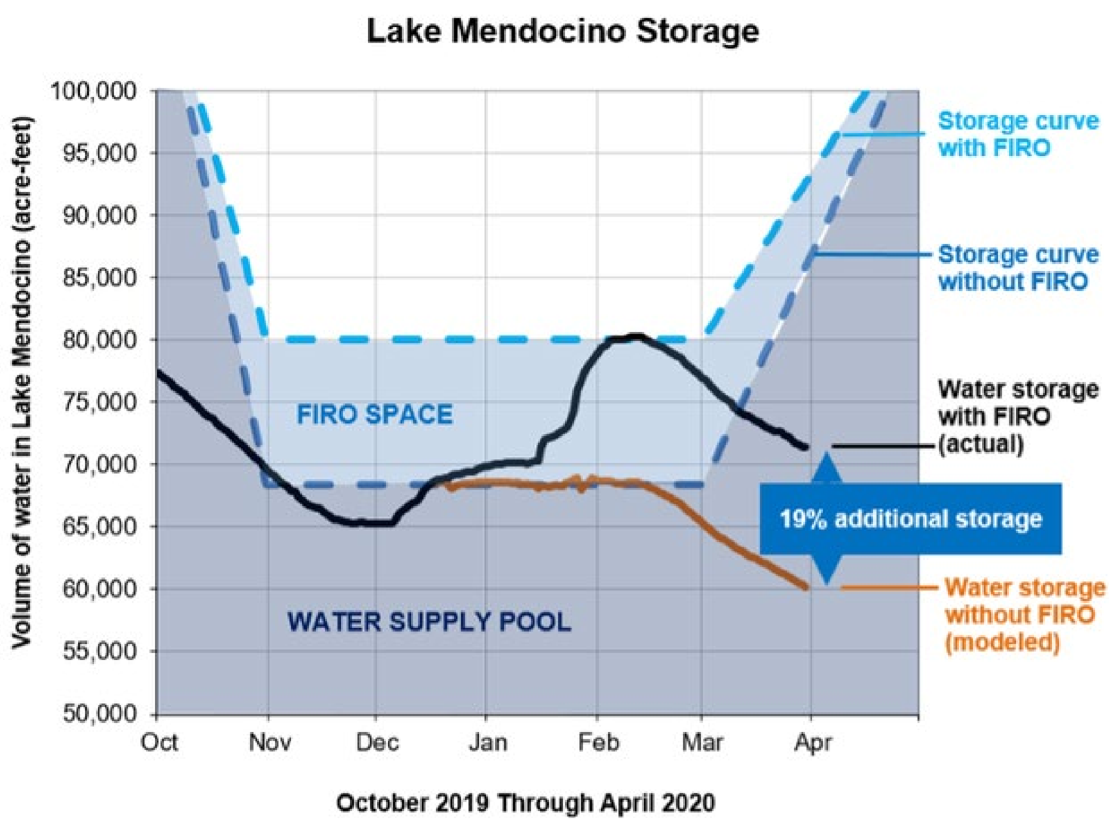

Figure 3. Example from Water Year 2020 of proposed reservoir storage at Lake Mendocino Storage including the implementation of FIRO. (https://www.sonomawater.org/firo, accessed April 15, 2025).

1.3.1.1.2 Flood Control Operations at CVD - Ramping Rates

Flood control operations at CVD (including FIRO) would be conducted under the Proposed Action consistent with the ramping schedule criteria previously identified by NMFS and USACE except when emergency flood control actions are required (NMFS 2016a). Flow releases for flood control may occasionally curtail flow releases where down-ramping rates exceed 100 cfs/hour in those circumstances where more expedient operations are required to meet operational criteria for flood control. This down-ramping schedule is summarized in Table 3-11 in the BA and in Table 3, below.

The basis of the proposed down-ramping schedule in Table 3 was generated from studies conducted downstream of CVD by USACE and NMFS and were designed to address RPM 3 of the 2008 Opinion (NMFS 2016a). At the time, USACE and NMFS monitored fish stranding and stage height changes along eight transects in the Upper River between the confluence of the West and East Forks and the Perkins Street Bridge under a series of flow releases. Results from the monitoring effort concluded that higher down-ramping rates (e.g., 500 cfs/hour to 1,000 cfs/hour) were likely to have adverse effects on listed salmonids. To minimize and avoid these effects, NMFS and USACE developed a ramping schedule with lower down-ramping rates (25-250 cfs/hour), for the period when CVD is within the flood control pool (see Table 3). NMFS provided a memo to the USACE with finalized ramping criteria in 2016.

Table 3. Down-Ramping Rates at CVD for Flood Control Operations (NMFS 2016a)

Flood Release Range (cfs)	Ramping Rate (cfs/hour)	Dates
2,500 and 4, 000	250	Prior to March 15
<2,500	100	Prior to March 15
< 250	25	March 15 and May 15
< 250	25	May 16 and March 14

1.3.1.1.3 Flood Control at CVD - Dam Inspection Flow Releases

Annual pre-flood inspections conducted at CVD during September and periodic inspections occurring once every five years would continue as part of the Proposed Action. Flow releases during dam inspection will be made as specified and consistent with revisions to inspection ramping guidelines below and contained in the Lake Mendocino WCM. A comprehensive outlet tunnel inspection is required at least every five years to ensure periodic inspections identify any issues that could compromise flood control releases. Outlet tunnel inspections will be conducted at any time when Coyote Valley Fish Facility's (CVFF) hatchery operations are offline, and natural flows measured at the West Fork are in excess of 300 cfs. Under the Proposed Action, these inspections would involve ramping down reservoir releases to zero, followed by a 4-hour inspection period of the 5- by 9-ft service and emergency gates and the 720-ft long steel-lined concrete conduit, after which normal operating releases are restored (Table 4).

Table 4. Ramping Rates at CVD for Dam Maintenance and Inspections (NMFS 2017a).

Ramping Rates	Applicable Period
12 cfs/hour and no more than 24 cfs/day	Maintenance and Inspection

USACE anticipates that up to 50 juvenile steelhead and 50 juvenile Chinook salmon may be stranded and require relocation with each dam inspection. USACE, therefore, proposes to coordinate the fish surveys with NMFS and, at least one week prior to each dam inspection, will provide NMFS with a fish survey plan documenting the survey and fish handling methodology, including the number of survey crews and stream reaches to be surveyed. Survey crews will be present on the East Fork downstream of CVD at the start of flow ramp down, and remain until flows are entirely ramped back up. USACE stated that it welcomes and encourages NMFS staff to be onsite during the surveys. The number and species of fish encountered and moved will be reported to NMFS in person or by phone on the survey day, and documented by email within 24 hours.

1.3.1.1.4 Flood Control Operations at CVD - Pulse Flow Releases

During the winter/spring (February 15 through May 1) adaptive management period, USACE proposes to provide flow augmentation to assist CDFW with steelhead hatchery releases at CVFF. Additionally, these pulse flow releases will be coordinated with other flow augmentation efforts targeting wild Chinook salmon and steelhead smolts outmigrating in the Upper River (coho salmon do not use the Upper River).at that time. The Reservoir Operations Group (see description in Section 1.3.1 above) will determine appropriate target flow release strategies based on monthly water supply projections and forecasts to optimize the conservation benefit to salmonids.

1.3.1.2 Flood Control Operations at WSD

Lake Sonoma was created by the construction of WSD on Dry Creek in 1983. The dam's purposes are flood control, water delivery for industrial and municipal uses, and recreation. When full, the lake has a surface area of more than 3,600 acres, a storage capacity of 381,000 ac -ft, and 50 miles of shoreline. Under the Proposed Action, USACE will continue to manage water releases at Lake Sonoma when the water levels rise above the top of the water supply pool (451.1 ft above mean sea level, Figure 4) and into the flood control pool, as described below.

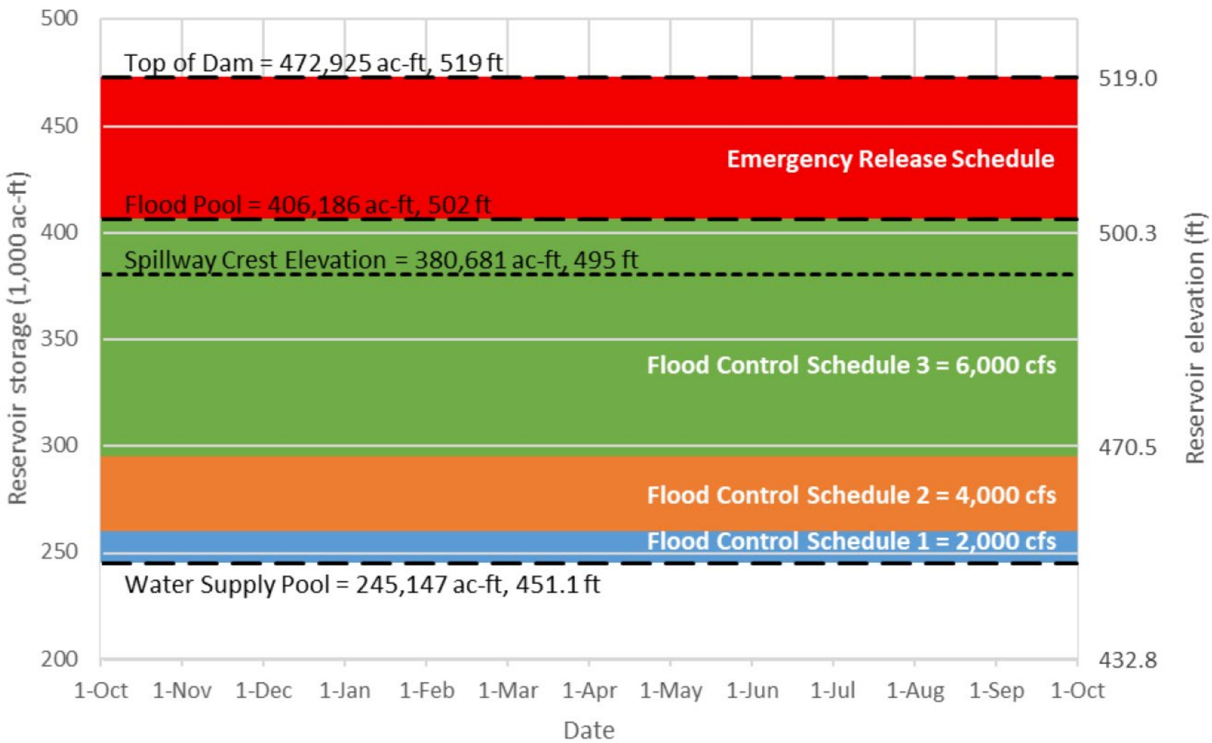

Figure 4. Simplified Water Control Diagram of the Existing Lake Sonoma WCM (USACE 1984). Reservoir Elevation is in relation to the National Geodetic Vertical Datum of 1929 (NGVD29).

1.3.1.2.1 Flood Control Operations at WSD - FIRO

Under the Proposed Action, flood control operations at WSD will proceed according to procedures set out in the Lake Sonoma WCM (USACE 1984). However, USACE and the Russian River FIRO Steering Committee are also currently evaluating FIRO alternatives that would be applied at Lake Sonoma. Potential proposed changes with respect to flood control operations for Lake Sonoma are still to be determined; however, any revisions will comply with minimum instream flow requirements in place at the time FIRO procedures are developed and finalized for WSD. This includes flood control release requirements that stipulate that such releases will be minimized when flows on the Russian River near Guerneville are greater than 35,000 cfs. As FIRO procedures are being considered, minor deviations have been implemented over the past two seasons as part of the evaluation process for FIRO procedures at Lake Sonoma. NMFS expects deviations to continue over the next ten years until FIRO is fully implemented at WSD. Minor deviations being considered for storage in Lake Sonoma includes a maximum FIRO pool of 254,500 ac-ft during the flood season. After February 15, the FIRO pool will increase by approximately 633 ac-ft per day until March 1, when it reaches a maximum summer storage of 265,000 ac-ft. Under the Proposed Action, it is anticipated that weather forecasting tools similar to those used under FIRO at Lake Mendocino will be utilized at Lake Sonoma. Development of these tools and any subsequent proposed changes in operations at WSD will be conducted in close coordination with NMFS and CDFW.

1.3.1.2.2 Flood Control Operations at WSD - Ramping Rates

Flood Control Schedules for each reservoir specify the rate at which water can be released and were developed within the respective WCMs at the time of their publication (USACE 1984, 1986). According to these Flood Control Schedules, flow releases are conditional on previous high reservoir stages and dictate maximum flow guidelines for the river reaches downstream. Operations at Lake Sonoma and WSD will comply with the Flood Control Schedule ramping schedule criteria summarized below in Table 5.

Table 5. Ramping Rates at WSD for Flood Control Operations (2008 Opinion).

Reservoir Outflow (cfs)	Down Ramping (cfs/hour)	Up Ramping (cfs/hour)
0-250	25	1,000
250-1,000	250	1,000
>1,000	1,000	2,000

1.3.1.2.3 Flood Control Operations at WSD - Dam Inspection Flow Releases

Annual pre-flood or periodic inspection of the dam structure and operating systems at WSD will continue to occur under the Proposed Action. During the periodic inspection periods, USACE provides a minimum bypass flow of 25 cfs. Similarly, annual and five-year periodic pre-flood inspections will continue for the WSD facilities. USACE proposes to continue to conduct inspections of WSD during those times of the year that avoid adverse effects to juvenile and adult salmonids. Inspections have occurred in late August or September to allow juvenile steelhead to reach a sufficient size to avoid stranding impacts during the ramp down of flow to the minimum stream levels maintained during inspection. Ramping rates in preparation for the inspection period at WSD are also designed to minimize effects on salmonids downstream (Table 6).

Table 6. Ramping Rates at WSD for Maintenance and Inspections (NMFS 2017a).

Ramping Rates	Applicable Period
12 cfs/hour and no more than 24 cfs/day	Maintenance and Inspection

1.3.1.2.4 Flood Control Operations at WSD - Blockwater Releases

During the winter/spring (February 15 through May 1) adaptive management period, USACE proposes to provide flow augmentation to assist steelhead, Chinook, and coho salmon juvenile and smolt outmigration if feasible and if water levels are at the flood control pool levels in Lake Sonoma at that time. The Reservoir Operations Group (see description above) would determine appropriate target flow release strategies based on monthly water supply projections and forecasts to benefit salmonids. These releases would be intended to stimulate out-migration cues.

See Section 1.3.1.5.2 below for more details on Adaptively Managed Blockwater. Sonoma Water, in coordination with USACE, proposes to commit up to 2,500 ac-ft of water (blockwater) on an annual basis (reset each year) to be used to augment releases from Lake Sonoma into Dry Creek and the Lower River to aid in salmonid migration and survival.

1.3.1.3 Turbidity at CVD

1.3.1.3.1 Turbidity Management at CVD - Flood Control and Water Supply

Elevated levels of turbidity remain a persistent condition in Lake Mendocino and in the reaches of the Russian River downstream of CVD. Earlier efforts by USACE attempted to analyze turbidity levels and potential impacts at a series of sampling stations downstream of the reservoir, but the need for additional information such as Russian River-specific flow-turbidity and turbidity-suspended sediment rating curves has become apparent. USACE has reaffirmed its commitment to investigating and developing turbidity management solutions aimed at reducing turbidity discharged from the reservoirs, particularly at CVD. These efforts include additional monitoring, the facilitation of a Turbidity Technical Advisory Committee (TAC) to develop long-term solutions, and experiments with existing infrastructure in the short-term (e.g., tainter gate positioning, ramping rates, and the use of settling ponds) to assess their effectiveness in reducing turbidity during flood control and water supply operations.

1.3.1.3.2 Turbidity at CVD - Turbidity Technical Advisory Committee

<u>Turbidity TAC Activities and Outcomes</u>

To determine appropriate actions for reducing elevated turbidity levels, USACE has established a turbidity TAC composed of fishery biologists, hydro-engineers, sediment transport and reservoir management scientists, and water quality specialists. The TAC is tasked with refining the definition of the problem, specifically as it influences ESA-listed species, and advising USACE on potential turbidity reduction solutions. The primary focus is to reduce measurable turbidity effects on ESA-listed salmonids to acceptable levels. Defining these acceptable turbidity levels in relation to current background conditions will be essential for identifying potential treatment actions and achieving targeted goals under specific hydrologic and watershed conditions.

To date, USACE has facilitated several TAC meetings, identified TAC members from NMFS, CDFW, the North Coast Regional Water Quality Control Board (NCRWQCB), and Sonoma

Water, and initiated the development of a formal charge outlining the TAC's goals and objectives. USACE proposes that the TAC is guided by and within the terms of a December 31, 1997 MOU among USACE, NMFS, and Sonoma Water "to establish a framework for the consultation and conference required by the ESA" for ESA-listed salmonids in the Russian River. Additionally, USACE has enlisted two TAC-approved peer reviewers with expertise in turbidity and/or suspended sediment dynamics in reservoirs and dam-impacted rivers to evaluate and assist developing TAC recommendations and technical products. A more detailed description of anticipated TAC activities and outcomes is provided below.

Turbidity TAC Objectives

1. **Finalize the Turbidity TAC's charge**, including the role of outside experts.

2. **Review USACE's proposed turbidity monitoring locations** to assess their suitability for establishing "background" turbidity levels in the Russian River and distinguishing various turbidity sources. As part of this task, the TAC will define or propose a method for determining a relevant, measurable "background" turbidity and may recommend alternative and/or additional monitoring locations.

3. **Review historical and new turbidity data** collected by USACE and the U.S. Geological Survey (USGS) to identify periods of elevated turbidity in the Russian River and potential causes. The TAC will suggest key research questions for USACE to investigate. Data and analyses will be presented by USACE to the TAC for review and further evaluation. The TAC will use these data to provide guidance to USACE on methods for reducing turbidity from CVD releases.

4. **Determine the sources and magnitude of turbidity** in the Upper River, including seasonal (i.e., temporal and spatial) patterns, attributable to USACE and Sonoma Water's flood control and water supply operations.

5. **Determine the magnitude and extent of turbidity impacts** to more precisely determine the influence of turbidity discharged during CVD releases on salmonids in the Upper River.

6. **Identify and evaluate solutions** to address the long-standing issue of periodic and prolonged increases in turbidity associated with CVD flow releases. The TAC will assess the feasibility and effectiveness of alternative measures to achieve measurable turbidity reduction actions.

Turbidity TAC Outside Expert Engagement

In addition to the TAC, USACE proposes to engage with two retained experts with specialized knowledge in turbidity and suspended sediment dynamics in reservoirs and dam-impacted rivers, particularly in relation to turbidity modeling. Their role will include:

1. **Participating in quarterly TAC meetings** and reviewing existing information and reports to assess completed work and available data. They will also recommend additional monitoring or data collection sites needed for modeling efforts.

2. **Providing guidance on potential short-term turbidity reduction actions** that could be implemented with current infrastructure capabilities and within the constraints of the CVD, WCM, and O&M manual, at least experimentally to test for effectiveness and potentially long-term implementation.

3. **Developing one or more sediment dynamics models** for Lake Mendocino and, if needed, for the Russian River, to evaluate watershed background turbidity levels.

4. **Developing turbidity-related models** to assess potential measurable longer-term turbidity reduction scenarios to be determined by the TAC.

5. **Providing guidance on potential long-term turbidity reduction actions** resulting from existing and future data collections and modeling results.

1.3.1.3.3 Turbidity at CVD - USACE Proposed Reduction Investigations and Evaluations

The USACE proposes the following activities, either in combination with or independently from the TAC efforts described above, to better define turbidity issues related to CVD releases:

1. Develop flow-turbidity curves, turbidity-suspended sediment curves, or other appropriate rating curves specifically for the Russian River.

2. Develop and refine a conceptual model for the processes leading to both episodic and chronic turbidity impacts.

3. Model sediment distribution and transport in Lake Mendocino and how they relate to the design and operation of the CVD Outlet infrastructure.

4. Increase understanding of turbidity dynamics in the Russian River, including organic versus inorganic material.

5. Develop and implement applicable/feasible operational changes to discretionary flood control and water supply operations that could help reduce impacts to ESA-listed salmonid species and their designated critical habitat in the Upper River.

6. Study and develop, if appropriate and authorized, structural changes to CVD, including modification(s) of the existing intake at the dam, that could help to reduce impacts to ESA-listed salmonids and their designated critical habitat in the Upper River.

7. Conduct a bathymetric survey of Lake Mendocino within two years of issuance of this Opinion to NMFS to determine the level of siltation and if dredging is a reasonable alternative to reduce turbidity levels.

8. Finalize a plan to complete or adjust installation of turbidity meters by December 31, 2025, as may be appropriate via guidance from the TAC and/or outside experts.

9. Finalize a plan to maintain, report, and provide accessible (online) turbidity data using USGS guidelines for the duration of this Opinion and provide annual reporting of the analysis of the data to NMFS. To be completed within one year of issuance of this Opinion.

10. Finalize a plan to analyze the data to determine if flood control and/or waters supply operations contribute to an increase in turbidity that impacts salmonid rearing and spawning habitat in the Upper River between CVD and Jimtown. To be completed within one year of issuance of this Opinion.

11. Should turbidity data and the analysis confirm that impacts to ESA-listed species are likely to occur or indicate effects are worse than expected, the USACE shall provide a draft plan to minimize and avoid these effects to NMFS for review no later than July 1, 2030.

1.3.1.3.4 Turbidity at CVD - Monitoring and Reporting

The USACE in coordination with the USGS and/or Sonoma Water, will conduct turbidity monitoring or collect turbidity data (i.e., sites not operated by the USACE) at the following gage sites listed below (Figure 5). Information also includes the current status of operation and monitoring agency for each site (listed up to downstream).

Figure 5. Map showing locations of turbidity monitoring gages within the Russian River watershed.

Turbidity Monitoring:

1. East Fork Russian River approximately 1 mile upstream of Lake Mendocino near Calpella (Gage No. 11461500); operated by USGS.

2. Lake Mendocino; in the thalweg with data collection at 20-foot intervals and at 5 feet (ft) off the bottom. Sonoma Water has been collecting these data during the months required by the NCRWQCB, TUCOs. The USACE will begin to collect these data in 2025, outside of the TUCO requirements.

3. East Fork Russian River downstream of CVD (Gage No. 11462000); operated by the USACE. Continuous turbidity monitoring began May 28, 2024.

4. West Fork Russian River at Lake Mendocino Drive Bridge (Gage No. 11461000); operated by the USACE. Continuous turbidity monitoring began on November 19, 2024. This gage will be periodically inactive due to low-flow or dry conditions during the summertime or drought periods.

5. The mainstem Russian River at Talmage, at or near USGS gage (Gage No. 11462080); proposed to be operated by the USACE. Turbidity meter installation has not yet occurred and is dependent upon reaching agreement with the landowner and USGS or operated by the USACE depending on prescribed gauging equipment. Turbidity monitoring at this location will occur continuously no later than September 15, 2025.

6. Russian River mainstem approximately 12 miles downstream of CVD near Hopland (Gage No. 11462500); operated by the USGS.

7. Dry Creek downstream of WSD (Gage No. 11465000); operated by the USACE. Continuous turbidity monitoring began May 22, 2024.

The USACE has acknowledged the importance of collecting turbidity data at Talmage (Ukiah), which is much closer to the confluence of the East Fork and West Fork than Hopland. It also is upstream of vineyards and farmland which may contribute to Russian River turbidity from runoff, thus allowing the turbidity from the East Fork (downstream of the CVD Outlet) to be tracked more efficiently. Monitoring at that location will require agreements with USGS gage sponsor and/or the City of Ukiah. The anticipated start of data collection for this site is September 15, 2025.

Turbidity Reporting:

1. The USACE will establish an online repository for continuous turbidity data collected. Data will be uploaded no less often than quarterly. A link will be provided to NMFS to access this data within the first three months of this Opinion issuance.

2. The USACE will collect turbidity data from the seven monitoring locations across all seasons (fall, winter, spring, summer) and summarize the data by water year (October 1

through September 30). The summarized data shall be submitted to NMFS no later than December 15 of the same year, and the resulting analysis of those data shall be provided to NMFS for review and approval no later than August 15. The USACE will also present the turbidity data and analysis in an annual report submitted to the TAC and NMFS by December 31. The initial annual report will be submitted on December 31, 2025. If an extension of the December 31 deadline is necessary in any given year, a written request with justification will be submitted to NMFS at least one week prior to the deadline.

3. The USACE will provide annual reports and analyze the new turbidity data in conjunction with watershed hydrologic conditions and reservoir release data. The USACE will summarize approximately three years of data (i.e., January 1, 2025 through December 31, 2028), assess potential impacts to salmonid rearing and spawning habitat using the methods of published scientific literature (e.g., Bash et. al. 2001; Newcombe and Jensen, 1996, and any monitoring data), and provide a report to NMFS no later than June 1, 2028.

Fisheries Monitoring Associated with Turbidity Discharged from CVD

The USACE will conduct fisheries monitoring associated with turbidity released from CVD in efforts to track Chinook salmon and steelhead production trends in the Upper River, while turbidity reduction investigations occur over the next several years. This commitment to fisheries monitoring will aid future evaluations of the magnitude and extent of turbidity impacts associated with CVD operations on ESA-listed salmonids in the Upper River, while ensuring that population productivity persists as future long-term turbidity determinations and/or potential solutions are implemented. Upper River fisheries monitoring objectives and timeframes include the following:

Relative Population Trends of Chinook Salmon (Fish-in/Fish-out) in the Upper River:

1. **Adult Chinook Salmon Relative Abundance Above Hopland (Fish-In):** Use sonar technology (e.g., ARIS or DIDSON) to count adult Chinook salmon migrating upstream in the turbidity-influenced reach above Hopland. Species identification and sonar calibration may incorporate direct observation techniques such as snorkel surveys, digital video analysis, or other non-handling methods. Additionally, multiple sonar units may be deployed to improve resolution of spawner estimates between the CVD Outlet and Hopland.

2. **Smolt Chinook Salmon Relative Abundance Above Hopland (Fish-Out):** Conduct downstream migrant trapping (e.g., screw traps) near Hopland to estimate the number of juvenile Chinook salmon emigrating from the turbidity-influenced reach upstream of Hopland. These data will provide insight into adult Chinook salmon spawning success and overall production above Hopland. Smolt abundance estimates may also incorporate mark-recapture methods.

Juvenile Steelhead Habitat Use and Growth in the Upper River:

1. **Coarse-Scale Juvenile Steelhead Summer Rearing Habitat Use in the Upper River:** A broad assessment of juvenile steelhead summer rearing habitat use will be conducted through electrofishing surveys, focusing on abundance within the turbidity-influenced reach above Hopland. Multiple sampling sites upstream of Hopland will be surveyed to estimate juvenile steelhead abundance in this reach. Mark-recapture estimates will be attempted at each site, but if determined adequate, single-pass electrofishing catch-per-unit-effort (CPUE) may be used as an alternative.

2. **Juvenile Steelhead Growth Estimates in the Upper River:** In conjunction with the electrofishing surveys described above, efforts will be made to PIT-tag individual juvenile steelhead at the beginning and end of the summer rearing season. This approach will allow for the calculation of average growth rates by measuring size differences over the season (i.e., size at the end of summer minus size at the beginning, standardized by day). If individual PIT-tag recaptures are insufficient, size distribution comparisons of juvenile steelhead captured at the beginning and end of the summer rearing season will be used as an alternative metric.

   The fisheries monitoring associated with turbidity discharge from CVD, as described above, will be evaluated following pilot monitoring efforts to confirm the viability of these methodologies. If pilot efforts determine these methodologies are ineffective, alternative approaches will be proposed to NMFS for approval. Pilot fisheries monitoring efforts will be conducted during water year 2026 (October 1, 2025 – October 1, 2026). A final NMFS approved Upper River Fisheries Monitoring Plan will be implemented in water year 2027 and will continue for the duration of this Opinion. Findings from this monitoring effort will be compared to similar efforts in Dry Creek, where turbidity conditions are considered significantly more favorable for Chinook salmon and steelhead productivity. Reporting and results from these monitoring efforts will occur in winter following the preceding water year, but no later than January 31.

1.3.1.3.5 Turbidity at CVD - USACE Proposed Short-Term (years 1-4) Turbidity Reduction Actions

The USACE proposes to continue evaluating and investigating the following three short-term operational adjustments (within three years of the Opinion's issuance), provided they are feasible and within USACE's discretion. The most effective operational scenario(s) will be determined and implemented within the constraints of the CVD, WCM, and Operations & Maintenance manual. USACE will meet with the TAC within one year of this Opinion's issuance to plan these activities and review existing data. Under the Proposed Action, USACE will assess the relationship between flow (and turbidity) inputs from the CVD Outlet and other turbidity monitoring sites to evaluate the effectiveness of the short-term turbidity reduction actions described below.

1. Reducing flood control ramping rates on the increasing leg (up-ramping). This could be implemented provided conditions in the watershed and forecasts do not compel a rapid increase in release.

2. Using settling ponds at Coyote Valley Fish Facility (CVFF) (when rearing fish are not present) to help to manage turbidity water discharged from CVD. A preliminary volumetric analysis has determined that implementing this action would reduce turbidity in the East Fork Russian River by a maximum of 10 percent (i.e., approximately 1-2 NTU) under ideal conditions. A more thorough evaluation and final determination of this action is underway.

3. Experimenting with service gate positions in "Flood Control Mode." This is a very rare condition in the field over the past 10-years, but is still operationally possible. However, doing so when not required would impact power generation and incur financial costs (e.g., loss of revenue for power generation) by the City of Ukiah. In addition, it is not clear to what extent the 1986 Agreement for Construction, Operation, and Maintenance of Lake Mendocino Power Project would need to be modified to support this operational approach under non-emergent conditions in flow or at the facility. This short-term turbidity reduction effort has been preliminarily determined to be very limited. A more thorough evaluation and final determination of this action is underway.

Overall, adjusting ramping ramps is viewed as the most applicable and feasible in the short-term, and the USACE intends to implement it twice per year for the first three years that this Opinion is in effect, provided the appropriate conditions exist. These "appropriate conditions" will be discussed in the TAC during the first year of this Opinion. As mentioned above, the USACE has engaged the services of two outside experts to review the existing turbidity documents and provide guidance on other potential actions that could be implemented in the short-term, at least experimentally, to test the effectiveness of these actions to reduce turbidity discharged from CVD.

1.3.1.3.6 Turbidity at CVD - USACE Potential Long-Term (years 4-10) Turbidity Reduction Actions

Long-term turbidity reduction actions will require extensive investigations and will likely result in complex solutions that necessitate separate authorization and funding from the current flood control and water supply project. Additionally, substantial uncertainty remains regarding the effectiveness of such solutions and whether they should be implemented. The USACE intends to seek funding under Section 216 of the Flood Control Act of 1970 (P.L. 91-611) for a reconnaissance-level study to commence within three years of this Opinion's issuance. The Turbidity TAC will provide input, model potential turbidity reduction scenarios to assess projected outcomes, and review study results. Based on these findings, USACE will determine a path forward, potentially leading to the implementation of one or more solutions, if deemed appropriate, pending authorization and funding.

Potential long-term solutions to reduce turbidity in and downstream from Lake Mendocino, including, but not limited to, those listed below, should be investigated as proposed by Turbidity TAC members and other stakeholders.

1. **Bathymetric Survey and Dredging Assessment** – As noted above, within two years of this Opinion's issuance, USACE will conduct a bathymetric survey of Lake Mendocino to assess siltation levels and evaluate whether dredging is a viable option for turbidity reduction. The two external experts identified by the Turbidity TAC will review the survey results and provide input on the feasibility of dredging or alternative measures to reduce turbidity in CVD outflows.

2. **Targeted Suction Dredging** – Conduct targeted suction dredging near the CVD Outlet works or other areas where sediment may be mobilized.

3. **Infrastructure Modifications** – Modify CVD infrastructure (e.g., the dam, outlet works, etc.) to allow variable water release locations based on prevailing conditions.

4. **Biofiltration Diversion** – Divert a portion of the CVD outflow into a biofilter to reduce turbidity.

5. **Upstream Sediment Reduction** – Implement measures to reduce sediment input into Lake Mendocino from upstream sources.

6. **Auxiliary Outlet Structure** – Utilize an auxiliary outlet structure or device that enables discharge from less turbid reservoir depths to reduce turbidity levels downstream of CVD.

7. **Turbidity Current Management** – Install physical structures within the upper reservoir to disrupt turbidity currents and enhance sediment settling within Lake Mendocino.

8. **Forebay Sediment Stabilization** – Implement modifications to the outlet works forebay, such as installing structural barriers (e.g., sheet piles) to minimize sediment sloughing near the CVD Outlet.

Additionally, the Fiscal Year 2024 Federal Budget allocated $500,000 for a USACE feasibility study of CVD with a primary purpose of investigating actions to address water supply objectives. USACE specified that this feasibility study is independent from its Proposed Action and in order to initiate the study (and for USACE to access the allocated funds), USACE and a non-federal sponsor must enter into a feasibility cost sharing agreement (FCSA). The non-federal sponsor is Mendocino County Inland Water and Power Commission and the Lytton Rancheria Tribe, and the FCSA was executed on March 31, 2025. While the primary purpose of the study is water supply, USACE feasibility studies must comprehensively formulate plans with respect to environmental, social, and economic benefits and effects. Accordingly, environmental benefits or effects related to turbidity and suspended sediment would be integrated in plan formulation and analysis. While the specific recommendations of such elements of the plan are uncertain, it is expected to consider structural measures such as raising CVD dam. Implementation is not guaranteed from this study; should implementation be authorized and funded by Congress, it would likely occur several years in the future.

The USACE proposes to make its best efforts to comply with all deadlines as written above (Section 1.3.1.3 in its entirety). The USACE also proposes that if there are any unforeseen circumstances beyond the USACE's control that interfere with the ability to meet the deadlines, the USACE shall communicate the justification for the delay and a reasonable deadline to comply.

1.3.1.4 Water Supply Operations at CVD

As the local sponsor, Sonoma Water makes releases from CVD to maintain the minimum instream flow requirements specified in its state water right permits and for downstream beneficial uses along the Upper Russian River, including diversions for domestic, municipal, industrial, and agricultural purposes. These releases are made by Sonoma Water when reservoir storage levels are in the water supply pool (also known as the water conservation pool), which is at or below the reservoir guide curve as established in the Lake Mendocino WCM (USACE 1986). Sonoma Water makes release decisions from CVD for the Upper River to comply with minimum instream flow requirements in its water right permits at compliance locations between Healdsburg and the confluence of the West and East Forks.

1.3.1.4.1 Water Supply Operations at CVD - Pulse Flow Releases

As part of the Proposed Action, Sonoma Water will develop and test Lake Mendocino water supply pool release strategies to facilitate the upstream migration of adult salmonids in fall during dry and critical hydrologic conditions. The reservoir release strategy will be implemented on a trial basis during the first two years of the 10-year term of this Opinion. A finalized operation plan will be implemented within two years of issuance of this Opinion. Sonoma Water will also coordinate water supply releases from Lake Mendocino to align with USACE's flow augmentation to assist spring outmigration of juvenile and smolt salmonids. Pulse flow adaptive management strategies (described below) will also consider coordination with CDFW hatchery releases from CVFF and Upper and Lower River survival studies to aid in estimating outcomes of effectiveness and recommendations for consideration in subsequent years.

In its Memorandum to NMFS: Reservoir Water Supply Pool Operations Adaptive Management Action (May 8, 2024), which provides additional detail and commitments related to the Proposed Action (see above, Section 1.3.1), Sonoma Water outlines the following conditions to support adaptively managing pulse flows from the water supply pool at Lake Mendocino (Sonoma Water 2024b). Pulse release will be contingent on Sonoma Water storage projections for Lake Mendocino within a given water year. As part of the Proposed Action, Sonoma Water will project Lake Mendocino storage based on existing conditions and hydrologic forecasts to assess water supply that could be made available for a pulse release without leading to a significant decline in Lake Mendocino storage, coldwater pool volume, or critical water supply condition. The Reservoir Operations Group (consisting of personnel from Sonoma Water, USACE, NMFS, CDFW, and SWRCB) will determine, based on a water year Sonoma Water storage projection, developed during fall (October through December) and winter/spring (February 15 through May

31) adaptive management periods, if a fall pulse release or late winter/early spring pulse release could be made based on criteria below:

1. Fall Pulse Release:

    a. Fall Pulse Release can occur one time from October through December for up to 14 days.

    b. Fall Pulse Release can occur only during Dry water supply conditions.

    c. Fall Pulse Release increases minimum instream flow requirement on Upper Russian River from 75 cfs to 105 cfs.

2. Late Winter/Early Spring Pulse Release:

    a. Late Winter/Early Spring Pulse Release can occur up to two times from February 15 through May 31 for up to 14 days total.

    b. Late Winter/Early Spring Pulse Release can occur only during Dry water supply conditions.

    c. Late Winter/Early Spring Pulse Release increases minimum instream flow requirement on Upper Russian River from 75 cfs to 150 cfs.

3. Pulse Flow Adaptive Management strategies will also consider coordination with CDFW hatchery releases from CVFF and Upper and Lower River Survival Studies to aid in estimating outcomes of effectiveness and recommendations for consideration in subsequent years.

1.3.1.4.2 Water Supply Operations at CVD - Survival Study Plan

In recent years, reservoir releases from CVD timed with volitional releases of steelhead smolts from CVFF have occurred with the aim of encouraging rapid downstream movement, thereby increasing survival. The effect of these releases on migration rate of these hatchery steelhead has yet to be evaluated. As part of the Proposed Action, Sonoma Water has agreed to work with NMFS, CDFW, and USACE to develop a Survival Study Plan to evaluate the effect of water supply and flood control operations in the Russian River managed by Sonoma Water and USACE on steelhead smolt migration survival (Sonoma Water 2024a). The objectives of this study are to:

1. Estimate reach-specific smolt migration survival and migration time through the mainstem Russian River at a variety of flows including (and if they occur) dry and critically dry hydrologic conditions.

2. Evaluate relationships between smolt migration survival and flow, smolt migration survival and temperature, and smolt migration survival and turbidity in the mainstem Russian River.

Study methodologies may include the use of acoustic telemetry, predation detection transmitters, boat electrofishing, predation event recorders, avian predator surveys, and other techniques. This study element will be conducted each smolt migration season during the 10-year period covered by this Opinion. If sources of mortality concern are attributed to Sonoma Water and/or USACE facility operations, Sonoma Water will implement contingency measures, such as flow augmentation strategies (including pulse and blockwater releases), to ensure that injury and mortality to listed salmonids are minimized.

The study area for steelhead smolts will encompass the mainstem Russian River from release in the East Fork near CVFF (river mile (rm) 9.8) to the Duncans Mills Fire Station (rm 6.5). Once fish reach the Forks area (0.87 miles downstream of the hatchery), they have an approximate 92-mile travel distance to Duncans Mills. The total distance from CVFF to Healdsburg will be divided into seven reaches and survival will be estimated in each.

Because little is known about travel time and survival of steelhead smolts in the Upper River and because there are several logistics (e.g., study design, sampling challenges) of the study yet to be addressed, the study will occur in phases with at least the first year of study (winter 2025) considered a pilot year. Based on data collected in early years of the study, details regarding study design (e.g., release timing and strategy, number of fish tagged, body sizes of fish tagged, tagging steelhead kelts, target flows) may change based on outcomes and data from pilot years.

A Survival Studies Work Group consisting of Sonoma Water, NMFS, CDFW, USACE staff, and outside experts will meet annually to review data collected from the previous season and develop plans for the upcoming season. Sonoma Water will work with the Survival Studies Work Group to address the objectives of each study element of the proposed studies.

1.3.1.5 Water Supply Operations at WSD

As part of the Proposed Action, Sonoma Water will continue to manage releases at Lake Sonoma made from the water supply pool. Sonoma Water makes releases from WSD to maintain the minimum instream flow requirements in Dry Creek and the Lower River specified in its water right permits and for downstream beneficial uses, including diversions for municipal, domestic, and industrial purposes. These releases are made by Sonoma Water when reservoir storage levels are in the water supply pool, which is at or below the reservoir guide curve as established in the Lake Sonoma WCM (Figure 4, USACE 1984). Sonoma Water makes releases to maintain minimum stream flow requirements, including downstream beneficial uses. However, this can be challenging, because Sonoma Water does not control all downstream diversions, and must estimate the water it will need to release by stream gage information at certain locations established to ensure minimum flow requirements are met. Thus, Sonoma Water releases from WSD can fluctuate if downstream diversion rates change. While Sonoma Water must release enough water to satisfy diversions and resulting stream depletions that occur along Dry Creek and the Lower River plus the amount needed for minimum instream flow compliance, Sonoma

Water does not control these diversions and the streamflow depletions can only be estimated from stream gage information at the compliance locations.

Based on modeled median monthly summer flow releases, Sonoma Water and USACE anticipate that the monthly median flow immediately below WSD during the low flow period (June 1 through October 15) will largely remain below 175 cfs throughout the 10-year consultation period. Additionally, the daily average flow rate immediately below WSD is expected to remain below 210 cfs. Daily average flows in excess of 200 cfs (i.e., between 200 and 210 cfs) will not occur more than 2 non-consecutive days per year during the 10-year Proposed Action, with each exceedance lasting no more than 24 consecutive hours.

1.3.1.5.1 Water Supply Operations at WSD - Mirabel/Wohler Diversion

Sonoma Water's diversion facilities along the Russian River include an inflatable dam and the Mirabel diversion facility (comprising three radial collector wells and the Russian River well field, a screened surface water intake, a fish ladder, a viewing area, and infiltration ponds) (Figure 6). As part of the Proposed Action, Sonoma Water will continue to operate and maintain these diversion facilities. These diversion facilities and their operations are detailed in pp. 3-62 through 3-69 of the BA. Pertinent information is included below.

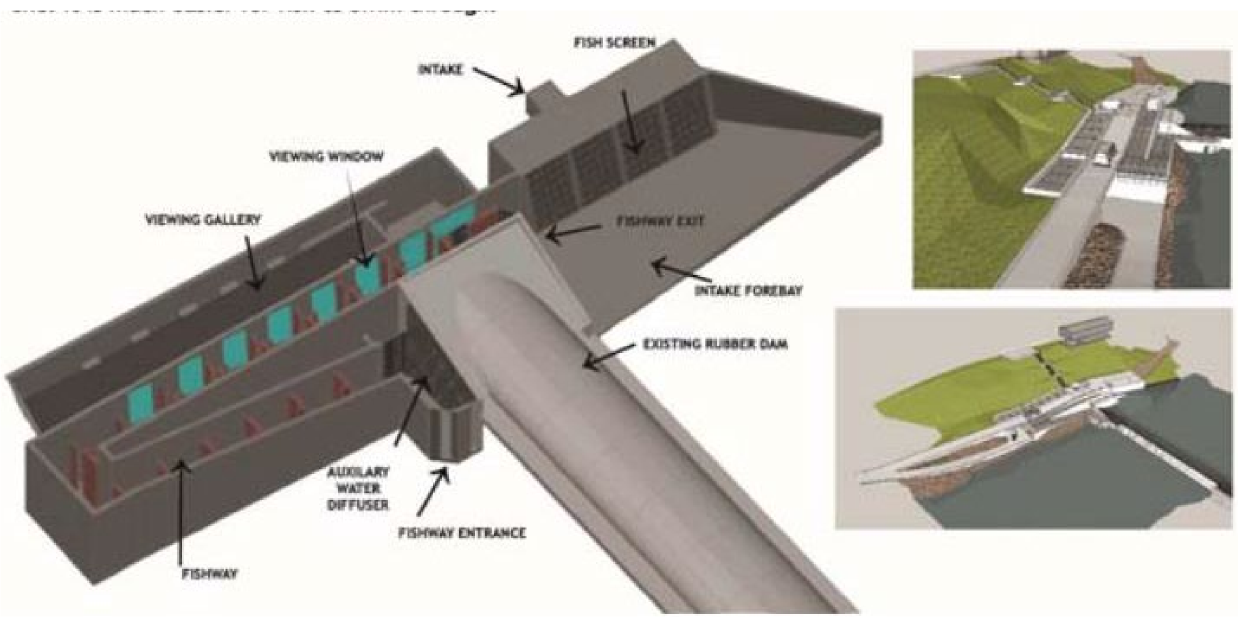

Figure 6. Mirabel Fish Ladder and Diversion Facility (ESA, Inc. 2023).

The ability of the Russian River alluvial aquifer to produce water is generally limited by the rate of recharge to the aquifer through the streambed in the vicinity of the Mirabel and Wohler diversion facilities. The inflatable Mirabel dam acts to increase the amount of recharge to the aquifer. It is inflated to create a pool (referred to as the Wohler Pool) upstream of the dam during low flow periods. The dam is usually raised in late spring when water demands increase and the Russian River drops below 2,000 cfs, then lowered in the fall or early winter when stream flow approaches 1,600 cfs. The dam is typically deployed for about seven months each year. During higher flows, the dam is deflated and lays flat on the river bottom. In addition to recharging the aquifer, the Wohler Pool also inundates an intake structure on the west side of the Mirabel Dam which is utilized to divert water from the Russian River into a series of aquifer infiltration ponds (43 ac combined). The intake structure is screened to prevent fish from entering the diversion.

The 2008 Opinion found that the fish screen had the potential to trap young, endangered coho salmon and threatened steelhead. Specifically, RPM 6 required Sonoma Water to complete design of a new fish screen at Mirabel within 3 years of the issuance of the Opinion and replace the fish screen within three years after completion of the design. Construction of the fish screen was completed in 2016.[1] In addition to replacing the fish screens as described above, the Mirabel Fish Screen and Ladder Replacement Project included construction of a new vertical slot fishway on the west side of the inflatable dam and facility improvements to address seismic vulnerabilities.

The fish ladder facility also includes a viewing area, separate from the video monitoring viewing window, which allows visitors to see into the side of the fish ladder. At a river elevation of 41 ft, the top of the viewing gallery is inundated and fish in the river can enter into the viewing gallery area from the top and become stranded. River flow elevations typically exceed 41 ft in elevation 4 to 5 times a season (remaining above 41 ft for 2-10 days at a time). As elevations recede below elevation 41 ft, fish that remain in the viewing gallery will be able to passively leave the viewing chamber through the 12-inch drain pipe connected to the alternative water supply pipe. After sustained river surface elevation drops below 35 ft, the valve for the 12-inch drain pipe in the floor sump of the viewing gallery will be closed. Sonoma Water fisheries biologists will then rescue any remaining fish from the viewing gallery area (first by seine, followed possibly by electrofishing) and the remaining water in the gallery will be pumped-out into the Mirabel infiltration basin. Sonoma Water anticipates that one rescue operation per year will be required; however, depending upon the timing of inundation events, additional rescue efforts may be necessary. To date, no salmonids have needed rescue during dam inflation/deflation.

Routine maintenance of levees, access roads, and infiltration ponds at Mirabel and Wohler involves removing vegetation with the use of herbicides and mowing of vegetation along levee roads. Vegetation maintenance does not occur on streambanks near the river but does occur along roads that are 200 to 250 ft from the Russian River and provide access to the Mirabel area.

Each time the inflatable dam is lowered, the fish screens at Mirabel are removed so they are not damaged during high-water events when the diversion is not operating. Raising the inflatable dam sometimes requires removing sediment that has accumulated during the winter on the flattened dam fabric and within the fish ladders. The accumulated sediment is typically removed with an excavator working only in areas naturally isolated from the flow of the Russian River to prevent turbid water from reaching the river channel. Spoils are then stored out of the flood plain or hauled away.

[1] A separate Section 7 consultation was conducted in 2014 analyzing the effects of the action (See Environmental Baseline Section for additional details).

Gravel bar grading will continue to be conducted in the Russian River near the Mirabel/Wohler diversion areas as needed to ensure both infiltration pond capacity and dam operations. Grading and removal of gravel will only be required after large depositional events following high flow periods and will only occur in areas that are not inundated by the active flow of the Russian River or in areas that can be isolated from the active flow. All equipment will remain outside the wetted channel. Material will be removed by excavator and placed in a dump vehicle to be hauled via access road to an upland location within Sonoma Water's Mirabel Property. Upon completion of gravel removal, the gravel bar area will be groomed to remove any tire ruts. The gravel removal area and the gravel bar will be inundated by the backwater created by raising the inflatable dam. Additionally, as described above, maintenance occasionally requires removal of gravels from on top of and adjacent (both upstream and downstream) to the dam as necessary to maintain the dam operations. BMPs that will be implemented to avoid excessive sedimentation and fish stranding during any gravel removal activities are listed on pp. 3-69 of the BA and in Section 1.3.6 below and are incorporated here by reference.

1.3.1.5.2 Water Supply Operations at WSD - Blockwater Releases

As part of the Proposed Action, Sonoma Water, in coordination with USACE, will commit up to 2,500 ac-ft of water (blockwater) on an annual basis (reset each water year) to augment releases from Lake Sonoma into Dry Creek and the Lower River to aid in adult and juvenile salmonid migration and survival. Sonoma Water, in coordination with USACE, NMFS, CDFW, and the SWRCB (Reservoir Operations Group) will identify and determine the appropriate target blockwater release strategy and develop an operations plan including flow schedules (specific timing, magnitude and duration of flows) for implementation within two years of the issuance of this Opinion. If the Reservoir Operations Group cannot reach agreement on a blockwater releases strategy, NMFS will have the ultimate decision authority on the action based on the guiding principles listed below. In addition to the potential use of blockwater, during dry and critical water supply conditions, Sonoma Water, in coordination with NMFS and CDFW, will release water from Lake Sonoma to facilitate the timely passage of adult Chinook salmon in the Lower River.

Under the Proposed Action, 2,500 ac-ft of Lake Sonoma blockwater could be used at any time (regardless of water supply condition) in consultation with the Reservoir Operations Group as described in Section 1.3.1 above. Some guiding justifications for the use of blockwater could include:

1. Fall Blockwater Release - could occur during the fall and winter adult salmonid migration season to augment flows in the Lower River and Dry Creek.

2. Late Winter/Early Spring Blockwater Release - (up to 2,500 ac-ft of water) to increase minimum instream flows on Lower River with the objective of achieving increased survival of outmigrating salmonids (smolts and kelts):

    a. The Reservoir Operations Group will identify and determine the appropriate target blockwater release strategy and develop an operations plan including flow schedules (specific timing, magnitude and duration of flows) for implementation.

b. Example Late Winter/Early Spring Blockwater Release (2,500 ac-ft) strategies could include:

    1. ~315 cfs for 4-day period
    2. ~180 cfs for 7-day period
    3. ~90 cfs for 14-day period
    4. Shaped (variable) release strategy that includes higher and lower variable flows (pulse) across 7-, 14-, or other multi-day period

3. Similar to the Lake Mendocino water supply pulse flow adaptive management strategies, Lake Sonoma water supply blockwater release adaptive management strategies will also consider coordination with Lower River survival studies to aid in estimating outcomes of effectiveness and recommendations for consideration in subsequent years.

4. In addition to potential blockwater release strategies, during dry and critical water supply conditions within the adult Chinook salmon migration season (October 15 through December 31), Sonoma Water, in coordination with NMFS and CDFW, will release timely water from Lake Sonoma to achieve minimum adult Chinook salmon passage flows (110 cfs)[2] in the Lower River *if* the Estuary inlet is open, allowing river entry for adult Chinook salmon, or if adult Chinook salmon presence is documented (through visual observation) in the Estuary and/or Lower River.

1.3.1.5.3 Water Supply at WSD - Survival Study Plan

Although information from ongoing monitoring data has been successful for evaluating a portion of the life cycle from juvenile release from Don Clausen Fish Hatchery (DCFH) into tributary streams, there is limited data on survival of smolts during their downstream migration through the mainstem Russian River. Sonoma Water has been evaluating coho salmon smolt migration survival and travel time in the Lower River each season from 2021-2023 with plans to continue work in 2024 that incorporates additional efforts to identify survival bottlenecks. Results from these studies show that coho smolt mortality is relatively high between the Dry Creek confluence and Mirabel Dam as compared to other Lower River reaches. Evidence from previous PIT-tagging efforts in Dry Creek also show high Chinook salmon smolt mortality in that same reach.

Sonoma Water has agreed to work with NMFS, CDFW, and USACE to develop Survival Study Plans to evaluate the effect of water supply and flood control operations in the Russian River managed by Sonoma Water and USACE on coho salmon and Chinook salmon (Sonoma Water 2024a). Special emphasis will be placed on addressing uncertainties associated with areas with higher loss rates identified from previous studies (confluence of Dry Creek and Russian River, Star Ponds, Mirabel Dam and Wohler Pool) and species of management concern (listed salmonids, native and nonnative predatory fishes, avian predators). Study methodologies may include the use of acoustic telemetry, predation detection transmitters, boat electrofishing,

[2] Note that 110 cfs was identified as adult passage flow in Lower River in recent TUCOs and recent empirical data shows that adult Chinook Salmon passed up to Mirabel on spawning migrations with flows less than 110 cfs.

predation event recorders, avian predator surveys, and other techniques. After conducting a multi-year study under the guidance of a Survival Studies Work Group consisting of Sonoma Water, NMFS, CDFW, USACE staff, and outside experts, if results indicate that Sonoma Water operations or facilities negatively affect salmonid survival, measures, i.e., the pulse flow releases described above, will be taken to improve fish survival.

For coho and Chinook salmon smolts, the study area will encompass approximately 31.7 miles of the Lower River and the Estuary, from Dry Creek confluence (rm 32.1) to the mouth of the Russian River in Jenner, and will be divided into eight reaches. Study fish will be hatchery-origin (HOR) coho salmon smolts and natural-origin (NOR) Chinook salmon smolts captured in the downstream migrant trap (DSMT) operated by Sonoma Water annually at rm 2.1 on Dry Creek. To the extent possible, timing of tagging of HOR coho salmon will coincide with the natural run-timing.

The study elements, timelines and objectives of these studies are as follows:

Study Element 1: Salmon and Steelhead Smolt Migration Survival and Travel Time. This study element will be conducted each smolt migration season during the period covered by the Opinion. The objectives of this study element are:

1. Estimate reach-specific smolt migration survival and migration time through the mainstem Russian River (Upper and Lower) at a variety of flows including (and if they occur) dry and critically dry hydrologic conditions.

2. Evaluate relationships between smolt migration survival and flow, smolt migration survival and temperature, and smolt migration survival and turbidity in the mainstem Russian River (Upper and Lower).

3. Characterize coho salmon and Chinook salmon smolt mortality from piscivorous fish predation in the Lower River and identify predation hotspots.

4. Characterize smolt mortality related to Mirabel Dam.

Study Element 2: Piscivorous Fish: Distribution, Relative Abundance and Small-Scale Movement. Based on data collected during the initial year of study and upon consultation with the Survival Studies Work Group, there may be a need to repeat this study element in more than one year to capture patterns that are related to hydrologic conditions. The objectives of this study element are:

1. Estimate the distribution and relative abundance of large piscivorous fish in the Lower River.

2. Compare spatial patterns of large piscivorous fish in Wohler pool to Lower River reaches outside Wohler pool when salmonid smolts are present (spring) versus not present (late summer/early fall).

3. Describe overall fish assemblage (all body sizes and species) and habitat use in the Lower River.

4. Characterize aquatic habitat types in the Upper and Lower River.

5. Characterize small-scale movement of large piscivorous fish near Mirabel Dam.

Study Element 3: Piscivorous Fish Habitat Characterization. This study element will be conducted once during the period covered by the Opinion with pilot studies occurring as needed. The objectives of this study element are:

1. Estimate the quantity and distribution of piscivorous fish habitat in the Upper and Lower River.

2. Estimate the change in piscivorous fish habitat in Wohler pool before and after Mirabel Dam inflation.

1.3.2 Dry Creek

1.3.2.1 Dry Creek - Phase III Enhancements Alternatives

As part of RPA 3 in the 2008 Opinion, Sonoma Water and the USACE were responsible for completing 6 miles of habitat enhancement in Dry Creek by 2020 (see Sections 2.4.2.3 and 2.4.4.4 in the Environmental Baseline for more detail). Due to landowner constraints, only approximately 4.5 miles were completed by the end of 2024. The USACE and Sonoma Water propose to complete the third and final phase (Phase III) of the Dry Creek Ecosystem Restoration Project (Dry Creek Project) as part of the Proposed Action. However, completion of this phase is dependent on acquisition of real estate interests and is unlikely at this time. Sonoma Water most recently projected that it will take two to three years to acquire these real estate interests and that the risk of inability to acquire the real estate interests is high. If the interests are obtained, it is expected to take another two years to award a construction contract and execute construction of Phase III, putting completion approximately around year five of the Proposed Action. Should some or all of the real estate interests for Phase III be infeasible to acquire, Sonoma Water and USACE will investigate, document, and seek appropriate approval (as described below) for changes to the Dry Creek Project originally authorized and appropriated by Congress, including reviewing alternative sites that could deliver the same or similar benefits.

The primary vehicle for investigating, documenting, and seeking approval for such changes is a USACE Post-Authorization Change Report (PACR). The scope, time, and approval authority needed for a PACR varies with the magnitude of the change(s) proposed in terms of project cost, authorized scope, location and design, and authorized purposes. For relatively minor changes, approval may be at the Division Commander or USACE Headquarters Chief of Engineers level; for major changes requiring a full general re-evaluation report, approval may require reauthorization by Congress. This process could take two to five years or more. The amount of time required for design and construction of a modified project, if a PACR were to be approved, is also highly uncertain and would depend on the magnitude of the change from the currently authorized project. In absence of an approved PACR, USACE states that it does not have the ability to use funding appropriated for the Dry Creek Project to anything other than the authorized project.

A separate opportunity for the USACE to potentially participate in ecosystem restoration in other locations in the Russian River watershed would be to pursue a new project, for example through a Continuing Authorities Program (CAP) study and project. The CAP includes a group of legislative authorities under which USACE can plan, design, and implement certain water resources projects of limited size, cost, scope, and complexity without additional project specific congressional authorization. Pursuing a project under CAP would be entirely separate from the current Dry Creek Project and would require a new planning phase, followed by a new design and implementation phase. It would also require a non-federal sponsor (presumably Sonoma Water) to cost share in the study/project. While CAP does not require congressional authorization for study or implementation, proposed CAP studies and projects compete with other proposals nationally. Therefore, the timing of USACE funding to conduct a CAP study, and subsequently USACE approval/funding to design and implement a project recommended under CAP, are also uncertain and could take up to eight years to complete.

Other efforts being considered in lieu of completing Phase III of Dry Creek, such as changes to USACE hatchery facility infrastructure or operations and/or developing instream habitat enhancement in Dry Creek (ex., boulder weirs to route sediment away from and downstream of existing enhancement sites), would require further scoping and both the feasibility and timing are uncertain given USACE operations' budgeting cycles and limitations.

Because of the uncertainties associated with implementation of the Phase III project(s) and/or process outcomes with seeking approval for development and implementation of alternatives to the Dry Creek Project, USACE and Sonoma Water are proposing to implement a process in coordination with NMFS and CDFW that includes formation of a Dry Creek Habitat Enhancement Alternatives Group to:

1. review and coordinate on the feasibility evaluations for completion of Phase III of the Dry Creek Project (described in the BA and incorporated here by reference), and

2. review and coordinate on the USACE approval processes required to make changes to the existing Dry Creek Project, and/or to participate in the development and implementation of alternatives.

Sonoma Water and USACE will convene a Dry Creek Habitat Enhancement Alternatives Group consisting of designated members from Sonoma Water, USACE, NMFS, and CDFW. This group will include designees from the coordinating agencies with technical expertise from each agency that contributes to completion of the Dry Creek Project (or alternatives). All coordination activities will be documented and reported in meeting minutes, briefing documents, and reports, including information regarding recommended pathways toward completion and schedules/timelines, and work plans. The group will develop feasibility evaluations for the following options:

1. Completion of Phase III of the Dry Creek Project;

2. USACE approval processes required to modify the authorized Dry Creek Project such that existing habitat restoration sites are enhanced for better efficacy against high flows (described in more detail in Environmental Baseline and Effects Sections) and seek approval to use existing funds to complete the modified project; and

3. Development and implementation of alternatives to Dry Creek Project at other locations in the Russian River watershed (see below for initial considerations).

Near-term commitments include:

1. Formation of Dry Creek Habitat Enhancement Alternatives Group within two months of the publication of this Opinion.

2. Establish feasibility decision point on Phase III of the Dry Creek Project within four months of the publication of this Opinion.

3. If Phase III actions are determined to be infeasible, initiate USACE process to modify the Dry Creek Project and seek approval to use existing funds to complete the modified project (PACR) or initiate a separate new study/project process (under CAP) for alternatives to the Dry Creek Project in the Russian River watershed.

4. If applicable, within six months of publication of this Opinion, select a small-scale habitat enhancement project to be funded by Sonoma Water (to be implemented by others).

5. If applicable, within two years of publication of this Opinion, Sonoma Water will provide funding for implementation of a small-scale enhancement project (to be implemented by others).

6. If applicable, within three years of publication of this Opinion select a larger-scale preferred alternative enhancement site(s) for Sonoma Water and/or USACE development and implementation.

7. If applicable, within five years of publication of this Opinion, Sonoma Water and/or USACE will provide funding and/or construction to implement a larger-scale habitat enhancement project.

The following projects have been identified as containing potential alternative enhancement actions in the Russian River watershed that could be taken in lieu of enhancement actions in Dry Creek (Sonoma Water 2024c). Whether additional restoration actions occur in Dry Creek and/or the following tributaries, the objectives will include creating over-wintering and summer rearing habitat for juvenile coho salmon and steelhead. The net effect(s) when constructed will be an increase in the amount and quality of rearing habitat.

- Lower Russian River Watershed Coho Habitat Restoration Project - Seven habitat enhancement and restoration sites have been identified within these two watersheds: three in Willow Creek and four in Green Valley Creek. These seven identified sites will advance recovery efforts for coho salmon, Chinook salmon, and steelhead by restoring 3.5 miles of highly modified floodplain into reconnected wetland complexes and improving habitat conditions. Both Willow and Green Valley Creeks have been categorized as high priority streams for salmonid recovery by NMFS and CDFW.

- Mill Creek - This project will develop 100 percent design plans to create up to eight backwater channel features on small sections of floodplain that would improve floodplain habitat by providing connectivity between the incised channel and the floodplain. Enhancements work would occur along an approximately 1.5-mile stretch of creek.

- Dutch Bill Creek - The restoration project conceptual plan includes placement of 10 large woody debris (LWD) structures in Dutch Bill Creek, upstream of Monte Rio. The wood structures include a combination of logs and rootwads secured together and anchored to engineered rock ballast installed in the stream. Low profile logs and spawning gravels could be placed in select locations at pool crests upstream of the wood structures to retain spawning bedload.

1.3.2.2 Dry Creek - Monitoring and Maintenance of Habitat Enhancements

For ten years immediately post-construction, Sonoma Water and the USACE will continue to jointly monitor and adaptively maintain all of the habitat enhancement sites constructed within Dry Creek. After a 10-year post-construction monitoring period, Sonoma Water will continue to use their Adaptive Management Plan (AMP) (Sonoma Water 2014) and will assume long-term maintenance responsibility for the entire project footprint. See Section 4.4.4 of the BA for a detailed discussion of completed Dry Creek restoration and monitoring and maintenance obligations. A Joint Monitoring Team (JMT) made up of representatives from Sonoma Water, USACE, NMFS, and CDFW, will decide if modifications to the existing habitat structures is appropriate if any of the sites suffer any damage or are not meeting habitat objectives. In general, the project will be restored to its as-constructed condition and adaptive management will result in changes to the as-constructed project design to better meet project objectives. Periodic maintenance to remove accumulated sediment or adapt to changing channel conditions resulting from high winter flows is anticipated, including the following activities:

- Inspection of features will occur after completion of construction. Follow-up inspections will occur annually after geomorphically effective flows occur (flows that mobilize sediment) or within three years of completion.

- Vegetation Maintenance. Removal of non-native vegetation and managing vegetation for habitat needs will be conducted as needed. Frequency of work depends on vegetation growth, but typically occurs every two to five years. Vegetation maintenance at a site typically requires a five-person team two days to conduct.

- Structure maintenance. Minor erosion control repair and excavation around structures will occur as necessary. Structure maintenance activities would require a five-person team two days to conduct, approximately every three years.

- Habitat Feature Maintenance. Removing sediment, repairing/stabilizing erosion, or adapting features to changing channel conditions, as needed.

As part of the Proposed Action, Sonoma Water will work with the JMT, to modify portions of the Dry Creek AMP to reflect Sonoma Water's current methods and experience implementing it over the past ten years. Revisions to the AMP may include simplifications to the effectiveness rating checklists to better reflect the hydrology and instream structure of Dry Creek. This may also include a recalibration of maintenance standards and triggers as well as a review of the depth and velocity metrics used to develop habitat ratings. This review process will also ensure that there is consistency between Sonoma Water's AMP regarding future adaptive management actions.

1.3.3 Channel Maintenance

1.3.3.1 Dry Creek

Channel structures at 15 sites along Dry Creek were built by USACE between 1981 and 1989 as part of the WSD and Lake Sonoma Project. The structures include three rock-type grade-controls, 5,800 ft of riprap bank protection, and flow-deflection fences. These structures were intended to provide bank and riverbed stabilization at sites where erosion previously occurred or where studies indicated that future erosion was likely due to the construction and operation of WSD. Maintenance responsibility for this channel stabilization project lies with Sonoma Water, as established by an agreement between Sonoma Water and USACE in June 1988. USACE provided Sonoma Water with the *WSD and Lake Sonoma Project, Russian River Basin, Dry Creek Channel Improvements, Sonoma County, California Operation and Maintenance Manual* (O&M Manual; USACE 1991). In 2018, one of the rock-type grade-control structures was removed by the USACE as part of the Dry Creek habitat enhancement efforts associated with the 2008 Opinion.

As part of the Proposed Action, Sonoma Water will continue to conduct channel maintenance activities at the remaining 14 Dry Creek structures as per BMPs included in its O&M Manual on an as-needed basis. These channel maintenance activities are mostly limited to maintaining channel flood control structures to prevent streambank erosion and include rock streambanks, board fences, concrete weirs, concrete sills and one rock sill and streambank (Table 7). Additionally, Sonoma Water may work with local landowners to implement bioengineering projects to assist with streambank erosion problems in Dry Creek. These activities will be initiated only by a request from a private landowner after a washout threatens property or structures. Based on history, such activities occur approximately once every five to ten years. Typical project lengths under these circumstances are approximately 500 ft, but could be up to 1,000 ft.

Activities will involve sediment, vegetation, and debris removal, and streambank stabilization. Vegetation removal will only occur to improve streambank stability if trees are leaning or otherwise directing high flows against the streambank, causing erosion, and/or to visually inspect a streambank stabilization structure. Streambank stabilization work typically involves replacing lost riprap and, if necessary, re-grading the streambank slope to its previous contours to provide a stable base for the riprap. Dewatering and fish relocation may be required to support riprap placement below the waterline. Detailed descriptions of maintenance activities and associated BMPs can be found in Sections 3.4.2.1 through 3.4.3.9 of the BA and are hereby incorporated by reference. BMPs are included in Appendix B of this Opinion.

Table 7. Channel Maintenance Sites on Dry Creek (ESA, Inc. 2023).

Site	Type	Length (feet)		Site	Type	Length
1	Rock Bank	600		9	Concrete Weir	-
2	Rock Bank	750		10	½ Rock Sill and Bank	-
3	Board Fence	700		11	Rock Bank	200
4	Rock Bank	200		12	Concrete Sill (removed)	-
5	Concrete Weir	-		13	Concrete Sill	-
6	Rock Bank	450		14	Concrete Sill	-
7	Board Fence	900		15	Rock Bank	500
8	Rock Bank	480				

1.3.3.2 Upper River

MCRRFCD will continue to perform any maintenance to which it is contractually obligated. In the past, such maintenance has included stream bank maintenance over a 36-mile reach of the Russian River in Mendocino County from the county line north of Cloverdale, upstream to the town of Calpella. In the past, the MCRRFCD has also undertaken channel maintenance actions in the East Fork Russian below CVD downstream to the confluence with the Russian River, a one-mile reach. Maintenance actions have included sediment removal and debris clearing, vegetation management, and streambank stabilization.

MCRRFCD will grade instream gravel bars that may be impeding flow, and inspect and maintain approximately 21 channel flood control improvement sites. Typical maintenance activities for channel improvement sites in the Upper River are similar to those on Dry Creek, and include removing loose anchor jacks from the river, repairing and replacing loose grout or riprap, adding bank erosion protection at sites found to be eroding, and managing vegetation and removing flood debris to reduce blockage of the river channel that is causing bank erosion or preventing inspection of channel improvement sites.

Over the course of the ten-year Proposed Action, no more than 30,000 linear ft of the Upper River will be affected by channel maintenance activities. This represents about six percent of the entire Russian River mainstem. Each county may work as much as 2000 ft of main stem channel per year, but neither county may work on more than 15,000 ft of channel over the course of the ten-year Project. No more than four maintenance sites are proposed for work in each county during the summer months. Each site is typically no more than 1,000 ft long in any given year.

Channel Maintenance that may be performed at these sites includes:

1. **Gravel Bar and Overflow Channel Maintenance in the Upper River**

Certain conditions may warrant some degree of gravel bar grading. Grading activities may be conducted if one or more of these conditions exist:

- Occurrence of severe bank erosion.
- Recent substantial changes in channel morphology likely to lead to severe bank erosion.
- Evidence of weakened levees.
- Threats of flooding to infrastructure or private property.

Sonoma Water and MCRRFCD will implement protocols described in the BA to limit the potential for negative effects on salmonids or their habitat. For example:

- Gravel bar grading will only occur between July 1 and October 1.
- A buffer of at least 25 ft or ten percent of the maximum bar width, whichever is less, will be maintained along the edge of the low flow channel, whether vegetation is present or not.
- The elevation of post graded bars will be at least 1.5 ft higher than the elevation of the edge of the low flow channel.
- Sediment will be contoured to create a slope that runs up and away from the centerline of the main low-flow channel that is at least a two percent grade from the water surface elevation at low flow, or baseline elevation at the water surface, whichever is higher.
- Large woody debris removed or extracted will be placed either on the upstream buffer area or along the low flow channel buffer where it can be redistributed in the high flows of the next rainy season. If it poses a risk to property, it may be anchored or placed elsewhere in the river.

2. **Vegetation Maintenance in the Upper River**

Under the Proposed Action, MCRRFCD may remove vegetation along the mainstem river banks, levees, or gravel bars consistent with the above-referenced protocols described in the BA that limit the potential for negative effects on salmonids or their habitat. For example:

- Vegetation removal will occur outside of a 25-ft buffer zone next to the low-flow channel.
- Vegetation within the buffer will be cropped (mowed).

- In channels that are wider than 200 ft, a vegetated buffer of no less than 50 ft will be maintained.
- All vegetation removal work will occur during low flows, between July 1 and October 1.
- Native vegetation that is removed will be relocated to the extent possible.
- Vegetation maintenance work may be conducted if one or more of these conditions exist:

    - Encroachment by Giant Reed (*Arundo donax*) or other exotic pest plant species.
    - Occurrence of severe bank erosion.
    - Recent substantial changes in channel morphology that are likely to lead to severe bank erosion.
    - Evidence of weakened levees.
    - Threats of flooding to infrastructure or private property.

1.3.4 Estuary Management

1.3.4.1 Sandbar Beach Management

Under the Proposed Action, Sonoma Water will continue to adaptively breach the naturally forming bar that closes the beach inlet, focusing on: 1) maximizing salmonid habitat while 2) minimizing flood risk to low-lying properties adjacent to the Estuary, 3) avoiding impacts to pinniped neonates (baby seals), and 4) ensuring worker safety. When natural inlet closure events occur, a decision-tree approach will be followed, with the primary decision points related to the choice of target water surface elevation in the lagoon and timing for breaching the inlet. The goals of the decision tree are to aid in making decisions to breach or not breach, to maximize habitat conditions for juvenile steelhead acclimating to salinity in spring months, enhance habitat conditions for steelhead rearing in summer, promote adult migration conditions for all salmonids in fall and winter, while continuing to maintain water levels below the flood risk threshold during closed-inlet conditions for all months of the year. Specific considerations for managing the beach vary throughout the year. Considerations for beach management are detailed in the Estuary AMP (Sonoma Water 2024e) and are summarized below and in Figures 7-10.

Chinook salmon, coho salmon, and steelhead smolt emigration:

- <u>Continue to maintain water levels below flood risk threshold during closed-inlet conditions for all months of the year</u>: Prevent water surface elevations from exceeding 9 ft above the NGVD29 at the Jenner visitor center gage; beach management schedule depends on potential for flood risk, logistics, safety, lagoon habitat conditions, Chinook salmon, coho salmon, and steelhead smolt emigration timing.

Juvenile steelhead rearing:

- <u>Manage for habitat conditions that benefit juveniles acclimating to salinity in spring months</u>: Limit management actions during the months of March through June. Allowing inlet closure events with lagoon water surface elevations approaching the 9-ft NGVD29 stage at this time allows juveniles to acclimate to higher salinities and increase in size before reaching the ocean. Beach management during this season is complicated by the presence of harbor seal pups on the beach in the vicinity of the inlet. A challenge with allowing for inlet closure to persist to elevations approaching the 9-ft NGVD29 stage in the early spring months is that watershed conditions may still be wetter and river flows tend to be higher and rainfall events still often occur. If forecasted river discharge conditions are expected to be high, the inlet would be managed to minimize flood risk.

- Enhance habitat conditions for summer rearing (May - October): Depending on the timing of closure and the juvenile steelhead's tolerance to salinity (to be informed by the water quality monitoring), it may be advantageous to allow the inlet to remain closed for as long as possible before reaching flood risk stage, or breaching the barrier beach sooner to improve habitat conditions.

Chinook salmon, coho salmon and steelhead adult immigration (Estuary entry):

- Manage for adult migration conditions in fall and winter: From October through March, monitor river temperatures and discharge at Hacienda Bridge. If river water temperatures or instream flow conditions are unfavorable for adult immigration, it may be favorable to allow the inlet to remain closed until water levels reach 9 ft NGVD29. If conditions are more favorable for upstream migration, consider breaching the barrier beach before water surface elevation approaches 9 ft NGVD29, to maximize the time available for immigration. Sonoma Water will coordinate with NMFS and CDFW staff on breach timing during this period with respect to breaching if water quality conditions in the river are determined to be detrimental to salmonids.

The decision tree (see Environmental Baseline Sections 2.4.2.6 and 2.4.4.7) shown in Figures 7 through 10 is intended to incorporate both seasonal and recent data collected by Sonoma Water and publicly available data collected by other agencies. Some of this data, such as Estuary water levels, are collected continuously, are available in real-time, and are considered throughout the decision-making process. Other data, such as fish monitoring, are only available after post-processing and compilation. Accordingly, they are available less frequently and used for the adaptive management of the decision-making process through annual updates to the beach management plan. As detailed in the Estuary AMP, a closure which starts in late September or early October may persist beyond the October 15 end of the previously characterized "lagoon management season" (May 15 - October 15). In this case, decision-making generally switches from lagoon-based to flood-minimization-based and must occur much faster by nature of generally higher river flows.

Once a closure occurs, the decision-making steps for beach management to facilitate lagoon conditions are as follows and shown on Figures 7 through 10:

A. Initial Notification – Sonoma Water notifies the staff from agencies involved with the AMP process, consisting of members from Sonoma Water, NMFS, CDFW, and USACE (Estuary AMP Team), by email about the closure and about relevant hydrologic and geomorphic conditions.

B. Gather Information and Forecasting – Sonoma Water intensifies hydrologic and geomorphic monitoring by more frequent collection of ocean wave, tide, and riverine discharge data and forecasts, forecasting the rate of the lagoon water surface elevation rise, and, to the extent feasible (given staff availability, safe beach access, and marine mammal presence), surveying minimum beach crest elevations north of the jetty groin. This phase also includes review of available water quality information in the Estuary, available from recent monitoring. This is used to infer habitat suitability in the Estuary.

C. Schedule Next Steps – Based on the elevation of the beach crest's low point and the water surface elevation forecast, Sonoma Water either continues monitoring (iterate back to Step B) or proceeds to prepare a plan for bar breaching.

D. Plan Beach Management Action – In collaboration with resource agency staff, Sonoma Water prepares a draft plan to breach the bar. Details regarding the selection of the action's type, timing, location, and dimensions are described in more detail in the AMP (Sonoma Water 2024e). In addition, Sonoma Water will include agency staff in iterative plan review and refinement, by hosting a field meeting overlooking the beach about one week before implementation, as schedules, available information, and Estuary conditions allow.

Section 9 of the Russian River Estuary Adaptive Management Plan 2024 (Sonoma Water 2024e) provides an example of the timing of notifications regarding bar breaching decisions. Depending on the timing of closure and river flows, ocean conditions, tides, and weather conditions, decisions may need to be made within 24 hours or up to several weeks. After the plan for bar breaching is finalized, Sonoma Water begins the logistical process for implementation. In the days just before implementation, Sonoma Water confirms beach access plans and conducts marine mammal monitoring, with particular attention to see if harbor seal pups less than one week old (neonates) are present and preclude beach access (typically mid-March to June). Beach management activity must be delayed if a pup less than one week old is on the beach along site access pathways and there must be a week-long break between management actions. The bar breaching would be delayed until the pup has left the site or the latest day possible to prevent flooding while still maintaining suitable fish rearing habitat. In the event that a pup remains present on the beach in the presence of flood risk, Sonoma Water shall consult with NMFS and CDFW to determine the appropriate course of action. Also, State Parks staff and local emergency services staff are notified.

Safe beach access is closely monitored up to and during personnel and equipment presence on the beach. Conditions such as wave overwash, de-stabilizing seepage flows, or lack of a sufficiently flat and dry access route can make beach access unsafe. To the extent that other schedule constraints allow, beach management to breach the barrier beach is implemented during a falling tide, to increase the potential for scour and breaching.

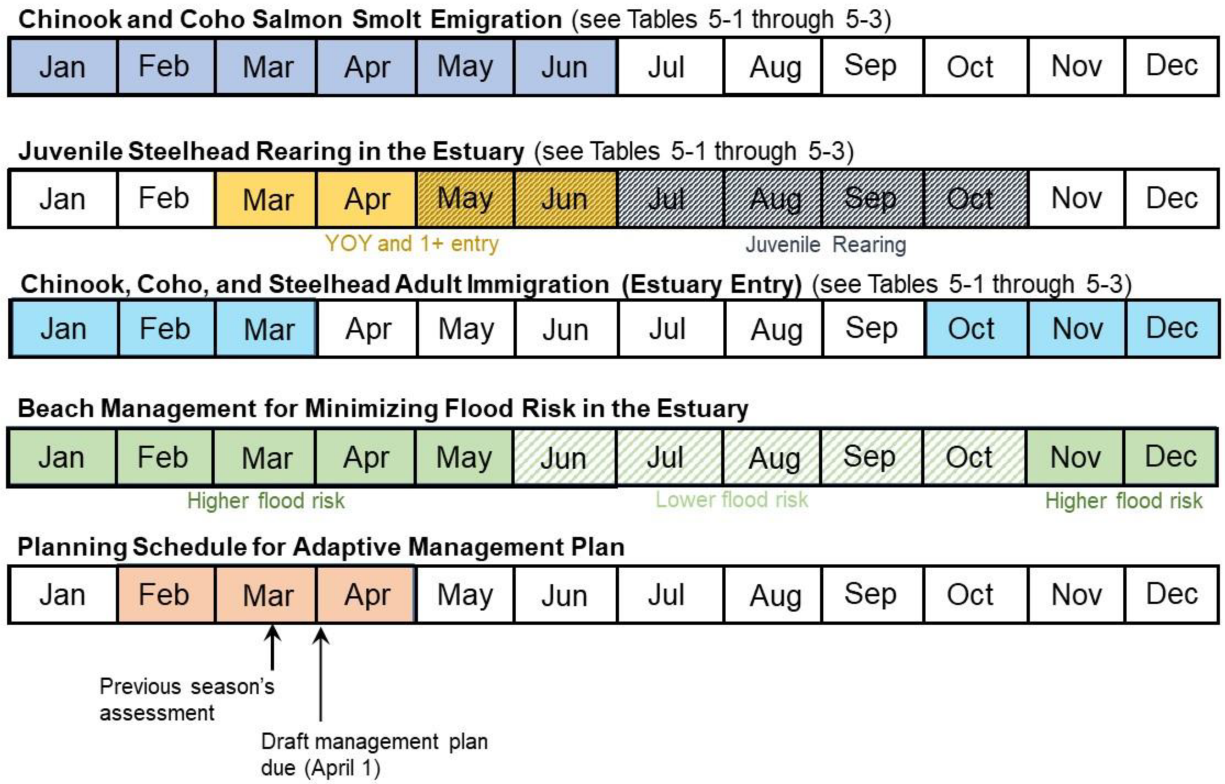

Figure 7. Considerations for Beach Management to Breach the Barrier Beach (ESA, Inc. 2023).

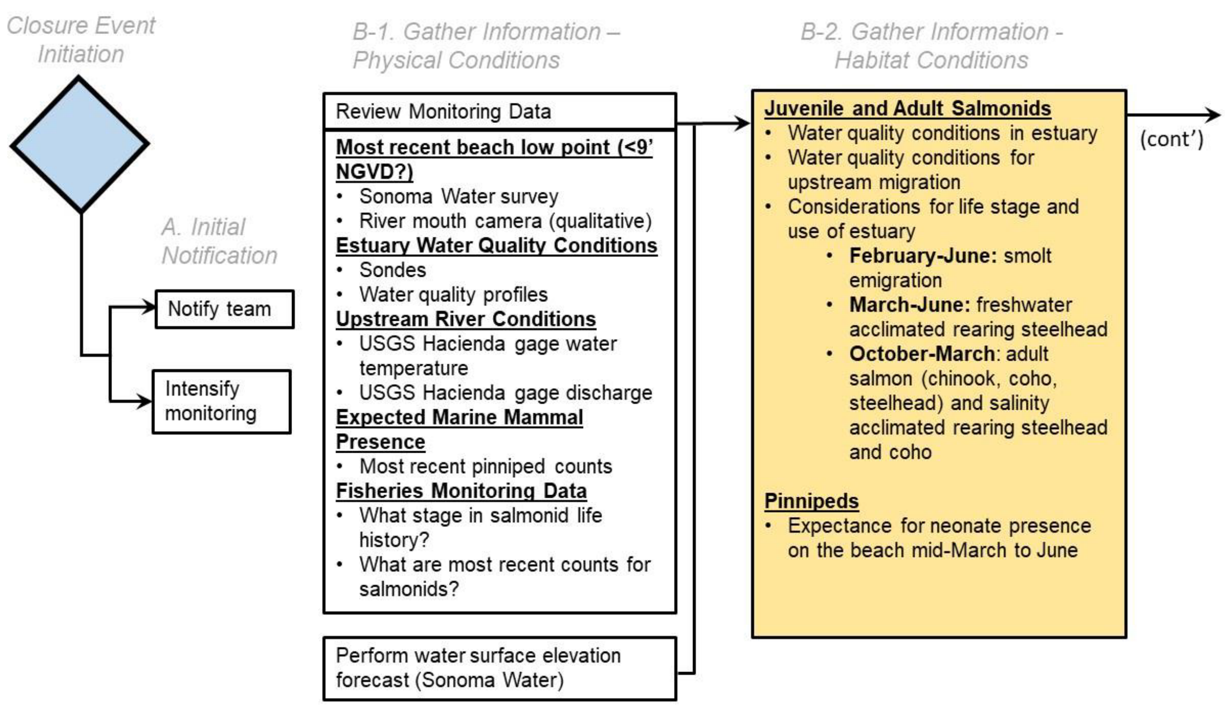

Figure 8. Adaptive Beach Management: Closure Event Monitoring and Planning (ESA, Inc. 2023).

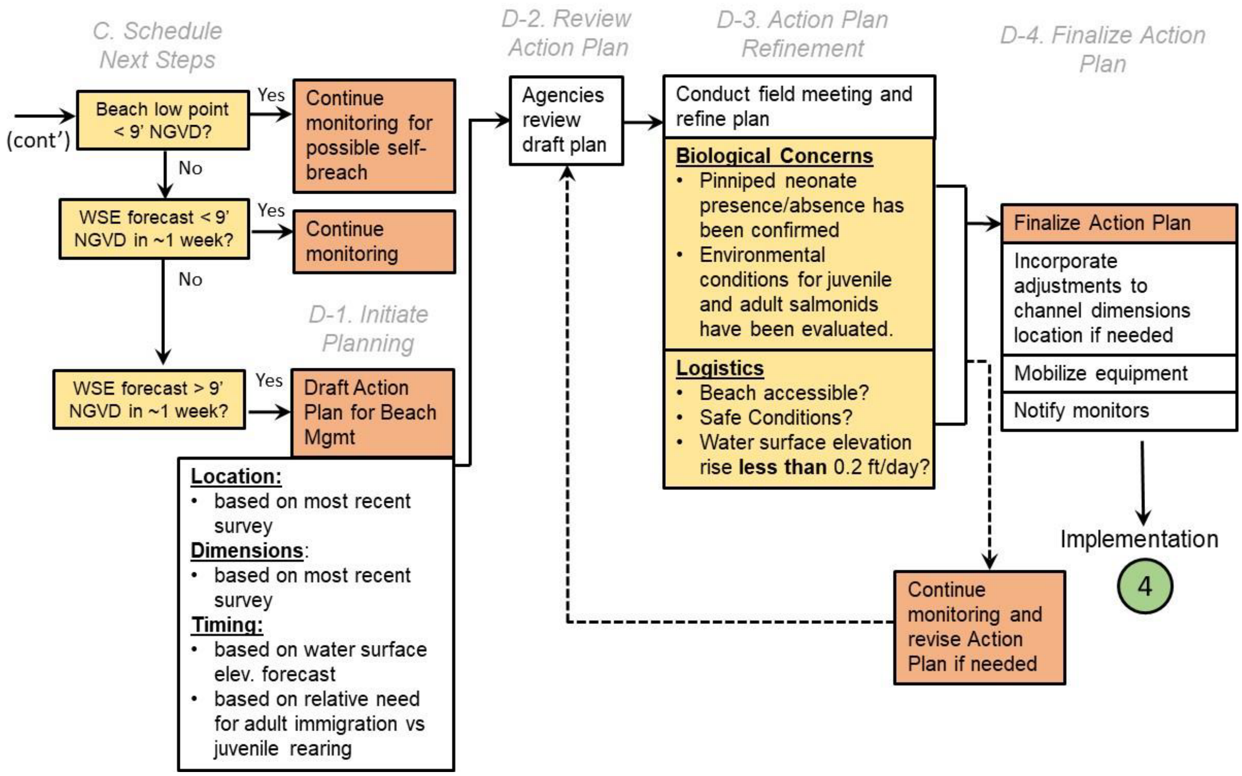

Figure 9. Adaptive Beach Management: Closure Event Monitoring and Planning (continued).

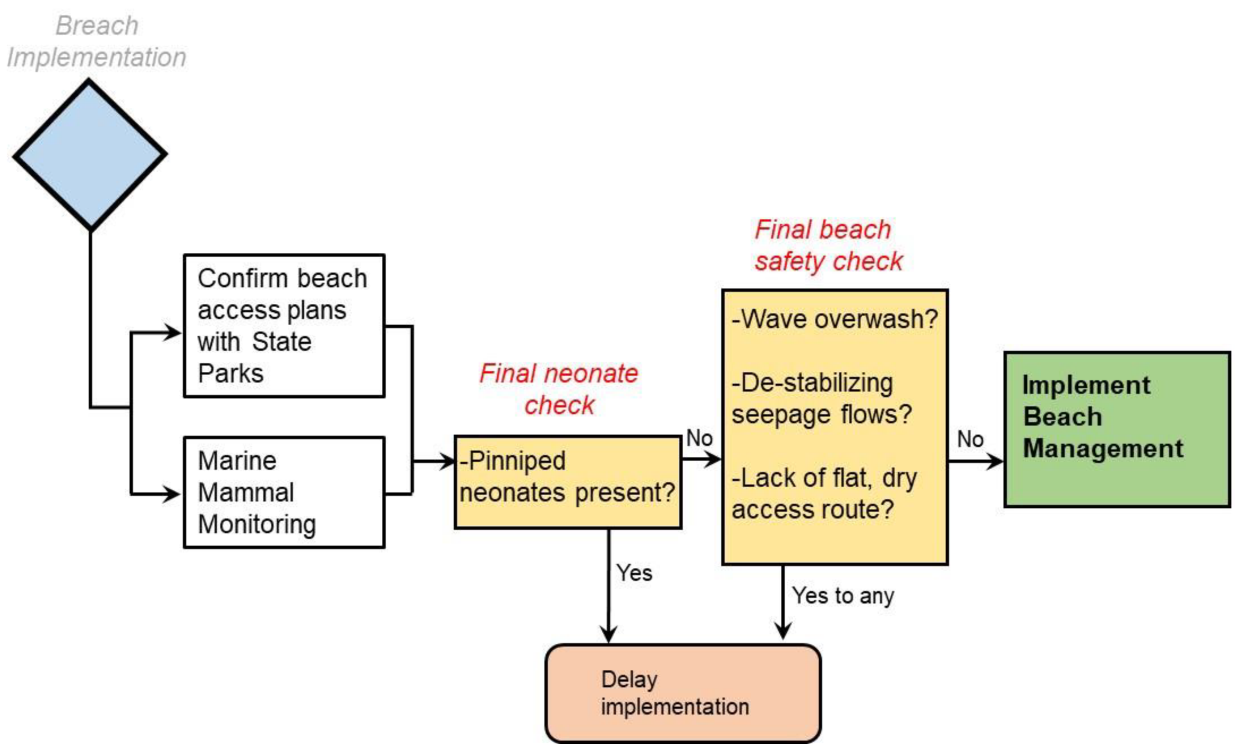

Figure 10. Adaptive Beach Management: Implementation Phase (ESA, Inc. 2023).

After a planned management activity, regardless of the outcome, Sonoma Water provides an email summary of the activity to the Estuary AMP Team. This summary briefly describes the conditions during the activity, how the activity was carried out relative to the plan, and resulting changes to the estuary in the days after the activity. Sonoma Water will host regular meetings to promote adaptive management of the beach, with a frequency determined by the Team. Sonoma Water will provide annual reports on December 15 that include summaries of all adaptive management actions taken in the prior year, their impacts, graphical and descriptions of water quality and biological monitoring data collected in or relevant to the Estuary.

1.3.4.2 Monitoring in the Estuary

Monitoring in the Estuary will focus on the biological and physical processes associated with artificial bar breaching and on responses to habitat enhancement opportunities. Proposed monitoring includes fish, water quality, and habitat monitoring, and monitoring of fish and water quality in potential enhancement areas (Section 1.3.7, Table 8).

Sonoma Water will conduct water quality monitoring in the lower, middle, and upper reaches of the Russian River Estuary between the mouth of the river at Jenner and Vacation Beach near Guerneville, including locations along the mainstem, two tributaries (Willow Creek and Austin Creek) and the Maximum Backwater Area (Figure 11). Water quality will be monitored using YSI Series 6600 multi-parameter datasondes, or similar instruments. Hourly salinity (parts per thousand), water temperature (degrees Celsius), DO (percent saturation), DO (parts per million), and pH (hydrogen ion) data will be collected from May 15 to October 15. When available, water quality data in the Estuary will be used to create a snapshot of habitat conditions during closure events, which can then inform decisions about the timing of artificial bar breaching (See step B-2 in Figures 8-9). Sonoma Water will also continue beach topographic surveys as needed to help inform beach management decisions.

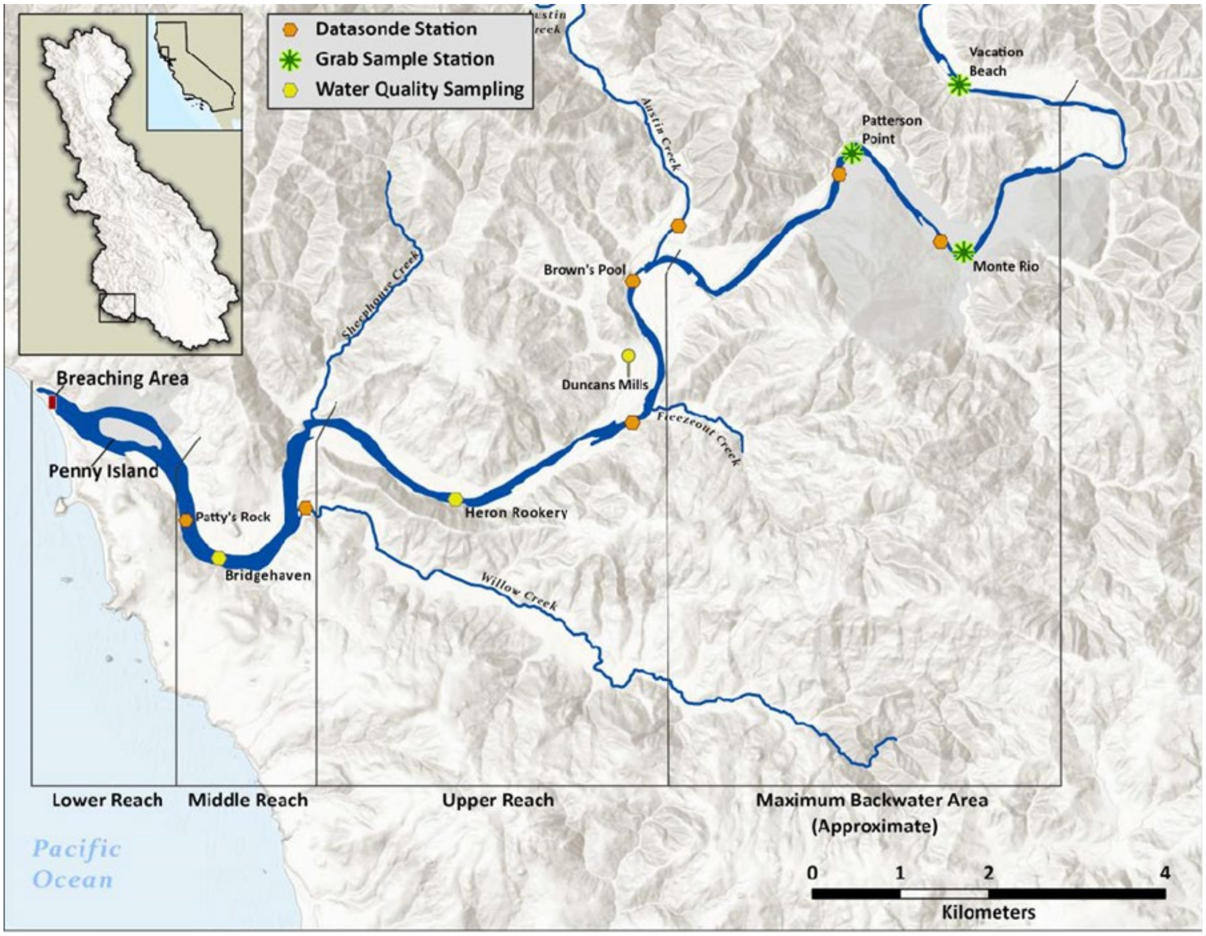

Figure 11. Estuary water quality monitoring locations (ESA, Inc. 2023).

Sonoma Water will continue to perform late summer boat-based seining surveys, and Passive Integrated Transponder (PIT) tagging and stationary PIT antenna arrays. PIT antenna arrays are located at Mirabel Dam, Dutch Bill Creek, near the mouth of Austin Creek, and Duncans Mills. Historically, the purpose of fish monitoring efforts has been to inform the timing of upstream/downstream movements through the Estuary, relative abundance, survival analysis, and the size and age structure of steelhead juveniles. Sonoma Water will continue these studies with modified objectives that focus on coho salmon adult and smolt abundance, migration timing, and survival. Monitoring may also be undertaken that includes understanding the effects of bar breaching on federal or state-listed non-salmonid fish species (e.g., longfin smelt).

1.3.4.3 Estuary Habitat Enhancements

Proposed bar breaching activities to reduce flood risk will occur during important months for steelhead rearing in the Estuary, and to a lesser extent coho and Chinook salmon. Under the Proposed Action, Sonoma Water will minimize the effects of bar breaching activities by implementing habitat enhancement measures in the Estuary. Proposed habitat enhancements in the Estuary include two types: addition of structures to the Estuary mainstem (e.g., two to four LWD, boulders), and enhancing three to five acres (not to exceed six acres) of wetland and/or floodplain habitat (littoral habitat). Sonoma Water will direct the development of conceptual feasibility studies for habitat enhancement opportunities. Sonoma Water will direct this process to implement measures in the short term, while planning for long-term project work that is still developing.

Sonoma Water will oversee the development and prioritization of a list of habitat enhancement projects, intended to improve migration and rearing habitat for juvenile steelhead and salmonids in the Estuary. Criteria will include:

- Ground surface elevation relative to water level regimes,
- Hydrologic connectivity of enhancement measures,
- Influence of measures on water quality,
- Site size,
- Current land use,
- Influence on flood hazards,
- Presence or absence of existing endangered species, and
- Cost.

Sonoma Water expects the size of each site to be scalable (within feasible bounds based on local geography, land ownership, existing habitats, and other constraints). Specifically, Sonoma Water expects that one or more sites could ultimately be scaled to meet a desired habitat benefit that is otherwise lost from activities part of the Proposed Action. For any one site, one or more measures could be combined as part of the Proposed Action to optimize the habitat enhancement opportunities at that specific location. Before implementing any of these enhancements, additional work regarding feasibility, design, environmental compliance, and funding will be needed. Potential measures may include several types of improvements:

- Grading areas adjacent to the Estuary: Re-grade the ground surface, by placing or excavating soil, to modify the ground surface elevation relative to water levels to provide better tidal inundation conditions or fish access to high quality littoral habitat.

- Improve hydrologic connectivity: At some sites, the ground surface of some or all of the site may already be at appropriate elevations. However, hydrologic connectivity to these elevations may be impeded by hydraulic structures or earthen berms, or limited to inundation only during overbank flow. At these sites, modifying or removing the barriers to inundation, or excavating connecting channels, can provide better inundation conditions and fish access. Based on existing channels in the Estuary, new channels would likely have thalwegs (lowest elevations) in the intertidal range to encourage fish access during high tide and closed conditions. However, new channels should be configured so as to not facilitate flow capture during high riverine discharge that could encourage channel or floodplain scour.

- Vegetation management: May be implemented to improve the extent and diversity of estuarine marsh and riparian upland plants. In addition to modifying the hydrology with the prior two measures, this measure may entail removing non-native species and planting target species. Target species are natives that secure soil in place, support the base of the food chain, and provide shade to adjacent waterways.

- In-water habitat structures: Can be provided with the addition of boulders or LWD, in the form of unhewn logs placed in inundated areas, with sufficient anchoring that they are unlikely to move during large flow events. LWD creates regions of flow and habitat diversity, which can increase shelter and prey availability for juvenile salmonids.

This list is based on a review of recent and current restoration and long-term management efforts in similar estuaries in California and Oregon. It includes several major categories of enhancements, but may include other complementary measures as continued adaptive management of the Estuary and continued monitoring data collection provide more understanding of the system. Other measures that may provide a habitat benefit could include management of the riparian zone (to provide additional shade and reduce water temperatures) and management of submerged aquatic vegetation, such as eelgrass (*Zostera marina*). A small amount of eelgrass has been mapped in the lower Estuary near Penny Island. However, it has not been observed upstream, and high temperatures in the middle and upper Estuary are known stressors that have limited eelgrass restoration efforts elsewhere.

Projects will be identified through a series of feasibility studies that will leverage prior monitoring data collected in the Estuary, and tools and studies developed for the Estuary as part of the Russian River Habitat Focus Area (RRHFA). These include the recent study by Boughton *et al.,* (2017) and the Estuary Habitat Viewer tool developed by U.C. Davis that identifies and quantifies juvenile steelhead rearing habitat zones in the Estuary based on water quality conditions. Feasible projects will be carried through design and permitting with oversight from Sonoma Water and regulatory agencies. Project feasibility will include short-term improvements to salmonid habitat in the Estuary, and long-term resilience in the face of sea-level rise and its expected changes to conditions in the Estuary. Sea-level rise assessments will include consideration of short-term (life of the Opinion) and long-term (mid- or late-century) horizons.

A number of initial sites have been identified as potential areas for habitat enhancement as part of the RRHFA. This list will be refined in the future under the Proposed Action and a screening process and opportunities and constraints assessment would be implemented to identify a subset of priority sites for continued design and construction. The following locations have been identified as critical habitat needing rehabilitation for threatened CCC steelhead rearing habitat, likely to also benefit CCC coho salmon and CC Chinook: 1) Penny Island, 2) Goat Hill Floodplain, 3) Patty's Rock Floodplain, and 4) Willow Creek Marsh and Lower Channel. The first three sites are located within the Russian River State Marine Recreational Management Area Marine Protected Area. As such, planning for enhancement measures within these sites will be conducted in coordination with CDFW. In addition, installation of LWD and/or boulders will be evaluated at two to four locations in the Estuary mainstem, between Duncans Mills Bridge to the middle or lower Estuary, to enhance habitat available to primarily benefit migrating salmonid adults (Sonoma Water 2024d).

In addition to the information presented in the BA, Sonoma Water is actively engaging with NMFS on the development of habitat metrics for the Estuary to support further analysis of potential adverse effects on listed fish species associated with bar breaching, as well as enhancement projects described in the Proposed Action to address potential adverse effects. As part of this process, metrics have been developed to capture the dynamic and variable nature of habitat conditions in the Estuary (Sonoma Water 2024f). The metrics include both habitat volume (acres of habitat type with depth components [littoral and limnetic, and epibenthic]) and duration (time represented as days across a month and/or year) for a composite spatiotemporal metric of suitable habitat acre-days (by habitat type: littoral, limnetic, and epibenthic). The metrics are being applied in a model-based analysis framework to river mouth (inlet) open (managed and natural) and closed conditions for both the baseline and Proposed Action scenarios. The modeling framework is built on data tools from the Habitat Viewer and work developed by UC Davis, ESA, Inc., and Sonoma Water under the RRHFA. Once the metrics have been fully agreed upon with NMFS, a full analysis will be completed to identify changes in habitat types associated with Estuary breaching under baseline and Proposed Action scenarios. Subsequent analyses, using the same approach, will be applied to enhancement projects being contemplated to address potential adverse effects. The metrics and model-based analysis approach will allow for further insights regarding the effects of the Proposed Action (changes in suitable habitat acre-days by habitat type) and the habitat enhancements (acres of enhancement in the Estuary) needed to minimize potential adverse effects.

The following updated timeline on Sonoma Water's commitments to implement an approximately three to five acres (no more than six acres) of habitat enhancement and LWD structure placement in the Estuary is incorporated here as part of the Proposed Action and was provided to NMFS via email from ESA, Inc. on April 6, 2025 (also summarized in Appendix C).

Feasibility Study: Feasibility studies are anticipated to be <u>initiated within four months</u> and <u>completed within two years of the publication of this Opinion</u>.

Design and Permitting: Design and permitting will proceed following completion of the feasibility studies and habitat enhancement (including Estuary mainstem LWD placement) site selection. Design and permitting will include development of methods and measures to avoid and minimize impacts related to habitat enhancement implementation. <u>Within five years of publication of this Opinion</u>, Sonoma Water anticipates completion of permitting and design on the selected enhancement site(s). However, the exact timetable for completion of these actions may vary depending on the site(s) selected.

Construction: Securing funding for enhancement construction (and land acquisition, if necessary) will proceed in tandem with the feasibility, design, and permitting phases. Sonoma Water anticipates that <u>within five years of publication of this Opinion, funding for construction will be procured</u> and <u>within eight years of publication, construction of the enhancement will be completed</u>.

Importantly, Sonoma Water may decide to fund habitat enhancement actions in the Estuary undertaken by other parties as an alternative delivery approach to meeting the anticipated three to five-acre habitat enhancement requirement. Sonoma Water may contribute funds to a project such as the Gold Ridge Resource Conservation District (GRRCD) Lower Russian River Watershed Coho Habitat Restoration Project which includes restoration of a 12-acre tidal wetland complex in Willow Creek. Under this alternative, timelines for completion of feasibility studies, design, permitting, and implementation would be at the discretion of the GRRCD, or implementing party, in partnership with NOAA's Restoration Center.

1.3.5 Santa Rosa Creek Diversion

Constructed in 1963 as part of the Sonoma Water's Central Sonoma Watershed Project (CSWP), the Santa Rosa Creek Diversion Structure is a critical flood protection element that works in tandem with Santa Rosa Creek Reservoir to reduce flooding along Santa Rosa Creek and throughout the City of Santa Rosa. The Diversion Structure consists of a weir, fish ladder, Vortex Tube (submerged flow-regulating culvert under Montgomery Drive), and diversion channel that carries diverted high flows to Spring Lake (Santa Rosa Creek Reservoir). The Spring Creek Diversion diverts flow from Spring Creek to Spring Lake during most flow conditions. Additional details on the specifications and operations of these features can be found in Section 3.5.1 of the BA and are hereby incorporated by reference.

As part of the Proposed Action, Sonoma Water will continue to maintain the Santa Rosa Creek Diversion Structure. During normal operating conditions, Santa Rosa Creek flows will pass through the Vortex Tube and the bypass pipe ends will be closed. The bypass pipe will only be placed into operation during Vortex Tube repair work to allow periodic future inspections of the integrity of the Vortex Tube if visible damage is observed, and to conduct maintenance, as needed. These inspections will require dewatering the Vortex Tube using cofferdams and operation of the bypass pipe that may take one to two weeks to complete.

1.3.6 Salmonid Protection Measures and BMPs

Detailed descriptions of BMPs and conservation measures that are part of the Proposed Action can be found in Sections 3.4.2.1 through 3.10 of the BA and are hereby incorporated into the Proposed Action by reference. NMFS has collated a list of these measures and included it as Appendix B of this Opinion. The Proposed Action includes implementation of these BMPs to further avoid and minimize impacts to listed fish and their designated critical habitat due to impacts that are likely to occur as a result of activities under the Proposed Action. BMPs include such measures as: June 15-October 15 work windows, length limitations for streambank stabilization, herbicide use restrictions, erosion control measures, salmonid protection measures during dewatering/relocation.

1.3.7 Additional Monitoring

Monitoring efforts that are included as part of the Proposed Action related to turbidity (physical and fisheries), Estuary management, effectiveness monitoring of constructed habitat sites in Dry Creek, and survival studies have already been discussed in sections above. Additional monitoring to occur as part of proposed habitat enhancements and reservoir operations is described below. Specific sampling objectives, methods, locations, and recommendations that were included in the Proposed Action for all proposed monitoring activities are included in Table 8 below. The expected numbers of each species that will be encountered as part of these actions, based on recent information provided by Sonoma Water, are detailed in Appendix A.

Sonoma Water and the USACE collect vertical profile data from each reservoir annually that is designed to understand the relationship between reservoir storage and habitat related water quality of reservoir releases. Sonoma Water staff will continue (began in 2013) to collect vertical profile data in Lake Mendocino for temperature, Dissolved Oxygen, pH, specific conductance, and turbidity. This information would also be collected annually by the USACE for Lake Sonoma, and more frequently (e.g., monthly or semi-monthly) during dry and critically dry water years, when water quality data, particularly water temperature, is essential for effective reservoir management and minimum instream flows downstream of WSD.

California Sea Grant (CSG) began work in 2013 in accordance with the California Coastal Salmonid Population Monitoring Plan (CMP). To accomplish CMP goals, basin-wide spawner surveys, basin-wide snorkel surveys, and life cycle monitoring (LCM) stations in four LCM streams are conducted to measure status and trends in anadromous coho steelhead and steelhead populations in the Russian River basin (Figure 12). Sonoma Water now conducts many of these activities under their NMFS Section 10(a)(1)(A) Research Permit for Monitoring Recovery of Salmonids in the Russian River Watershed (File # 14419-4R) or separate NMFS ESA Section 10 permits that were issued for each HGMP. Many of the monitoring activities that were part of the 2008 consultation have since been included in Sonoma Water's 10(a)(1)(A) research permit. In this Opinion, we are assessing the effects of those monitoring activities that are now proposed as part of the Proposed Action. Those activities will be included in this Opinion (and removed from the Section 10 permit), whereas activities associated with the broader population monitoring under the CMP and HGMP's will continue to be part of existing, individual Section 10 permits.

Sonoma Water will continue to implement monitoring activities for coho salmon, steelhead, and Chinook salmon throughout the Russian River watershed as part of the Proposed Action. With data generated from these field efforts, Sonoma Water will update data on adult abundance, spatial structure of juveniles, and freshwater survival of successive cohorts in Dry Creek.

Sonoma Water will continue to monitor fish passage at the Wohler-Mirabel facilities with a DSMT for juvenile salmonid monitoring and video monitoring inside the fish ladder for adult salmonids. Monitoring will also include stationary PIT antenna arrays to facilitate life cycle monitoring and survival analysis (Figure 12). Monitoring will continue in Dry Creek with a DSMT, stationary PIT antenna arrays, and late-summer surveys to assess AMP validation metrics for coho salmon and steelhead including habitat use as well as survival, fidelity, and growth when possible.

Sonoma Water and the USACE will coordinate monitoring of the stream reaches below CVD and WSD during the pre-flood inspection activities and down-ramping events. Two-person stream survey crews will survey specific stream reaches below the dams and make observations related to changes in stream characteristics and fish distribution. If flow reductions of 12 cfs per hour or 24 cfs per day are made, Sonoma Water will conduct an in-stream survey on the East Fork below the fish ladder to the CVFF downstream to the confluence of the mainstem Russian River and note any regions of the stream that are disconnected or any areas of isolated pools. Sonoma Water will provide locations of disconnection and isolated pools to CDFW and NMFS on the following business day.

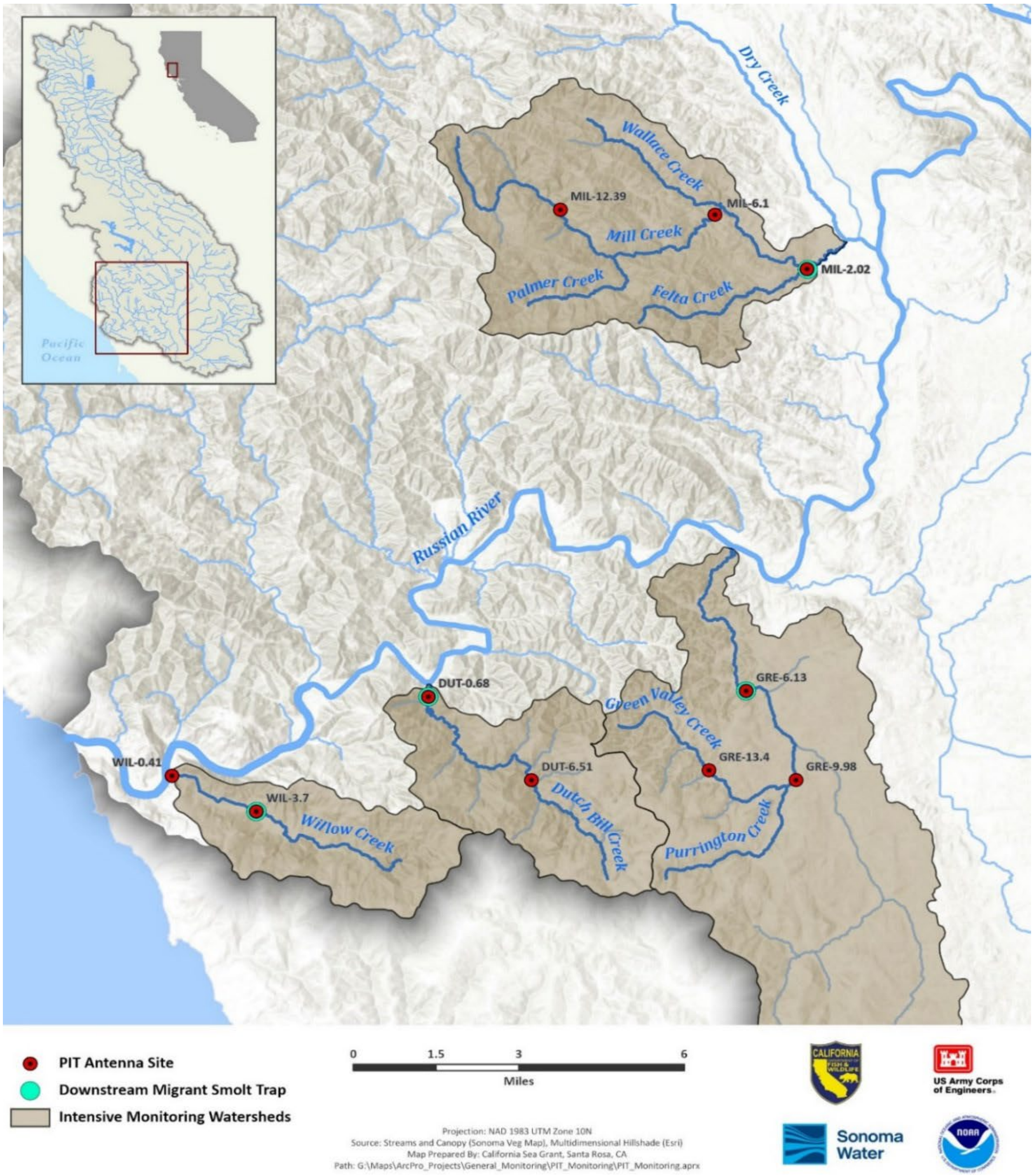

Figure 12. Coho salmon and steelhead LCM watersheds (shaded polygons) with stationary PIT antennas and DSMTs. Blue line segments represent reaches containing habitat for one or more species (Sonoma Water and CSG 2023).

Table 8. Proposed monitoring objectives, methods, locations, and recommendations (ESA, Inc. 2023).

Project Element	Target Species, Life Stage, Habitat	Objectives	Method	Locations	Responsible Organization	Comments/Action
Reservoir Operations	Chinook salmon adults	Adult return estimations	Video	Russian River (Mirabel Dam)	Sonoma Water	Continue with inclusion of PIT antenna arrays
		Validation and distribution	Spawner survey	Dry Creek	Sonoma Water	
		Access to spawning habitat	spawner/riffle crest survey	Upper River	Sonoma Water	Develop monitoring plan based on flow conditions
	Salmonid smolts	Abundance and survival	PIT antenna	Dry Creek	Sonoma Water, USACE	Develop study plan to document salmonid smolt survival
		Migration survival	Acoustic telemetry	Upper, Lower River and Estuary	Sonoma Water, USACE	
	Salmonid habitat conditions	Water quality	Grab sample, sondes	Upper River	Sonoma Water	Designed to understand the relationship between reservoir storage, habitat related water quality of reservoir releases.
			Vertical profiles	Lake Mendocino/Lake Sonoma	Sonoma Water, USACE	Lake Mendocino vertical profiles are collected by Sonoma Water and Lake Sonoma profiles by USACE
Estuary Management	Steelhead juveniles, Coho salmon smolts, and possibly Chinook salmon smolts in some years	Source of PIT tagged fish for future Estuary habitat enhancement monitoring Habitat use for future habitat enhancement monitoring	DSMT	Dry Creek, Russian River (Mirabel Dam), lower river tributaries defined as downstream of Mirabel Dam	Sonoma Water	
			PIT antenna	Estuary	Sonoma Water	May include habitat use by coho salmon and Chinook salmon smolts in some years
	Salmonid habitat conditions	Water quality	Sondes	Estuary	Sonoma Water	Routine sampling used in estuary management decisions; may include targeted monitoring for new habitat projects
		Physical process	Camera, topographic surveys	River mouth	Sonoma Water	Routine sampling used in estuary management decisions.
Dry Creek Habitat Enhancements	Coho salmon and steelhead juveniles	Implementation	See AMP checklists	Dry Creek	Sonoma Water	Include maintenance and any new sites; update to add annual visual site evaluation (drone, checklists) for completed sites
		Effectiveness (1°): velocity, depth, shelter value, pool/riffle ratio	Habitat mapping	Dry Creek	Sonoma Water	Update 2014 AMP (revise checklists) and continue based on annual work plans; adjust rotating panel
		Effectiveness (2°): water quality	Water quality	Dry Creek	Sonoma Water	Continue to follow 2014 AMP to monitor as needed
		Validation (1°): habitat use	PIT antenna, snorkel	Dry Creek	Sonoma Water	Snorkeling no possible at some sites; propose defining frequency and duration of monitoring
		Validation (1°): abundance/density	Electrofish, seine	Dry Creek	Sonoma Water	Propose changing to secondary metric and recommend developing guidance for frequency, locations (based on conditions), and number of years to monitor
		Validation (1°): relative abundance	DSMT	Dry Creek	Sonoma Water	Chinook smolt estimate; cannot accomplish steelhead or coho estimate with DSMT alone, will explore estimates using PIT antennas
		Validation (2°): fidelity, growth/size, survival	PIT antenna, electrofish, seine	Dry Creek	Sonoma Water	Continue to follow 2014 AMP to monitor as needed

Project Element	Target Species, Life Stage, Habitat	Objectives	Method	Locations	Responsible Organization	Comments/Action
Annual Monitoring of Salmonid Migration in the Russian River at Mirabel/Wohler and Dry Creek	Coho and Chinook salmon and steelhead juveniles	Juvenile outmigration	DSMT	Dry Creek	Sonoma Water	Continue with inclusion of PIT antenna arrays
	Chinook salmon adults	Adult return estimation	Video	Russian River (Mirabel Dam)	Sonoma Water	Continue with inclusion of PIT antenna arrays

1.3.8 Other Activities Caused by the Proposed Action

We considered, under the ESA, whether the Proposed Action would cause any other activities and determined that Sonoma Water's operation and maintenance of their water transmission system and WSD hydroelectric facility to be other activities caused by water releases at CVD and WSD. We considered the effects of such activities below in the effects section (Section 2.5.1) of this Opinion.

Water Transmission

Water releases for water supply are part of the Proposed Action. After water is released from CVD and/or WSD, Sonoma Water delivers water to its customers through its water transmission system, which has a peak monthly average production demand of 42.9 million gallons per day (2018 through 2022), and a capacity of up to 92 million gallons per day. Currently, Sonoma Water's water transmission system has 88 miles of pipes in place to distribute water from the diversion facilities to water users in Sonoma and Marin Counties. Sonoma Water has 18 storage tanks in southern Sonoma County with 129.6-million-gallon total storage capacity. The diversion and treatment facilities are located adjacent to the Russian River in the vicinity of Forestville at Mirabel (an area near the former Mirabel resort) and Wohler (a site near Wohler Road). The transmission system includes radial collector wells, disinfection and corrosion control (pH adjustment) facilities, pipelines, storage tanks, pumps, and conventional wells. Six radial horizontal collector wells and seven vertical wells adjacent to the Russian River near Wohler Road and Mirabel, extract water from the alluvial aquifer beneath, and adjacent to, the streambed. The wells provide up to 7 million gallons per day of emergency production capacity. The water transmission system also includes three groundwater wells located along the Russian River-Cotati Intertie pipeline at Occidental Road, Sebastopol Road (Highway 12), and Todd Road.

Wastewater Treatment

Proposed action operations for purposes of water supply result in the diversion of up to approximately 65,000 ac-ft of water from the Russian River each year. A substantial portion of this water supply is consumed, eliminated as waste, treated as wastewater, and ultimately either recycled or discharged back into the Russian River watershed or San Pablo Bay as treated effluent. Several wastewater treatment plants serve Sonoma Water's primary and secondary water contractors. Wastewater discharges are controlled and scheduled under the established policies of the Water Quality Control Plan for the North Coast. Water treated to a tertiary level is discharged back into the Russian River, Jones Creek, Dutch Bill Creek, Mark West Creek, and the Laguna de Santa Rosa tributaries of the Russian River. None of the facilities discharge to tributaries of the Russian River between May 15 and October 1; some commence discharges beginning in November, some end discharges by April 30.

WSD Hydroelectric Facility

The WSD Hydroelectric Facility was completed in December 1988. Sonoma Water operates the facility under a 50-year license issued by the Federal Energy Regulatory Commission on

December 18, 1984. Energy production varies according to the flow of water through WSD and average annual energy production totals approximately 13.6 Gigawatt hours. Hydroelectric operation of the dam is conducted by Sonoma Water in collaboration with USACE. As of 2015, the hydroelectric facility at WSD provided approximately 27 percent of Sonoma Water's energy.

The hydroelectric facility is located within the control structure of the outlet works of WSD. Water from Lake Sonoma flows to the hydraulic turbine via a vertical well located in the control structure that draws water from the horizontal, low-flow tunnels. Water from the tunnels travels down the vertical well between approximately 115 and 194 ft into the turbine. Water passing through the turbine flows from the flood control tunnel into a stilling basin located at the base of the dam. From the concrete-lined mouth of the outlet tunnel stilling basin, water flows through a channelized portion of Dry Creek or is diverted for use in DCFH adjacent to WSD. A two-step weir, approximately 18 ft high, is used to reduce the water velocity from the outlet tunnel to keep fish downstream of the dam from entering the outlet.

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.

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.

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 listed 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.

2.2. Rangewide Status of the Species and Critical Habitat

This Opinion examines the status of each species that is likely to be adversely affected by the Proposed Action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This informs the description of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" for the jeopardy analysis. The Opinion also examines the condition of their designated critical habitat, evaluates the conservation 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 purpose of this section is to characterize the condition of the species under consultation relative to their likelihood of viability (extinction risk), and to describe the conservation role and function of their respective critical habitats. The three principal components to this section are: 1) a summary of relevant life-history characteristics for each species; 2) status of the species; 3) status of critical habitat; and 4) limiting factors/threats affecting species and critical habitat. This information will be used as the foundation for determining whether the Proposed Action is, or is not, expected to appreciably reduce the likelihood of the survival and recovery of a species by reducing the reproduction, numbers, or distribution of that species, or result in the destruction or adverse modification of its critical habitat.

NMFS assesses four population viability[3] parameters to discern the status of the listed ESUs and DPSs and to assess each species' ability to survive and recover. These population viability parameters are: abundance, population growth rate, spatial structure, and diversity (McElhany *et al.,* 2000). While there is insufficient data to evaluate these population viability parameters quantitatively, NMFS has used existing information to determine the general condition of the populations in the CCC coho salmon and CC Chinook salmon ESUs and CCC steelhead DPS and the factors responsible for the current status of these listed species. We use these population viability parameters as surrogates for "reproduction, numbers, and distribution" in the regulatory definition of "jeopardize the continued existence of" (50 CFR 402.02). For example, abundance, population growth rate, and distribution are surrogates for numbers, reproduction, and distribution, respectively. The fourth parameter, diversity, is related to all three regulatory criteria. 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.

This Opinion analyzes the effects of the Proposed Action on the following federally-listed species' ESUs, DPS, and designated critical habitat.

CC Chinook salmon ESU
Threatened (70 FR 37160; June 28, 2005)
Critical habitat designation (70 FR 52488; September 2, 2005);

CCC coho salmon ESU
Endangered (70 FR 37160; June 28, 2005)
Critical habitat designation (77 FR 19552; April 2, 2012);

[3] NMFS defines a viable salmonid population as "an independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation, local environmental variation, and genetic diversity changes over a 100- year time frame" (McElhany et al., 2000).

CCC steelhead DPS
Threatened (71 FR 834; January 5, 2006)
Critical habitat designation (70 FR 52488; September 2, 2005);

Southern resident killer whale DPS
Endangered (80 FR 7380; February 10, 2015)
Critical habitat designation (86 FR 41668; August 2, 2021).

2.2.1 CC Chinook Salmon - ESU Status

2.2.1.1 CC Chinook Salmon Life History

Chinook salmon are the largest anadromous member of *Oncorhynchus*. The CC Chinook salmon are fall-run, ocean-type fish. A spring-run (river-type) component existed historically, but it is now considered extinct (Bjorkstedt *et al.,* 2005).

Chinook salmon in the CC Chinook salmon ESU generally remain in the ocean for 1 to 5 years (Healey 1991), and tend to stay along the California and Oregon coasts. CC Chinook salmon usually enter rivers from August to January. These fall-run Chinook salmon typically enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the main stem or lower tributaries of rivers, and spawn within a few weeks of freshwater entry (Healey 1991). However, some return from the ocean to spawn one or more years before full-sized adults return; these are referred to as jacks (males) and jills (females). Run timing is partially a response to stream flow characteristics, with most spawning occurring in November and December. They typically spawn in the lower reaches of rivers and tributaries at elevations of 200 to 1,000 ft. Egg deposition must be timed to ensure that fry emerge during the following spring at a time when the river or estuary productivity is sufficient for juvenile survival and growth. Adult female Chinook salmon prepare redds in stream areas with suitable gravel composition, water depth, and velocity. Spawning generally occurs in swift, relatively shallow riffles or along the edges of fast runs at depths greater than 9.4 in. Optimal spawning temperatures range between 5.6 and 13.9°C (Allen and Hassler 1986). Redds vary widely in size and location within the river. Preferred spawning substrate is clean, loose gravel, mostly sized between 1.3 and 10.2 cm, with no more than 5 percent fines (Allen and Hassler 1986). Gravels are unsuitable when they have been cemented with clay or fines, or when sediments settle out onto redds, reducing intergravel percolation (62 FR 24588). Minimum intergravel percolation rate depends on flow rate, water depth, and water quality. The percolation rate must be adequate to maintain oxygen delivery to the eggs and remove metabolic wastes. The Chinook salmon's need for a strong, constant level of subsurface flow may indicate that suitable spawning habitat is more limited in most rivers than superficial observation would suggest.

Chinook salmon eggs incubate for 90 to 150 days, depending on water temperature. Successful incubation depends on several factors including dissolved oxygen (DO) levels, temperature, substrate size, amount of fine sediment, and water velocity. Fry emergence begins in December and continues into mid-April (Leidy 1984). Emergence can be hindered if the interstitial spaces in the redd are not large enough to permit passage of the fry. In laboratory studies, Bjornn and

Reiser (1991) observed that Chinook salmon and steelhead fry had difficulty emerging from gravel when fine sediments (0.25 inches or less) exceeded 30 to 40 percent by volume.

The smolt outmigration typically occurs from April through July (Myers *et al.,* 1998). In California, ocean-type Chinook salmon tend to use estuaries and coastal areas for rearing more extensively than stream type Chinook salmon (Thorpe 1994). Brackish water in estuaries moderates the physiological stress that occurs during the parr-smolt transition.

Many of the fry of ocean-type Chinook salmon migrate downstream immediately after emerging from spawning beds and take up residence in river estuaries to rear to smolt size (Healey 1991). In the Sixes River, Oregon, Reimers (1973) reports that the most common juvenile life-history pattern was 3 months rearing in the river and 3 months rearing in the estuary. In the Campbell River, British Columbia, juvenile Chinook entered the estuary between April and June, spending 40 to 60 days in low salinity water (0 to 5.5 parts per thousand (ppt) salinity) before moving into a transition zone (5.5 to 25 ppt salinity) between May and July. After that they moved into a more marine zone (>25 ppt salinity) (Thorpe 1994). In the Sacramento-San Joaquin River delta, Sazaki (1966) observed that young Chinook salmon were most abundant from April through June, similar to the timing observed in more northern deltas. However, MacFarlane and Norton (2002) demonstrated little estuarine dependency for juvenile Chinook salmon in the San Francisco Estuary. These conflicting results suggest variability in the use of estuaries, some of which may be attributable to the highly modified condition of San Francisco Bay.

2.2.1.2 CC Chinook Salmon Viability Assessment

The new information available since 2016 indicates that recent trends across the ESU have been mixed and that overall extinction risk for the ESU is moderate and has not changed appreciably since the previous viability assessment (SWFSC 2023). Although conservation efforts for CC Chinook salmon have reduced some threats for this ESU, many threats remain unchanged since the previous 5-year review. In addition, increased risks of wildfires, drought, and poor ocean conditions are likely to continue and worsen. Based on the 2024 status review, NMFS concluded that the CC Chinook salmon ESU remains threatened (NMFS 2024a).

The CC Chinook salmon ESU includes all naturally spawned populations of Chinook salmon from rivers and streams south of the Klamath River, in Humboldt County, to the Russian River (70 FR 37160). Seven artificial propagation programs were considered part of the ESU at the time of listing: the Humboldt Fish Action Council (Freshwater Creek), Yager Creek, Redwood Creek, Hollow Tree, Van Arsdale Fish Station, Mattole Salmon Group, and Mad River Hatchery fall-run Chinook hatchery programs.

The CC Chinook salmon ESU was historically comprised of approximately 32 Chinook salmon populations (Bjorkstedt *et al.*, 2005, Figure 13). About 14 of these populations were independent, or potentially independent. The remaining populations were likely more dependent upon immigration from nearby independent populations than dependent populations of other salmonids (Bjorkstedt *et al.*, 2005). The ESU is divided into the North Coast, North Mountain Interior, North-Central Coastal, and Central Coastal Diversity Stratas. The Central Coastal Diversity Strata includes the Navarro, Garcia, Gualala, and Russian Rivers.

The availability of data for CC Chinook salmon has improved since the previous viability assessment. The current 5-year mean estimate of CC Chinook salmon across the ESU is 13,169 adult returns and 2,392,807 juvenile outmigrations (NMFS 2024a). Adult Chinook salmon abundance estimates include: 1) sonar-based estimates on Redwood Creek and the Mad and Eel rivers, 2) weir counts at Freshwater Creek (one tributary of the Humboldt Bay population), 3) trap counts at Van Arsdale Station (representing a small portion of the upper Eel River population), 4) adult abundance estimates based on spawner surveys for six populations on the Mendocino Coast, and 5) video counts of adult Chinook salmon at Mirabel Dam on the Russian River. Prior viability assessments have included maximum live/dead counts in three index reaches in the Eel River (Sproul and Tomki creeks) and Mad River (Cannon Creek); however, these efforts have been discontinued or replaced with the more rigorous efforts to monitor populations in the Eel and Mad rivers using sonar methods. Summaries of available data are presented by diversity stratum below.

CC Chinook salmon populations remain widely distributed throughout much of the ESU (Figure 13). Notable exceptions include the area between the Navarro River and Russian River and the area between the Mattole and Ten Mile River populations (Lost Coast area). The lack of Chinook salmon populations both north and south of the Russian River (the Russian River is at the southern end of the species' range) makes it one of the most isolated and essential populations for recovery in the ESU. Myers *et al*., (1998) reports no viable populations of Chinook salmon south of San Francisco, California.

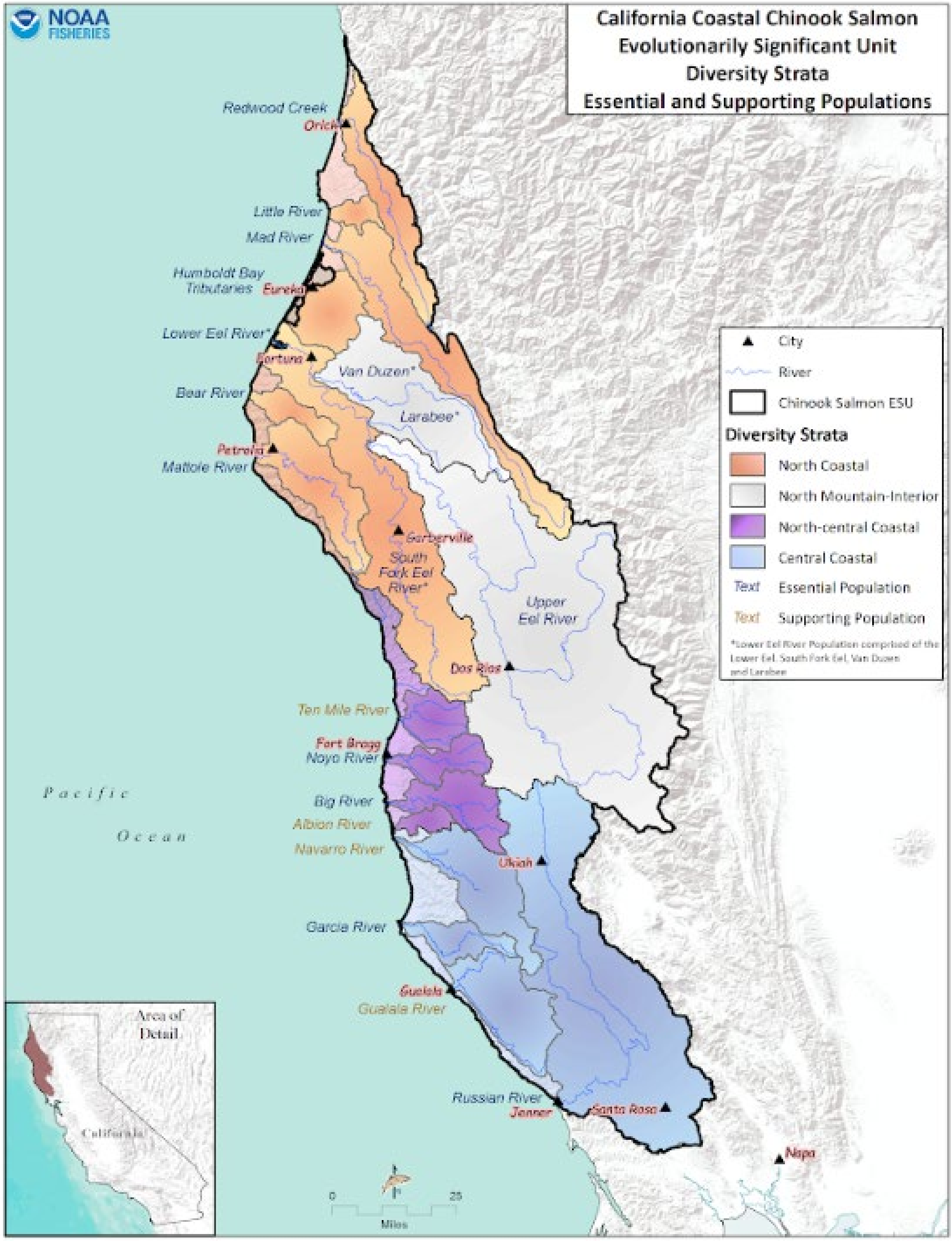

Figure 13. The California Coastal Chinook Salmon ESU, and location of the Russian River Chinook Population within the Central Coastal Diversity Strata.

Because of their prized status in the sport and commercial fishing industries, CC Chinook salmon have been the subject of many artificial production efforts, including out-of-basin and out-of-ESU stock transfers (Bjorkstedt *et al.*, 2005). Therefore, it is likely that CC Chinook salmon genetic diversity has been significantly adversely affected despite the relatively wide population distribution within the ESU. An apparent loss of the spring-run Chinook life history in the Eel River Basin and elsewhere in the ESU also indicates risks to the diversity of the ESU.

North-Coastal stratum - Population-level estimates of abundance are currently available for three of seven independent populations of CC Chinook salmon in the North Coastal stratum. Estimates based on sonar counts of Chinook salmon in Redwood Creek are available for 8 of 10 years since the 2010 spawning season. Population estimates have averaged 2,896 (range 1,455–4,541) over the 8 years of sampling, showing a slightly positive, but not significant trend ($p = 0.31$). The population mean represents 85 percent of the recovery target of 3,400 spawners (SWFSC 2023).

Estimates of CC Chinook salmon adult abundance based on sonar counts have also been made for the Mad River beginning in the 2014 season. Estimates have averaged just over 7,000 fish (range 2,169–12,667) over the 5 years of monitoring, and though the time series is too short for formal trend analysis, numbers have increased during this brief period. The mean estimated abundance exceeds the recovery target of 3,000 for this population. This monitoring effort represents a vast improvement in information on Mad River Chinook salmon, as the Cannon Creek index counts, which have been discontinued, typically ranged from tens to low hundreds of fish over the 35-year period of record (SWFSC 2023).

Spawner surveys have been conducted in the Mattole River watershed since the 2013 spawning season, with results reported as total redd estimates. During this time, redd estimates have averaged 862 (range 331–2,202). The sample frame has varied among years; thus, formal analysis of trends is not appropriate (SWFSC 2023).

In addition to these population-level estimates, longer time series are available for two partial populations. Weir counts have been made at Freshwater Creek (a portion of the Humboldt Bay population) since the 2001 spawning season. These counts are considered incomplete, as the weir is not 100 percent effective in catching upstream migrating Chinook salmon as fish may pass over or through under certain flow conditions. Counts have averaged 29 fish (range 0–154) over the 19-year period of record, and there has been a negative and significant downward trend ($p = 0.0001$). Estimates of Chinook salmon redds have been made in 4 of the last 9 years in the South Fork Eel River. The average estimate has been 768 (range 68–1829) during this period, with no statistically significant trend ($p = 0.709$) (SWFSC 2023).

North Mountain Interior Stratum - The North Mountain Interior stratum contains the upper Eel River Chinook salmon population, as well as the portion of the lower Eel River population that inhabits watersheds of the interior mountains of the Eel River basin, including the Van Duzen River and Larabee Creek basins. A long-running time series (since 1947) of adult counts is available for the Van Arsdale Fish Station. Over these 23 years, an average of 680 Chinook salmon (range 26–3,471) have been counted, and there has been no significant trend in abundance ($p = 0.709$). Over the past 12 years, the mean abundance was higher than the 23-year average (mean = 948), but the trend was negative and marginally significant ($p = 0.084$), as high counts in 2011–2013 were followed by 6 years of below-average counts from 2014–2019. A sonar-based program for estimating abundance of the Upper Eel River Chinook salmon population was initiated in 2019 and produced an estimate of 3,844 adult Chinook salmon, a year in which only 94 fish were counted at Van Arsdale. These new data highlight the fact that the Van Arsdale count represents only a small (and potentially variable) fraction of the total Upper Eel River population (SWFSC 2023). More recent sonar-based estimates show results similar to those from 2019, with over 8,100 adult Chinook salmon estimated above the South Fork Eel River confluence (Upper Eel River population) and fewer than 500 observed at Van Arsdale in 2022/23 and 2023/24 (CDFW 2025).

North-Central Coastal Stratum - Implementation of the CMP in this stratum beginning in 2009 indicates that small numbers of Chinook salmon continue to return to these watersheds in most years. In the Ten Mile River, adult estimates have averaged 92 fish (range 0–638 fish over the 11 years of record, with no significant trend ($p > 0.10$). The mean represents 11–22 percent of the recovery target for this population, which is classified as a "supporting" population in the Federal recovery plan. The Noyo River estimate has averaged 19 (range 0–98) during this time, while Big River has averaged 16 (range 0–60). These mean values are less than 1 percent of proposed recovery targets and fall below the depensation thresholds for high risk (SWFSC 2023).

Central Coastal Stratum - Population monitoring has continued for three of four independent populations of CC Chinook salmon in the Central Coastal Stratum: Navarro, Garcia, and Russian River (Gualala River is the 4th). Monitoring of the Navarro and Garcia river populations was initiated in 2009 and has shown sporadic occurrence of low numbers of Chinook salmon in these watersheds over the last 10 years. In the Navarro River, small numbers ($n = 10$) of Chinook salmon were reported in both 2010 and 2011, but they have not been observed since. In the Garcia River, estimates have averaged 34 (range 0–125) fish, with the highest numbers being reported in the last 3 years of the time series, resulting in a significant positive trend ($p = 0.04$), though the population mean is currently less than 2 percent of the recovery target. Both populations are categorized as high risk based on depensation and effective population size criteria (SWFSC 2023). Information for the Russian River population of Chinook salmon can be found below in the Environmental Baseline (Section 2.4.3.1)

2.2.2 CCC Coho Salmon - ESU Status

2.2.2.1 CCC Coho Salmon Life History

The life history of coho salmon in California has been well documented by Shapovalov and Taft (1954) and Hassler (1987). In contrast to the life history patterns of other anadromous salmonids, coho salmon in California generally exhibit a relatively simple 3-year life cycle (Shapovalov and Taft 1954; Hassler 1987). Adult coho salmon typically begin the freshwater migration from the ocean to their natal streams after heavy late-fall or winter rains breach the sand bars at the mouths of coastal streams (Sandercock 1991). Adult migration continues into March, generally peaking in December and January, with spawning occurring shortly after the fish return to the spawning grounds (Shapovalov and Taft 1954).

Female coho salmon choose spawning sites usually near the head of a riffle, just below a pool, where water changes from a laminar to a turbulent flow and there is small to medium gravel substrate. Flow characteristics at the redd usually ensure good aeration of eggs and embryos, and the flushing of metabolic waste products. The water circulation in these areas also facilitates fry emergence from the gravel. Preferred spawning grounds have nearby overhead and submerged cover for holding adults, water depths of 3.9 to 21.3 in, water velocities of 0.66 to 2.62 ft/s, clean, loosely compacted gravel (0.5 to 5-inch diameter) with less than 20 percent fine silt or sand content, cool water (4 to 10°C) with high DO (8 parts per million (ppm)), and intergravel flow sufficient to aerate the eggs. The lack of suitable gravel often limits successful spawning in many streams.

Fecundity of coho salmon is directly proportional to female size; average fecundity is about 2000 eggs (Sandercock 1991). Coho salmon are semelparous (they spawn once and then die). Coho salmon eggs generally incubate for 4 to 8 weeks, depending on water temperature. Egg survival and development rates depend on temperature and DO levels within the redd. According to Baker and Reynolds (1986), under optimum conditions, egg mortality can be as low as 10 percent, but under adverse conditions of high scouring flows or heavy siltation, mortality may be close to 100 percent. McMahon (1983) found that egg and pre-emergent fry survival drops sharply when fines make up 15 percent or more of the substrate. The newly-hatched fry remain in the gravel from 2 to 7 weeks before emergence (Shapovalov and Taft 1954).

Upon emergence from the gravel, coho salmon fry seek out shallow water, usually along stream margins. As they grow, they often occupy habitat at the heads of pools, which generally provide an optimum mix of high food availability and good cover with low swimming cost (Nielsen 1992). Juvenile coho salmon prefer well shaded pools at least 3.3 ft deep with dense overhead cover; abundant submerged cover; DO levels of 4 to 9 ppm; and water velocities of 0.3 to 0.8 ft/s in pools and 1.0 to 1.5 ft/s in riffles. Water temperatures for good survival and growth of juvenile coho salmon range from 10 to 15° C (Bell 1973; McMahon 1983). Growth is slowed considerably at 18° C and ceases at 20ºC (Stein *et al.,* 1972; Bell 1973). The likelihood of juvenile coho salmon occupying habitats that exceed 16.3° C maximum weekly average temperature declines significantly (Welsh *et al.,* 2001).

Preferred rearing habitat has little or no turbidity and high sustained invertebrate forage production. Juvenile coho salmon feed primarily on drifting terrestrial insects, much of which are produced in the riparian canopy, and on aquatic invertebrates growing in the interstices of the substrate and in the leaf litter within pools. Smolt out-migration for coho salmon begins in late March/early April and usually peaks in mid-May. Although they can range widely in the north Pacific, the oceanic movements of California coho salmon are poorly understood.

The amount of time coho spend in estuarine environments is variable, but the time spent in estuaries may be less in the southern portion of their range (CDFG 2002). The extensive trapping studies of Shapovalov and Taft (1954) indicate that nearly all coho salmon in Waddell Creek (on the California coast south of the Russian River) migrate downstream as yearlings (1+) to enter the marine environment as smolts. Research conducted by Moser *et al.,* (1991), suggests that coho salmon smolt migration through estuaries is slower than riverine migration due to the need for a period of estuarine residency that allows for developmental changes in osmoregulatory capability, orientation for their return migration, feeding, and reduction in vulnerability to predators. After smoltification, estuarine residence times for radio tracked age 1+ coho smolts are often short, and can average 1 to 3 days (Miller and Sadro 2003).

Some coho juveniles will migrate to the estuaries before smolting to rear during the summer, including those in the Russian River. Baker *et al.,* (2025) found coho in the Russian River exhibit two distinct rearing strategies that include a group that migrates to the estuary before smoltification for extended rearing. Miller and Sadro (2003) and Wallace (2006) also report that a portion of YOY coho salmon juveniles move to estuaries during the spring months in Freshwater Creek Slough, Humboldt Bay, and reared there for 11 months. Baker *et al.,* (2025) found that the early migrators represented a greater proportion of adult returns in most years, and suggest that variation in life history strategies increases population stability and is driven by variable environmental conditions. Movement of YOY coho salmon has, alternatively, been attributed to displacement by high spring runoff, freshet events during fry emergence, or over-seeding and displacement of sub-dominant juveniles (Miller and Sadro 2003, Murphy *et al.,* 1997). Information from Miller and Sadro (2003) and Wallace (2006) shows that juvenile coho salmon movements and residency times in estuaries can be complex.

Some of the YOY coho salmon that moved to Oregon's Winchester Creek estuary in the spring were found to remain in the estuary to rear during the summer, and appeared to move further upstream in the estuary as the seasons changed. Miller and Sadro (2003) indicate that rising water temperatures and salinity may cause fish to move upstream in the summer, and higher flows may be responsible for YOY moving out of the estuary in the fall. Similarly, in California's Freshwater Creek, some YOY reared in the estuary during the summer, but they also appeared to move upstream when lower sloughs became saltwater in the late spring and summer (Wallace 2006). YOY coho salmon appeared to move upstream in both estuaries studied when salt content and temperatures rose to similar levels, making either or both reasonable explanations for the observed movements.

NMFS notes that some of the physical conditions in the estuaries discussed above are different in many ways from those in some other coastal California estuaries. For example, the Winchester Creek and Freshwater Creek estuaries are located on wide, flat floodplains with abundant wetlands and sloughs, whereas the Russian River is much more constrained by hillsides near its mouth and it has more limited marsh and slough habitats. Miller and Sadro (2003) indicate that the importance of estuarine rearing to coho salmon populations may be based on the amount of wetland and slough habitats present.

Coho salmon juveniles have been found in other estuaries in coastal California. Small numbers of YOY coho salmon have been found during the summer in the Redwood Creek estuary in Humboldt County in Northern California and in the Albion River estuary in Mendocino County (Maahs and Cannata 1998; S. Cannata, CDFW, personal communication, December 2004). Somewhat larger numbers of coho salmon YOY (roughly 1,000) have been found in Big Lagoon at the terminus of Redwood Creek in Marin County (Golden Gate National Recreation Area 2008).

2.2.2.2 CCC Coho Salmon Viability Assessment

Overall, the available new information since the 2016 viability assessment for CCC coho salmon indicates the extinction risk has not changed appreciably, with slight improvements in the two northern-most diversity strata, but little change in the Coastal Diversity Stratum and perhaps worsening conditions in the Santa Cruz Mountain Stratum. The extinction risk for CCC coho salmon as a whole thus remains high (SWFSC 2023). Based on the 2023 status review, NMFS concluded that the CCC coho salmon ESU remains endangered (NMFS 2023).

The CCC coho salmon ESU is defined as all naturally spawned coho salmon originating from rivers south of Punta Gorda, California, to and including Aptos Creek, as well as such coho salmon originating from tributaries to San Francisco Bay (Figure 14). In accordance with NMFS' 2005 Hatchery Listing Policy (70 FR 37204), the ESU also includes coho salmon from the three following artificial propagation programs: the DCFH Captive Broodstock Program, the Scott Creek/Kingfisher Flat Conservation Program, and the Scott Creek Captive Broodstock Program (70 FR 37159; 77 FR 19552; 85 FR 81822). These artificial propagation programs were included in the listed ESU when it was reclassified as endangered in 2005 (70 FR 37159) and the purpose of the programs are specific to conservation. Therefore, HOR coho salmon from these Programs are included when NMFS considers viability criteria and recovery goals.

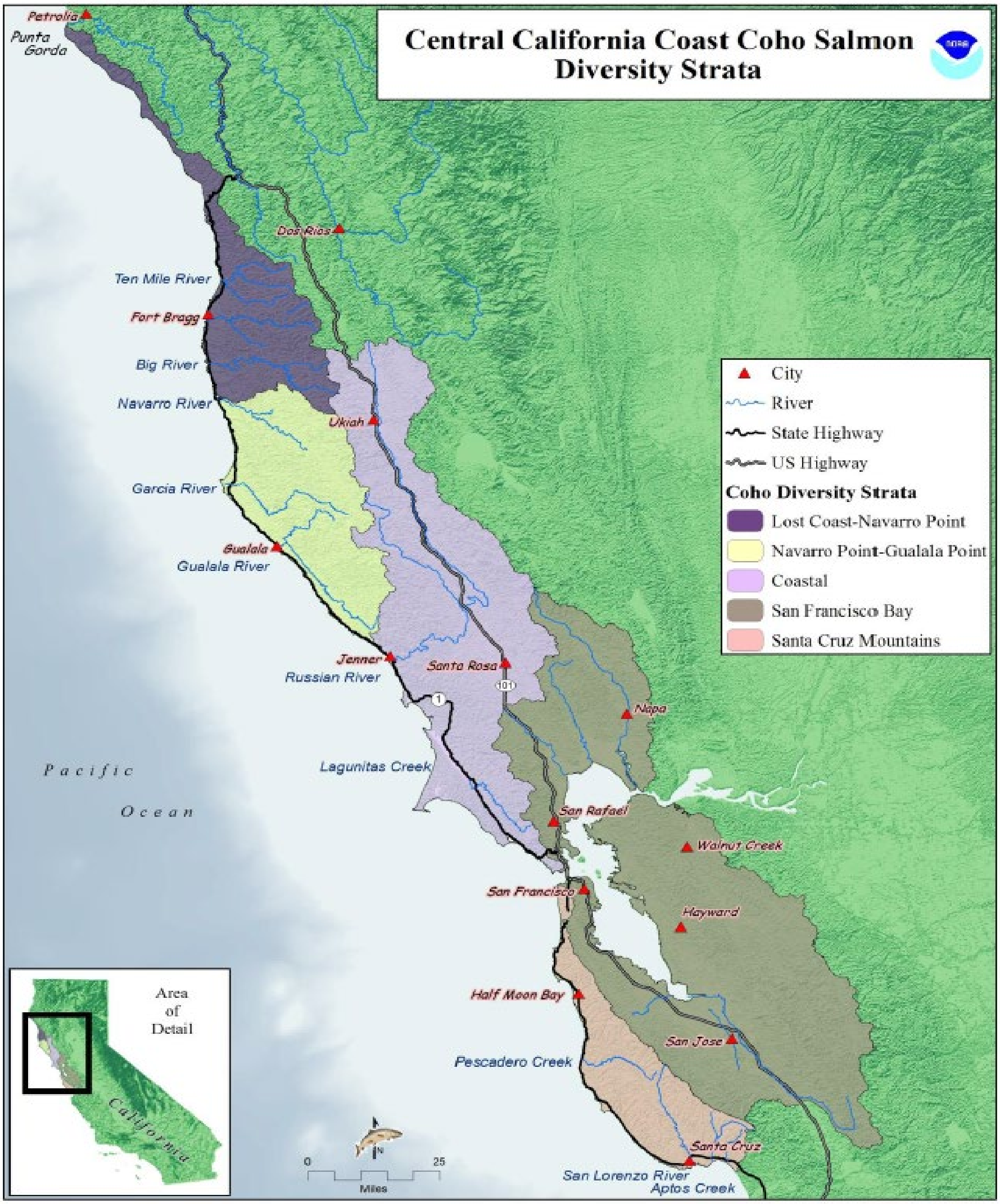

Figure 14. CCC coho salmon ESU and location of the Russian River Population within the Coastal Diversity Strata (NMFS 2012).

Historically, the CCC coho salmon ESU was comprised of approximately 76 coho salmon populations. Most of these were dependent populations that needed immigration from other nearby populations to ensure their long-term survival. There are now 11 functionally independent populations (meaning they have a high likelihood of surviving for 100 years absent anthropogenic impacts) and 1 potentially independent population of CCC coho salmon (Spence *et al*., 2008; Spence *et al*., 2012). Most of the populations in the CCC coho salmon ESU are currently not viable, hampered by low abundance, range constriction, fragmentation, and loss of genetic diversity (Figure 15).

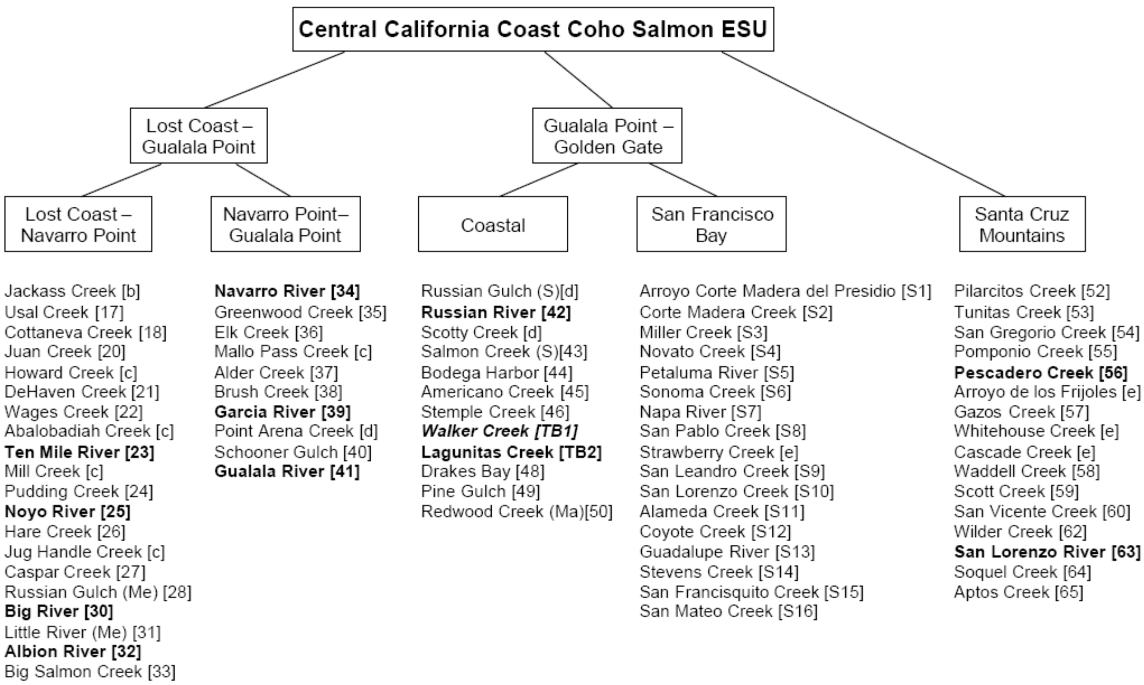

Figure 15. Historical population structure of the CCC coho salmon ESU, arranged by Diversity Strata. Independent populations are in bold, potentially independent populations are in italics and dependent populations are all others (NMFS 2012).

Brown *et al*., (1994) estimated that annual spawning numbers of coho salmon in California ranged between 200,000 and 500,000 fish in the 1940s. Abundance declined further to 100,000 fish by the 1960s, then to an estimated 31,000 fish in 1991. In the next decade, abundance estimates dropped to approximately 600 to 5,500 adults (NMFS 2005a). CCC coho salmon have also experienced acute range restriction and fragmentation. Adams *et al*., (1999) found that in the mid-1990s, coho salmon were present in 51 percent (98 of 191) of the streams where they were historically present, and documented an additional 23 streams within the CCC coho salmon ESU with no historical records. Recent genetic research has documented reduced genetic diversity within subpopulations of the CCC coho salmon ESU (Bjorkstedt *et al*., 2005), likely resulting from interbreeding between hatchery fish and wild stocks.

Available data from the few remaining independent populations suggests population abundance continues to decline, and many independent populations essential to the species' abundance and geographic distributions have been extirpated. This suggests that populations that historically provided support to dependent populations via immigration have not been able to provide enough immigrants to support dependent populations for several decades. The viability of many of the extant independent CCC coho salmon populations over the next couple of decades is of serious concern. These populations may not have sufficient abundance levels to survive additional natural or human caused environmental change.

Lost Coast-Navarro Point and Navarro Point - Gualala Point Diversity Strata -Recent data from the Lost Coast-Navarro Point and Navarro Point-Gualala Point diversity strata suggest a slight improvement in the viability of independent populations since the last status review (NMFS 2023), with most populations having rebounded somewhat since low levels reached during California's multi-year drought between 2012 and 2016.[4] However, for dependent populations in these strata, while the abundance of some populations has improved slightly since the previous status review, long-term trends have generally continued downward and remain a concern. The slight improvement in abundance of some populations is encouraging considering both the extended drought and the unprecedented warm ocean temperatures and associated marine ecosystem impacts that began in 2014 and have persisted most years since (SWFSC 2023).

Abundance estimates for the entire Lost Coast Diversity Stratum, which includes sampling across both independent and dependent populations, indicate that stratum-wide abundance averaged 3,470 fish (range 672–7991) between 2009 and 2018. Reduced sampling during the 2019 precluded generating a stratum-wide estimate for this spawning year. The stratum average is roughly 45 percent of the downlisting spawner target and 22 percent of the delisting spawner target identified for the stratum in the CCC coho salmon recovery plan (NMFS 2012). Overall, the trend in the stratum during this time has been positive and significant (slope = 0.22; p = 0.015) (SWFSC 2023).

Abundance estimates for the Navarro Point Diversity Stratum indicate that stratum-wide abundance averaged 428 fish (range 2–843) between 2009 and 2018. Reduced sampling during the 2019 precluded generating a stratum-wide estimate for this spawning year. Note that these estimates do not include the Gualala River watershed, which has not been monitored. However, coho salmon are believed to be either extirpated or at very low numbers in this watershed. The stratum average is roughly 5 percent of the downlisting spawner target and 3 percent of the delisting spawner target identified for the stratum in the CCC coho salmon recovery plan (NMFS 2012). Overall, no trend in abundance is evident (slope = 0.04; p = 0.84) (SWFSC 2023).

Recently, promising trends have been reported for CCC coho salmon returns along the Mendocino Coast. Monitoring led by CDFW estimated more than 15,000 adult coho salmon returned to spawn during the 2023/24 season. The Ten Mile and Noyo rivers exceeded recovery targets and the Big and Garcia rivers experienced record returns. These robust returns are likely due to the significant long-term investment in restoration projects. Since 2000 NOAA's Office of Habitat Conservation has spent $20.6 million (combined with numerous partner dollars) to support more than 100 restoration projects on the Mendocino Coast.

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[4] California entered another period of drought in 2020. These drought periods are now likely part of a larger drought event in the Southwest US (Williams et al., 2022).

Coastal Diversity Strata - No stratum-wide estimates of abundance are available for the Coastal stratum; however, given the population-level information available, it is clear this stratum is only at a small fraction of its recovery target of 15,300.

The substantial decline in the Russian River coho salmon abundance led to the formation of the RRCSCBP in 2001. Under this program, offspring of wild captive-reared coho salmon are released as juveniles into tributaries within their historic range with the expectation that some of them will return as adults to naturally reproduce. Coho salmon (all life stages, but primarily smolts) have been released into several tributaries within the lower Russian River watershed as well as in Salmon, Walker, and Redwood Creeks (additional detail is provided in the Environmental Baseline Section 2.4.3.2).

Over the 22-year period of record in Lagunitas Creek, the redd count has averaged 247 (range 26–634). Assuming an average spawner:redd ratio of 2:1, this average equates to approximately 20 percent of the recovery target of 2,600 for this population. The population is considered at moderate risk based on the effective population size criterion. The long-term trend is slightly downward, though not significant ($p = 0.216$) (SWFSC 2023). Within the ten-year period from 2011 to 2019, the population appears to have increased from a low reached during the 2009 spawning season. The coho salmon population in Lagunitas Creek rebounded in 2024/25 with 1,186 adults returning, the second-largest run on record (E. Ettlinger, Marin Water, pers comm 2025).

Since 2008, opportunistic spawner surveys have been conducted in Walker Creek, and redd counts have ranged from zero to 39 over that period (E. Ettlinger, Marin Water, personal communication 2025). The inconsistent frequency of surveys precludes formal analysis of these data, but genetic analysis on juveniles collected from Walker Creek in 2017 indicate that parents include fish of both hatchery and natural origin (M. Kittel, CDFW, personal communication).

Population monitoring has also been conducted by the National Park Service for two dependent populations in the stratum: Redwood Creek and Pine Gulch. For Redwood Creek, the average redd count over the last 22 years has been 26 (range 0–90). Assuming a spawner:redd ratio of 2:1, this total represents about 19 percent of the recovery target of 272. In Pine Gulch, very small numbers (range 0–3) of coho salmon were seen intermittently between 2001 and 2012 and again from 2020 through 2024.

Santa Cruz Mountain Diversity Strata - Assessment of independent populations in Santa Cruz Mountain diversity strata remains difficult due to the scarcity of reliable data. The extremely low numbers of coho salmon in the Santa Cruz Mountain diversity stratum, the high dependence of population persistence on the ongoing captive rearing program, and loss of genetic diversity in the hatchery broodstock (which has necessitated infusion of out of-stratum broodstock from DCFH into the program) remain major concerns.

Monitoring of populations in the Santa Cruz Mountain stratum was initiated during the 2012 spawning season and continued through 2019. A conservation hatchery program centered at the Kingfisher Flats Hatchery in the Scott Creek watershed was established in the early 2000s. The program currently operates primarily as a captive broodstock program, with opportunistic inclusion of NOR fish from Scott Creek and neighboring watersheds. In recent years, fish from the RRCSCBP, have also been used as broodstock to help improve genetic diversity. CCC coho smolts have been released into Scott Creek, late-fall parr have been released into Scott Creek and Waddell Creek, and spring parr were released into Gazos Creek and San Vicente Creek. For the two historically independent populations, the San Lorenzo and Pescadero populations, observations of adult coho salmon have been rare since surveys began in 2012. In the San Lorenzo, small numbers (<3) of either live coho salmon or coho salmon carcasses have been observed in 3 of 7 years surveyed during spawner surveys. In addition, in 2014, a total of 19 returning jack males were collected by seine from the lower San Lorenzo River. In Pescadero Creek, three coho salmon carcasses, all of hatchery origin (HOR), were recovered in 2015. The status of dependent populations of CCC coho salmon in the Santa Cruz Mountain stratum is equally precarious. In most years, fewer than 30 adults have returned to the watershed, despite the intensive conservation hatchery effort. It is evident that all dependent populations in this stratum are either extirpated or at critically low levels (SWFSC 2023).

2.2.3 CCC Steelhead - DPS Status

2.2.3.1 Life History of CCC Steelhead

Steelhead spend anywhere from 1 to 5 years in saltwater, however, 2 to 3 years are most common (Busby *et al.,* 1996). Some return as "half-pounders" that over-winter one season in freshwater before returning to the ocean in the spring. Only "winter" steelhead are found in the CCC steelhead ESU. The timing of upstream migration is correlated with seasonal high flows and associated lower water temperatures. Adult CCC steelhead begin returning in December, with the run continuing into April. The minimum stream depth necessary for successful upstream migration is about 13 cm (Thompson 1972). The preferred water velocity for upstream migration is in the range of 1.3-3.0 ft/s, with a maximum velocity, beyond which upstream migration is not likely to occur, of 8.0 ft/s (Thompson 1972).

Most spawning takes place from January through April. Steelhead may spawn more than one season before dying (iteroparity), in contrast to other species of the genus *Oncorhynchus*. Most adult steelhead in a run are first time spawners, although Shapovalov and Taft (1954) reported that repeat spawners are relatively numerous (about 17 percent) in California streams. Because rearing juvenile steelhead reside in freshwater all year, adequate flow and temperature are important to the population at all times. Generally, throughout their range in California, steelhead that are successful in surviving to adulthood spend at least 2 years in freshwater before emigrating downstream. Steelhead spawn in cool, clear streams featuring suitable water depth, gravel size, and current velocity. Intermittent streams may be used for spawning (Everest 1973; Barnhart 1986). Reiser and Bjornn (1979) found that gravels of 0.5-4.6 inches in diameter were preferred by steelhead. The survival of embryos is reduced when fines smaller than 6.4 millimeters (mm) comprise 20 to 25 percent of the substrate. Studies have shown a higher survival of embryos when intragravel velocities exceed 0.7 ft/hr (Coble 1961; Phillips and Campbell 1961). The number of days required for steelhead eggs to hatch is inversely proportional to water temperature and varies from about 19 days at 15.6ºC to about 80 days at 5.6ºC. Fry typically emerge from the gravel 2 to 3 weeks after hatching (Barnhart 1986).

Upon emerging from the gravel, fry rear in edgewater habitats and move gradually into pools and riffles as they grow larger. Instream cover is an important habitat component for juvenile steelhead both as velocity refuge and as a means of avoiding predation (Meehan 1991). However, steelhead tend to use riffles and other habitats not strongly associated with cover more than other salmonids during summer rearing. Young steelhead feed on a wide variety of aquatic and terrestrial insects, and emerging fry are sometimes preyed upon by older juveniles. In winter, they become inactive and hide in any available cover, including gravel or woody debris. Water temperature influences juvenile steelhead growth rates, population density, swimming ability, and their abilities to capture and metabolize food, and withstand disease (Barnhart 1986; Bjornn and Reiser 1991). Rearing steelhead juveniles prefer water temperatures of 7.2-14.4ºC and have an upper lethal limit of 23.9ºC. However, they can survive short periods up to 27ºC with saturated DO conditions and a plentiful food supply. Fluctuating diurnal water temperatures also aid in survivability of salmonids (Busby *et al.,* 1996).

DO levels of 6.5-7.0 ppm affect the migration and swimming performance of steelhead juveniles at all temperatures (Davis *et al.,* 1963). Reiser and Bjornn (1979) recommended that DO concentrations remain at or near saturation levels with temporary reductions no lower than 5.0 mg/l for successful rearing of juvenile steelhead. Low DO levels decrease juvenile steelhead swimming speed, growth rate, food consumption rate, efficiency of food utilization, threat avoidance behavior, and ultimately survival.

During rearing, suspended and deposited fine sediments can directly affect salmonids by abrading and clogging gills, and indirectly cause reduced feeding, avoidance reactions, destruction of food supplies, reduced egg and alevin survival, and changed rearing habitat (Reiser and Bjornn 1979). Newcombe and Jensen (1996) found that turbidity measurements of 1.7 to 490 nephelometric turbidity units (NTU, converted from suspended sediment mg/L) represent potential sub-lethal thresholds, while turbidity measurements of greater than 490 NTU represent potential lethal thresholds for rearing juvenile salmonids.

Because rearing juvenile steelhead often migrate downstream in search of available freshwater habitat (Bjornn 1971), significant percentages of the juvenile steelhead population can end up rearing in coastal lagoons and estuaries (Zedonis 1992; Shapovalov and Taft 1954). The migration of juvenile steelhead to lagoons occurs throughout the year, but is concentrated in the late spring/early summer and in the late fall/early winter period (Zedonis 1992; Shapovalov and Taft 1954). For populations along the coast, estuarine habitats consist primarily of seasonal, "bar-built" lagoons. The lagoons form in spring or summer as sandbars form separating the freshwater and marine environments. The lagoons provide a highly productive environment where rearing juvenile salmonids can experience rapid growth and where the brackish waters provide an opportunity for them to acclimate to saltwater prior to ocean entry. If estuarine or coastal lagoon rearing habitat is unavailable or of poor quality, the potential survival of these emigrants is low. Past and present development for other land use activities and water resource development has decreased lagoon habitat extent and quality. In addition, management of lagoons throughout the DPS, such as sandbar breaching for flood control, recreation, and access, has altered natural lagoon function and the quality of rearing habitat (NMFS 2016b).

Two discrete groups of juvenile steelhead utilize different kinds of habitat provided by lagoons: steelhead juveniles that use coastal lagoons for freshwater rearing throughout the year, and smolts that drop down from the watershed and use the lagoon primarily in the spring prior to seawater entry (Boughton *et al.,* 2017). Freshwater acclimated juveniles, especially those of small size such as YOY, are unlikely to be able to survive for long periods of time in the salt water environments of estuaries that are open to the ocean. McCormick (1994) indicates that steelhead juveniles need to be 2+ in age (or 0.8 inches in size) to be able to withstand full seawater (35 ppt). Survival time increases with juvenile size and decreases with salt concentration. For example, YOY rainbow trout/steelhead (3.1 to 3.9 in) exposed to 25 ppt salinity were able to survive for about 19 hours, while larger age 2+ steelhead/rainbow trout (5.9-7.9 in) were unaffected for the duration of the experiment (Parry 1960).

Small freshwater-acclimated steelhead juveniles are likely to avoid salt water and brackish environments, and while they can be acclimated to brackish water, their growth is likely hindered. In the Navarro River estuary north of the Russian River, steelhead juveniles segregated by size when the estuary was open to the ocean. YOY and age 1+ juveniles were found mostly in the upper areas of the estuary (a few were found in the middle area), where salinity in the surface layers remained lower and was less influenced by tidal action (Cannata 1998). In the Mattole River lagoon, juvenile movement to the upper areas of the lagoon in one year was attributed to substantial salt water overwash into the lower lagoon (Zedonis 1992). In Redwood Creek, the substantial decrease in steelhead numbers in the estuary following breaching was likely caused, in part, by the sudden shift from fresh to saltwater (Larson 1987). Steelhead juveniles can be acclimated to different concentrations of salt water if done relatively slowly. Morgan and Iwama (1991) acclimated steelhead fry and juveniles to 4, 8, 12, and 16 ppt salinity by raising salinities 1 to 2 ppt per day with less than five percent mortality. Nevertheless, growth rates declined as salinity increased. Steelhead growth rates declined 16 percent over the range of salinities tested. The distribution of juveniles seen in the lagoons described above, and the avoidance of salt water by smaller juveniles indicates that saltwater acclimation, especially for YOY, is not the norm in tidally influenced (or overwashed) estuaries in Northern California.

Smoltification appears to be triggered by changes in photoperiod combined with sufficient body size suitable for survival in the ocean (Handeland and Stefansson 2002; Satterthwaite *et al.*, 2009; Beakes *et al*., 2010). Other cues including temperature, stream flow, and lunar phase may combine with photoperiod to cue the timing of downstream migration to brackish waters after smoltification (Spence and Dick 2014).

2.2.3.2 Viability Assessment for CCC Steelhead

The CCC steelhead DPS includes naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from the Russian River to and including Aptos Creek, and all drainages of San Francisco and San Pablo Bays eastward to Chipps Island at the confluence of the Sacramento and San Joaquin Rivers (Figure 16). This also includes steelhead from the DCFH, CVFF, and Kingfisher Flat Hatchery Program. The hatchery fish from the DCFH and CVFF (and Kingfisher) are included in the listing, but the ESA Section 9 take prohibitions are not applied to these fish. These hatchery fish are considered surplus and not essential to the conservation of the DPS. They are fin clipped to facilitate identification by anglers, who may keep these fish. The Russian River is the largest drainage in the CCC steelhead DPS.

Historically, approximately 70 populations[5] of steelhead existed in the CCC steelhead DPS (Spence et al., 2008; Spence et al., 2012). About 37 of these were considered independent, or potentially independent (Bjorkstedt et al., 2005). The remaining populations were dependent upon immigration from nearby CCC steelhead DPS populations to ensure their viability (McElhaney et al., 2000; Bjorkstedt et al., 2005). The Russian River contains multiple dependent and independent populations across two diversity strata (Interior and North Coastal, Figure 16).

While data availability for this DPS remains generally poor, the new information for CCC steelhead available since the previous viability assessment (Spence 2016) indicates that overall extinction risk is moderate and has not changed appreciably since the prior assessment (SWFSC 2023). Although conservation efforts for CCC steelhead have reduced some threats for this DPS, most threats remain unchanged since the previous 5-year review. In addition, increased risks of wildfires, drought, and poor ocean conditions are likely to continue and worsen. Based on the 2024 status review, NMFS concluded that the CCC steelhead DPS remains threatened (NMFS 2024b).

[5] Population is defined by Bjorkstedt et al., 2005 and McElhaney et al., 2000 as, in brief summary, a group of fish of the same species that spawns in a particular locality at a particular season and does not interbreed substantially with fish from any other group. Such fish groups may include more than one stream.

Figure 16. The CCC steelhead DPS, and the location of the Russian River within the two diversity strata (Interior and North Coastal) (NMFS 2024b).

Information on the abundance of adult steelhead in the CCC steelhead DPS remains relatively scarce. Population-level estimates of adult abundance are entirely lacking for the 25 independent populations in the North Coastal, Interior, Coastal San Francisco Bay, and Interior San Francisco Bay diversity strata identified as essential or supporting in the Federal recovery plan. A recently initiated program in the Russian River basin provides aggregate estimates of abundance for multiple independent and dependent populations within the basin, which has improved our understanding of basin-wide steelhead abundance, but the sample frame has changed through time; thus, the ability to analyze trends is limited. A few survey efforts that are targeting coho salmon do collect data on steelhead as well, but generally surveys do not encompass the entire spawning space or season for steelhead. Implementation of the CMP in the Santa Cruz Mountain stratum has been intermittent, and difficulties in assigning redds to species (steelhead versus coho salmon) confound interpretation of these data. The LCM station in Scott Creek, which has operated since 2002, provides the only data for examining longer-term trends in abundance. The lack of data continues to make it very difficult to assess the status, trends, and viability of populations in the DPS. The limited available information is summarized below by diversity stratum.

North Coastal and Interior Strata - The North Coastal stratum includes tributaries in the lower Russian River watershed downstream of the confluence of Mark West Creek, as well as coastal watersheds of Sonoma and Marin counties. The Interior Stratum includes the Russian River and its tributaries upstream of the Mark West confluence (additional detail is provided in the Environmental Baseline Section 2.4.3.3). Spawner surveys have also been conducted in the Lagunitas Creek watershed since 2002; however, these target coho salmon and are not considered reliable indicators of steelhead trends (SWFSC 2023).

Coastal San Francisco Bay Stratum - Population-level estimates of adult abundance for CCC steelhead are not available for any of the six independent or two dependent populations within this stratum identified as essential or supporting in the Federal recovery plan (NMFS 2016d). However, since the previous viability assessment, several new monitoring programs have been initiated. In the Guadalupe River, juvenile surveys have been conducted since 2015, which have documented the occurrence of juvenile *O. mykiss* in several tributaries. Additionally, in 2018 and 2019, a VAKI camera was operated at the Alamitos fish ladder to detect migrating salmonids. Several large *O mykiss* (>500 mm) were observed in 2018, indicating the presence of steelhead. Spawner surveys have been conducted in San Mateo Creek downstream of Lower Crystal Springs Reservoir each year since 2015. Redd counts have ranged from 6 to 31; however, no live fish or carcasses have been observed that would confirm the presence of anadromous *O. mykiss*. Juvenile surveys have also been conducted in Stevens Creek since 2013 that have documented the continued presence of juvenile *O. mykiss* in the creek. Collectively, while useful for confirming the continued presence of *O. mykiss* in these watersheds and supporting management actions in these watersheds, these new surveys do not provide the level of information needed to evaluate whether there has been any change in viability across the stratum (SWFSC 2023).

Interior San Francisco Bay Stratum - Population-level estimates of adult abundance are also lacking for all nine independent populations and three dependent populations of CCC steelhead in the Interior San Francisco Bay Stratum identified as essential or supporting in the Federal recovery plan. Spawner surveys primarily targeting Chinook salmon (but occasionally steelhead) have been conducted in recent years in selected portions of the Napa River watershed and its tributaries. These efforts have produced occasional observations of steelhead redds, live fish, or carcasses. Additionally, a rotary screw trap operated near the upper limit of tidal influence has resulted in capture of 31 to 242 smolts annually since 2009. Smolt trap efficiency has averaged about 12 percent during this period, suggesting that total smolt production has generally ranged from a few hundred to perhaps 2,000 fish. Likewise, limited spawner surveys in selected tributaries of the Petaluma River produced observations of small numbers of live steelhead, carcasses, and redds in Adobe and Lichau creeks. Again, these limited surveys confirm steelhead presence in the watershed, but do not allow conclusions to be drawn about current viability.

In Pinole Creek, redd counts ranged from 7 to 24 between 2017 to 2020. Although no adult steelhead or carcasses were observed during the surveys and the majority of redds were small in size and thus presumed to have been made by resident *O. mykiss*, from 1 to 5 redds were classified each year as likely having been produced by anadromous fish based on redd characteristics. Summer snorkel surveys conducted in Suisun Creek documented occurrence of *O. mykiss* in 2017. In the Alameda Creek, resident *O. mykiss* continue to persist in the upper watershed. However, a 12-ft concrete drop structure known as the BART weir located approximately 10.5 miles upstream of the creek mouth blocked passage by anadromous fish since its construction in the 1970s until 2022. Fish ladders at the BART weir were completed in late 2022 (Alameda County Water District 2023), which allows access to more than 20 miles of spawning and rearing habitat upstream. Finally, in Coyote Creek, surveys have been conducted at sites up to 5.5 miles downstream of Anderson Dam (impassable to upstream-migrating salmonids) in summer or fall each year since 2014. These surveys documented low numbers of YOY in some, but not all years. A video camera was also installed in Coyote Creek at the Coyote Percolation Dam fish ladder in 2019 and 2020 to monitor adult salmonids, but no steelhead were detected (SWFSC 2023).

Santa Cruz Mountains Stratum - Population-level estimates of abundance for populations in the Santa Cruz Mountain Stratum remain scarce. Evaluating changes in status of both independent and dependent populations within the Santa Cruz Mountain diversity stratum remains extremely challenging due primarily to uncertainty associated with methods for assigning redds to species. Scott Creek remains the only population for which robust estimates are available for more than a few years, and while the population appeared to be declining, a sizable return in 2019 indicates that the population is somewhat resilient. Adult steelhead populations in the San Lorenzo River and Pescadero Creek appear to typically number in the low hundreds of fish, while other independent populations appear to number in the tens of fish. Two dependent populations (Gazos and San Vicente creeks) likewise appear to number in the tens of adult steelhead in most years, with considerable variation in numbers among years. Though uncertainty remains high for nearly all of these populations, it is clear that they are well below recovery targets (SWFSC 2023).

2.2.4 Status of Salmonid Critical Habitat

The primary purpose of this section is to identify the current function of critical habitats within the ESU or DPS of each species to support the intended conservation role for each species. Such information is important for an adverse modification analysis because it establishes the context for the evaluation of any effects that the Proposed Action may have on critical habitat.

Critical habitat for the CCC coho salmon ESU encompasses all accessible river reaches within the ESU (i.e., from Punta Gorda south to the San Lorenzo River), including two streams entering San Francisco Bay: Arroyo Corte Madera del Presidio and Corte Madera Creek. Critical habitat consists of all waterways, substrate, and adjacent riparian zones below long-standing, naturally-impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). Areas specifically excluded from critical habitat included historically-occupied habitat upstream of Indian tribal lands and specific dams (including WSD and CVD) identified in the FR notice designating critical habitat for CCC coho (64 FR 24049).

Critical habitat for CCC steelhead DPS was designated within the current freshwater and estuarine range inhabited by the DPS (i.e., from the Russian River (inclusive) south to Aptos Creek (inclusive), including the San Francisco Bay tributaries). 1,465 miles of streams were designated as critical habitat. (70 FR 52488). Certain Indian lands were excluded from designation for reasons articulated in the final rule (Id. at 52525-6). Approximately 367 stream miles and 56 square miles (mi^2) of estuarine habitat were excluded because the economic benefits of exclusion outweighed the benefits of designation (Id. at 52530).

Critical habitat for the CC Chinook salmon ESU consists of naturally-spawned Chinook salmon originating from rivers and streams south of the Klamath River to and including the Russian River. The Russian River basin presently contains the southernmost persistent population of Chinook salmon on the California coast (70 FR 52488).

When it designated critical habitat for steelhead and Chinook salmon, NMFS developed a list of PBFs specific to these species ((70 FR 52629; September 2, 2005; NMFS 2005a). These PBFs include sites essential to support one or more of the life stages of the species to which it applies (*i.e.*, sites for spawning, rearing, migration and foraging). These sites in turn contain PBFs essential to the conservation of the species (for example, spawning gravels, water quality and quantity, side channels, forage species). Specific types of sites and the features associated with them include, but are not limited to the following:

1. Freshwater migration corridors free of obstruction with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.

2. Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation, and larval development.

3. Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

4. Estuarine areas free of obstruction with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

NMFS developed a similar list of species PBFs for CCC coho salmon (64 FR 24049):

1. Juvenile summer and winter rearing areas,
2. Juvenile migration corridors,
3. Areas for growth and development to adulthood,
4. Adult migration corridors, and
5. Spawning areas.

Within these areas, PBFs of coho salmon critical habitat include adequate: (1) substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food, (8) riparian vegetation, (9) space, and (10) safe passage conditions.

2.2.5 Factors and Threats Affecting Salmonids and their Critical Habitat

2.2.5.1 Freshwater Habitat Degradation

The coastal drainages used by the CCC coho salmon and CC Chinook salmon ESU and CCC steelhead DPS provide relatively higher amounts of the freshwater rearing PBFs, maintain connectivity, and result in a wider distribution of the species in these drainages than in inland drainages. Inland drainages provide important freshwater migration corridors, freshwater spawning, and freshwater rearing PBFs unique within the inland ecotype. However, most areas of critical habitat in both coastal and inland drainages have been degraded compared to conditions that once supported thriving populations of salmonids and steelhead.

The condition of freshwater habitats has been degraded from conditions known to support viable salmonid populations. NMFS has determined that present depressed population conditions are, in part, the result of the following human-induced factors affecting habitat (including critical habitat): logging, agricultural and mining activities, urbanization, stream channelization, dams, wetland loss, and water withdrawals, including unscreened diversions for irrigation. Impacts of concern include alteration of stream bank and channel morphology, alteration of water temperatures, loss of spawning and rearing habitat, fragmentation of habitat, loss of downstream recruitment of spawning gravels and large woody debris, degradation of water quality, removal of riparian vegetation resulting in increased stream bank erosion, increases in erosion entry to streams from upland areas, loss of shade (higher water temperatures) and loss of nutrient inputs (Busby *et al.,* 1996; 69 FR 33102; 70 FR 52488). Depletion and storage of natural river and stream flows have drastically altered natural hydrologic cycles in many of the streams in the ESU. Alteration of flows have caused migration delays, loss of suitable habitat due to dewatering, stranding of fish from rapid flow fluctuations, entrainment of juveniles into poorly screened or unscreened diversions, and increased water temperatures harmful to salmonids.

Widespread water diversions in rivers and streams, as well as the pumping of groundwater hydraulically connected to streamflow, has dramatically altered the natural hydrologic cycle in many of the streams within the CCC coho salmon and CC Chinook salmon ESU and CCC steelhead DPS which can delay or preclude migration and dewater aquatic habitat. Stream channelization, commonly caused by streambank hardening and stabilization, represents a very high threat to instream and floodplain habitat throughout much of the designated critical habitat for these species, as detailed within recovery plans (NMFS 2012, 2016a). Streambank stabilization confines stream channels and precludes natural channel movement, resulting in increased streambed incision, reduced habitat volume and complexity.

2.2.5.2 Climate and Ocean

Another factor affecting the range-wide status of CCC steelhead, coho salmon, CC Chinook salmon, 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).

Impacts from global climate change are already occurring in California. For example, 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).[6] Other current detrimental impacts from climate change include lower and more variable stream flows, warmer stream temperatures, and changes in ocean conditions. California experienced well below average precipitation during the 2012-2016 drought, as well as record high surface air temperatures in 2014 and 2015, and record low snowpack in 2015 (Williams et al., 2016). Paleoclimate reconstructions suggest the 2012-2016 drought was the most extreme in the past 500 to 1000 years (Williams et al., 2016, 2020, 2022). Anomalously high surface temperatures substantially amplified annual water deficits during 2012-2016. California experienced another period of extreme drought from 2020-2022. 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 (Williams et al., 2019, 2020, 2022; Diffenbaugh et al., 2015).

The threat to listed salmonids and steelhead 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.,

[6] CCC coho salmon and CCC steelhead considered in this Opinion have few (if any) populations associated with streams heavily affected by snowmelt. Some CC Chinook Salmon populations do dwell in snowmelt streams.

2018). Estuarine productivity is likely to change based on changes in freshwater flows, nutrient cycling, and sediment amounts (Scavia et al., 2002; Ruggiero et al., 2010).

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; Brewer and Barry 2008; 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 (Beamish 2018). 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.

Ocean conditions remain a critical component to survival and reproductive success of salmon who spend the majority of their lives in the ocean. Northern anchovy possesses thiaminase, an enzyme that breaks down vitamin B1, and diets high in northern anchovy can cause thiamine deficiency complex (TDC) in their consumers, which can appear as high mortality or serious sublethal effects in subsequent progeny (SWFSC 2023). Thiamine deficiency can occur in adult chinook salmon and influence reproductive success and health of their progeny (Harder *et al.,* 2018). In fall and winter of 2019, Chinook salmon populations in the Central Valley of California (fall-, spring-, and late fall-run) were diagnosed with TDC. This diagnosis was based on high rates of early life stage mortality observed in hatcheries and rapid recovery of juveniles exhibiting aberrant swimming behaviors following thiamine treatment by USAFS California-Nevada Fish Health Center. The primary hypothesis for thiamine deficiency in Central Valley salmon is that a reorganization of food webs in the central California Current resulted in the dominance of northern anchovy in salmon diets.

Current research is underway to better understand this emerging stressor and potential treatment options to mitigate these nutritional deficiencies. To assess TDC and its effects over time, since 2020 egg thiamine levels have been systematically measured at various hatcheries in central and northern California. Unfertilized eggs from mature Chinook salmon, steelhead, and coho salmon were collected across California to measure thiamine concentrations. This ongoing surveillance has shown a rising incidence of TDC in nearly all populations in California’s Central Valley and coastal hatcheries. Specifically, CCC steelhead from WSFH were found to be severely impacted from 2022-2023. Additionally, laboratory studies have investigated the relationship between egg thiamine concentration and offspring survival, helping to understand population-level impacts of thiamine-dependent mortalities (https://oceanview.pfeg.noaa.gov/projects/salmon_thiamine/intro accessed August 8, 2024).

2.2.5.3 Artificial Propagation

Releasing large numbers of hatchery fish can pose threats to salmonid stocks through genetic impacts, competition for food and other resources, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). The genetic impacts of artificial propagation programs are primarily caused by the straying of genetically distinct hatchery fish and the subsequent hybridization of hatchery and wild fish. Artificial propagation threatens the genetic integrity and diversity that protect overall productivity against changes in the environment (see species status sections above for additional detail).

2.2.5.4 Reduced Marine-Derived Nutrient Transport

Reduction of marine-derived nutrients (MDN) to watersheds is a consequence of the past century of decline in salmon abundance (Gresh *et al.,* 2000). MDN are nutrients that are accumulated in the biomass of salmonids while they are in the ocean and are then transported to their freshwater spawning sites. Salmonids may play a critical role in sustaining the quality of habitats essential to the survival of their own species. MDN (from salmon carcasses) has been shown to be vital for the growth of juvenile salmonids (Bilby *et al.,* 1996, 1998). The return of salmonids to rivers can make a significant contribution to the flora and fauna of both terrestrial and riverine ecosystems (Gresh *et al.,* 2000). Evidence of the role of MDN and energy in ecosystems suggests this deficit may result in an ecosystem failure contributing to the downward spiral of salmonid abundance (Bilby *et al.,* 1996). The loss of this nutrient source may perpetuate salmonid declines in an increasing synergistic fashion.

2.2.5.5 Marine Mammal Predation

The three main pinniped predators of ESA-listed salmonids in the eastern Pacific Ocean are harbor seals (*Phoca vitulina richardii*), California sea lions (*Zalophus californianus*), and Steller sea lions (*Eumetopias jubatus*). With the passing of the Marine Mammal Protection Act in 1972, these pinniped stocks along the West Coast of the United States have steadily increased in abundance (Carretta *et al.,* 2024). With their increasing numbers and expanded geographical range, marine mammals are consuming more Pacific salmon and steelhead, and some are having an adverse impact on some ESA-listed species (Marshall *et al.,* 2016; Chasco *et al.*, 2017a; Thomas et al., 2017).

Chasco *et al.,* (2017a) estimated that by 2015, seals and sea lions (pinnipeds) consumed double the amount of Chinook salmon consumed by Southern Resident killer whales and six times the combined commercial and recreational catches. Chasco *et al.,* (2017a) 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 U.S. West Coast. Chasco *et al.,* (2017a) determined that the number of individual salmon, including smolts, consumed annually by marine mammals in the entire Northeast Pacific has increased by 6-fold between 1975-2015, likely to be primarily a result of increasing populations of sea lions and harbor seals.

Most authors have focused research on Chinook salmon because they have the highest energy value for predators (O'Neill et al., 2014). However, some study authors have found that pinnipeds like harbor seals can have a significant impact on other species of salmon (Thomas et al., 2017) and steelhead (Moore et al., 2021) through the consumption of outmigrating juveniles.

Harbor seal predation data specific to California is not currently available, so whether predation of outmigrating juveniles is a threat to ESA-listed salmonids in California rivers and estuaries is currently unknown.

2.2.6 Life History of Southern Resident Killer Whales

SRKW are included in this Opinion since Chinook salmon are a primary prey for SRKW in the Pacific Ocean. This link results in effects in the Pacific Ocean where SRKWs feed on concentrations of adult Chinook salmon (Hanson et al., 2021; NMFS 2021d).

Southern Resident killer whales (SRKWs) are an ecotype of fish-eating killer whales in the eastern North Pacific. The SRKW DPS, composed of J, K, and L pods, was listed as endangered under the ESA on November 18, 2005 (70 FR 69903). A 5-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 publications (NMFS 2021a).

Killer whales, including SRKWs, are a long-lived species and sexual maturity can occur at age 10 (NMFS 2008b). 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).

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 (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 in a single day (Baird 2000; Erickson 1978), 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 2021a; 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., 2010; 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 and Emmons 2010; Olson et al., 2018; NMFS 2021b) with late arrivals and fewer days present in recent years (NMFS 2021a; Ettinger et al., 2022; Shields 2023; Stewart et al., 2023).

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). Satellite-linked tags deployed on nine male SRKW from 2012 to 2016 revealed that members from K and L pods spent the majority of their time in coastal waters from late December to mid-May, whereas members from J pod generally spent more time in the inland waters of Washington and British Columbia (Hanson et al., 2017). Passive acoustic recorders were deployed off the coasts of California, Oregon and Washington in most years since 2006 to assess SRKW seasonal uses of these areas via the recording of stereotypic calls of the SRKWs (Hanson et al., 2013; Emmons et al., 2019). Between 2014-2017, 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). Together, these SRKW sightings have confirmed their presence as far north as Chatham Strait, off southeast Alaska, and as far south as Monterey Bay, California (NMFS 2021c).

SRKWs consume a variety of fish species (22 species) and one species of squid (Ford et al., 1998; Ford et al., 2000; Ford and Ellis, 2006; Hanson et al., 2010; Ford et al., 2016) but salmon are identified as their primary prey. The best available information suggests an overall preference for Chinook salmon during the summer and fall. Chum (*O. keta*), coho, 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 and Ellis 2006); however, these data may underestimate the extent of feeding on bottom fish (Baird 2000). A number of smaller flatfish, lingcod (*Ophiodon elongatus*), greenling (*Hexagrammos* spp.), and squid have been identified in stomach content analysis of resident whales (Ford et al., 1998).

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 3 and up) Chinook salmon. Chinook salmon is their primary prey despite the much lower abundance in comparison to other salmonids in some areas and during certain time periods. Factors of potential importance include the Chinook salmon's large size, high fat and energy content, and year-round occurrence in the whales' geographic range. Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (kilocalorie/kilogram (kcal/kg)) (O'Neill et al., 2014). 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. 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 percent) (Hanson et al., 2010, Ford et al., 2016). Genetic analysis of the Hanson et al., (2010) 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; Hanson et al., 2021). Results indicate that, as is the case in inland waters, Chinook salmon are the primary species detected in diet samples on the outer coast, although steelhead, chum salmon, and Pacific halibut were also detected in samples. Foraging on chum and coho salmon, steelhead, Big skate (*Rana binoculata*) and lingcod was also detected in recent fecal samples (Hanson et al., 2021). The occurrence of K and L pods off the Columbia River in March suggests the importance of Columbia River spring runs of Chinook salmon in their diet (Hanson et al., 2013). Chinook salmon genetic stock identification from samples collected in winter and spring in coastal waters from California through Washington included 12 U.S. west coast stocks, and showed that over half the Chinook salmon consumed originated in the Columbia River (Hanson et al., 2021). Columbia River, Central Valley, Puget Sound, and Fraser River Chinook salmon collectively comprise over 90 percent 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 17). 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).

Chinook salmon are a very important part of the SRKW diet; Hilborn et al., (2012), Hanson et al., (2013), Hanson et al., (2021), 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 so more work is needed to determine the extent to which Chinook salmon abundance impacts different SRKW vital rates. Hilborn et al., (2012) found that, though 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.

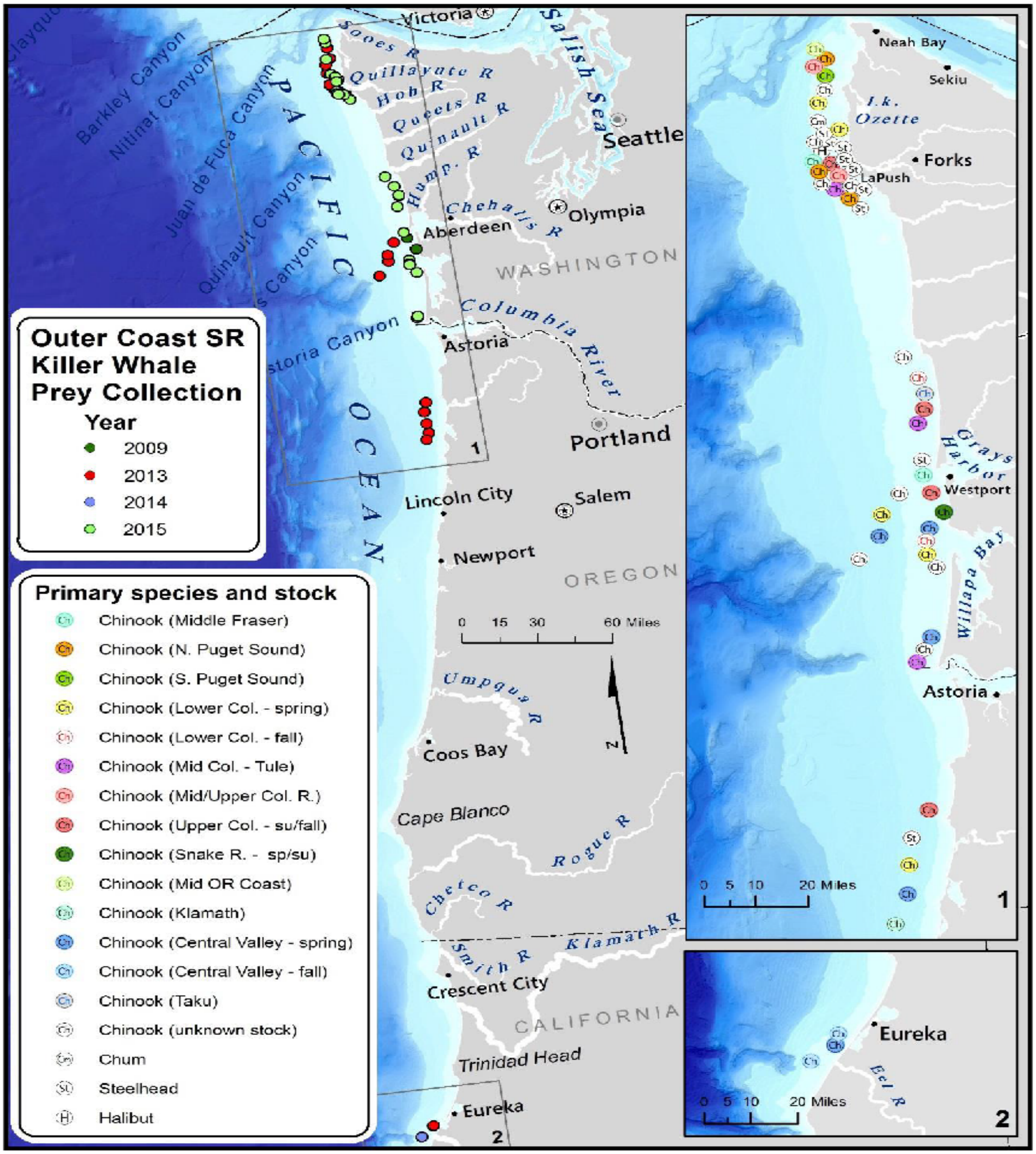

Figure 17. Location and species for scale/tissue samples collected from SRKW predation events in outer coastal waters (stock IDs are considered preliminary) (NMFS 2021c).

2.2.7 Southern Resident Killer Whale Viability Assessment

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 18). At the time of the 2024 summer census, the Center for Whale Research reported 73 SRKWs in the population (CWR 2024) (Figure 18). Since the 2024 census, one adult male is presumed dead and one new calf has survived, so the population size remains 73 individuals. The previously published historical estimated abundance of SRKWs was 140 animals (NMFS 2008b), 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.

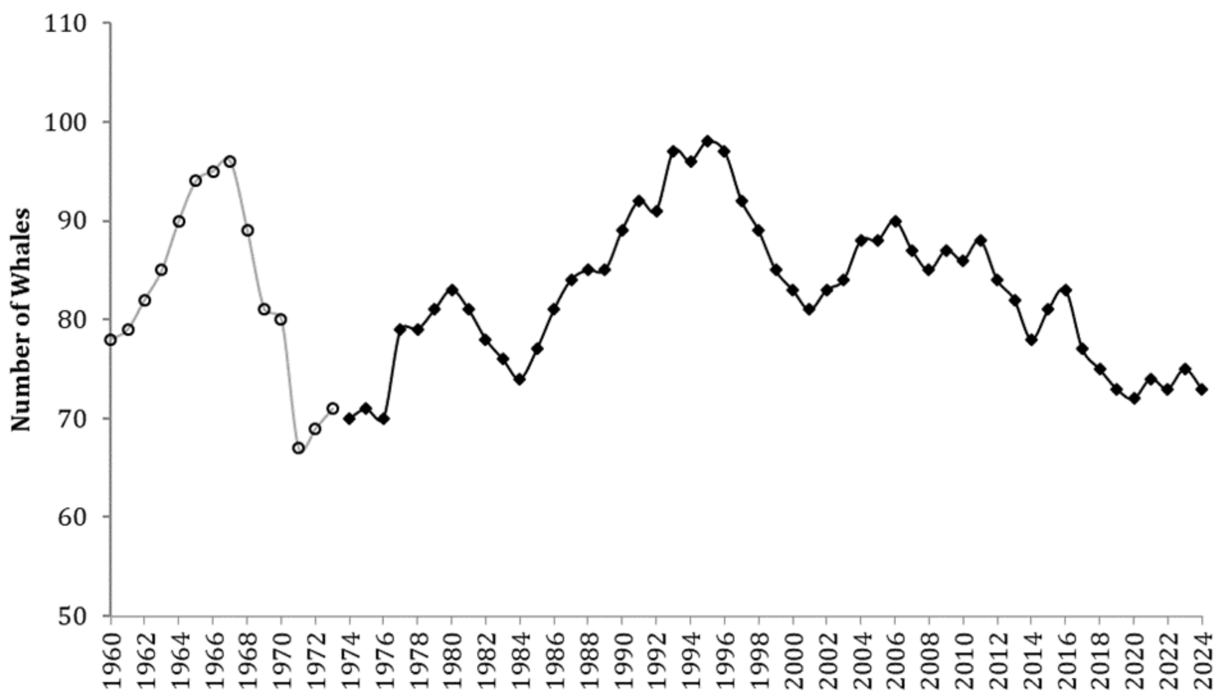

Figure 18. Population size and trend of SRKWs, 1960-2024. Data from 1960-1973 (open circles, gray line) are number projections from the matrix model of Olesiuk et al., (1990). Data from 1974-2024 (diamonds, black line) provided by the CWR (unpublished data) and NMFS (2008b). Data for these years represent the number of whales present at the end of each calendar year, or after the summer census for 2012 onwards.

Seasonal mortality rates among SRKWs and NRKWs may be highest during the winter and early spring, based on strandings 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 (Center for Whale Research (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).

The 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 5-year status reviews (NMFS 2011a; 2016e; 2021a). Subsequently, population estimates, including data from five recent years (2017-2021), project a downward trend over the next 25 years (Figure 18). 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 percent male and 45 percent female following current trends), but also related to the relatively low fecundity rate observed over the period from 2017 to 2021. 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). 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 (2017-2021) survival and fecundity rates may be a more reliable estimation if current levels of survival and poor reproduction continue. 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. 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.

Another factor to consider is the potential effects of inbreeding (generally a risk for any small population). 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).

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. Sources of random environmental variation in combination with demographic stochasticity amplify the probability of extinction (Gilpin and Soulé 1986; Fagan and Holmes 2006; Melbourne and Hastings 2008). The larger the population size, the greater the buffer against stochastic events and genetic risks.

Individual variation in reproductive success can also influence broader population growth or decline, especially for smaller, more isolated populations such as the SRKW (Coulson *et al.,* 2006). 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, and 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 19).

Additionally, 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). Fecal hormone data from SRKWs showed that up to 69 percent of detected pregnancies do not produce a documented calf. Recent aerial imagery corroborates this high rate of loss (Fearnbach and Durban 2021). This trend of declining female fecundity at age 20 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.

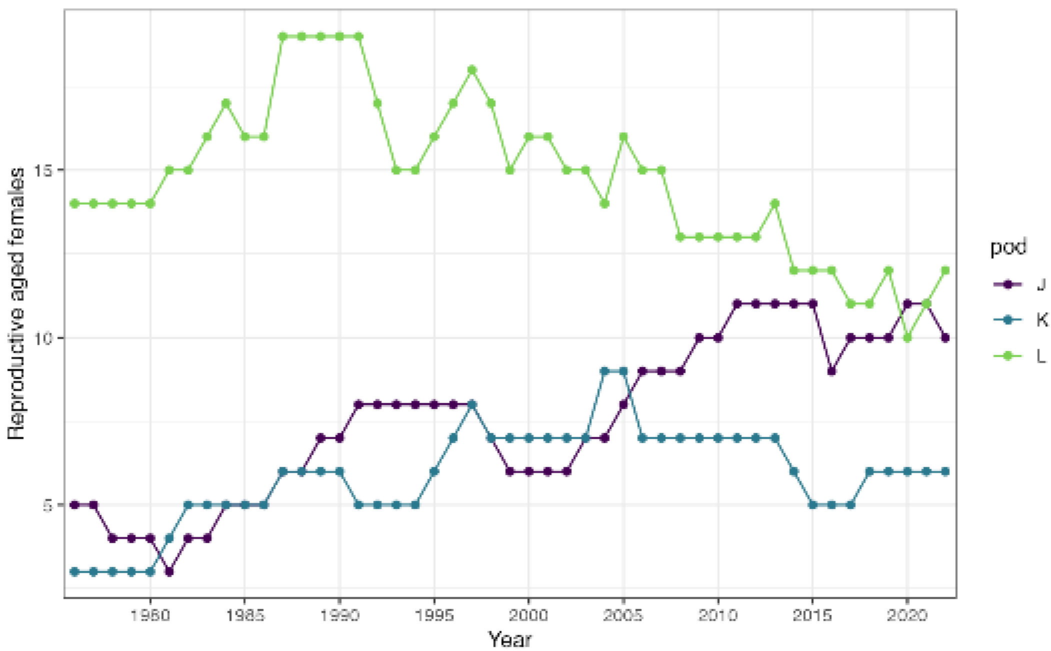

Figure 19. Time series of reproductive age females (10-42, inclusive) for SRKWs by year since 1976 (reproduced from Ward 2021).

2.2.8 Status of Southern Resident Killer Whale Critical Habitat

Critical habitat for the SRKW DPS was first designated on November 29, 2006 (71 FR 69054) in inland waters of Washington State. 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, adding approximately 15,910 mi^2 (Figure 20). 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, as well as 15,910 mi^2 of marine waters along the U.S. west coast between the 20-ft depth contour and the 656.2-ft depth contour from the U.S. international border with Canada south to Point Sur, California. Based on the natural history of SRKWs and their habitat needs, NMFS identified the following PBFs 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 PBFs 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 of the Species (Section 2.4.6). We briefly summarize information relating to sufficient quantity, quality and availability of prey species here, as the Proposed Action will directly affect this SRKW critical habitat essential feature. An additional summary of the other PBFs of SRKW critical habitat (1) water quality and (3) passage conditions can be found in the most recent 5-year review (NMFS 2021a). 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 20. Specific areas of coastal critical habitat containing essential habitat features for SRKW (86 FR 41668).

2.2.9 Factors and Threats Affecting Southern Resident Killer Whales and their Critical Habitat

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 2008b). 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 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 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 biphenyls (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 Indirect Effects: Reduction of primary prey in NMFS 2024c for more detail), but in general, the findings by Williams et al., (2024) support the large body of knowledge (see SRKW Viability Assessment, 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.

The available quantity and quality of prey is the most relevant limiting factor with respect to this Opinion, therefore, details are included below. A summary of the other major threats to recovery of SRKW populations and their critical habitat, including information about the toxic chemicals that accumulate in top predators, impacts from sound and vessels, water quality concerns and passage conditions to allow for migration, resting, and foraging can be found in the most recent 5-year review (NMFS 2021a).

Quantity and Quality of Prey

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.

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 2008b). The release of hatchery fish has not been identified as a threat to the survival or persistence of SRKWs and there is no evidence to suggest the whales prefer wild salmon over hatchery salmon. Increased Chinook salmon abundance, including hatchery fish, benefit this endangered population of whales by enhancing prey availability to SRKWs, and hatchery fish often contribute significantly to the salmon stocks consumed (Hanson et al., 2010). Currently, hatchery fish play a mitigation role of helping sustain Chinook salmon numbers while other, longer term, recovery actions for natural fish are underway. Although hatchery production has contributed to balance some of the historical declines in the abundance of NOR salmon within the range of the whales, hatcheries also pose risks to NOR salmon populations (Nickelson et al., 1986; Ford 2002; Levin and Williams 2002; Naish et al., 2007).

Over the last forty years, predation on Chinook salmon off the West Coast of North America by marine mammals has been estimated to have more than doubled (Chasco *et al.,* 2017a). In particular, southern Chinook salmon stocks ranging south from the Columbia River have been subject to the largest increases in predation, which Chasco *et al.,* (2017a) suggest may be potentially due to large subsidies of hatchery produced fish. Due to Chinook salmon's northward migratory pathway and assumptions about their ocean residence, Chasco *et al.,* (2017a) suggested that SRKWs may be at a competitive disadvantage to other resident killer whales and marine mammals that also prey on Chinook salmon. In other regions such as the Salish Sea, the combined mammal predation of Chinook salmon likely exceeds removal by fishery harvest after accounting for the growth and survival of juvenile fish consumed (Chasco *et al.,* 2017a; 2017b). However, for modeled northern Chinook salmon stocks (specifically off Washington, the western coastal Vancouver Island, and coastal British Columbia, and off southeast Alaska), predation by marine mammals is near or below fishery harvest (Chasco *et al.,* 2017a), and coastal Washington is an area of high use by SRKWs within their coastal habitat.

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

In 2019, the Pacific Fishery Management Council (PFMC) convened an ad-hoc workgroup (Workgroup) to reassess the effects of PFMC ocean salmon fisheries on SRKWs. As part of their risk assessment, the Workgroup included conducting updated correlative analyses in the relationships between Chinook salmon abundance and SRKW demography similar to those included in the Panel Report (Hilborn et al., 2012) and described by Ward et al., (2013). These new analyses include more recent data and include a broader range of SRKW demographic indices. Similar to past efforts, the Workgroup found predicting the relationship between SRKWs and Chinook salmon abundance to be challenging. The relationships between modeled Chinook salmon abundance and SRKW demographics examined by the Workgroup in this most recent analysis appear weaker than those from prior analyses. Although the Workgroup emphasized that caution is warranted when interpreting the results given the limitations of the data, they concluded that these results, coupled with the potential occurrence of SRKWs in the North of Falcon (NOF)[7] coastal 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 coastal area (i.e., off the coasts of Oregon and California; PFMC 2020).

However, further interpretation of these results by NMFS have concluded that the SRKW demographic data alone would not be expected to help provide anything more than weak evidence for or against a significant change related to prey abundance or any other perturbation (NMFS 2021d). 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 2021d). Given all the available information, and considering the uncertainty that has been highlighted, we assume that the overall abundance of Chinook salmon as experienced by foraging SRKWs throughout their range may be influential on their health and vital rates, even if Chinook abundance in different areas could be more influential than others.

Due to the uncertainty in the modeling efforts attempting to link SRKW vital rates to specific salmon stocks, NMFS and Washington Department of Fish and Wildlife (WDFW) developed a priority stock report identifying the Chinook salmon stocks along the West Coast (NMFS and WDFW 2018) 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. The priority stock report was created by using observations of Chinook salmon stocks found in scat and prey scale/tissue samples, observations of the killer whale body condition through aerial photographs, and estimating the spatial and temporal overlap with Chinook salmon stocks ranging from Southeast Alaska to California. Extra weight was given to the salmon runs that support the SRKWs during times of the year when the whales' body condition is more likely reduced and when Chinook salmon may be less available, such as in winter months. Table 9 is a summary of those stock descriptions. However, it is 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

[7] The NOF management area encompasses the Washington coast and northern Oregon (the coastal waters from U.S./Canadian border to Cape Falcon, OR).

actions and there are no abundance estimates for each stock that are factored in, it is currently not designed to assess prey availability within any given area.

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

Priority	ESU/Stock Group	Run Type	Rivers or Stocks in Group
1	North Puget Sound South Puget Sound	Fall	Nooksack, Elwha, Dungeness, Skagit, Stillaguamish, Snohomish, Nisqually, Puyallup, Green, Duwamish, Deschutes, Hood Canal Systems
2	Lower Columbia Strait of Georgia	Fall	Fall Tules and Fall Brights (Cowlitz, Kalama, Clackamas, Lewis, others), Lower Strait (Cowichan, Nanaimo), Upper Strait (Klinaklini, Wakeman, others), Fraser (Harrison)
3	Upper Columbia and Snake	Fall	Upriver Brights, Spring 1.3 (Upper Pitt, Birkenhead; Mid and 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 Vancouver Island Wild
16	Southern OR and Northern CA Coastal	Fall and Spring	Rogue, Chetco, Smith, Lower Klamath, Mad, Eel, Russian

It is also important that SRKW have access to high quality prey. 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. There is some information available for contaminant levels of Chinook salmon in inland waters (Krahn et al., 2007; O'Neill and West 2009; Veldhoen et al., 2010; Mongillo et al., 2016). Populations of Chinook salmon that originated from the northern end of the SRKW range had much lower concentrations of certain contaminants than salmon populations with more southern distributions like those from the U.S. West Coast (Mongillo et al., 2016).

SRKW prey is highly contaminated, causing contamination in the whales themselves. A recent study found higher levels of 4NPs in SRKWs compared to Bigg's killer whales which could be related to their greater association with an estuarine food-chain (Lee et al., 2023). Additionally, O'Neill and West (2009) discovered elevated concentrations of PCBs in Puget Sound Chinook salmon compared to those outside Puget Sound. Similarly, J pod (the SRKW pod most frequently seen in Puget Sound) has also been found to have higher levels of PCBs, consistent with these higher PCB concentrations in Puget Sound Chinook salmon (O'Neill et al., 2006; Krahn et al., 2007). A recent publication reported levels of PCBs and polybrominated diphenyl ethers (PBDEs) in Puget Sound Chinook salmon that were 10- and 4-fold lower than concentrations reported in 2009, respectively (Holbert et al., 2024). The Chinook sampled for this publication were collected along southwest Vancouver Island or northeast Vancouver Island (Holbert et al., 2024), whereas the Chinook sampled in 2009 were collected either in-river or within Puget Sound (O'Neill and West 2009). The Chinook from O'Neill and West may have contained a higher proportion of resident Puget Sound Chinook which remain in Puget Sound while rearing (O'Neill and West 2009). But the levels of both PCBs and PBDEs reported in 2024 were still higher relative to other Chinook populations residing outside of Puget Sound, with the exception of Chinook from the Harrison River and the Cowichan River (Holbert et al., 2024). All three of these populations utilize more coastal habitat close to land-based sources of pollution relative to other Chinook (Holbert et al., 2024). 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).

Build-up of pollutants can lead to adverse health effects in mammals. 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), with the average size of Chinook salmon decreasing and older, larger Chinook becoming less prevalent in many areas. In California, where most Chinook populations are generally shifted towards younger ocean ages, the loss of older individuals mostly applies to declining 3 and 4-year-old Chinook (Ohlberger et al., 2019). 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 salmon in order to meet their caloric needs as a result of a decrease in average size of older Chinook salmon.

A recent study by Lerner and Hunt (2023) looked at variation in energy content of different runs of Fraser Chinook salmon. Specifically, they found that Spring-52 and Summer-52 Fraser Chinook salmon management units had greater lipid content then Summer-41 and Fall-41 management units of Fraser, and that lipid content decreased as Chinook salmon migrated. Authors note that the most lipid rich stocks arrive earliest in the Salish sea and are only available to SRKW for a limited window. Also, because less energy rich fish are available in fall, the authors estimate that 30 percent more fish are needed for SRKW to meet energy requirements in fall compared to in the spring.

Nutritional Limitation and Body Condition

In addition to sufficient quantities 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. When prey is scarce or in low density, SRKWs likely spend more time foraging than when prey is plentiful or in high density. Increased energy expenditure and prey limitation can cause poor body condition and nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources, and as a chronic condition, can lead to reduced body size of individuals and to lower reproductive and survival rates in a population (Trites and Donnelly 2003). During periods of nutritional stress and poor body condition, cetaceans lose adipose tissue behind the cranium, displaying a condition known as “peanut-head” in extreme cases (Pettis et al., 2004; Bradford et al., 2012; Joblon et al., 2014). Between 1994 and 2008, 13 SRKWs were observed from boats to have a pronounced “peanut-head”; all but two subsequently died (Durban et al., 2009; Center for Whale Research 2021 unpublished data). None of the whales that died were subsequently recovered, and, therefore, the 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. The most recent photogrammetry work by

Fearnbach and Durban (2023) for pod body conditions in 2023 show that out of five body condition groups, 40 percent of L pod are in the poorest body condition (an increase in the percent in poorest condition from 13 percent in 2022) and that 32 percent of J pod are in the poorest body condition (an slight increase in the percent in poorest condition from 20 percent in 2022); this is less for K pods at 6 percent (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 percent, J pod has the lowest proportion of individuals above normal body condition (below 35 percent, 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 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., 2021), 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 1 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 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 2015-2017 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 percent of the time. Prey sharing presumably would distribute more evenly the effects of prey limitation across individuals of the population than would otherwise be the case (i.e., if the most successful foragers did not share with other individuals), 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 and Donnelly 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).

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 the 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 the 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.

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 Opinions; e.g., NMFS 2019a). Based on an estimated caloric density of 6.9x10^7 Joules per fish, and daily energy requirements for individual females and males that range from 1.7x10^8 Joules per day to 1.1x10^9 Joules per day, respectively, Noren (2011) estimated a population with 82 individuals would consume 289,131-347,000 Chinook salmon per year. Williams et al., (2011) 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.,* (2017a) also modeled SRKW prey requirements and found that in Salish Sea and U.S. West Coast coastal waters.[8] 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.

In previous Opinions we estimated the food energy of prey available to the whales relative to the estimated metabolic needs of the whales. The resulting forage ratios indicate how much prey is available relative to the whales' needs by the magnitude of the value. For example, a forage ratio of 5.0 indicates that prey availability is 5 times the energy needs of the whales. 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. Relatively low foraging ratios were estimated in the summer months (July-September) in inland waters of WA. Specifically, we estimated previously in NMFS (2019a) that forage ratios in inland waters ranged from 17.57 to 29.77 in October-April, 16.39 to 30.87 in May-June, and 8.28 to 16.89 in July-September from 1992-2016 (assuming a SRKW population size of 75 individuals, using maximum daily prey energy requirement, and using Chinook salmon abundance derived from the Fishery Regulation Assessment Model (FRAM) validation scenario based on post season information that approximates what actually occurred; see NMFS (2019a) for further details). In coastal waters off Washington, Oregon, and California, forage ratios ranged from 10.84 to 33.41 in October-April, from 29.24 to 88.15 in May-June, and from 42.67 to 154.79 in July-September (NMFS 2021d). The abundance estimates in Table 18 of NMFS (2024c) 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 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

[8] These estimates do not include prey requirements off British Columbia, Canada.

mortality rates of Chinook salmon are likely substantially higher than the previous analyses suggest.

2.2.10 Summary of the Rangewide Status for Southern Resident Killer Whales and their Critical Habitat

SRKWs inhabit the inland waters of Washington and British Columbia and the coastal waters off the U.S. west coast and Vancouver Island, with their range extending from central California to Southeast Alaska (Carretta *et al.,* 2023). Long-term monitoring through annual summer censuses in the Salish Sea, utilizing photo-identification techniques since the early 1970s, has documented a decline in SRKW abundance, with the 2024 census recording only 73 individuals, nearing historically low levels (Bigg et al., 1990; CWR 2019, 2023). SRKW face many threats including prey quantity, quality and availability, toxic contaminants, vessel-related disturbances, oil spills and disease (NMFS 2008b). Population modeling indicates these threats are likely interacting and contributing to this decline (Murray et al., 2021), with projections suggesting the steepest declines under recent fecundity rates (2017–2021) and ongoing but slower declines under longer-term averages (1985–2021) (Krahn et al., 2004; Hilborn et al., 2012; Ward et al., 2013). Genetic analyses reveal that inbreeding depression is likely exacerbating population declines (Kardos et al., 2023).

2.3. Action Area

"Action area" means all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). The Proposed Action is located in the Russian River Basin of California. For the purposes of this Opinion, the Action Area consists of the geographic extent anticipated for potential effects of proposed activities on the physical environment. As reflected in other sections of this Opinion, the Proposed Action's effects on listed species and critical habitat in the Action Area would vary according to species, depending on their distribution or expected distribution, species life history stage timing, and the timing or type of effects.

The Proposed Action includes water supply and flood control operations at WSD and CVD. Activities related to these proposed operations include flow releases into the Russian River and Dry Creek, water diversions and storage (Wohler Pool and Santa Rosa Creek), Estuary management, channel and facility maintenance, managing Dry Creek habitat enhancements, sites where future habitat restoration efforts may occur, monitoring, and conservation measures. These activities are likely to affect the following areas in the Russian River watershed (Figures 21-26):

1) Upper River - The East Fork Russian River below CVD and the mainstem Russian River from the confluence of the East Fork Russian River to the town of Cloverdale to just above Healdsburg. Several reaches of the Upper River are referenced throughout this Opinion, including:

    a) Ukiah Reach - the upper five-mile stretch just below CVD to Ukiah,

    b) Hopland Reach - begins 12 miles downstream of CVD,

c) Canyon Reach - the 14-mile stretch from Hopland to Cloverdale (30 mi downstream of CVD);

2) Lower River - The mainstem Russian River from just above Healdsburg to the mouth of the Russian River at Jenner;

3) Lower River Tributaries - Restoration activities may include actions in the lower Russian River tributaries including, but not limited to the following creeks: Willow, Green Valley, Dutch Bill, and Pena (uppermost tributary to Dry Creek). Thus, certain portions of these tributaries are also included in the Action Area;

4) The Estuary and nearshore environment directly adjacent to the mouth;

5) Santa Rosa Creek near the Santa Rosa Creek Diversion and Santa Rosa Creek Reservoir;

6) Dry Creek downstream of WSD, including its confluence with the mainstem of the Russian River; and

7) Areas affected by other activities (water transmission and the WSD Hydroelectric Power Facility) include areas in Sonoma and Marin County outside of those delineated above.

The sections of the Russian River watershed above Lake Mendocino or in the West Fork Russian River are not included as part of the Proposed Action nor included in the Action Area since these areas are not influenced by the reservoir operations at CVD/Lake Mendocino.

The Action Area for SRKW is different from the Action Area for the salmonids described above as there are no effects of flow management that directly affect SRKWs. Rather there is a link to SRKWs from effects on Chinook salmon and Chinook salmon spawning and rearing habitat in the Russian River basins because Chinook salmon are a primary prey for SRKWs in the Pacific Ocean. This link results in effects in the Pacific Ocean where SRKWs feed on concentrations of adult Chinook salmon (Hanson et al., 2021; NMFS 2021d). The Action Area includes the Pacific Ocean where there is species overlap between Russian River Chinook salmon and SRKWs. The exact boundaries of this area cannot be precisely defined based on current information; however, it includes coastal waters ranging from northern California through central Oregon up to the mouth of the Columbia River (Weitkamp 2010; Bellinger et al.; 2015; Shelton et al., 2019). This portion of the Action Area also includes coastal critical habitat for SRKWs (86 FR 41668; August 2, 2021).

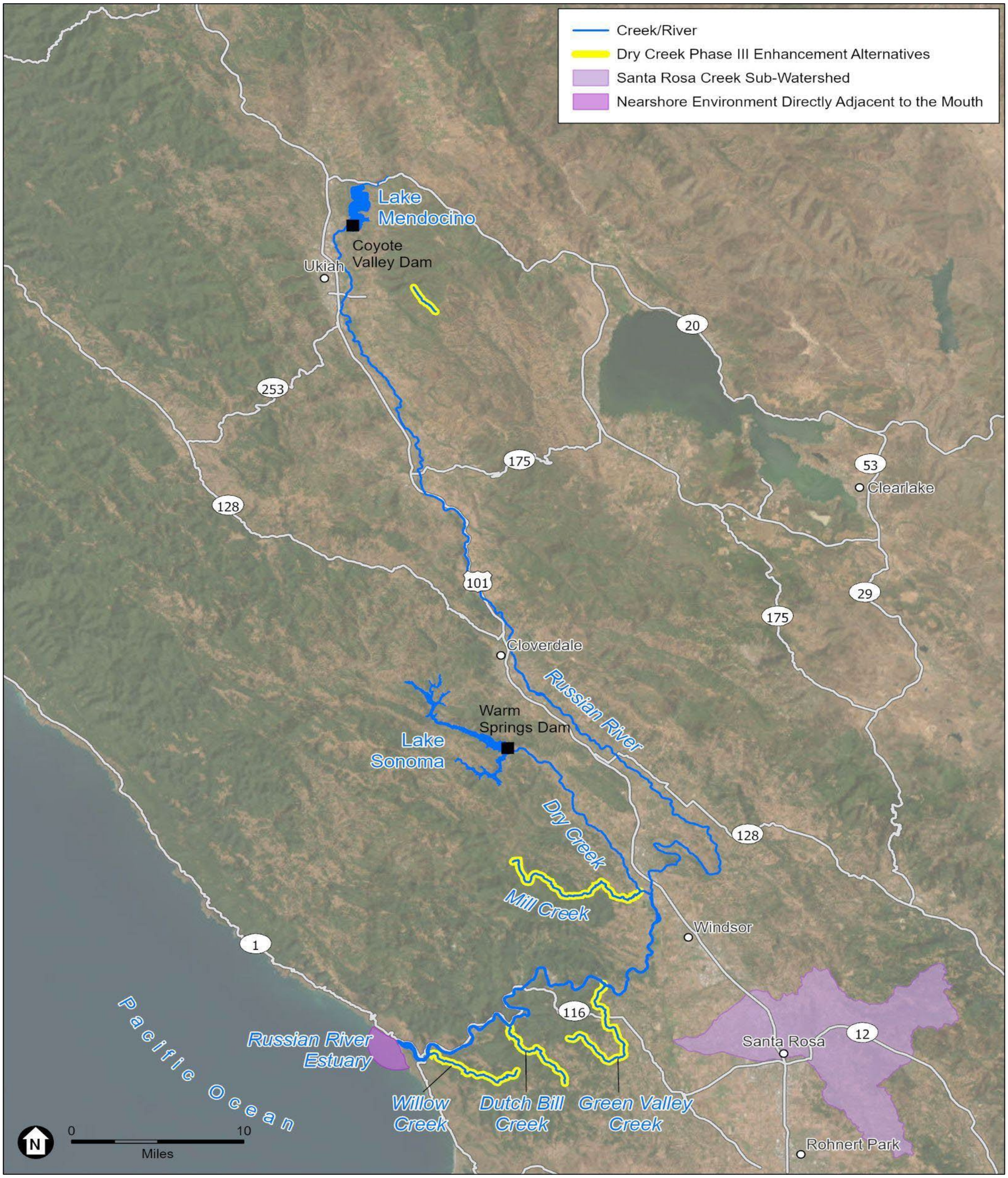

Figure 21. Map of the Action Area within the Russian River watershed and Santa Rosa Creek sub-watershed.

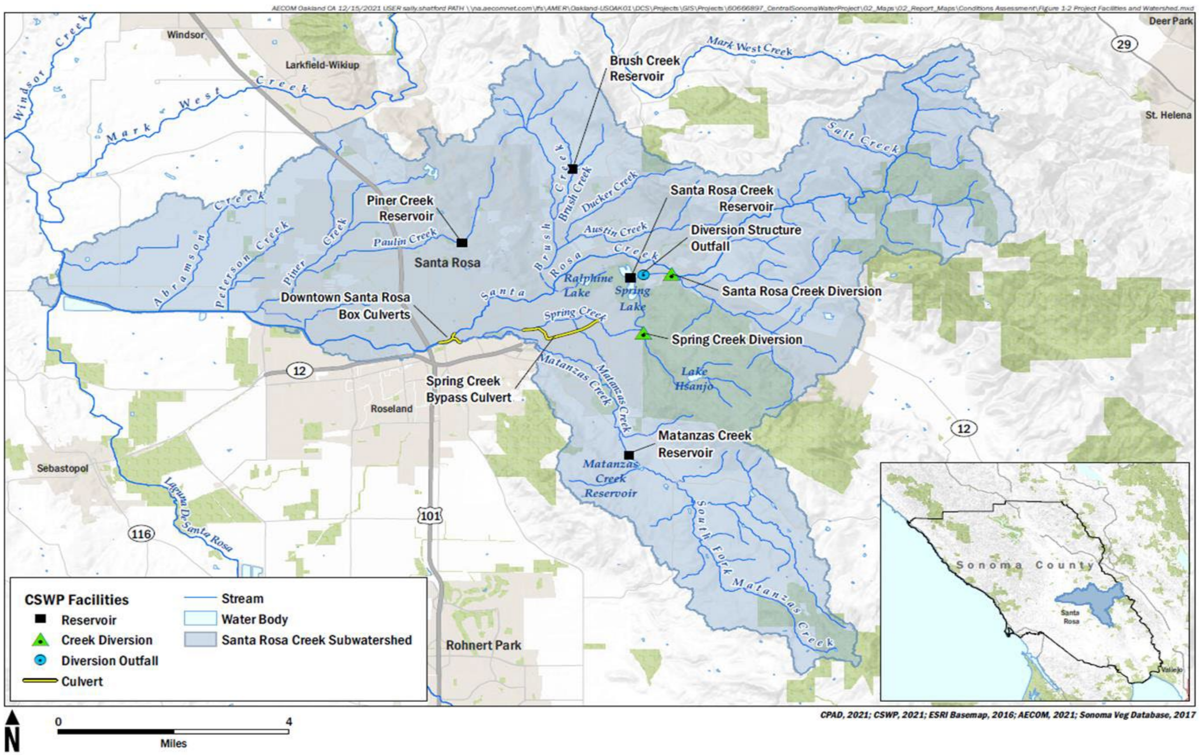

Figure 22. Map showing the location of the Santa Rosa Creek Diversion and associated project elements, including the diversion outfall (Vortex tube), and Santa Rosa Creek Reservoir.

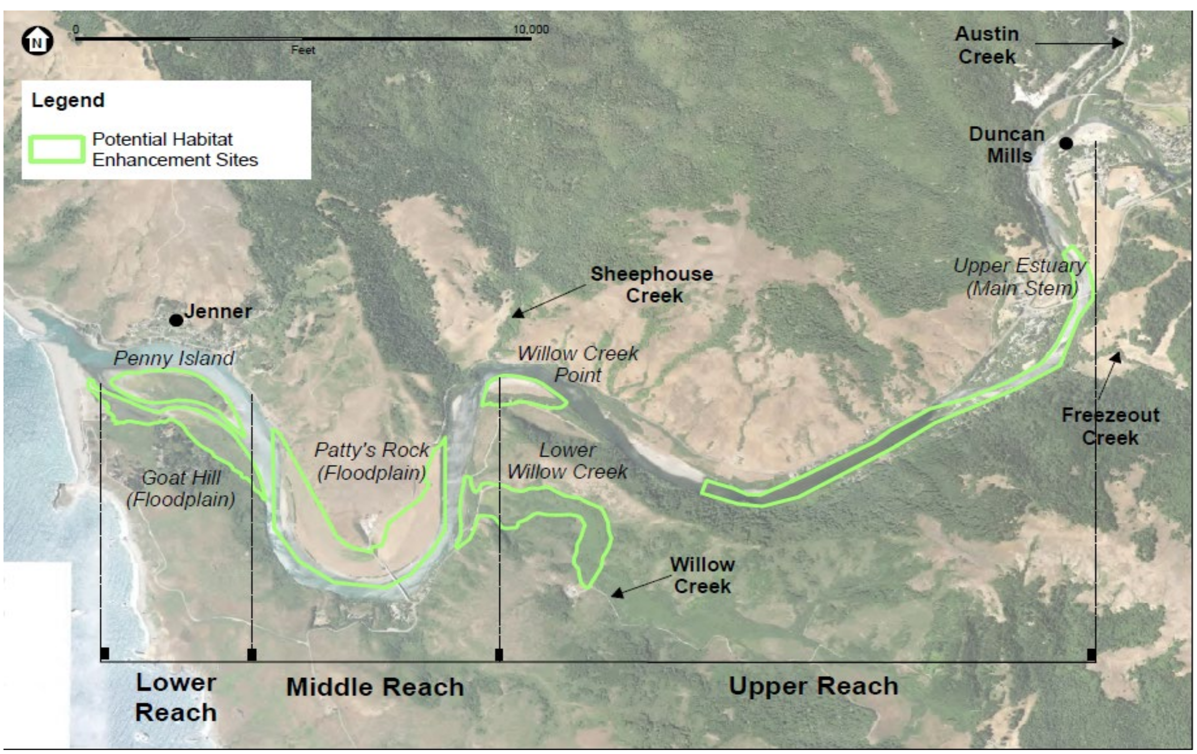

Figure 23. Map of Estuary reaches (lower, middle, upper) and potential habitat enhancement locations introduced in Section 1.3.4.3 and detailed further in 2.5.3.6 (Sonoma Water 2024d).

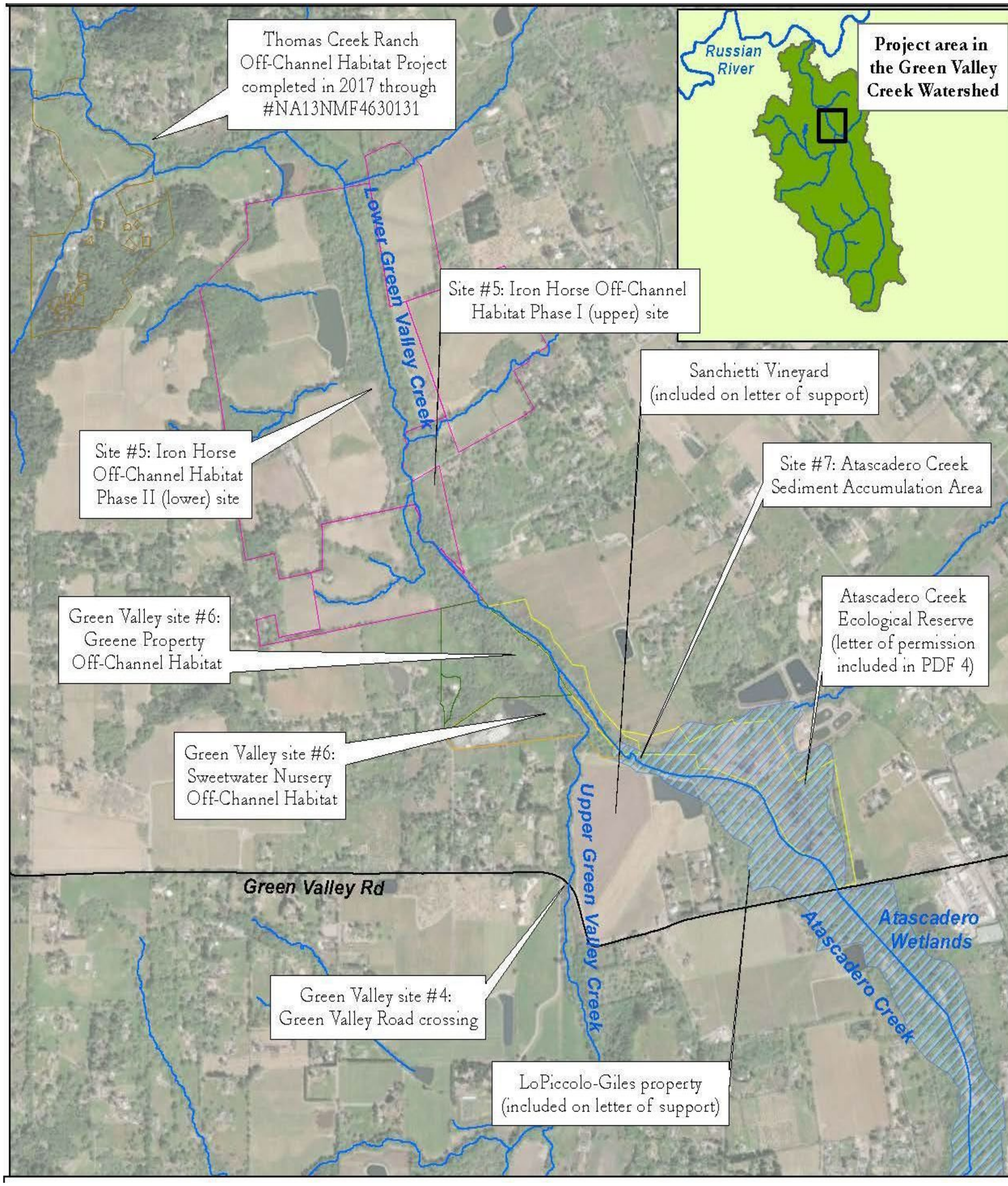

Figure 24. Map of proposed restoration project locations within Green Valley Creek (Gold Ridge Resource Conservation District).

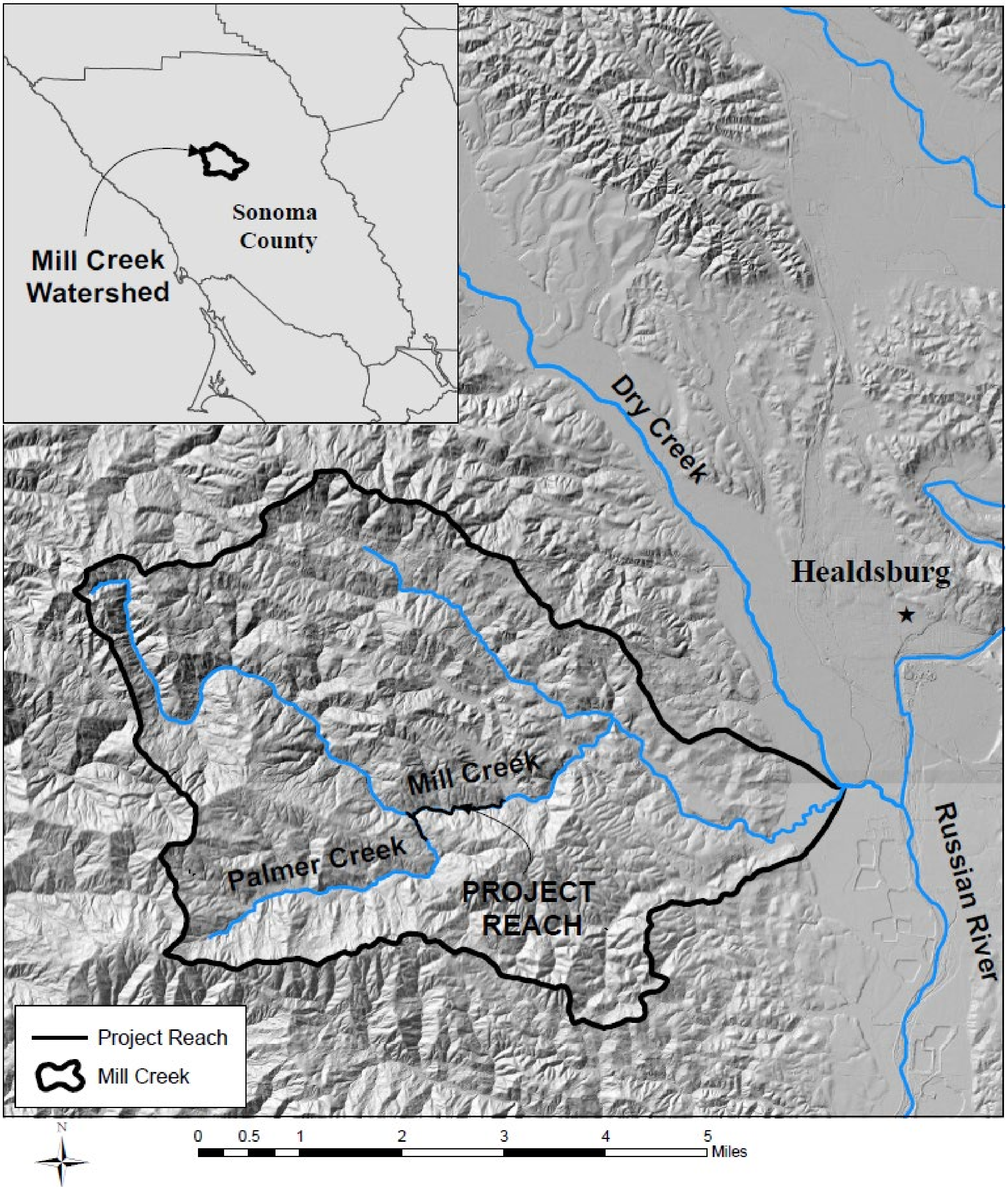

Figure 25. Map of proposed restoration project locations within Mill Creek (NOAA Restoration Center).

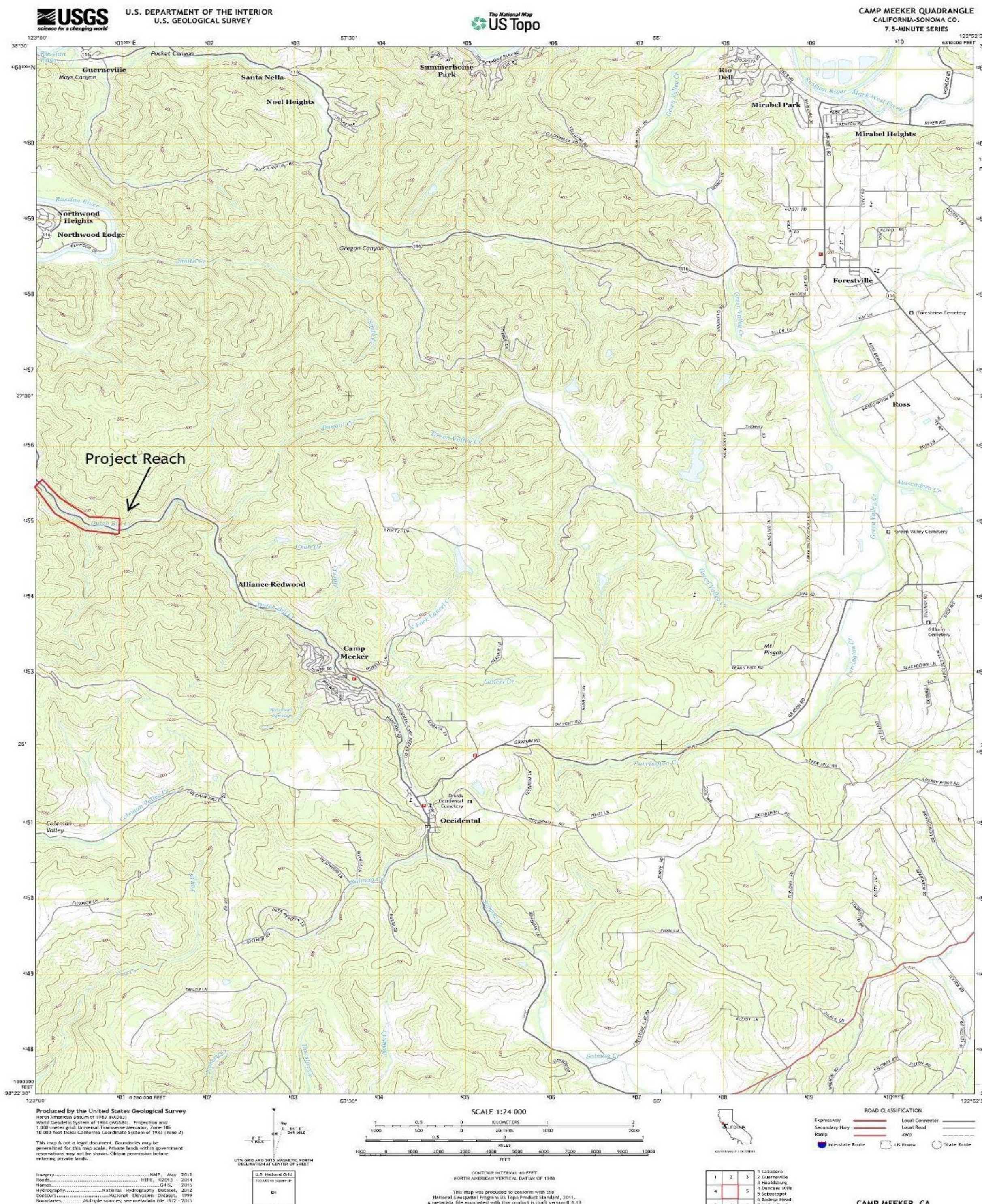

Figure 26. Map of proposed restoration reach in lower Dutch Bill Creek.

2.4. Environmental Baseline

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the Action Area, without the consequences to the listed species or designated critical habitat caused by the Proposed Action. The Environmental Baseline includes the past and present impacts of all federal, state, or private actions and other human activities in the Action Area, the anticipated impacts of all proposed federal projects in the Action Area that have already undergone formal or early Section 7 consultation, 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).

Text in several sections of the Environmental Baseline was taken directly from the BA or from the 2008 Opinion and has been incorporated as written where current conditions in the Action Area remain the same or similar to those conditions described in the 2008 Opinion (NMFS 2008a); this is also described in the BA (ESA, Inc. 2023). In some cases, some conditions in the Action Area have improved since the 2008 Opinion, often in response to changes in dam operations, estuary water level management, and restoration activities undertaken to implement the 2008 Opinion's RPAs and RPMs. Those improvements in species and habitat conditions are also described below, as are conditions that have worsened or otherwise changed, thus capturing the current Environmental Baseline.

2.4.1 General Watershed Description for Salmonids

The Russian River originates in central Mendocino County, approximately 15 miles north of the City of Ukiah and flows into the Pacific Ocean at Jenner in Sonoma County, about 20 miles west of the City of Santa Rosa. The Russian River watershed drains an area of approximately 2,390 mi^2 including much of Sonoma and Mendocino counties and is approximately 110 miles long. The watershed lies within a series of narrow valleys between the Mendocino Range to the west, in the Mayacamas Mountains to the east, and the Sonoma Mountains to the south. Hills and valleys make up most of the watershed (85 percent), while the remainder lies within alluvial valleys.

Within the Action Area (Figures 21-26), the Russian River flows through several physiographically distinct sections, beginning with the Upper River (Figure 27). CVD forms Lake Mendocino and impounds water from 169 mi^2 of the upper watershed on the East Fork (approximately 7 percent of the entire basin), just upstream of the confluence with the mainstem Russian River. Downstream of CVD, the Upper River consists of the East Fork flowing into the mainstem Russian River near Ukiah and through a series of valleys in Ukiah, Hopland and Alexander through the town of Cloverdale to just above the City of Healdsburg.

The Lower River then turns abruptly west through a sinuous bedrock canyon, and south through an alluvial valley past the town of Windsor, and is then confined by a bedrock constriction near the Wohler Bridge near Forestville. The Lower River includes WSD that forms Lake Sonoma and impounds water from 210 mi^2 of the 349 mi^2 Dry Creek watershed (approximately 60 percent of the Dry Creek watershed), and flows downstream 14 miles to meet the confluence with the mainstem Russian River just below Healdsburg. Dry Creek is the second largest tributary by area within the Russian River watershed, but contributes the largest amount of annual runoff. The Lower River then continues west from the confluence of Dry Creek through a series of canyons and alluvial valleys through the town of Guerneville (approximately 74 miles downstream of CVD), cutting across the Coast Ranges past the town of Cazadero. Near the community of Duncans Mills, the river flows through a series of alluvial valleys before coming to the Estuary, where the tidal influence of the Pacific Ocean causes ocean water to mix with Russian River water. Tributaries that are included as part of the Action Area include: Santa Rosa Creek (Mark West tributary), Willow, Dutch Bill, Mill, and Green Valley Creeks (all tributaries of the Lower River).

Figure 27. Map of the Russian River Sub-Watersheds. The Action Area includes Dry Creek, the Upper, Lower Russian River, as well as Santa Rosa Creek, a tributary of the Mark West Sub-Watershed. Note “Middle River” as noted on this map is considered part of the “Upper River” throughout this Opinion (ESA, Inc. 2023).

2.4.1.1 Climate

Climate in the Russian River watershed is influenced by the watershed's proximity to the Pacific Ocean. Precipitation patterns within the watershed reflect a Mediterranean climate, with hot, dry summers and cool, wet winters. Mean daily summer temperatures range from 22.2 to 23.9°C inland (with maximum temperatures in excess of 32.2°C) to 16.1 to 17.8°C near the coast, while precipitation normally falls during the wet season, October to May, with a large percentage of the rainfall typically occurring during three or four major winter storms. These major storms often come in the form of an Atmospheric River (AR), which is the horizontal transport of large amounts of water vapor through the atmosphere along a narrow corridor. Although brief, ARs can produce 30 to 50 percent of the Russian River watershed's annual precipitation during a few days. Rainfall tends to be heaviest at higher elevations near the coast, with average annual rainfall of 80 inches per year near Cazadero at the western edge of the watershed. In lower elevation valley areas, annual precipitation ranges from 22 inches per year near Santa Rosa to 41 inches per year at the City of Healdsburg. A significant part of the region is subject to marine influence and fog intrusion.

2.4.1.2 Hydrology

There are six USGS stream gages along the Upper River, all with varying periods of record (Table 10, Figure 5). Focusing on the four gages with the longest periods of record and that encompass the Upper River from the mainstem just upstream of the confluence at the East Fork through Hopland to Healdsburg (USGS gage No. 1146100; USGS Hopland gage No. 11462500; USGS Cloverdale gage No. 11463000; USGS Healdsburg gage No. 11464000), all show the same median monthly flow pattern with high flow in the winter and low flow in the summer. Mean monthly flow is greatest in February and lowest from June through October, reflecting the Mediterranean climate.

Discharge at the Russian River near the Ukiah stream gage is lowest across all months as it is the most upstream and has the least contributing area of all gages along the mainstem. The gage is also upstream of the confluence with the East Fork and is not affected by releases from CVD. As such, this point is typically dry or nearly dry from late-summer to early-fall. Downstream of Ukiah, flow is nearly constant from June through October at the Hopland, Cloverdale, and Healdsburg gages owing to release flows from CVD to meet minimum instream flow requirements. Prior to the dam construction, the river experienced greater median monthly winter flows that peaked in January and lower, more variable summer flow. Dam operations for flood control and water supply mute winter peak flows (compared to unregulated conditions) and stabilize flow from June through October.

There are two USGS flow gages in the Lower River located at the Hacienda Bridge (USGS Guerneville Gage No. 11467000) and near Riverfront Regional Park (USGS Windsor Gage No. 11465390). Flow at the Russian River near Guerneville gage is substantially higher in the winter and spring, but similar in the winter and fall as compared to the Upper River or Dry Creek. The period of record for the Russian River near Guerneville gage encompasses pre- and post-regulation by Coyote Valley (before 1959) and Warm Springs (before 1984) dams. Gage records show that CVD had a minor effect on winter median monthly flows as it controls only seven percent of the total watershed area (the dam did have an effect on the duration and timing of flood peaks associated with impoundment). WSD has a greater effect on winter median monthly flows as it controls a greater area (339 versus 272 mi^2) on Dry Creek which contributes the largest annual runoff to the Lower River. Under pre- and post-dam regulation, median monthly flow was consistent, but low, during the summer and fall.

There are three gages along Dry Creek from WSD to the Russian River confluence with varying periods of record and seasonal operation. Focusing on the gage with the longest period of record (Dry Creek near Geyserville, USGS Gage No. 11465200) median monthly flow shows characteristics that are similar to the Upper River. The median mean monthly flow is greatest in March and lowest from May through October. The period of record for this stream gage (October 1959 to present) encompasses pre- and post-dam hydrologic conditions. Before regulation (i.e., before the closure of WSD in 1984), surface flow in Dry Creek typically peaked in February and nearly disappeared from June to October. Dam operations mute peak flows (compared to unregulated conditions) and release a consistent summer flow, which reflects the flood control and water supply functions of WSD. Based on a review of WSD release and downstream gage data, during the wet season, runoff from tributaries accounts for most of the flow in Dry Creek. During the dry season, most of the flow in Dry Creek consists of water released from Lake Sonoma.

Table 10. USGS Flow Gages along the Russian River and Dry Creek, including drainage area period of record (Sonoma Water 2016).

Gage Name	Gage No.	Drainage Area (mi^2)	Period of Record
Upper River near Ukiah	11461000	100	1991-present
Upper River near Talmage	11462080	286	2009-present
Upper River near Hopland	11462500	362	1939-present
Upper River near Cloverdale	11463000	503	1951-present
Upper River near Geyserville	11463500	655	1910-1913; 2013-present
Upper River near Jimtown	11463682	684	2009-present
Upper River near Digger Bend	11463980	791	1987-present
Upper River near Healdsburg	11464000	793	1930-present
Lower River near Guerneville	11467000	3,465	1939-present
Lower River near Windsor	11465390	2,647	2009-present
Dry Creek near Geyserville	11465200	420	1959-present
Dry Creek near Lambert Bridge	11462080	453	2011-present
Dry Creek near Healdsburg	11465350	562	1981-present

2.4.1.3 Groundwater

In the portions of the Action Area where groundwater is most closely connected to the Russian River mainstem and Dry Creek, the principal inflows to groundwater are precipitation and surface water from rivers and streams. Seasonal groundwater-level fluctuations vary from one to two ft (primarily along Dry Creek) to five to ten ft in other areas. The seasonal high groundwater- levels generally correspond with high river and stream flows and indicate that groundwater within the alluvial aquifer is in close hydraulic communication with surface water. Groundwater-levels in the southern portion of the Healdsburg area sub-basin are also locally influenced by a series of quarry ponds which have been excavated along the Upper River. During the rainy, high-flow season, surface water overtops banks and floodplains, infiltrating into and recharging unconfined aquifers. As flows drop, surface water is gained as aquifers discharge into rivers and stream channels. Through the summer and early-fall, the groundwater table elevation can gradually drop below surface water surface elevation along some reaches, and streamflow enters the aquifer. Additionally, in areas where groundwater is pumped through wells located near the river, streamflow depletion can occur and locally result in lower river flows.

2.4.1.4 Historical Overview

Prior to European settlement in 1850, forests covered much of the Russian River and Dry Creek valleys. During precipitation events, the steep slopes of the surrounding basin conveyed water into channels at discharges much higher than the mean annual flow. In the summer, stream flow in the Russian River's main stem was about 20 cubic feet per second (cfs) (SEC 1996); these low flow conditions persisted until the first winter rains.

The mainstem of the Russian River was a dynamic meandering river which migrated across its floodplain creating ox-bows and side sloughs, and had a profusion of side channels, sand bars, islands and sloughs (Florsheim and Goodwin 1993). Rivers hydraulically segregate their sediments such that the coarser, larger gravels are stored in depositional sites in upland reaches, while smaller gravels are stored in the lower reaches (Mount 1995). This was probably the case for the Russian River and its tributaries in their unaltered state; most of the suitable spawning gravels were likely in upper reaches, with reduction of suitable spawning gravel in the middle and lower reaches. Most of the 110 miles of mainstem Russian River, and hundreds more miles in the tributaries, were historically available for salmonid spawning. The gravel available for spawning purposes was of suitable size and relatively free of fine silt. There was a high pool/riffle ratio which provided sufficient habitat for spawning purposes. An abundance of LWD was available in the form of root wads and fallen logs to create scour pools and provide cover and foraging sites for rearing salmonids. Low summer flows in the summer resulted in high water temperatures; however, the main stem probably contained numerous deep pools with lower cooler layers (Circuit Rider Productions 1994). Salmonids were able to survive in summer by seeking refuge in these stratified pools. The tributaries provided good quality habitat consisting of pools, instream cover, clean gravels, and sufficient canopy cover. In the tributaries there was more LWD instream as trees were recruited into the streams during storm events, bank erosion, landslides, and windthrow. This allowed for the creation of rearing pools and other elements of complex habitat. While there were ephemeral or intermittent streams in some areas of the

Russian River watershed historically, Russian River tributary streams had more surface flow available throughout the year than currently available.

In the Estuary, flows during the summers were low and were unlikely to have breached the barrier beach once it formed. Only limited flow data are available prior to the construction of the PVP. At Geyserville, flows have been estimated at 20 cfs or less during most summers (SEC 1996). Flows were higher at the Estuary, but not anywhere near the average 200 cfs summer season flow documented at the Guerneville gage for the period 1940 - 1980 (RREITF 1994). Other information supporting the conclusion of a barrier beach at the Russian River's mouth in most summers includes reports in the late 1800s from early settlers, the Coastal Pilot, and the U.S. Coast and Geodetic Survey (RREITF 1994). In some wetter years, a perched lagoon may have formed, with freshwater outflow over the Estuary bar. The duration of the perched lagoon through the summer as river flows receded is unknown.

The migration timing of Russian River salmonids evolved to correspond with seasonally higher stream flows and open estuary connection to the ocean (Fukushima and Lesh 1998). Migration opportunities for adult Russian River salmonids usually began around October or November following sufficient rainfall. Chinook salmon would be the first salmonid to begin adult immigration, followed by coho salmon, then steelhead (Figure 7). Anticipated juvenile Russian River salmonid emigration corresponds with high winter and spring flows. In some years, depending upon weather and hydrology patterns, the Estuary may have opened late or closed early, which may have prevented some portion of migrating adult salmonids from entering the Russian River to spawn, or preventing some juveniles to migrate to the ocean as smolts. Given the likely larger historical size of salmonid populations in the Russian River, these natural climate fluctuations are unlikely to have had any long-term impacts on salmonid population viability in the watershed.

Artificial breaching of the barrier beach that periodically forms at the mouth of the Russian River has been documented since the early 1900s to prevent flooding of low-lying properties. Residents would initiate artificial breaching by digging a channel across the beach with shovels. From the 1960s to the early 1990s, breaching was performed more regularly by Sonoma County. This breaching continues through the present day. Starting in the mid-1990s, artificial breaching was performed by Sonoma Water, in accordance with the Russian River Estuary Study conducted in 1992-1993 (RREITF 1994). The guidance provided by the study called for breaching following a river mouth closure when the water surface elevation in the Estuary was between 4.5 and 7.0 ft above NGVD29, as read at the Jenner gage located at the Jenner Visitors' Center. This was intended to be a compromise between limiting flooding in Jenner, while also reducing the risk of low DO water forming in Willow Creek Marsh (due to natural biochemical oxygen demand within the marsh during periods of high-water levels). It was thought that low DO water would be released from the marsh into the Estuary during subsequent breach events, creating a threat for fish kills.

The 2008 Opinion found that the Estuary breaching conducted by Sonoma Water was one of the activities responsible for the Jeopardy and Adverse Modification conclusion that NMFS reached at that time. The RPA from the 2008 Opinion directed the USACE and Sonoma Water to modify breaching activities to minimize flood risk while at the same time managing Estuary conditions to enhance rearing habitat for juvenile salmonids, specifically steelhead, from May 15 to October 15 (referenced as the "lagoon management season"), and has continued to evolve as part of the RPA implementation (AMP) (ESA, Inc. 2023). Given what we know about similar estuaries and historical accounts, NMFS expects that prior to dams and diversions in the Russian River watershed, the Estuary was likely open to ocean tides for several months between late fall and early spring in nearly all years, and then closed to ocean tides sometime during the late spring through the early fall of most years. More information about Estuary bar management can be found in the Factors section below (Section 2.4.4.7).

Information does not exist on water quality conditions in the Estuary prior to increased summer flows in the Russian River from PVP operations. NMFS expects that historically, the Russian River Estuary either converted to freshwater after bar closure, or stratified, with denser salt water remaining at depth. The Estuary's condition after bar closure was likely variable. If the Estuary converted to freshwater historically, habitat was likely high quality for salmonids rearing during the summer months. Smith (1990), Zedonis (1992), Larson (1987), and Bond (2006) evaluated closed freshwater lagoons in California and found good salmonid rearing habitat in those lagoons, including abundant food supplies and increased salmonid growth rates over stream-raised fish. If the Russian River remained stratified during the summer, rearing salmonid productivity was also likely relatively high. Uncertainty remains regarding the historical frequency or duration of bar closure, conversion to freshwater or stratification, and steelhead productivity in the Russian River Estuary during the summer and fall. Nevertheless, NMFS concludes that the following is reasonable given the information presented above: that historically, Estuary closures during the summer and fall occurred more often in most years and steelhead productivity during the summer and fall was higher than more recently when the Estuary has remained more frequently open to the ocean.

2.4.2 Status of Salmonid Critical Habitat in the Action Area

Many of the conditions described in this section have not changed much since the 2008 Opinion and are, therefore, expected to be very similar. Changes that have occurred due to actions taken as a result of the RPA in the 2008 Opinion will be described below where appropriate, and other changed conditions will be discussed.

The condition of critical habitat for CCC coho salmon, CCC steelhead and CC Chinook salmon within the Russian River basin has been degraded from conditions known to support viable salmonid populations. Russian River water management and habitat disturbances have worked in concert with the introduction of exotic species to cause major shifts or declines in fish populations throughout the basin (SEC 1996). SEC (1996) cite USACE (1982) and Prolysts, Incorporated and Beak Consultants, Inc (1984) who found that since 1922 increased summer flows and temperatures in the mainstem Russian River not only decreased salmonid habitat, but actually created ideal warmwater species habitat. Critical habitat in the streams within the Action Area currently consists of limited quantity and quality summer and winter rearing habitat, as well as marginal spawning habitat for all three species. Compared to historical conditions, there are fewer pools, limited cover, and reduced habitat complexity. The limited instream cover that does exist is provided mainly by large cobble and overhanging vegetation. Instream LWD, needed for foraging sites, cover, and velocity refuge is especially lacking in most of the streams throughout the basin. SEC (1996) reviewed sources which indicated that Sacramento pikeminnow, a native warm water species in the Russian River, which competes with or directly preys upon juvenile salmonids, dominate much of the mainstem Russian River and have become a widespread predator in the basin. NMFS has determined that these degraded habitat conditions are, in part, the result of many human-induced factors affecting critical habitat including: dam construction, agricultural and mining activities, urbanization, stream channelization, water diversion and logging among others. These factors will be discussed in more depth in subsequent sections of the Environmental Baseline.

Not all streams in the Russian River watershed were designated as critical habitat for CCC steelhead, CC Chinook salmon, and CCC coho salmon.

Complete descriptions of the locations of CC Chinook salmon and CCC steelhead critical habitat in the Russian River watershed can be found in the critical habitat designation final rule (70 FR 52488). Their general distributions are described briefly below, and the status of their critical habitat is described in more detail in respective subsections.

Designated CC Chinook salmon critical habitat includes only the mainstem of the Russian River (including the Estuary) and some of its largest tributaries (such as Dry Creek below WSD). This includes all areas in the Action Area (the Russian River mainstem and Dry Creek portions of the Action Area) where Chinook are known to occur.

Designated CCC steelhead critical habitat includes all river reaches accessible to steelhead within the range of the ESU, which includes the mainstem and dry creek as well as numerous smaller tributaries in the Russian River watershed, but not all the smaller tributaries are designated. For example, the Santa Rosa Creek watershed was not designated as CCC steelhead critical habitat, and multiple tributaries along the Upper River between Felix Creek and Forsyth Creek are also not designated critical habitat.

Complete descriptions of the locations of CCC coho salmon critical habitat in the Russian River watershed can be found in the critical habitat designation final rule (64 FR 24049). Designated critical habitat for CCC coho salmon includes all river reaches accessible to coho salmon within the range of the ESU. NMFS defines "accessible" to include all reaches below longstanding natural barriers and several dams, including CVD and WSD (64 FR 24049). Therefore, all of the stream reaches accessible to coho salmon in the Action Area are part of critical habitat for CCC coho salmon, including stream reaches upstream of culverts which currently block coho salmon access as well as much of the Santa Rosa Creek watershed. However, coho salmon are now restricted to a few tributaries in the Lower River watershed (CDFG 2002), and rear only in isolated areas of suitable habitat.

2.4.2.1 Upper River

The 20-mile reach of the Upper River in the Action Area is characterized by its low gradient, which influences the quality of habitats used by steelhead. Sonoma Water surveyed segments of this reach in 2002, and found 94 percent flatwater habitat, one percent deep pool, less than one percent cascade, and five percent riffle habitat (Sonoma Water 2003). Habitat utilization by juvenile steelhead during the summer was found to be almost exclusively in cascade and riffle habitat types (Sonoma Water 2003). Halligan (2004) reports that this reach is dominated by gravel substrates, with 80 percent of the embeddedness values rated as good (i.e., pool tailouts <25 percent embedded), or fair (25 to 50 percent embedded). Halligan (2004) considered rearing habitat for steelhead to be poor because shelter ratings are low in riffles, pools and flat habitats. As a result of flood conditions that occurred in late 2006, current shelter ratings may have improved slightly over those reported by Halligan.

The upper 4-mile section of the Canyon Reach from Hopland downstream is similar to the rest of the Upper River with dominant flatwater habitats and a heavily vegetated riparian zone; whereas the 10-mile segment upstream of Cloverdale is characterized by steep canyon topography, fast water habitats, and substrates consisting of large boulders and bedrock. Surveys conducted by Sonoma Water (2003) found that riffle habitat comprised 34 percent and cascade habitat made up 2 percent of the segment, the greatest concentration of these preferred rearing habitats for steelhead in the Russian River. This reach also has suitable stream temperatures that are conducive to juvenile steelhead rearing during the summer. Given the surrounding land uses, NMFS expects conditions remain similar in this reach today.

Migration habitat in the mainstem Russian River appears to be in moderate condition for all three species. Winter flows in normal water years generally provide unimpeded passage conditions for adults that utilize the mainstem and tributaries for spawning. During dry water years stream flow in reaches downstream of Cloverdale may be insufficient for adult salmonid passage between storm events. Seasonal dams and road crossings in the mainstem may cause minor delays for early adult Chinook salmon migrating, while given their later spawning migration times, coho salmon and steelhead are generally not impacted by these impediments during normal water years. In general, steelhead use Russian River tributary streams for spawning more often than Chinook salmon. Coho salmon do not utilize the Upper River for spawning or rearing.

Elevated summer flows from water supply releases at CVD have affected the following salmonid habitat PBFs in the Upper River: 1) freshwater rearing habitat of steelhead and Chinook salmon, 2) adult migratory habitat of Chinook salmon, 3) spawning habitat of Chinook salmon, and 4) rearing habitat for salmonids (in conjunction with turbidity). Salmonid spawning habitat in the entire mainstem of the Russian River has been negatively affected by geomorphic changes to the stream channel caused by dam construction and changes in sediment delivery and stream flow patterns, gravel extraction, channelization, and agricultural impacts. Nevertheless, the majority of the remaining good Chinook salmon spawning habitat is located in the Upper River. Elevated fall flows associated with water management provide good spawning habitat for adult Chinook salmon prior to the onset of winter rain events. Coho salmon do not utilize the mainstem Russian River for spawning. About half the spawning habitat for steelhead in the Russian River is rated as fair, with the rest being rated either poor or unknown (NMFS 2005b). Steelhead use Russian River tributary streams for spawning more often than Chinook salmon.

Rearing conditions for steelhead are marginally suitable in the Upper River, with the best habitat in the Canyon Reach. Streamflow conditions are largely controlled by sustained releases from CVD for many weeks or months during the summer. An interagency flow-habitat assessment conducted prior to 2008 found a clear negative relationship between flow levels and availability of rearing habitat for steelhead in the Upper River (Appendix F of USACE and Sonoma Water 2004). As flows increase, usable rearing habitat space declines due to the lack of cover for juvenile fish to escape high flows that can wash them downstream into unsuitable habitat. Subsequent to the 2008 Opinion, flow releases during the summer have been reduced by implementation of the RPA and through implementation of temporary change petitions. (See Section 2.4.4.1 below for more information). As a result, more summer rearing habitat is available to steelhead in the Upper River in the segment between the East Fork and Cloverdale. Summer rearing habitat in the mainstem from Cloverdale downstream to Healdsburg remains poor due to summer water temperatures that typically exceed thermal tolerances of rearing salmonids (USACE and Sonoma Water 2004). According to SEC (1996) pool temperature stratification in the mainstem Russian River is impacted by summer releases from CVD which releases 15 to 20 times the amount of pre-regulated flows in the mainstem Russian River with flows generally exceeding 125 cfs, resulting in marginal quality summer rearing habitat.

2.4.2.2 Lower River

Below Healdsburg, the Russian River warms to temperatures that are stressful to salmonids, which can persist throughout the summer and early fall. Increased flows in the Russian River have also created habitat conditions more favorable to introduced and non-native warmwater fish species such as Sacramento pikeminnow (*Ptychocheilus grandis*) and smallmouth bass (*Micropterus dolomieu*). Recent analysis suggests survival of emigrating coho salmon smolt is significantly lower when traversing the lower Russian River than within Dry Creek (discussed in 2.4.3.2 and ESA, Inc. 2023). While several factors may be working in combination to lower smolt survival in the Lower River, the primary suspect is high predation rates by above-noted piscivorous fish. The backwater effect caused by Mirabel dam creates a lentic environment (Wohler pool) that favors predatory fish survival and predation success.

The Wohler Pool, located near Forestville in the Lower River, is created by Mirabel Dam which is operated by Sonoma Water as described above in the Project Description and below in the factors section (Section 2.4.4.5). Pool conditions are likely to diminish the value of this 5 km reach as salmonid habitat by: 1) preventing the establishment of emergent riparian vegetation, 2) reducing the ability of the river to cool at night (in the pond), and 3) potentially improving habitat conditions for known salmonid predators (Sacramento Pikeminnow and Smallmouth Bass; see additional discussion below in the factors Section 2.4.4.5).

Because Sonoma Water proposes to continue operation and maintenance of Mirabel Dam and Wohler Pool as part of the Proposed Action, these effects on PBFs of critical habitat (and listed species) are described in detail in the Effects of the Action Section. The effects on PBFs are briefly summarized here since this facility has been in operation for several decades and its past and present operations have affected the critical habitat in the Action Area.

The rubber dam creates Wohler pool and likely disrupts migration habitat resulting in delay of salmonid adults, juveniles, and smolts during their migrations. NMFS anticipates that adult migration delays are minimal, while delay of emigrating juveniles is more pronounced (see the Effects Section for more detail). Inflation and deflation of the dam, as well as gravel bar grading at the dam site, may create habitat conditions that strand juvenile salmonids on dry areas of the channel bottom when flows recede. Gravel bar grading also further degrades habitat complexity and adds small amounts of turbidity to aquatic habitat when flows first return to graded areas. Impounding water with the inflatable dam results in a small temperature increase in the already warm water in the impoundment. DO is only minimally affected.

The diversion intakes create habitat conditions that may entrain some juvenile salmonids, harming or killing them. The off-channel diversion ponds can trap salmonids if the river flood flows enter the ponds. Sonoma Water has rescued Chinook salmon and steelhead stranded in the ponds. In addition, Sonoma Water rescues any fish stranded during dam inflation/deflation. RPM 6 in the 2008 Opinion required that measures be undertaken to ensure that harm and mortality to listed salmonids is minimized from diversion operations, maintenance and fish screen replacement at Wohler and Mirabel. As part of the RPM's Terms and Conditions (Item C), Sonoma Water was required to decommission or modify the infiltration ponds on the east side of the Russian River at the Wohler facility to prevent fish entrapment in the ponds during flood events. As a result of the work Sonoma Water did to address RPM 6, the improvements to habitat conditions since 2008 have resulted in no salmonids needing rescue during dam inflation/deflation.

2.4.2.3 Dry Creek

In Dry Creek, flow regulation has resulted in elevated summer baseflow conditions that produce ideal conditions for growth of riparian trees and shrubs. Regulation has also resulted in severe curtailment of major floods, which limits disturbance and removal of newly recruited and established vegetation. This combination of effects has resulted in extensive vegetative colonization of formerly active bar surfaces. Colonization of the bar surfaces serves to limit lateral migration of the active channel within the channel corridor, and has the effect of sequestering a reservoir of gravel within the system. Vegetative colonization of bar surfaces has also led to an active channel that is efficient at moving significant amounts of gravel supplied to the stream from tributaries downstream of the dam despite the reduced flood flow hydrology. Mature vegetation and dense understory growth hydraulically concentrate high flow velocities in the channel during high flow events.

Dry Creek and its tributaries up to WSD are generally accessible to salmonids, though some small seasonal dams on tributaries may block migration. Flow in Dry Creek, augmented by WSD releases, is usually sufficiently deep to allow migrating fish to easily pass most shallow areas and water temperatures are sufficiently cool and suitable for immigration of all three adult salmonids. Habitat conditions are also sufficient for smolt emigration for all three species. Instream habitat structure has improved greatly in Dry Creek since the 2008 Opinion and will be discussed further below.

Stream bank erosion on Dry Creek has caused increased delivery of fine sediment, negatively affecting the quality of spawning habitat. WSD blocks sediment from recruiting to lower Dry Creek; this has resulted in numerous sites of exposed bedrock along the creek (S. White, Sonoma Water, personal communication, January 3, 2007). The availability of spawning habitat in Dry Creek is less for coho than for steelhead or Chinook salmon because coho salmon use smaller gravels for spawning than steelhead or Chinook salmon (USACE and Sonoma Water 2004).

These smaller gravels may be getting transported out of the upper reach of Dry Creek more readily due to the high flows in this creek (USACE and Sonoma Water 2004).

Coho salmon redds, which are constructed from November through January, are more subject to scour because they are subjected to a higher frequency of winter flow events. Higher flows, occurring in the latter part (January) of the spawning and incubation season, have the greatest potential to scour the most redds and incubating alevins (USACE and Sonoma Water 2004). In an evaluation of potential scouring of salmonid redds conducted by Sonoma Water, coho salmon redds had the highest frequency of scour potential in Dry Creek. Water temperatures are good in Dry Creek for incubation. However, in the lower portion of Dry Creek during the latter part of the spawning season (April and May) water temperatures are too warm for incubation, often exceeding 15° C.

Prior to action taken in response to the 2008 Opinion's terms and the start of habitat restoration activities in 2012, Dry Creek was lacking in riffles, cover, and instream structure that severely limited juvenile salmonid survival (SEC 1996). The lack of these habitat elements resulted in limited areas where juveniles could find refuge from high water velocities and cover for escaping predators. This lack of cover also limited sites where there is deposition of loose gravels and cobbles which provide habitat for aquatic invertebrates – the preferred prey of juvenile salmonids (USACE and Sonoma Water 2004). The low incidence of pools in the creek limited rearing habitat for coho salmon in particular, since they prefer pool habitat over riffle habitat. Velocities resulting from the flow releases exceeded the tolerance of juvenile salmonids, thereby reducing habitat suitability. Poor winter rearing habitat conditions are exacerbated by the USACE's flood control releases, which further limited foraging opportunities for juvenile coho salmon and steelhead by increasing the duration of flows at which these juveniles must seek velocity cover.

Since 2012, habitat restoration carried out in response to the 2008 Opinion's RPA has reduced the impacts to salmonids from high flow velocities (110 to 175 cfs) during the low flow season. The completed habitat enhancements have increased low velocity habitat, provided off channel refuge habitat, enhanced spawning habitat, increased shelter through LWD and boulder placement, and increased bank stabilization to significantly improve salmonid habitat along five miles of Dry Creek. In addition, the highest flow releases were curtailed in an effort to reduce turbidity and minimize stranding further improving habitat conditions during some years (ESA, Inc. 2023).

2.4.2.4 Lower Tributaries

The Lower River tributaries, including those in the Action Area, provide much of the habitat capacity for numerous Lower River steelhead populations as well as for the coho salmon population. Many tributary streams throughout the watershed and the mainstem channel in the Lower River have poor overwinter and outmigration habitat conditions from decreased habitat complexity. Summer rearing conditions are stressed due to dewatered stream reaches and high temperatures. Protection from predators is lacking, and unnaturally high fine sediment loads from surrounding land use are apparent (Ritter and Brown 1971; NCRWQCB 2000; CDFG 2002). Surrounding commercial and residential development and other land uses also contribute to poor summer rearing conditions in critical habitat areas throughout the watershed for coho salmon and steelhead, including the Action Area. Critical habitat conditions that represent PBFs for winter spawning, egg development, and summer rearing are considered marginal across the basin for salmonids.

2.4.2.5 Santa Rosa Creek Diversion

Constructed in 1963 as part of the CSWP, the Santa Rosa Creek Diversion Structure is a critical flood protection element that works in tandem with Santa Rosa Creek Reservoir to reduce flooding along Santa Rosa Creek and throughout the City of Santa Rosa. The Diversion Structure consists of a weir, fish ladder, Vortex Tube (submerged flow-regulating culvert under Montgomery Drive), and diversion channel that carries diverted high flows to Spring Lake (Santa Rosa Creek Reservoir). No changes to the Diversion Structure's specifications, structure, or operation are proposed in the BA (ESA, Inc. 2023) and the Diversion Structure is only a small component of designated CCC steelhead habitat. Additional details on the specifications and operations of the Diversion Structure can be found in the BA (ESA, Inc. 2023).

The habitat along the Santa Rosa Creek Diversion Structure is generally accessible to salmonids and is within designated critical habitat for CCC steelhead. The existing riparian corridor along the Diversion is extremely narrow and a small remnant of its former extent. These factors have led to a reduction in the native riparian vegetation, the introduction of non-native plants, increased straightening and engineered channelization for flood control purposes, increased erosion and sedimentation, loss of habitat complexity, increased urban run-off, water diversions, and increased fish passage impediments during low and high flow periods. Furthermore, the hydrology and natural geomorphic processes have been severely altered and non-point sources of pollution, such as urban and agricultural runoff, continue to contribute to the degradation of water quality within the Action Area.

Due to these factors and the factors listed above, it is expected that the ability for CCC steelhead to occupy the Action Area has declined and that critical habitat within the Action Area is degraded.

2.4.2.6 Estuary

The specific habitat functions provided by the Estuary include: successful passage of adult CC Chinook, CCC coho, and CCC steelhead migrants upstream, successful passage of salmonid smolts migrating to the ocean, successful growth and smoltification of steelhead parr, and growth and smoltification of some coho and Chinook salmon variants. The Estuary must, therefore, be open to the ocean tides during significant portions of the adult and smolt migration seasons, provide large areas of freshwater rearing space, as well as some areas of brackish and saltwater, and provide for an abundant and diverse invertebrate prey community as a food base for rearing juveniles.

The Estuary is highly valuable in that it is perhaps the only habitat that must support every individual from each of 16 populations of CCC steelhead (described in Section 2.4.3.3). With any other PBF of critical habitat, the species is distributed among different habitat patches. For example, while both the Austin Creek and Maacama Creek populations require summer rearing habitat, they may each experience very different habitat quality as a result of being in two different watersheds. Therefore, if something happens to the Maacama Creek habitat, the effect is limited to just that population. On the other hand, if habitat were degraded in the Estuary, it would affect not only the Austin Creek and Maacama Creek populations, but all 16 populations in the basin. The Estuary is, in this way, inextricably linked to the recovery of all populations in the Russian River.

General habitat conditions in the Estuary have changed little since 2008 and remain consistent with the description in the 2008 Opinion. Below we describe these conditions and largely positive changes benefiting aspects of habitat in the Estuary resulting from implementation of parts of the 2008 Opinion's RPA.

The Estuary extends from the mouth of the Russian River upstream approximately 11 km upstream between the communities of Duncans Mills and Austin Creek (Figure 28). Periodically, a barrier beach forms and closes the inlet between the Estuary and the Pacific Ocean. This closure causes the Estuary to switch from tidally fluctuating water levels to slowly rising water levels from river inflows and wave overwash creating a backwater lagoon to Monte Rio and as far upstream as Vacation Beach. The salinity in the Estuary is a mixture of tidal seawater and freshwater river flows. Closed mouth conditions restrict tidal exchange and limit salinity contribution to wave overwash and, typically, increase the depth of the freshwater lens in the Estuary and shifts brackish water upstream to as far as Brown's Riffle near Austin Creek (ESA, Inc. 2023).

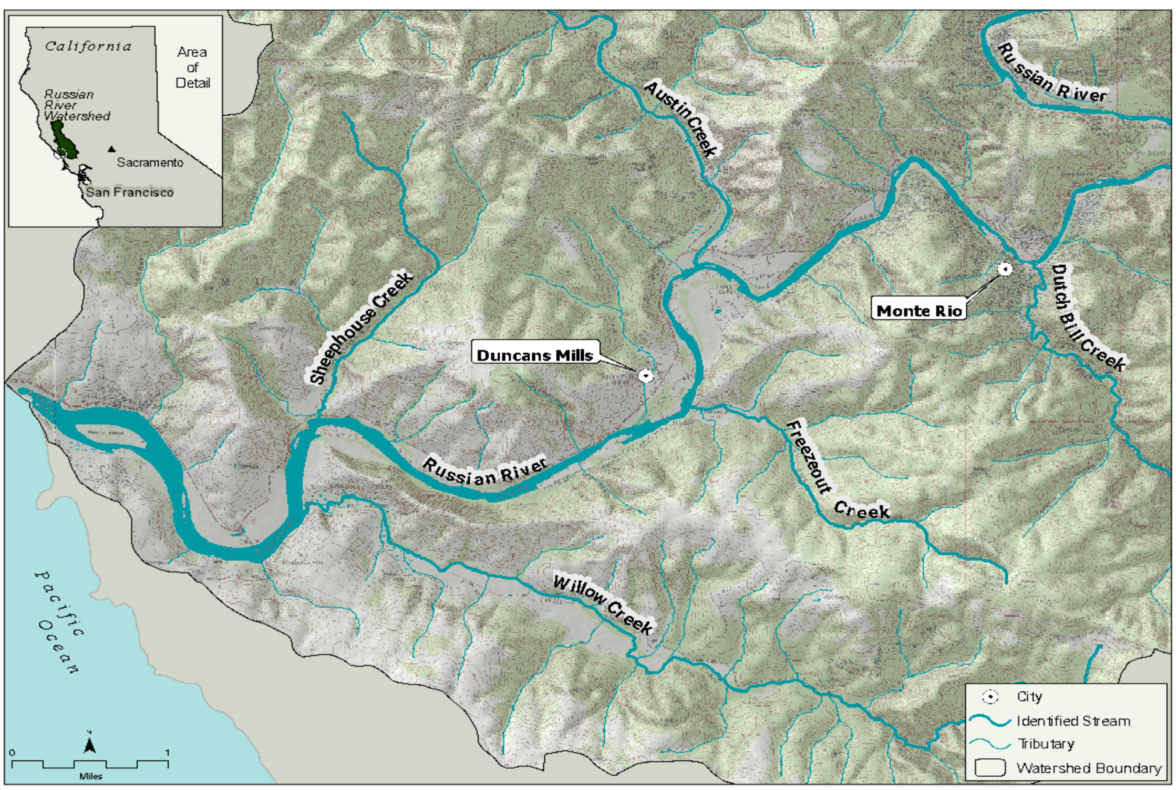

Figure 28. Map of the Russian River Estuary and main tributaries.

Sonoma Water has performed fish sampling the Russian River Estuary since 2004. They completed an Estuary Fish Survey Methods Study in 2003 that detailed co-occurring fish species in the Estuary (Cook 2004). Marine and estuarine species were commonly found in the lower reach (Figure 23) include: topsmelt (*Atherinops affinis*), surf smelt (*Hypomesus pretiosus*), and staghorn sculpin (*Leptocottus armatus*). The middle reach had a broad range of salinities and a diversity of fish tolerant of these conditions, including those found in the lower reach plus shiner surfperch (*Cymatogaster aggregata*) and bay pipefish (*Syngnathus leptorhynchus*). Freshwater dependent species, such as the Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), and Russian River tule perch (*Hysterocarpus traskii pomo*) were predominantly distributed in the upper reach. Anadromous fish, such as steelhead (*Oncorhynchus mykiss*) and American shad (*Alosa sapidissima*), which can tolerate a broad range of salinities, occurred throughout the Estuary. Habitat generalists, such as threespine stickleback (*Gasterosteus aculeatus*) and prickly sculpin (*Cottus asper*), occurred in abundance throughout the Estuary, except within full-strength seawater in the lower reach. Longfin smelt (*Spirinchus thaleichthys*) have been detected utilizing the mouth and higher salinity portions of the Estuary (1997-2000) (USACE and Sonoma Water 2004), though not in a recent study by Brennan *et al.,* (2022), but it is unclear the extent to which they may utilize Estuary habitat for spawning.

Sonoma Water implemented ten years (from 2010 to 2019) of extensive aquatic invertebrate (salmonid prey) research for the Russian River Estuary Management Project (reported in Fuller 2011; Seghesio 2011; Accola 2021). The more important salmonid dietary macroinvertebrates common in the Estuary included both insect larvae and benthic/epibenthic organisms, and were identified as larval insects (*Ephemeroptera, Chironomidae*), amphipods (*Americorophium spinicorne, Eogammarus confervicolus*), oppossum shrimp (*Neomysis mercedis*), and isopods (*Gnorimosphaeroma insulare*) (Seghesio 2011). Previous studies of macroinvertebrate diversity also reported other macroinvertebrates such as bay shrimp (*Crangon sp.*) and Dungeness crab (*Cancer magister*) to be present across the Estuary (USACE and Sonoma Water 2004).

Pinnipeds found in the Estuary and on its bar include harbor seals (*Phoca vitulina*) present year-round, as well as sea lions (*Zalophus californianus*) and elephant seals (*Mirounga angustirostris*), which are found less regularly (USACE and Sonoma Water 2004).

The Estuary is a bar-built estuary, meaning that its behavior is heavily influenced by the characteristics of the barrier beach (bar) that periodically forms and closes the river mouth. Though closure happens most often during the fall when long-period ocean swell waves can deposit more sand in the inlet than tidal and riverine flow can scour, it can occur in any month of the year. At times of stronger wave conditions or weak river discharge conditions, sand deposition into the tidal inlet may completely block the inlet, creating a continuous barrier beach that separates the ocean from the Estuary. This 'closure' of the inlet alters the characteristics of the Estuary over the subsequent days and weeks, shifting conditions from colder and well-mixed vertically to a water body with vertical layers of differing salinity, temperature, and DO. When water quality conditions in the Estuary are otherwise favorable, these 'lagoon' conditions can at times provide valuable rearing habitat for juvenile salmonids during the late spring into summer months when closures coincide with juvenile steelhead rearing. This behavior is common for the majority of smaller estuaries in California, as well as a number of sites in Oregon. During inlet closures, flow from these estuaries may spill in one direction over the beach without eroding a tidal inlet. This is referred to as 'outlet channel' or 'perched outlet channel' conditions. At the Russian River, perched conditions are rare, occurring only as a transitional state immediately before closure or full inlet breaching (ESA, Inc. 2023).

As described in 2.4.1.4, prior to dams and diversions in the Russian River watershed, the Estuary was frequently open to ocean tides for several months between late fall and early spring of most years, and closed to ocean tides sometime during the late spring through the early fall of most years. This pattern of open estuarine conditions in the late fall, winter and early spring, followed by estuary closure to ocean tides in the late spring, summer, or early fall, remains evident more recently. For example, the bar at the mouth of the Estuary closed in the spring (April-June) in 8 out of 12 years for the period 1996 to 2007. This occurred even with inflows augmented by the dam releases. During the 12-year period, 1996 to 2007, when the Estuary closed in the spring, the Estuary remained open after breaching for about 90 days on average during the late spring through early fall, ranging between about 44 and 144 days open.

Closure of the Estuary's bar is a fairly complex process related to tides, waves and swells, sediment transport, and river flows (RREITF 1994; Nelson et al., 2008). For example, closure of the bar in 1992 occurred during both spring and neap tides, but favored neap tides (RREITF 1994). In general, the timing of the highest anticipated Russian River stream flows generally coincides with larger coastal waves at the mouth; with these conditions, the Russian River often flows to the ocean. As Russian River stream flow wanes in the spring, sufficient hydraulic energy is not available to maintain a direct connection to the ocean. This, combined with the presence of bar building wave events[9], often causes a barrier beach to form at the outlet of the Estuary. In some instances, closure does not occur until late summer (Nelson et al., 2008; Sonoma Water 2024d) due to the absence of bar building wave events in the spring.

Closed estuaries in California can become productive freshwater lagoons (Smith 1990), dependent upon the time of initial closure and freshwater inflow to the estuary. Conversion to freshwater occurs when freshwater from upstream builds up on top of the salt water layer, gradually forcing the salt water layer to seep back into the ocean through the barrier beach. In the estuary/lagoon systems Smith (1990) studied, it took at least one month for a freshwater lagoon to form. Freshwater conditions can also result from perched lagoons, a condition (as described above) where the estuary is closed to ocean tides but freshwater flows out over the bar. The freshwater outflow entrains some of the salt water at the boundary between fresh and salt layers, steadily removing salt water from the lagoon.[10] NMFS staff have observed such a conversion in the Carmel Lagoon from 2005-2007 (John McKeon, NMFS, personal communication, 2008).

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[9] Under stormy seas conditions, sand is eroded from a barrier beach by long period swells that break high on the beach and then transport beach sand offshore. When the storm seas subside and shorter period waves and swells predominate, sand is transported back onshore, rebuilding barrier beaches (Dean 1973).

[10] Several studies have demonstrated salt water flushing related to freshwater flows over salt water layers. See, for example, Debler and Imberger (1996), Western *et al.,* (1998), Coates *et al.,* (2001), and Coates and Guo (2003).

Over longer lagoon durations, this seepage gradually converts to freshwater, leading to deepening of the freshwater lens and enhanced estuarine rearing habitat for salmonids.

Based on data obtained from 2000 to 2021, the Estuary is most often wide open (66 percent of the year) or closed (24 percent), with occasional artificial breaches occurring in the fall. Of the ten prolonged closure events that occurred from 2010 to 2022, the majority (seven) ended in a natural breach (self-breach: Table 11): artificial breaches during the lagoon management season (May 15 to October 15) have been rare (less than once per year on average) in the 2010-2020 period. Since the 2008 Opinion, during the fall it has been observed that bar closures in the Russian River Estuary do not last longer than three weeks. Increasing flows in the mainstem during the fall usually overtop the bar within two to three weeks of bar closure, naturally opening the migration route for migrating salmonids (Table 11).

In the Russian River Estuary, the longest closure events observed between 2009 and 2020 lasted four to five weeks and showed signs of decreasing salinity in the lower reach's mid-depths, possibly due to seepage of saline water from the Estuary through the barrier beach to the ocean (ESA, Inc. 2023). Observations are not available for longer closure events that may have occurred historically, but application of a Quantified Conceptual Model ("Jetty Study") suggests that over several months, salinity would continue to decrease near the mouth, but not enough to allow freshwater to occupy the entire water column within the timeframe of the management season (Behrens et al., 2015; ESA, Inc. 2023).

Table 11. Observed Russian River outlet channel and prolonged inlet closure events: 2010-2020 (ESA, Inc. 2023).

Event	Time Period	End Mode	Jenner Gage Water Level (ft)	Limiting Factors
Outlet Channel: Natural	6/27/2010-7/4/2010	Mouth closure	7.2	None
Outlet Channel: Implemented	7/8/2010	Mouth closure	5.6	None
Inlet closure (25 days)	6/8/2013-7/3/2013	Self-breach	7.7	Beach inaccessible – topography
Inlet closure (21 days)	**9/24/2013-10/15/2013**	**Artificial breach**	**7.4**	**Water level below 7 ft NGVD29**
Inlet closure (35 days)	9/17/2014-10/22/2014	Self-breach	8.7	Beach inaccessible – waves, topography
Inlet closure (24 days)	**10/24/2014-11/17/2014**	**Artificial breach**	**7.9**	**After management season**
Inlet closure (26 days)	9/8/2015-10/4/2015	Self-breach	6.7	Beach inaccessible - topography
Inlet closure (26 days)	**10/10/2015-11/5/2015**	**Artificial breach**	**9.3**	**Beach inaccessible - topography**
Outlet channel: Implemented	6/7/2016	Self-breach	7.8	None
Outlet channel: Implemented	6/27/2016	Self-breach	7.8	None
Outlet channel: Natural	6/27/2017-7/3/2017	Mouth closure	7.8	None
Outlet channel: Implemented	7/17/2017	Self-breach	7.8	None
Inlet closure (22 days)	8/5/2017-8/27/2017	Self-breach	8.3	Beach inaccessible - topography
Outlet channel: Implemented	9/28/2017-10/3/2017	Beachgoer breach	8.3	None

Event	Time Period	End Mode	Jenner Gage Water Level (ft)	Limiting Factors
Inlet closure (29 days)	10/15/2018-11/13/2018	Self-breach	8.5	After management season
Inlet closure (27 days)	9/28/2020-10/25/2020	Self-breach	7.3	Water level below 7 ft NGVD29
Inlet closure (26 days)	9/28/2021-10/24/2021	Self-breach	11.2	Jenner gage inoperable, estimate from Hwy 1 gage
Inlet closure (25 days)	**10/21/2022-11/15/2022**	**Artificial breach**	**8.3**	**None**

Monitoring since the 2008 Opinion has shown that conditions during closure events rapidly shift in different parts of the Estuary (Table 12).

The salinity in the Estuary is a mixture of tidal seawater and freshwater river flows. Closed mouth conditions restrict tidal exchange and limit salinity contribution to wave overwash and, typically, result in stratification with a freshwater lens on top and saline water at depth, and shifting brackish water upstream to as far as Brown's Riffle near Austin Creek.

DO levels in the Estuary fluctuate significantly during the monitoring season (May 15 to October 15). Fluctuations are not necessarily associated with tidal cycles or a diurnal cycle, but DO levels do decline in the stratified marine deep layer after bar closure (Table 12). If breaching is timed poorly, the low DO can mix through the water column in the lower estuary and creates the potential for a fish kill (ESA, Inc. 2023). DO levels in the Estuary depend upon factors such as the extent of diffusion from surrounding air, and water movement including freshwater inflow and tidal exchange: as a result, surface water remains well-mixed with the overlying air and has high DO levels even after bar closure. DO levels are also a function of nutrients, which can accumulate in standing water during an extended period and thus promote high plant and algal growth. However, as these species die off and decay, this decomposition consumes DO, resulting in low DO conditions. Estuaries tend to be naturally eutrophic (high nutrient) because land-derived nutrients drain from the entire watershed to an estuary before entering the marine environment.

Seasonal temperatures at the surface (freshwater or fresher water layer) in the lower and middle Estuary are mostly controlled by weather conditions on the coast. In the upper Estuary, water temperatures are more dependent on the temperature of freshwater inflow. As a result, surface temperatures in the upper Estuary are higher, but less variable and tend to peak in July and August. Bottom temperatures in the Estuary appear to be heavily influenced by the presence of seawater. When saltwater moves upstream during low river discharge conditions or during periods of inlet closure, it often coincides with warmer temperatures at mid-depths above the halocline (the depth at which distinct salinity layers are observed), and colder saltwater at the bottom with low oxygen.

During open estuary conditions, water temperatures in the mainstem are consistently higher (up to 25°C) in the freshwater surface layer than in the saline layer at the bottom (10 to 18°C), and surface temperatures tend to peak in July and August. The differences in temperatures between the underlying saline layer and the overlying freshwater layer can be attributed in part to the marine source of saline (saltwater) and inland source of freshwater. During open Estuary conditions, the Pacific Ocean (typically 10°C), is the source of saltwater in the Estuary. Whereas in the mainstem, water temperatures reach as high as 27°C in the interior valleys.

During closed Estuary conditions, increasing temperatures associated with fresh/saltwater stratification are observed to occur in the middle reach. Density and temperature gradients between freshwater and saltwater play a role in stratification and serve to prevent or minimize mixing of the freshwater and saline layers. During the warmer dry months of summer and fall, when the Estuary is closed or the river mouth is perched and the supply of cool tidal inflow is reduced, solar radiation heats the overlying freshwater surface layer and underlying saline layer. The overlying freshwater surface layer restricts the release of this heat from the underlying saline layer, which can result in higher water temperatures in the underlying saline layer than in the overlying freshwater layer. Stratification-based heating has also been observed to result in higher temperatures in the mid-depth saline layer compared to the bottom layer in deep pools, forming a three-layered water column (ESA, Inc. 2023). This stratification-based heating can also contribute to higher seasonal mean temperatures in the saline layer than would be expected to occur under open conditions.

Table 12. Typical observed shifts in water quality conditions during closure in the lower, middle and upper Estuary (ESA, Inc. 2023). See Figure 23 for a map of Estuary regions.

	Lower Estuary	Middle Estuary	Upper Estuary	
Inlet State and Time Period	**Mouth**	**Patty's Rock, Bridgehaven, Willow Cr (at confluence) Sheephouse Creek**	**Heron Rookery, Freezeout Cr, Browns Pool, Austin Cr**	**Notes**
Wide open: >1 week before closure	S: Mixed, oceanic	S: Mixed, brackish	S: Mixed, fresh	Strong tidal influence in the Lower and Middle Reaches, fresher conditions upstream. Well mixed. Low water levels.
	T: Cold	T: Cold	T: Warm	
	DO: High (well mixed)	DO: High (well mixed)	DO: High (well mixed)	
Muted: <1 week before closure	S: Stratified, oceanic at depth	S: Stratified, brackish at depth	S: Stratified, brackish at depth	Reduced tidal exchange allows freshwater upper layer to form/thicken. Stratification and initial settling of saltwater. Low water levels.
	T: Cold	T: Cold	T: Warm	
	DO: Declining at depth	DO: Declining at depth	DO: High; if brackish declining at depth.	
Day of Closure	S: Mixed (wave overwash), oceanic	S: Stratified, increasingly oceanic at depth	S: Stratified, brackish at depth	Oceanic influence at mouth from significant wave overwash during closure. Additional saltwater trapped.
	T: Cold	T: Cold	T: Warm	
	DO: Low at depth	DO: Low at depth	DO: High; if brackish declining at depth.	
1 Week after closure	S: Stratified, oceanic at depth	S: Stratified, oceanic at depth	S: stratified, brackish at depth	Trapped saltwater at mouth settles into Middle Reach at depth. Loss of tidal exchange allows temperature to increase. Declining DO at depth where saltwater is trapped.
	T: Warm, increasing	T: Warm, increasing	T: Warming during peak summer air temperatures	
	DO: Declining at depth	DO: Declining at depth	DO: Declining at depth	
2 Weeks after closure	S: Stratified, oceanic at depth	S: Stratified, oceanic at depth	S: Stratified, increasingly brackish at depth	Saltwater at depth spreading to Heron Rookery and Freezeout Creek. Warmer conditions at the fresh/salt interface. Becoming anoxic at depth.
	T: Warm, increasing	T: Warm, increasing	T: Warming during peak summer air temperatures	
	DO: Hypoxic/anoxic at depth	DO: Hypoxic/anoxic at depth	DO: Hypoxic/anoxic at depth	
4 Weeks after closure	S: Stratified, decreasingly oceanic at mid-depth	S: Stratified, decreasingly oceanic at mid-depth	S: Stratified, increasingly brackish at mid-depth	Saltwater leaving lower Estuary by seepage. Saltwater reaching Browns Pool. Still anoxic at depth and warmer at the fresh/salt interface throughout Estuary.
	T: Warm	T: Warm	T: Warming during peak summer air temperatures	
	DO: Anoxic at depth	DO: Anoxic at depth	DO: Anoxic at depth	

NOTES: 'S' refers to salinity, 'T' refers to temperature, 'DO' refers to dissolved oxygen'

During the onset of stratified conditions during bar closure, habitat expands for freshwater acclimated juvenile steelhead in the freshwater lens atop the Estuary and any newly flooded littoral habitat. Aquatic invertebrates, the prey base for juvenile steelhead, are often more diverse and abundant in a lagoon. During longer periods of lagoon closure, freshwater habitat expands, and freshwater-acclimated steelhead can have more abundant space and prey for survival.

Artificial breaching by Sonoma Water has generally facilitated the persistence of a mostly marine environment in the Estuary in the summers. Although there is uncertainty regarding whether or not the Estuary historically converted to a completely freshwater lagoon or remained stratified after bar closure, artificial breaching and high summer flows have had large impacts on salmonid habitat conditions. The following is a summary of these impacts since the 2008 Opinion.

Every time the barrier beach is mechanically breached, much of the limited existing freshwater lens (rearing habitat for younger juveniles) in the lower 4 miles of the Estuary runs out into the ocean. Near the mouth of the Estuary aquatic conditions (e.g., salinity or temperature) through the water column become nearly marine. The extent of the upstream effect of these conditions depends upon tidal fluctuation and freshwater inflow from the Lower River and Estuary tributaries. The juvenile steelhead rearing PBF of critical habitat is degraded in the Estuary during the late spring, summer, and early fall by repeated mechanical breaching for flood control. Estuarine habitat is important to steelhead as rearing and migration habitat, and is influential in providing growth and survival opportunities as juveniles transition to the ocean phase of their life cycle. Bond (2006) found up to 48 percent of the juvenile steelhead population in Scott Creek had reared in the Estuary and that they made up a disproportionate number (85 percent) of returning adults. It is likely that the Estuary historically provided similar functions for steelhead in the basin, though its precise contribution to steelhead productivity in the basin is unknown. Current conditions are not conducive to successful rearing of large numbers of freshwater-acclimated juveniles due to the limited extent of freshwater rearing habitat.

Rearing habitat for juvenile steelhead in much of the Estuary often remains heavily influenced by the marine environment for months, limiting the amount of freshwater-acclimated juvenile steelhead that can successfully use the Estuary, due to their low salinity tolerance. However, these habitat conditions do support larger steelhead juveniles some of which may be “half-pounders” (i.e., post smolt/sub-adult steelhead juveniles) that return early from the ocean to rear in river and streams before going out to sea to become spawning adults (Snyder 1925; Kesner and Barnhart 1972; Fuller 2011).

Estuarine habitat for Russian River coho salmon has also recently been shown to be more important than previously thought for rearing and adult returns for a subset of coho salmon variants. In a 9-year PIT-tagging study, Baker *et al.,* (2025) found a portion of coho salmon released annually by the conservation hatchery in upper Willow Creek down-migrated to estuarine habitat in lower Willow Creek an average of 117 days earlier than “natal fish” that remained in the freshwater habitat in upper Willow Creek, and those variants rearing in the Estuary exhibited higher growth rates and proportionally higher adult returns than the natal fish in most years.

The estuarine rearing habitat conditions for freshwater-acclimated “natal” coho salmon are likely worse than for steelhead. High salinity concentrations during open conditions probably limit habitat availability to the upper Estuary below Austin Creek. However, coho salmon have less tolerance for high water temperatures than steelhead, which likely preclude their use of most of the upper Estuary in the summer. As noted above, the Estuary has relatively limited marshlands, which some variants of coho salmon utilize for estuarine rearing areas (Miller and Sadro 2003; Baker *et al.,* 2025).

As described in Section 2.2.1, some variants of Chinook salmon juveniles will utilize estuarine habitat for two to three months for rearing (Healey 1991). Wetland habitats within estuaries are likely important for Chinook rearing and for providing life history variation that can enhance adult returns (Macdonald *et al.,* 1988; Miller and Simenstad 1997). The limited wetland habitats in the Russian River Estuary may also be a limiting factor for Chinook rearing. Populations have recently been too low to confidently assess the extent of current Chinook that may be rearing in the Russian River Estuary.

In sum, satisfactory freshwater rearing habitat for salmonids may only be currently maintained consistently at the upstream end of the Estuary and near tributary mouths, where freshwater inflow maintains low salinity conditions regardless of tidal action or beach state. The resulting high salinity in the lower Estuary during open conditions likely limits accessible habitat for freshwater-acclimated juvenile salmonids rearing in the Estuary. Rearing habitat for freshwater-acclimated steelhead expands when the beach is closed and freshwater littoral habitat is inundated, but current inflow conditions do not promote prolonged beach closure events based on recent history.

Salmonid migration habitat in the Estuary is in relatively good condition. The Estuary is usually open due to winter storms during the steelhead and coho migration period. During the spring months the Estuary is usually open, which allows for salmonid smolt outmigration. In the fall, the Estuary is often open, but it does close periodically. When it closes, it may breach naturally or require mechanical breaching to open. CC Chinook typically begin migrating in late summer when the Estuary may at times be closed (Figure 7). Breaching in the fall may provide attraction flows which could encourage more Chinook salmon to migrate upstream prior to fall and winter rains, which may expose some adults to impacts from recreational fishing, above optimal water temperatures, or inability to access upstream habitats due to low stream flows. NMFS compared the dates of Estuary closure and breaching in the fall with Chinook salmon counts at Mirabel Dam. In some cases, the salmon counts appear to rise shortly after the Estuary is breached. However, NMFS found at least one year (2002) when over 1,000 Chinook salmon were counted at Mirabel (26-Sept.) prior to closure of the bar (30-Sept.) and the onset of fall breaching. Thus, breaching does not always trigger large numbers of Chinook salmon to enter the Estuary. Increases in numbers of Chinook salmon are also more generally correlated with increased flows in the Russian River which often start in late October or early to mid-November. Summer water temperatures are generally adequate as the result of the coastal climate, until the barrier beach closes off exchange with cold ocean water and warm freshwater from the river builds up at the surface.

Currently, little shelter (e.g., LWD, boulders) exists in the Estuary mainstem. The current status of the habitat in potential enhancement sites (Figure 23) for wetland and/or floodplain habitats is described briefly below.

Willow Creek currently provides important wetland habitat, including littoral and epibenthic habitat types, primarily supporting steelhead, as well as some coho and Chinook salmon. The creek's perennial flow provides freshwater that runs through the center of the site. This freshwater tempers the salinity of the Estuary, and can provide refugia for juvenile salmonids that are not marine-acclimated. The creek's vegetated floodplain creates robust marsh habitat when inundated and riparian vegetation also provides some shading to help reduce water temperature.

Water quality data in the confluence of the creek with the Estuary shows that Willow Creek is generally fresher than nearby sites at Bridgehaven and Sheephouse Creek in wide open, muted, and closed conditions. It is warmer than other middle reaches of the Estuary during wide open inlet conditions and tends to be colder than nearby sites in muted or closed inlet conditions. Willow Creek temperatures are more moderate compared to stations further upstream due to greater exposure to marine fog and winds, and enhanced shading from dense riparian canopy, which is mostly absent across most of the Estuary. Willow Creek experiences a greater range of DO than adjacent sites under all inlet conditions.

During closed conditions, low summer creek inflow and limited hydraulic connectivity, as well as the high biological oxygen demand, means that water in the lower creek and its inundated floodplain in its current state often becomes anoxic after two to three weeks from the start of closure (RREITF 1994), particularly during periods of high-water levels (ESA, Inc. 2023). When the mouth of the Estuary breaches, these anoxic waters can surge out into the river's main stem and result in stress or mortality of any fishes residing in the area.

Patty's Rock comprises 140 acres, arranged as a horseshoe along an inner bend of the river (Figure 23). The site's elevations range from subtidal to uplands, with higher elevations on the eastern portion of the site. The interior of the site contains a seasonal freshwater wetland. The parcel is currently used for cattle grazing and is privately owned, as two parcels, one on either side of Highway 1. Existing channels on the site are linear ditches and short segments just penetrating the site at its downstream end. Hydrologic connectivity currently only occurs during bank overtopping when water levels exceed the typical tide range. The floodplain's southern banks along the river vary from steeper slopes armored with riprap to gentler slopes with existing short channel sections.

The Goat Hill floodplain in the lower Estuary (Figure 23) is typically inundated with saline water when the mouth is open. The majority of this site is publicly-owned, as part of Sonoma Coast State Beach. A part of the eastern portion may be privately-owned land. The site extends for 53 acres and comprises two portions that are separated by intertidal areas where the slope of the hillside comes right down to the water's edge, and provide wetland transgression space for sea-level rise. The majority of the western portion is within intertidal elevations. The eastern portion has higher ground surface elevations that are in the supratidal range and slope upwards towards flood tide elevations. Historical maps indicate that the western portion was tidal marsh and the eastern portion was grass uplands (ESA, 2023). Both portions are currently vegetated with a mix of wetland and upland species.

Penny Island (Figure 23) consists of 48 acres of vegetated floodplain close to the river's mouth. The island is publicly-owned. Most of the island falls within a parcel owned by State Parks as part of Sonoma Coast State Beach. Other portions of the island fall within the public trust tidelands, which is managed by the State Lands Commission. The western portion of the island is within the intertidal range. The eastern portion of the island is higher, and its elevations are only inundated by supratidal or flood state conditions that can occur when the mouth is closed. Historic mapping shows two small tidal marsh regions on the island, with the remainder of the island vegetated with upland grassland (ESA, Inc. 2023). The site has hydrologic connectivity along its entire border, but primarily in the form of overbank flow since only a few short tidal channels currently penetrate into the island. Vegetation on the site includes nonnative species.

In most cases in California, Chinook salmon, coho salmon, and steelhead do not spawn in estuaries with conditions similar to the Russian River Estuary. Therefore, to our knowledge the Estuary does not contain spawning PBFs for Chinook salmon, coho salmon, and steelhead.

2.4.3 Status of Salmonids in the Action Area

2.4.3.1 CC Chinook Salmon in the Action Area

There are few references to the occurrence of anadromous salmonids in the Russian River prior to 1900. Although lacking in detail, accounts suggest the presence of Chinook salmon in the Russian River historically. The earliest record of a salmon fishery found for Sonoma County was from 1888. The U.S. Commission of Fish and Fisheries described a commercial fishery consisting of 19 men gillnetting “winter salmon” from the Russian River (salmonids were not identified to species). In 1888, 33,597 pounds of salmon were captured by commercial fishermen and shipped to San Francisco. In addition, local consumption of fish (multiple species) was estimated at 150,000 pounds. The report observed that the commercial fishery of the Russian River had become “rather unimportant” by 1888 but had been noted for its abundance of salmon. Overfishing was cited as the reason for the decline. Although Chinook salmon are considered native to the Russian River, CDFW memos from the 1940s and 1950s stated that few, if any, Chinook salmon inhabited the river (although a few sources did suggest Chinook salmon were observed in the Russian River). Rich et al., (1944) does not mention Chinook salmon in a report discussing the fishery of the Russian River for 1941. Returns to DCFH from 1980 to 1996 ranged between 0 and 304, with the biggest count in 1988. Similar to the 1940s, Sonoma Water fishery biologists in 1999 concluded that few Chinook salmon inhabited the watershed. However, a juvenile trapping program and the operation of underwater video cameras since 2000 (Figure 29) has documented a robust, self-sustaining Chinook salmon population.

Within the CC Chinook salmon Central Coastal diversity stratum, there is one essential population that inhabits the Russian River: the Russian River Chinook salmon population (NMFS 2016c). Within the Action Area, Chinook salmon rear and spawn primarily in the Upper River and in the mainstem Dry Creek and its uppermost tributary, Pena Creek. There are also documented spawning occurrences in a few tributaries of the Russian River that are outside of the Action Area such as Mark West and Mariposa Creeks. All Chinook salmon from this population use the Estuarine and Lower River portion of the Action Area for adult and smolt migration.

Based on run timing, Chinook salmon inhabiting the Russian River are considered fall-run. Adult Chinook salmon have been observed at the Mirabel fish counting station as early as August through at least early February; however, the adult upstream migration consistently peaks in October and November. Juvenile Chinook emigrate downstream from approximately late-February through July, with peak emigration from mid-April through mid-May. It is likely that the extended migration period in the Russian River is related to the anomalous conditions created in Dry Creek. The cold water released from Lake Sonoma masks the seasonal cues that occur in the rest of the watershed. While water temperatures exceed 20º C by mid-May in the Russian River upstream of Healdsburg, water temperatures in Dry Creek are typically 4 to 5º C cooler during this period. Chinook salmon captured in the rotary screw trap at the Mirabel dam site have an average size of 3.5 inches fork length (range 1.3 to 5.5 in).

Currently, the only reliably quantitative population estimate in the Russian River is the video counts of Chinook salmon migrating past the Mirabel fish ladders conducted by Sonoma Water since 2000 (Figure 29; Sonoma Water 2024g). In 2012, 6,730 adult Chinook salmon were counted at the station which was the highest total counted to date. However, in 2020, only 626 adult Chinook salmon were counted, the lowest total since counting began. Numbers rebounded in 2022 with 1,180 counted and 1,997 observed in 2023. While there appears to be a slightly downward trend in these data, the statistical significance of this trend cannot be evaluated. The average count represents about 32 percent of the viability target for the Russian River and the population is considered low risk based on the effective population size criterion (SWFSC 2023).

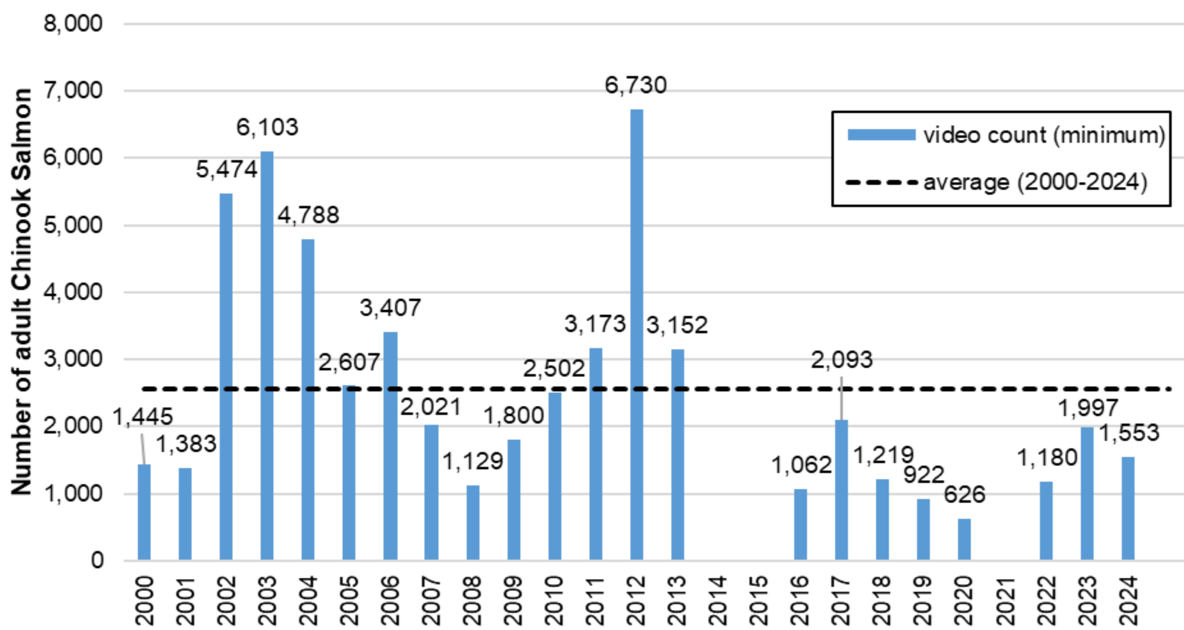

Figure 29. The minimum adult Chinook count for the Russian River for return years 2000 to 2024. Typical start-end dates of the Chinook run in the Russian is 9/1 to 12/15. The Chinook estimate is from a video count taken from the fish ladders at the Mirabel inflatable dam on the mainstem Russian River at river kilometer 39.7 and represents a minimum fish count that should only be considered representative of the yearly magnitude of the run. The camera was not operated at Mirabel in 2014 and 2016 because the dam was being replaced. No counts are reported for 2021 because the camera was removed early in the year (10/23) due to high flows associated with an unusually early large rain event (J. Smith, Sonoma Water personal communication, 2025).

Since 2002, Sonoma Water has surveyed and documented relatively large numbers of Chinook salmon redds in the Upper River (less so since 2013) and in the mainstem of Dry Creek (Table 13). In Dry Creek, the number of redds observed has declined since 2013 with an average of 250 redds observed from 2003 to 2013 and only an average of 89 redds observed from 2016 to 2022. In the watershed as a whole, the total number of redds observed ranged from 1036 and 1157 in 2002 and 2003 respectively, to only 687 in 2013, the last year redds were consistently surveyed.

Most Chinook salmon redds have been located in the Upper River, near Ukiah and in Dry Creek. In general, the abundance of redds progressively increases moving upstream in the Upper River and this pattern occurs annually (Table 13). Based on reach length, the relative contribution of redds in Dry Creek was proportionately greater than in the Russian River mainstem. The Dry Creek reach included 16.0 percent (21.7 rkm) of the study area compared to 84.0 percent (113.9 rkm) of the Upper River. However, Dry Creek contributed from 22.1 percent to 38.0 percent of the redds observed annually (Sonoma Water 2008). Additionally, these spawning surveys didn't include redds in Pena Creek, a tributary to Dry Creek, that has since found to be a high-density spawning area for Chinook salmon (Sonoma Water and CSG 2020).

Pena Creek is the most upstream stream in the Dry Creek basin and is the last major tributary that enters downstream of WSD. Likely because of this proximity to DCFH, the Pena Creek watershed is prone to having disproportionately high adult spawning activity compared to other streams in the Russian River watershed. Results from CMP surveys in the Russian River watershed indicate that more salmonid spawning occurs in Pena Creek than in any other tributary within the Russian River watershed (Sonoma Water and CSG 2020). For example, during the winter of 2018/19, 157 salmonid redds were observed in Pena Creek, representing 30 percent of the 516 redds observed in 53 Russian River tributaries surveyed. Similarly, in 2023/24, 50 percent of all salmonid redds and 100 percent of the Chinook redds observed in the Russian River watershed were seen in Pena Creek (Sonoma Water and CSG, unpublished data). A combination of its large watershed size (22.6 mi^2), extensive drying each summer, high water temperatures and limited human development, makes Pena Creek watershed a prime location to benefit from salmonid restoration projects (Pena Creek Watershed Flow Enhancement Support Tool 2024).

Many more migrating adults were counted at Mirabel Dam as described above. NMFS assumes that overlapping redds (superimposition), spawning occurring after survey work, spawning outside of the study areas, and the loss of some fish prior to spawning due to predation or illegal fishing are likely explanations for the small number of redds observed compared to adults counted. Redd counts are from a single pass survey counts during the peak of fall spawning activity. Due to high flows and turbid conditions during peak season, redd surveys are often either not conducted or incomplete (missing data in Table 13), thus numbers should be considered as index estimates.[11]

[11] Counts of salmon reds provide an indirect estimate (index) of the effective population size of reproductively active adults.

Table 13. Chinook salmon redd surveys have been conducted in the Upper River and in Dry Creek since 2002 (Martini-Lamb and Manning 2024).

Reach	River km	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22
Ukiah	33.1	511	464	284	*	248	118	20	38	*	*	90[2]	81	*	*	*	*	*	*	*	*	*
Canyon	20.8	277	190	169	*	68	88	36	38	*	*	*	43	*	*	16[2]	*	*	*	*	11	*
Alexander Valley	26.2	163	213	90	*	62	131	65	129	*	97	185	163	*	61[2]	41[2]	39	25	*	*	26	15
Upper Healdsburg	25.6	79	40	8	*	23	67	48	38	*	66	53	57	*	*	1[2]	14	*	*	29	2	*
Lower Healdsburg	8.2	6	0	7	*	1	2	9	30	*	7	4	18	*	*	*	6	*	*	18	0	*
Russian River Total	**113.9**	**1036**	**907**	**558**	*	**402**	**406**	**178**	**273**	*	**170**	**332**	**362**	*	*	*	*	*	*	*	*	*
Dry Creek	21.7	*	256	342	*	201	228	65[1]	223	269	229	362	325	*	78	90	112	86	15	91	*	154

[1]Redd numbers are an estimate.
[2]Redd numbers are presumably an underestimate due to poor survey conditions.

The total number of Chinook salmon smolts captured in Sonoma Water's DSMTs in Dry Creek and in the Lower River at Mirabel for years 2009 to 2022 is presented in Table 14. Trends generally show decreases in trap counts from the late 2000s to present with relatively low count for all years. However, the abundance estimates are affected by the trapping period. Due to flow conditions, the Mirabel trap typically operates for fewer days than the Dry Creek trap and, therefore, many smolts are likely missed in the mainstem trap.

Table 14. Estimated abundance (±95% CI) of Chinook Salmon smolts, at Dry Creek and Mirabel (Lower River) downstream migrant traps, 2009 to 2022. Note that abundance estimates are affected by the trapping period. The Mirabel trap typically operates fewer days than Dry Creek due to flow conditions (Sonoma Water, unpublished 2025).

Year	Dry Creek Westside Road	Russian River Mirabel	Comments
2009	200,415 (±22,206)	41,663 (±10,208)	
2010	84,785 (±16,291)	109,540 (±47,463)	
2011	225,392 (±29,834)	372,662 (±85,676)	
2012	117,930 (±20,956)	57,828 (±10,680)	
2013	105,211 (±14,281)	167,823 (±17,320)	
2014	172,444 (±17,321)		No estimate
2015	85,895 (±5,495)		Mirabel not fished due to new fish ladder construction
2016	64,385 (±3,874)		
2017	37,260 (±6,221)		No estimate

Year	Dry Creek Westside Road	Russian River Mirabel	Comments
2018	43,250 (±12,335)	49,666 (±21,535)	
2019	17,665 (±5,661)	23,815 (±6,861)	
2020	109,896 (±44,135)	220,196 (±126,658)	
2021	68,533 (±115,138)	62,088 (±7,276)	
2022	197,332 (±37,931)	285,393 (±80,098)	

A small number of Chinook juveniles and smolts have been documented in the Estuary. The 2007 and 2008 surveys in the Estuary exhibited the highest capture rates of Chinook salmon since seining was initiated in 2004, with fish/set capture rates of 4.53 and 5.18, respectively (Figure 30). Since 2008, Chinook salmon abundance in the Estuary has remained relatively consistent, averaging 0.85 fish/set between 2009 and 2022.

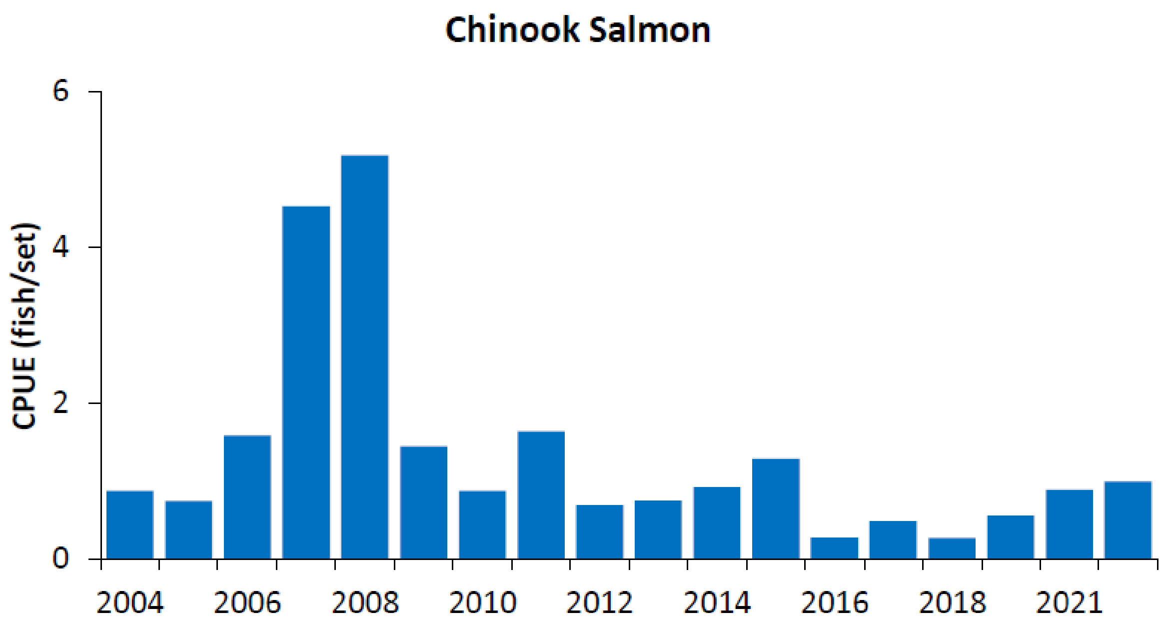

Figure 30. Abundance index (CPUE) of juvenile Chinook salmon captured by beach seine in the Russian River Estuary, 2004-2022. Samples from 84 to 303 seine sets conducted annually from May to October (Martini-Lamb and Manning 2024).

As the Russian River is the southernmost extent of the range for the CC Chinook salmon ESU (64 FR 50394), the biological review team that reported on the status of the species believed these Russian River population southern populations represented a considerable portion of the genetic and ecological diversity within the ESU (Myers et al., 1998). Its extinction would, therefore, constitute a substantial range restriction, the loss of the largest population in the Chinook Central Coastal stratum, and probably the loss of a unique genetic component of the ESU. For these reasons, the survival and recovery of the Russian River population of CC Chinook is important to the conservation of the ESU as a whole. Genetic diversity is an important measure of viability as well. Genetic analysis of Russian River Chinook salmon suggests they are not closely related to either the nearby Eel River or Central Valley Chinook salmon, and likely evolved as part of a diverse group of native coastal populations (Hedgecock et al., 2002). Water diversions, the confinement of the river channel, limited riparian vegetation, and ongoing sedimentation from roads, agriculture, and other developments remain important unresolved threats to the success of the Russian River Chinook salmon.

2.4.3.2 CCC Coho Salmon in the Action Area

Information on the historic run size of coho salmon in the Russian River is limited with late 19th and early 20th Century records sparse, or non-specific as to species (Chase *et al.,* 2007). Rich *et al.,* (1944) stated that the coho salmon abundance in the Russian River was "small and sporadic," while Shapovalov reported "appreciable" numbers of coho salmon in tributaries to the Russian River near Duncans Mills (Shapovalov 1944). Although there are no historical quantitative estimates for coho salmon, a few qualitative estimates have been reported in the literature. Lee and Baker (1975) cite CDFW in estimating 7,000 coho salmon in the Russian River with an annual harvest of 2,000 fish. Surveys conducted in the early 2000s found few juvenile coho salmon, and the consensus among local biologists was that the total run of adult coho salmon returning to the Russian River was at most in the tens of fish.

NMFS Intrinsic Potential habitat model of historic coho salmon distribution developed by Agrawal et al., (2005) indicates that the historic (predevelopment) distribution of coho salmon in the Russian River watershed likely included 710 linear miles of stream habitat.[12] This does not include segments of the mainstem which supported seasonal migrations, but were too warm to support juvenile rearing during summer months. This Intrinsic Potential habitat model indicates that prior to development in the 18th century, coho salmon were likely distributed throughout most tributaries to the Lower River (Figure 31).

[12] The calculation of 710 linear miles is based on the intrinsic potential model computations with a water temperature mask eliminating stream segments where mean August air temperature is less than 20.5°C.

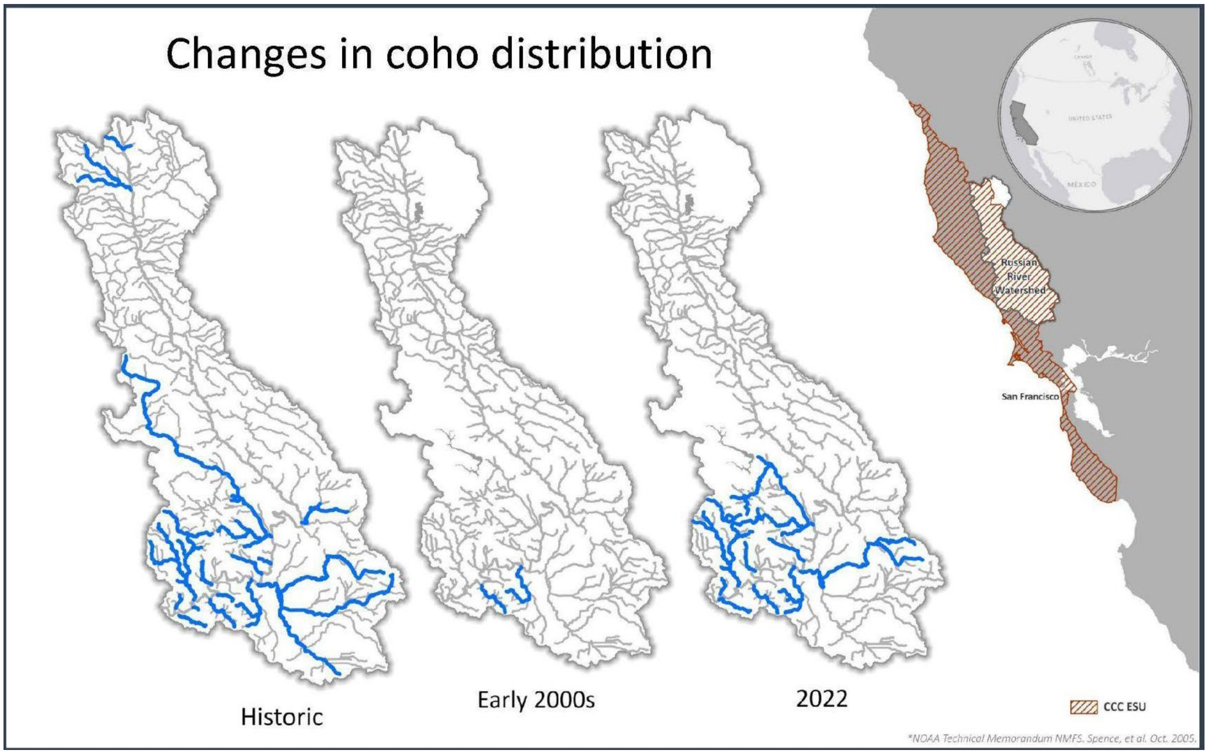

Figure 31. Changes in coho distribution in the Russian River Watershed from historic times to 2022 (Spence et al., 2005; CSG and Sonoma Water 2024).

A review by Bjorkstedt (2005) found both strong departures from genetic equilibrium and evidence of recent, severe population bottlenecks. Historical hatchery practices may also have contributed to these results (additional discussion below). This evidence suggested an acute loss of genetic diversity for the Russian River coho salmon population. In the early 2000's based on its decline in abundance, restricted and fragmented distribution, and lack of genetic diversity, the Russian River population of coho salmon was determined to be in what was likely an extinction vortex (Frankham et al., 2002). Only three (Green Valley, Dutch Bill, and Felta Creeks), of the 32 historic coho salmon streams within the Russian River (referenced in Brown et al., 1994) had confirmed wild juvenile coho salmon and only in intermittent years (Conrad and White 2006).

Coho salmon in the Russian River are considered one independent population within the Coastal diversity strata. The few coho salmon that remain in the Russian River watershed spawn and rear in a small set of tributaries in the Action Area, primarily in the Lower River from Maacama Creek downstream to Willow Creek and including Dry Creek. Coho salmon do not spawn in the mainstem Russian River or the Estuary, but use these habitats seasonally as a migration corridor. Residence time in the Estuary by smolting juveniles has been assumed to be short based on prior work (see 2.2.2 Status of CCC Coho Salmon), however, recent studies suggests a small but important subset of juveniles migrate to the Estuary (Willow Creek) before smolting for extended rearing, and those early migrators can exhibit higher growth rates and represent a greater proportion of returning adults (Baker *et al.,* 2025). Adult and juvenile coho salmon have recently been documented in un-stocked tributaries indicating that straying program fish, or returning ocean returns are reproducing at some albeit low level. Some coho salmon juveniles born in Dry Creek tributaries likely attempt to rear in the recently constructed Dry Creek Habitat Enhancements.

Out-of-basin coho salmon stocks have been planted into the Russian River watershed, from the early 1930's through 1998 (FishPro and Entrix 2000). Adult coho salmon returns to DCFH averaged 254 coho salmon between 1991 and 1996. Following the cessation of releases, no more than four coho salmon were trapped at DCFH in subsequent years. In 2001, the RRCSCBP was initiated at DCFH with wild juvenile coho salmon to prevent extinction of coho salmon in the Russian River basin, and to reestablish self-sustaining runs of coho salmon in tributary streams within the Russian River basin (Obedzinski *et al.,* 2007; see Section 2.4.4.8 below for details).

While coho salmon numbers remain low in the Russian River population, fish are reproducing naturally in several watersheds that have received outplants of HOR fish. Over 5 years of surveys in the Russian River, an average of 128 redds have been estimated annually. Methods for expanding redd counts to adult abundance based on LCM stations are not currently considered reliable (M. Obedzinski, CSG, personal communication). Assuming an average spawner:redd ratio of 2:1, adult numbers, (ranging from 19 individuals in 2009/10 to 763 in 2017 to 18; Figure 32) are less than three percent of the recovery target for this population. 2024/25 turned out to be a record-breaking year with approximately 251 redds observed (Sonoma Water unpublished data 2025). Notably, redd estimates for the Russian River include redds produced by both HOR and NOR fish. As recovery criteria are based on returns of NOR fish, the population is farther from the recovery target than indicated above. In recent years, expanded adult counts have been calculated from antenna detections of PIT- tagged adults returning and the known proportion of PIT-tagged juveniles from each group of hatchery fish released. Methods of obtaining adult counts also include presence/absence snorkel surveys, spawner surveys, and DSMT.

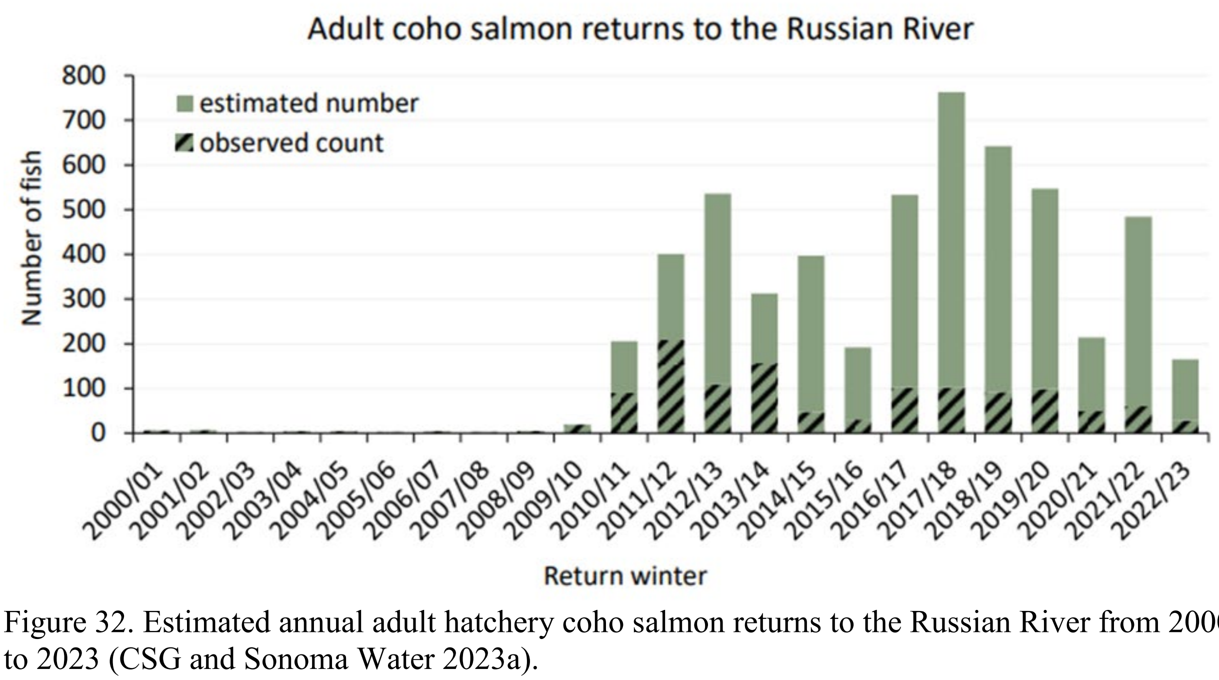

Figure 32. Estimated annual adult hatchery coho salmon returns to the Russian River from 2000 to 2023 (CSG and Sonoma Water 2023a).

Additionally, Sonoma Water completed survival studies for juvenile coho salmon in 2021 through 2023 in the Lower River, between the confluence of Dry Creek and the Wohler Pool (Sonoma Water 2024a). Initial findings of the study show that while survival from Dry Creek was relatively high, survival from Dry Creek to Wohler was low. Additional survival studies have been conducted by Sonoma Water using predator tags which indicate when a salmonid is eaten by a predator (tag coatings dissolve with fish stomach acids). Results of these survival studies identified high rates of predation in the reach below Dry Creek, potentially negating the benefits of enhanced coho salmon rearing habitat in Dry Creek that were constructed per the RPA. Proposed studies will determine the future level and location of juvenile/smolt stockings and potential actions to address predator population levels in the Wohler Pool.

Based on the decline in abundance, fragmented distribution, reduced stocking, and predicted lower survival of released juvenile fish, and ongoing concerns regarding genetic diversity, the Russian River population of coho salmon remains in immediate danger of extinction (NMFS 2023). The Russian River population is in the middle of the CCC coho salmon ESU's range and represents a third of the entire ESU by geographic area. For these reasons, irrespective of the condition of the watershed, the Russian River has great potential to provide important geographic continuity, diversity, and habitat space for the species. The continued existence of CCC coho salmon in the Russian River is, therefore, significant to the survival and recovery of the species.

2.4.3.3 CCC Steelhead in the Action Area

Russian River steelhead runs once ranked as the third largest in California behind the Klamath and Sacramento rivers. The Russian River was renowned as one of the world's finest steelhead rivers during the 1930's and on through the 1950's (SEC 1996). According to the Steelhead Recovery Plan (NMFS 2016d), little information is available on the historic abundance of adult steelhead in the Russian River watershed. Historically, upwards of 65,000 adult steelhead may have been present in the river system, dropping to 1,750 to 7,500 in the 1990’s. Since the mid-20th Century, Russian River steelhead populations have declined. The information available suggests that recent basin-wide abundance of wild steelhead has declined considerably from historic levels.

Based on run timing, steelhead in the Russian River are considered “winter run” and are the most widely distributed salmonid in the Russian River watershed. There are currently 6 essential, independent, and ten supporting, dependent, populations of CCC steelhead within the North Coast and Interior Diversity Stratums, occurring throughout 240 named tributaries and the mainstem of the Russian River watershed (Spence *et al.,* 2012; Figure 33). We expect all of these populations to occur within the Action Area to some degree. For instance, all steelhead must enter and exit the Estuary and use the Lower and/or Upper River to migrate between their spawning grounds and the ocean. Of the following 16 steelhead populations, those found in Green Valley, Dry, Willow, and Dutch Bill Creeks, as well as in the Upper River are known to spawn and rear within the immediate Action Area. However, there may be some overlap between populations due to straying. While the majority of spawning occurs in tributaries, some spawning and rearing of the functionally independent population of steelhead also occurs in the Upper River, with peak abundances recorded in the Canyon Reach and near Ukiah. Limited rearing has also been observed in the Lower River near the confluence with Austin Creek, and in the

Estuary. Steelhead spawning habitat in the Upper River and Dry Creek overlaps with Chinook salmon. The Dry Creek population spawn and rear in the mainstem Dry Creek and its tributaries.

Below in the Effects and Integration and Synthesis sections, we have identified specific populations if there are important differences in the effects of the Proposed Action among different steelhead populations.

Essential (Independent) Populations
- Austin Creek (Potentially Independent)
- **Green Valley Creek (Potentially Independent)**
- Mark West Creek (Potentially Independent)
- Maacama Creek (Potentially Independent)
- **Dry Creek (Potentially Independent)**
- **Upper Russian River (Functionally Independent)**

Supporting Dependent Populations
- North Coastal Diversity Stratum
    - **Willow Creek**
    - Sheephouse Creek
    - Freezeout Creek
    - **Dutch Bill Creek**
    - Porter Creek
    - Hulbert Creek

- Interior Diversity Stratum
    - Crocker Creek
    - Gill Creek
    - Miller Creek
    - Sausal Creek

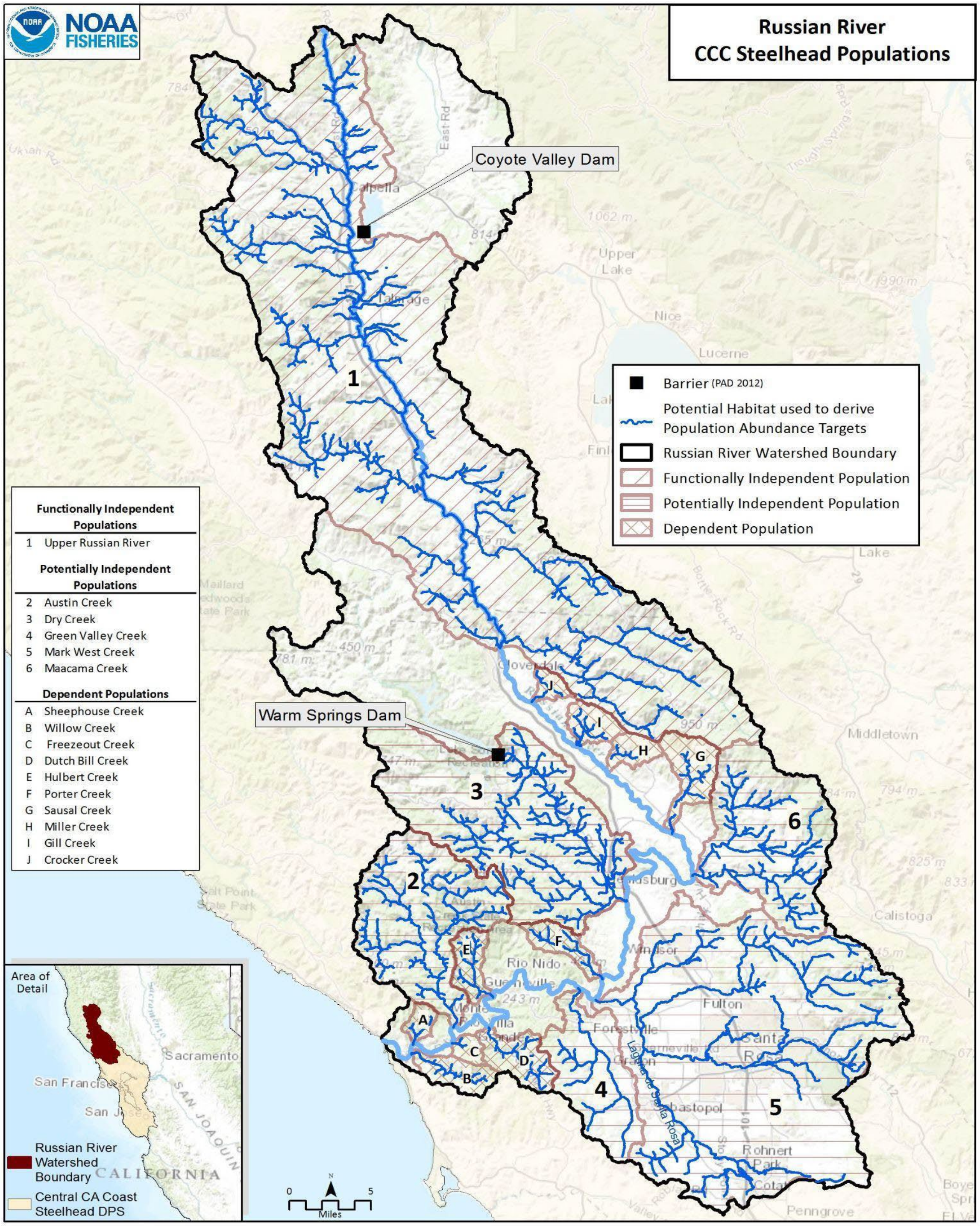

Figure 33. Russian River Steelhead Populations depicting Independent and Dependent populations, and lost habitat above Coyote and Warm Springs dams (NMFS 2024d).

Despite declines in abundance, steelhead remain widely distributed within the basin (NMFS 2005b). The primary exceptions to this are the barriers to anadromy caused by CVD and WSD. CVD has blocked approximately 21 percent of the historical habitat of the Upper River population, and WSD has blocked approximately 60 percent of the Dry Creek population's historical habitat (Spence 2006) (Figure 33 above).

Certain aspects of the steelhead life history have afforded it greater resistance to extinction. For example, juveniles' ability to tolerate a wider range of habitat conditions than most salmonids have allowed them to survive where others cannot (in very low numbers in portions of constructed flood control channels for example). One apparent adaptive strategy, however, appears to have created a challenge to their recovery. The habit of rearing in the Estuary affords significant growth opportunities to that portion of the population which spends some or all of its time doing so, rather than in the stream environment (Bond 2006; Hayes et al. 2006). The propensity for estuarine rearing appears to increase with populations in more southern latitudes and may be an adaptation to reduced instream growth opportunities in more arid regions where summer rearing habitat may be limited. Steelhead parr in the Russian River have been detected moving downstream towards the Estuary (Figure 34; Chase *et al.,* 2005; Katz *et al.,* 2006) in quantities sufficient to suggest that a significant portion of the Russian River populations attempt to rear there. Rearing conditions for freshwater-acclimated juveniles in the Estuary, however, are often poor. This, in combination with degraded habitat upstream, is likely a major determinant in maintaining the current depressed population levels.

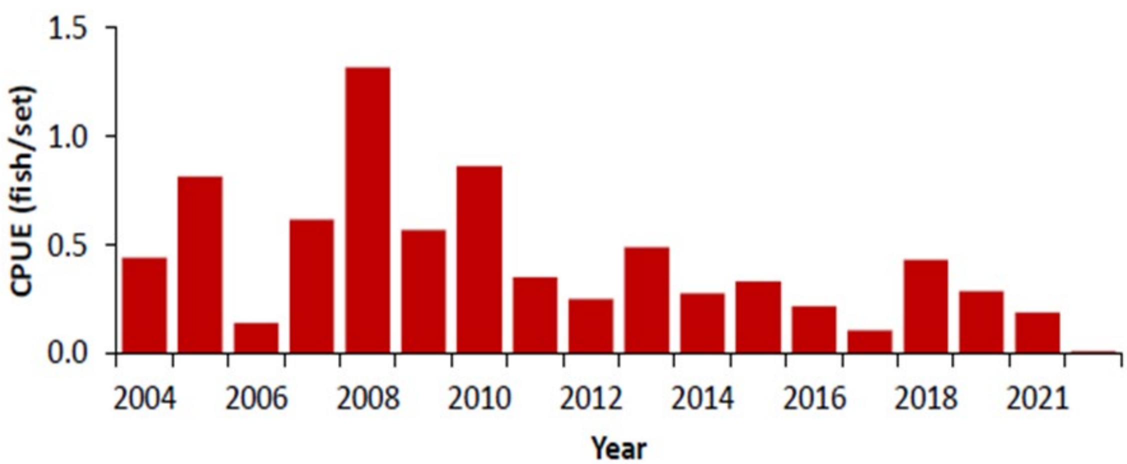

Figure 34. Annual abundance (represented as catch per unit effort) of juvenile steelhead captured by beach seine in the Estuary, 2004 to 2022. Samples are from station 98-300 (Martini-Lamb and Manning 2024).

In 2021 an HGMP was developed to implement the Russian River Steelhead Integrated Harvest Hatchery Program (CDFW and USACE 2021a), and a permit for its implementation was issued by NMFS in 2024 (see Section 2.4.4.11 for additional information). This NMFS Section 10(a)(1)(A) permit authorizes the collection, propagation, release, and monitoring of CCC steelhead at the DCFH and CVFF. The HGMP aims to maximize fitness of hatchery steelhead broodstock by ensuring that NOR fish from the various independent (i.e., Austin Creek, Green Valley Creek, Mark West Creek, Maacama Creek, and Dry Creek and Upper River) populations are incorporated into the broodstock. The proportion of NOB from various populations is now equal to or greater than 50 percent, and the proportion of HOS is reduced in the tributaries for the duration of the permit period. With implementation of the HGMP, and progress towards performance objectives, NMFS expects that both the hatchery steelhead population, and various wild populations in the Russian River will benefit substantially from improved fitness. Additionally, these benefits should translate into benefits for the other salmonid populations in the Russian River via the implementation of specified, proposed BMPs to reduce predation and competition by hatchery fish.

Based on video counts of fish at Mirabel Dam on the mainstem Russian River, total adult steelhead (HOR + NOR) annual production averaged 367 fish from 2000-2016. HOR fish made up 67.2 percent of the identifiable steelhead recorded at the dam and small numbers of adult steelhead were also recorded at the Healdsburg fish ladder and in Dry Creek in migration years 2013-2016. Because the dam counts occurred over a small portion of the total steelhead run the numbers are considered an index of steelhead abundance.

The NOR adult abundance in the Russian River is unknown, but using sport angling data CFDW and USACE (2021) estimated the population of approximately 3,233 adult NOR steelhead spawners by comparing HOR adults, which are caught in the sport fishery at a 2 to 1 ratio to NOR adults. Other recent estimates from Russian River CMP survey data from 2018 to 2020 put the total population of adult steelhead spawning in the wild, including hatchery steelhead at 800 to 2000 adult steelhead (SWFSC 2023). Annual adult returns averaged 3,526 fish at DCFH and 2,207 fish at CVFF (5,733 total adults) from winter 2005/06 to 2020/21. Returns ranged from minimums of 870 and 371 at DCFH and CVFF (1,241 total adults), respectively, during winter 2008/09, to maximums of 7,201 and 5,330 (12,531 total adults) at the two facilities during winter 2006/07 (Figure 35). Thus, it is evident that HOR fish outnumber NOR fish by several fold. In this same time period, data from spawning ground surveys indicate that 51 percent of all fish observed in natural spawning areas were of hatchery origin (M. Obedzinski, unpublished data 2021). Thus, potential introgression between hatchery and wild fish is a significant concern (SWFSC 2023).

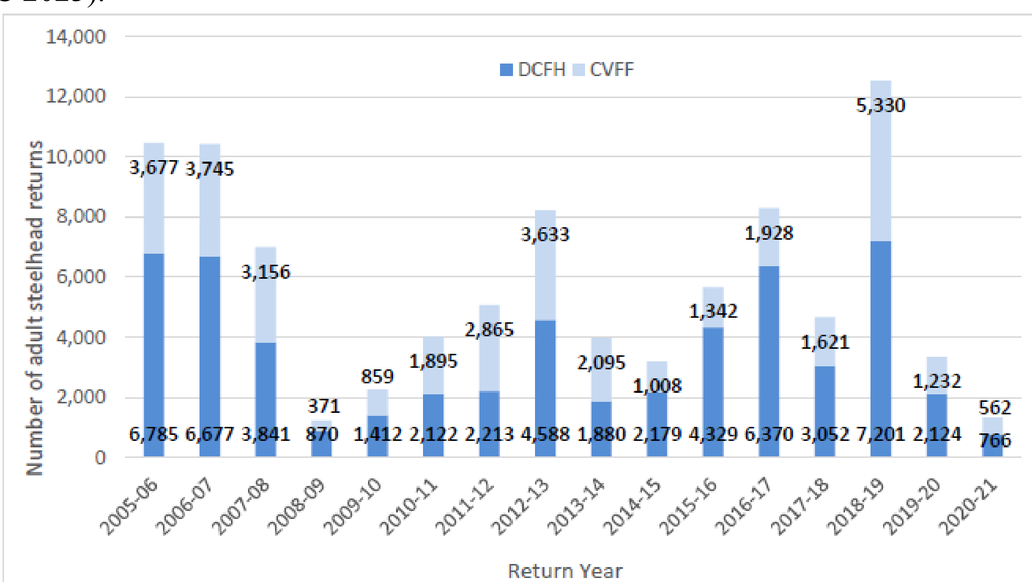

Figure 35. Russian River steelhead returns to CVFF and DCFH from 2001 to 2022 (ESA, Inc. 2023).

The NOR Russian River populations of steelhead are important to the survival and recovery of CCC steelhead for several reasons. First, because they were historically among the primary source populations for the DPS, they presumably still have the potential to play that important role in supporting the survival and recovery of the DPS. Second, since the Russian River lies at the northern extent of the CCC steelhead range, it supports an important component of the species geographic distribution across two diversity strata. And third, because the basin is so large, it supports a significant diversity of habitats, from wet coastal to arid interior environments, which foster important diversity components for the species, as evidenced by the nine separate populations of steelhead the basin supports. The continued survival of Russian River steelhead is, therefore, integrally important to the overall survival and recovery of the CCC steelhead DPS.

2.4.4 Factors Affecting Listed Salmonids and their Habitat within the Action Area

Among the most serious and ongoing threats to the survival of Russian River salmon populations in the Action Area are changes to natural hydrology, habitat degradation and habitat loss. Much of the Russian River watershed is affected by multiple human factors. Some of these anthropogenic factors are related to activities undertaken or authorized by the USACE or Sonoma Water for flood control and water supply, but many factors are independent of the USACE or Sonoma Water. Factors related to the USACE or Sonoma Water activities which are ongoing and were analyzed in the 2008 Opinion are discussed briefly in this section as they relate to current population and habitat conditions. We provide a more detailed analysis of those same factors, as a result of actions to be carried out into the future as part of the Proposed Action, in the Effects of the Action section of this document. In this section below, we also discuss factors not related to USACE and Sonoma Water proposed activities, and naturally-occurring events, such as droughts or variation in ocean productivity, which affect salmonids and their habitat in the Action Area.

2.4.4.1 Coyote Valley Dam

The completion of CVD in 1959 on the East Fork blocked up to 143 miles of access to salmonid spawning and rearing habitat (USACE 1982, Prolysts 1984, CDFG 2002). The habitat lost upstream of CVD was considered to be some of the highest quality habitat available for salmon and steelhead spawning and rearing (SEC 1996). Prolysts (1984) estimated annual steelhead productivity lost in the East Fork following placement of the CVD ranged from 2,213 to 7,685 adult fish and 51,465 to 178,721 wild, ocean-bound smolts (Prolysts 1984).

Construction of CVD also reduced sediment supply to the mainstem Russian River. Sonoma Water estimates that the CVD has trapped about 21,000 tons of sediment per year from the 105 mi^3 watershed that drains to Lake Mendocino (Florsheim and Goodwin 1993). This reduction in sediment transport downstream of CVD contributes to channel incision and increases in erosion of stream banks in reaches below the dam as the river attempts to adjust to equilibrium (USACE 1997). The gravel retention by CVD coupled with sediment deficits from gravel extraction has caused channel incision in the mainstem and tributaries of the Upper River.

Operation of CVD by the USACE has provided flood protection for areas below the dam and supplies water for domestic and agricultural uses (USACE and Sonoma Water 2004). The USACE limits releases from CVD to prevent flooding at Hopland that can occur when flows exceed 8,000 cfs. Specific criteria for flood control operations are described in an update made to the WCMs (USACE 1998). CVD affects the natural hydrology in the mainstem river below the dam by reducing the peak flood discharge and storing runoff and then releasing the storage between storms (Florsheim and Goodwin 1993). Releases from the flood control pool typically extend the periods of high flows when they would otherwise be receding. A USACE study of the 1964 flood indicated that CVD reduced peak flows 12 miles downstream at Hopland by 29 percent, 30 miles downstream at Cloverdale by 21 percent, and 74 miles downstream at Guerneville by seven percent (USACE and Sonoma Water 2000).

CVD has less effect on more frequent flood events such as the 1.5-year event in the mainstem Russian River. The dominant discharge for a 1.5-year event at Hopland was approximately 14,500 cfs in an unregulated condition and 9,500 cfs with flood control provided by CVD (USACE and Sonoma Water 2000). At Healdsburg, the effects of CVD winter flood flow regulation are negligible, with a flow for a 1.5-year event of about 25,000 cfs for the regulated and unregulated condition.

Flood Control Operations at CVD Since 2008

USACE has implemented operational refinements (detailed in the Proposed Action section) in response to the following 2008 Opinion RPMs, which were designed to address streambed scour and bank erosion, down-ramping rates, and turbidity to minimize reservoir flood operation impacts (primarily associated with operational requirements for pre-flood and periodic inspections and maintenance activities) on salmonids below CVD.

- RPM 2: Undertake measures to ensure that harm and mortality to listed salmonids from pre- flood/periodic maintenance at CVD are low.

- RPM 3: Undertake measures to ensure that harm and mortality to listed salmonids from ramping procedures at CVD are low.

- RPM 4: Undertake measures to assist NMFS in determining the amount of take resulting from turbidity releases at CVD.

USACE has also been implementing flood control operations associated with a Planned Major Deviation to the 1986 Lake Mendocino WCM (initiated in Water Year (WY) 2021), and application of FIRO procedures will continue as part of the Proposed Action for this Opinion.

In the 2004 BA, USACE and Sonoma Water (2004) identified the following potential issues related to flood control operational effects on salmonid habitat conditions, which are consistent with the analysis that then occurred in the 2008 Opinion:

1) Flood releases to scour spawning gravels. Scour impacts from CVD releases of 1,000 to 6,400 cfs may have sufficient stream power to mobilize streambed sediment that could result

in scour of salmonid redds. The discharge that typically mobilizes the streambed is referred to as the dominant discharge and has a recurrence interval of 1.5 to 2 years on average (Florsheim and Goodwin 1993; Mount 1995). A dominant discharge of 4,200 cfs is likely to be sufficient to mobilize the streambed in the Upper River's Ukiah Reach.

2) Stream bank erosion. Bank erosion due to flood operations of CVD were assessed by Entrix (USACE and Sonoma Water 2004). Initiation of bank erosion was found to occur at flows of 6,000 cfs at Hopland and 8,000 cfs at Cloverdale. Prolonged dam releases have likely exacerbated bank sloughing due to channel incision and have resulted in modified banks from Ukiah to Hopland.

3) Effects from flood flows ramping and flood inspections to salmonids, the 2008 Opinion identified impacts to salmonids from flood ramping and dam inspections. USACE has since adopted recommended ramping rates into their project description. The USACE proposes to continue fish rescues which will minimize impacts from flow drawdown during dam inspections (see Effects Section 2.5.1.1.2.6 for additional details).

4) High and persistent turbidity levels in the mainstem. Consistent with the concerns identified in the 2008 Opinion: The potential duration of turbid water in releases from the CVD is a particular concern for both salmonids and their habitat (see Effect Section 2.5.1.1.4 for additional details). Although the Russian River watershed was found to clear fairly rapidly after major storms in the mid-late 1960s (Ritter and Brown 1971), this is not the case today. As described above, Sonoma Water estimates that the CVD has trapped about 21,000 tons of sediment per year from the 105-mi^3 watershed that drains to Lake Mendocino (Florsheim and Goodwin 1993). Although releases from CVD provide some salmonid habitat in the Upper River, releases from this dam contribute high and persistent levels of turbidity to the mainstem. The dam releases water from near the bottom of Lake Mendocino. Turbidity can remain high at the bottom of the lake after inflow and/or the lake's surface has cleared, mainly because of the depth of the lake, the small size of the sediment particles, turbidity currents, and releases from the bottom of the lake. Following rainstorms, NMFS staff conducting an overflight of the area observed turbid water being released from Lake Mendocino even though water entering the lake was clear (B. Cluer, NMFS, personal communication, February 2007). Information from the mid-late 1960s also indicates the potential for persistent turbidity from CVD releases. Ritter and Brown (1971) found that the CVD operations increased the amount of time required for the East Fork of the Russian River to transport over half of its suspended sediment load by two to three times, lengthening the amount of time it takes for turbid water to flow downstream into the mainstem. RPM 4 from the 2008 Opinion focused on more precisely quantifying the impact of turbidity from CVD on salmonid emergence, growth, and survival. CVD contributes to persistent elevated turbidity in the Upper River, which may adversely affect steelhead and Chinook salmon eggs and alevins within gravel substrates, or rearing juveniles. USACE was directed to install turbidity monitoring meters at existing USGS gages, conduct a bathymetric survey of Lake Mendocino, and develop and implement a plan to minimize incidental take.

The USACE conducted a bathymetric scan survey of Lake Mendocino in 2010. Additionally, USACE collected turbidity data at seven locations in the Russian River watershed (Figure 5, See

Effects Section 2.5.1.1.4 for additional details regarding NMFS' analysis of data recently reported by the USACE).

The USACE was also required under RPM 4 in the 2008 Opinion to determine if turbidity from CVD or WSD is adversely affecting listed salmonids as described and if so, to complete and begin implementation of a plan to minimize and avoid these adverse effects by 2014. Though the USACE provided a final Turbidity Report in 2023, a plan has not been fully developed and implemented to minimize and avoid identified adverse effects. USACE has convened a Turbidity TAC, including two recently-appointed experts on related issues, to assist in developing and implementing a plan to minimize and avoid adverse effects from turbidity (see Section 1.3.1.3). The Turbidity TAC met twice in 2023 and twice in 2024. Both short-term avoidance and minimization measures and continued investigation of a potential long-term solution to reduce elevated turbidity levels are necessary.

Water Supply at CVD since 2008

In response to the 2008 Opinion (NMFS 2008a), Sonoma Water has reduced summer flow releases through annual interim change petitions as described in the Proposed Action above to improve salmonid habitat in the Upper River. The Upper River provides cool water to the river between CVD and Hopland. While this capacity in a portion of the Upper River has been enhanced by reducing the high flow releases via interim petitions for temporary changes to D1610 requirements and conserving the cold-water pool in Lake Mendocino, these benefits may be limited by ongoing high levels of turbidity occurring during the summer rearing period for Chinook salmon, and the Upper River steelhead population.

2.4.4.2 Warm Springs Dam

Located 14 miles upstream from the mouth of Dry Creek, WSD blocks anadromous fish access to 50 to 105 miles (Cramer et al. 1995) of the Dry Creek watershed. The dam and its 381,000 ac-ft reservoir regulate year-round stream flow in Dry Creek, providing substantially augmented stream flows during historic low flow periods and reducing the magnitude of high flows during winter storm events. This change in flow regime for the 14-mile segment of Dry Creek below the dam has greatly altered habitats for steelhead, coho salmon, and Chinook salmon.

For context, before WSD was constructed, summer flows in Dry Creek were generally about one to three cfs during late summer; in several years, late summer flows below the confluence of Pena Creek were less than one cfs (USGS Gage No. 11465200). Summer flows in Dry Creek are markedly different today. Sonoma Water operates WSD in normal years with a targeted minimum flow of 80 cfs between WSD and the mouth of Dry Creek from May 1 to October 31. For dry years, the goal is a minimum flow of 25 cfs in Dry Creek between April 1 and October 31. However, the actual flow in Dry Creek during summer is dependent upon water demand (USACE and Sonoma Water 2004).

The water released from Lake Sonoma is of a high quality and is managed for its use in the DCFH, where it is monitored for turbidity, suspended sediment concentrations, temperature, and DO. Flow releases from Lake Sonoma result in cool water temperatures in Dry Creek that are suitable for rearing juvenile coho salmon (Figure 36). Temperature data collected at the USGS Dry Creek below WSD stream gage (USGS 11465240) before and after the construction and operation of Lake Sonoma were observed to have maximum temperatures as high as 27°C before the dam and maximum temperatures in the low 8°C range after the dam. Following construction of WSD, water temperatures were driven by releases from Lake Sonoma, typically ranging between 10°C and 17°C.

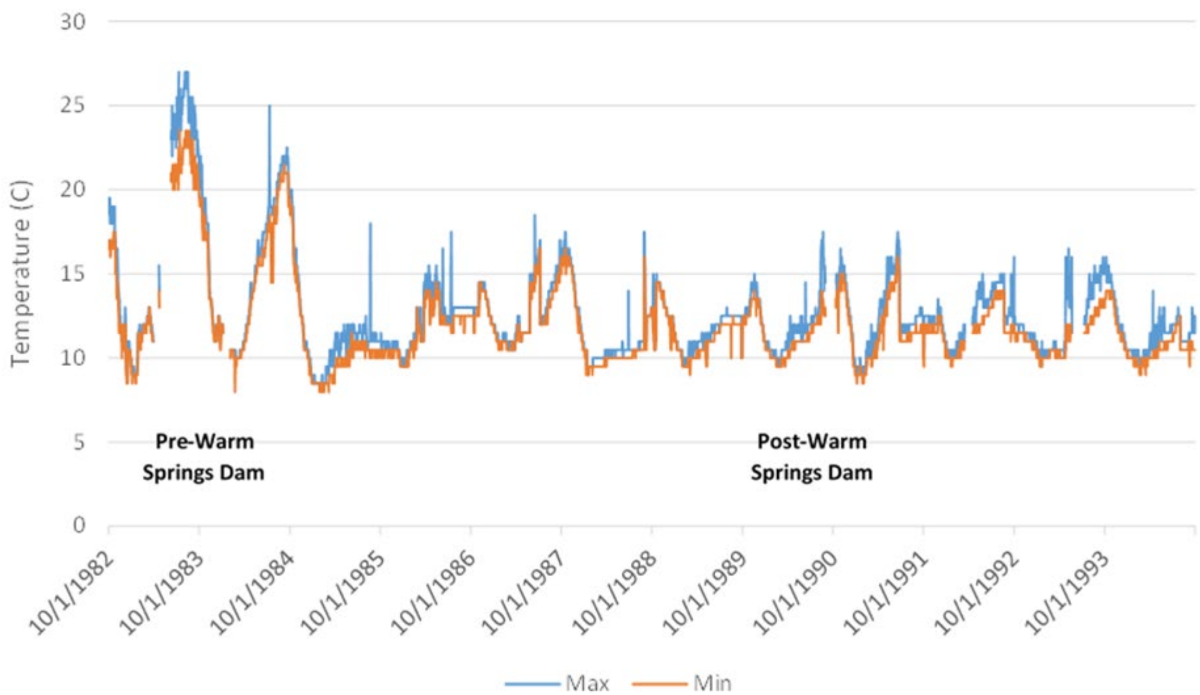

Figure 36. Daily Maximum and Minimum Water Temperatures at USGS WSD stream gage (ESA, Inc. 2023).

Prior to the construction of WSD in 1983, of all the Russian River tributaries, Dry Creek was the greatest contributor to the overall sediment load of the river (Ritter and Brown 1971). Goudey et al., (2002) report that the gravel bed streams within the Dry Creek watershed are capable of transporting large amounts of sediment. Extraction of these high quantities of gravel began in the 1900s in the lower reaches of Dry Creek. This activity has caused considerable geomorphic changes in Dry Creek, particularly since 1940 when intensive gravel extraction was occurring along the Middle reach of the Russian River (Swanson 1992). Gravel continued to be extracted from Dry Creek until 1979 (USACE and Sonoma Water 2004). USACE concluded that past gravel extraction operations on Dry Creek and the mainstem Russian River had caused 10ft of channel incision along 14-miles of Dry Creek (USACE 1987, USACE and Sonoma Water 2004).

There are a number of circumstances that are likely contributing to the dynamic sediment transport conditions in Dry Creek. First, there is the accumulation of sediment from unregulated tributaries moving downstream from WSD. These tributaries have the potential to supply a large quantity of sediment to the main stem channel of Dry Creek during peak storm events. Next, in a wet winter when water levels have entered the WSD flood control pool, sustained clear-water (not containing sediment) is released from WSD to empty the pool following storm events. This has the potential to carry sediment in the main stem channel from the upper reaches to the lower reaches of Dry Creek. Then, the established riparian vegetation from elevated base flow has created a uniform channel that is efficient at transporting the sediment in the main stem channel downstream of WSD.

Historical aerial photographs show that on Dry Creek, below WSD, the riparian vegetation has extensively encroached, causing the channel to narrow, and likely fostering channel incision. This incision has resulted in bank erosion and widening of the channel in the lower portion of Dry Creek (USACE and Sonoma Water 2004). These conditions are still prevalent today. The USACE constructed bank stabilization at 15 sites from 1981 to 1989 (USACE and Sonoma Water 2004) as part of the construction of WSD. However, these projects also simplified instream habitat conditions, removed shelter and floodplain, and compromised habitat conditions for spawning and rearing habitat for salmonids. As noted in the Proposed Action section above, Sonoma Water will continue to maintain these sites into the future.

Flood Control at WSD since 2008

Prior to construction of WSD, channel forming flows of 5,000 cfs (USACE and Sonoma Water 2004) occurred in 60 percent of the years reviewed by NMFS. Since construction, flows exceeding 5,000 cfs only occur in about 14 percent of years. Lake Sonoma has a 130,000 ac-ft flood control capacity, which is sufficient to store watershed runoff from a 100-year, 6-day flood event. USACE determines releases from the reservoir when lake elevation is above 451.1 ft mean sea level. USACE attempts to avoid flood releases from the dam that exceed 6,000 cfs, and to the extent possible manages releases to help limit flows on the Russian River at Guerneville to 35,000 cfs. Flow ramping rates for flood operations since 1998 have followed an interim ramping schedule agreed to by the USACE and NMFS (NMFS 2016a).

As described in the 2008 Opinion, WSD has also altered the hydrologic regime and geomorphic conditions of Dry Creek. An example of the WSD's value in reducing peak flows is reported in EIP (1994), which compares the maximum pre-dam flood of 32,400 cfs in January 1963 with the maximum post dam peak flow in Dry Creek of 5,280 cfs. The floods of 1963 and 1986 on Dry Creek were of comparable size, which demonstrates that WSD can reduce peak flood flows by as much as 83 percent (EIP 1994 as cited in USACE and Sonoma Water 2004). Similarly, a 1.5-year peak flow prior to dam construction was 11,000 cfs, and now is reduced to about 2,500 cfs in the post- dam condition (ESA, Inc. 2023).

Even with the reduction to peak flow, releases from WSD may be sufficient to mobilize the streambed and impact salmonid spawning areas below the dam. In addition to the risk of redd scour, the USACE and Sonoma Water (2004) evaluated the potential for these operations to initiate bank erosion, to decrease flushing flows that are needed to maintain spawning habitat suitability, and the potential impacts that flow ramping releases may have on salmonids in Dry Creek (see the Effects Section 2.5.1.2).

USACE has been implementing flood control operations at WSD consistent with the Lake Sonoma WCM (USACE 1984); future proposed modifications associated with application of FIRO procedures, which are in development, are part of the Proposed Action, but have not been implemented to date. FIRO procedures at WSD will be addressed in the Effects of the Action section below.

Water Supply at WSD since 2008

Prior to 2008, summer flow releases in Dry Creek limited the amount of rearing habitat available to salmonids due to the lack of cover from high flows. Rearing juvenile salmon and steelhead were at high risk of being washed downstream out of Dry Creek and into inhospitable areas of the Russian River mainstem (NMFS 2008a). Similar to the changes made in flow releases in the Upper River, implementation of the RPA from the 2008 Opinion reduced flow releases from Lake Sonoma. These flows now provide more suitable summer rearing habitat in 14 miles of Dry Creek for both coho salmon and steelhead, and to lesser extent Chinook salmon via lower flow velocities. Habitat conditions have also been enhanced by WSD's cold water releases and Sonoma Water and USACE's habitat restoration work implemented since the 2008 Opinion (see Dry Creek Habitat Enhancements Section below).

2.4.4.3 Channel Maintenance the Mainstem Russian River and Dry Creek

See Section 1.3.3 of the Proposed Action for a description of ongoing channel maintenance activities conducted by Sonoma Water in Dry Creek and MCRRFCD in the Upper River. The effects due to these activities to critical habitat are ongoing. Past channel maintenance actions have contributed to a decrease in salmonid spawning and rearing habitat suitability in the Upper River. The past effects of channel maintenance have likely affected salmonid populations by reducing pool habitat, high flow refuge, shade canopy, and cover utilized by various life stages of salmonids (USACE and Sonoma Water 2004).

2.4.4.4 Dry Creek Habitat Enhancements

The 2008 Opinion had RPA elements which included six miles of Dry Creek habitat enhancements, contained within the 13.9-mile stretch between WSD and the Russian River confluence. This part of the RPA was to create both winter and summer rearing habitats for juvenile steelhead and coho salmon. Enhancement projects were designed and implemented to address the lack of low water velocity areas with adequate cover and appropriate water depth that limit habitat suitability for juvenile salmonids in general, and juvenile coho salmon in particular. An estimated 275,745 ft^2 of habitat enhancement sites, including 20 boulder clusters, had been constructed by the end of 2024 (Figure 37 and Table 15) (ESA, Inc. 2023). The following habitat enhancements within Dry Creek tributaries were also completed:

- Grape Creek Habitat -installation of 17 LWD/boulder structures and 1,900 linear ft streambank planting.

- Willow Creek Fish Passage -culvert removal and new bridge installation resulted in increased adult and juvenile steelhead densities. Shortly after completion, the 1st documented coho spawning since 1995.

- Mill Creek Fish Passage - removed highest priority barrier for coho salmon within the Russian River; created 200 ft of new channel and 100-ft side channel; reconnected 11.2 miles upstream habitat.

Table 15. Estimated total area (square meters/miles) of habitat enhanced in Dry Creek from 2012-2024. Source: Dry Creek Habitat Enhancement Hydraulic Habitat Summary (Sonoma Water, unpublished data 2024).

Reach/Subreach (Confluence to WSD)	Phase Totals	Planned Miles Enhanced	Actual Miles Enhanced (2024)	As Built, Instream Habitat Area Enhanced (Most recent build if repaired) ft^2
7, 15	**I**	1	0.95	54,695
8a, 8b, 14a,14b	II	1.3	0.94	69,186
2b, 4a, 4b, 5a, 5b	III	1.4	0.85	68,864
10a, 10b, 13a, 13b, 10a1	IV	0.8	1.09	51,243
2a, 4c (2024)	IV	0.8	0.60	21,909
Dry Creek Habitat Enhancement Totals		5.3	**4.43**	**275,745**
Dry Creek Habitat Enhancement Totals (per mile)				**62,244**

Sonoma Water Notes:

1. Instream habitat data include habitat units within excavated channels, as well as habitat units containing constructed LWD features, constructed riffles, or boulder fields located in the main channel of Dry Creek.
2. Hydraulic Habitat data is derived from the intersection of polygons representing Velocity <= 0.5 ft/s and Depths of 0.5-4.0 ft, which is considered the optimal range for juvenile coho per the Dry Creek AMP.
3. For Enhancement Reaches, or portions of reaches that were repaired, the most recent post-repair data survey [is] considered the 'As Built' survey.
4. Habitat unit [boundaries] can change between years and sometimes cross site delineations, so areas within the same enhancement reach may change from year to year.
5. Demonstration Reach 7, 15 did not have 'As Built' surveys conducted so the first Post-Effective Flow survey data is used in lieu of an As Built survey for reaches constructed prior to 2015.
6. Phase III Reaches 4b, 5b, and 8a have not been built as of 2024.
7. The Phase III reach 4a (FO) site was 0.32 mi as originally built but shortened to 0.28 mi after the repair was completed.
8. Construction of the Phase IV reach 10a (10a1, SC) enhancement will finish in 2024. As Built Phase IV habitat areas reflect three Reach 10 sites (SE, FA, PE) finished in 2023, and Reach 13a,b sites finished in 2022 and 2023.
9. Phase IV 'First Post-effective Flow' totals include only the 13a enhancement reach. Topographic data for the reach 10 and 13 sites built in 2023 has been collected but not processed.
10. Due to depth and site stability or seasonality for high flow channels, the RU and QU Reach 7 habitat enhancements were only visually assessed following the initial Post-Effective Flow surveys in 2015 and 2016.
11. Reach 5a was last surveyed in 2022 due to landowner access issues; the river left channel has disconnected at the inlet since then.

NMFS Notes:

12. Side channel at site 10a1 estimated to be approximately 0.15 mi, 12,073 ft^2 using Google Earth.
13. Areas restored at Sites within reaches 2a and 4c estimated from pre-built 99 percent project designs. These amounts are subject to change after post-construction and post-effective flow monitoring.

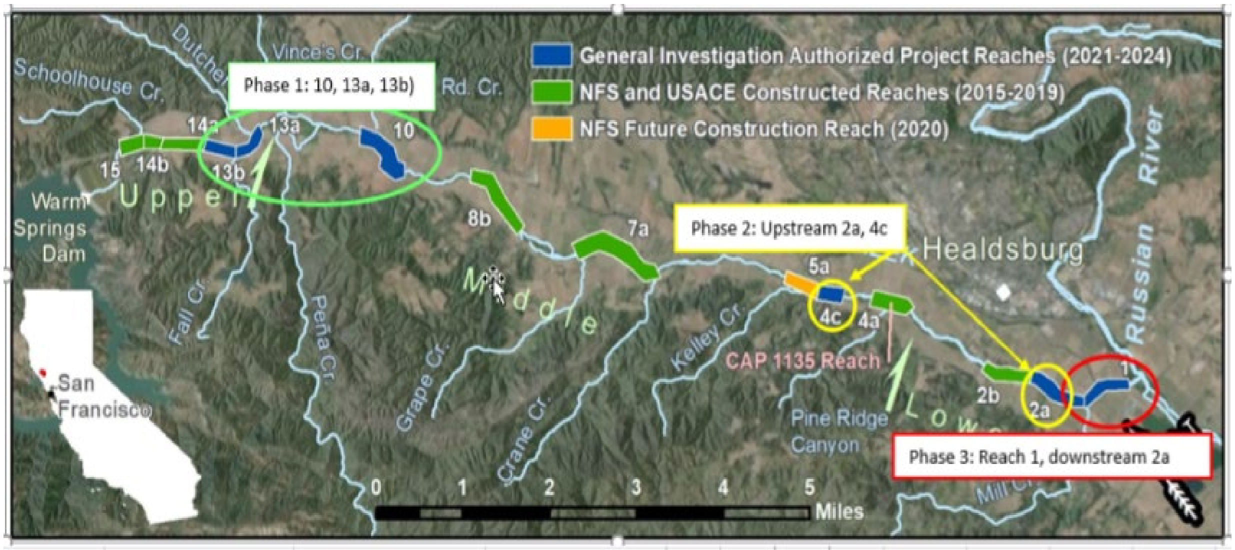

Figure 37. Map of habitat enhancement reaches constructed by the USACE and Sonoma Water in Dry Creek. Phase 3 and reach 5a within Phase 2 will likely not be completed due to landowner constraints.

RPA 3 of the 2008 Opinion provided that Sonoma Water and USACE would complete the six miles of enhancement by Year 12 (2020). Significant construction delays ensued due to difficult negotiation for access with private landowners, and only approximately 4.5 of the 6 miles were completed by 2024. Importantly, delays in the completion were not the result of inaction on the part of Sonoma Water and USACE. Pre-construction tasks including conceptual design, permitting, and pre-monitoring efforts were initiated immediately upon issuance of the 2008 Opinion but took longer than had been anticipated. In particular, the extensive time required to identify and enlist willing landowners slowed the rate at which enhancement actions could be identified, designed, permitted, and eventually constructed.

The BA contains detailed descriptions of each reach and phase of construction (ESA, Inc. 2023). The 2008 Opinion identified that success of these enhancements was to be determined through three stages of monitoring: 1) implementation monitoring to determine if the habitat enhancement was done according to the approved design, 2) effectiveness (habitat) monitoring to determine if the enhancement is having the intended effect on physical habitat quality, and 3) validation (fish) monitoring to assess whether the habitat enhancement is achieving the intended biological objective (see BA and Martini-Lamb and Manning 2024 for a detailed description). Post-construction habitat monitoring provides data which NMFS and Sonoma Water have used to evaluate the effectiveness of habitat features, sites, and reaches. Performance measure data collection focuses on data to assess the Dry Creek Habitat Enhancement Project against the primary performance measures of water depth (0.5 to 2 or 2 to 4 ft) and velocity (<0.5 ft/s), pool to riffle ratio, and amount of instream cover (shelter score) from the AMP (Porter et al., 2014). Depth, velocity, pool to riffle ratio, and shelter score also provide a means to directly assess against optimal habitat values suggested as part of the RPA in the 2008 Opinion. Data was collected from April to November during summer baseflow conditions. Daily average discharge ranged from 95 to 135 cfs over the monitoring period, and most monitoring did not occur at discharges above 135 cfs to ensure accuracy and consistency when measuring depth and velocity, determining habitat types and evaluating cover. In 2021, spring flow monitoring was added. In June 2021, Sonoma Water releases from WSD resulted in flow rates ranging from 162 to 184 cfs. Side channel sites of three enhancement reaches were monitored during 165 cfs to evaluate conditions during higher than normal summer discharges. According to Table 16 below, most of the constructed habitat enhancement sites are functioning as designed and scored a rating of "good" (see BA for additional details on scoring metrics and methods) as of 2022. The exceptions are for two sites in the lower reach of Dry Creek (reaches 2) that scored either "fair" or "poor" and two sites in Reach 7 that scored "excellent."

Table 16. Post-effective flow effectiveness monitoring by enhancement reach in Dry Creek listed from upstream to downstream[1] (Martini-Lamb and Manning 2024).

Enhancement Reach[1]	2015	2016	2017	2018	2019	2020	2021	2022	Latest post-effective flow rating
Reach 15 (USACE)	-	Excellent	-	-	Good		-	Good	Good
Reach 14b (USACE)	-	-	-	-	Good	-	-	Good	Good
Reach 8a (Gallo)	-	-	-	-	-	Good	Good	-	Good
Reach 8a (Weinstock)	-	-	-	-	Good	Good	Good	-	Good
Reach 8b (Truett Hurst)	-	-	Poor	Good	Fair	Good	Good	Good	Good
Reach 8b (Meyer)	-	-	Fair	Fair	-	-	Good	-	Good
Reach 8b (Carlson, Lonestar)	-	-	-	Good	-	-	Good	-	Good
Reach 7 (Quivira)	-	Excellent	-	-	-	-	-	-	Excellent
Reach 7 (Van Alyea)	-	-	Good	-	-	Excellent	-	-	Excellent
Reach 7 (Rued)	Good	-	-	-	-	-	-	-	Good
Reach 7 (Farrow Wallace)	-	-	Fair	-	Good	Good	Good	Good	Good
Reach 5a (Boaz/Gros-Balthazard (includes Stromberg)	-	-	-	-	-	-	-	Good	Good
Reach 4a (Ferrari-Carano, Olson)	-	-	-	-	Fair	Fair	-	Good	Good
Reach 2b (City of Healdsburg Yard)	-	-	-	Good	Poor	-	-		Poor
Reach 2b (Geyser Peak)	-	-	Poor	Fair	Fair	Fair	Fair		Fair

[1] There are a few sites that are not included in the effectiveness rating table (Reaches 13, 10, 4b, and 2a) because they are either not fully constructed, or haven't been monitored post effective flows.

Fish monitoring in Dry Creek is challenging due to environmental and safety constraints. However, based on the results of recent validation monitoring, there is clear evidence that juvenile salmonids are using the completed 4.5 miles of habitat enhancements in Dry Creek (Table 4-19 of the BA). Nearly all life stages of all three species have been observed using the habitat structures. Across all nine subreaches sampled in 2019, the average juvenile steelhead density was 1.0 fish/ft^2 (range 0.62 to 1.7 fish/ft^2) (Figure 4-20 in ESA, Inc. 2023).

2.4.4.5 Native and Nonnative Predacious Species

Native and nonnative predatory fish are negatively impacting outmigrating juvenile salmonids in the Russian River (see Section 2.4.3.2). Two species of particular concern are native Sacramento Pikeminnow and nonnative smallmouth bass.

Sacramento Pikeminnow are native to the Russian River where they were the dominant piscivore ("fish eater") prior to the introduction of non-native species (Taft and Murphy 1950; Moyle 2002). Most of what is known about their biology and life history comes from studies conducted in other river systems, primarily in the Sacramento and San Joaquin (Merz and Vanicek 1996). In addition, a considerable amount of work has been conducted on the closely related Northern Pikeminnow (*P. oregonensis*) predation on salmonid smolts in the Columbia River Basin (Buchanan *et al.,* 1981).

Sacramento Pikeminnow prefer warm (26˚C), moderate depth streams (1.5 to 4.5 ft) with abundant pools, cover, substrate of gravel to boulder, and relatively low water velocities (<0.5 cfs) (Taft and Murphy 1950; Moyle and Nichols 1973; Knight 1985). Compared to salmonids, Sacramento Pikeminnow show a preference for warmer water, tolerate low DO levels, and do not show a metabolic response to hypoxic conditions (DO levels at 25 percent of saturation for each temperature tested) at temperatures up to 25˚C (Cech *et al.,* 1990; Moyle 2002). In the Russian River, spawning takes place in April and May. Pikeminnow inhabiting large rivers and reservoirs migrate into tributary streams to spawn during high flows.

Sacramento Pikeminnow feed on aquatic insects as juveniles, switching to a diet primarily of fish as they grow. Adult Sacramento Pikeminnow are known to eat salmon and steelhead smolts (Moyle 2002). Adults feed primarily at dawn, dusk and at night, and tend to be sedentary during daylight hours (Smith 1982; Brown 1990). Northern Pikeminnow can be a significant predator on juvenile salmonids below large dams when smolts become disoriented or injured while passing dams, and below hatcheries following large releases of smolts (Shively *et al.,* 1996). Both Buchanan *et al.,* (1981) and Thompson (1959; cited in Brown and Moyle 1981) found that pikeminnow were opportunistic and fed on whatever prey source was most abundant. This may explain why they are such active predators of salmonids below dams and after hatchery releases. There is also evidence that the presence of adult pikeminnow can result in a shift in habitat used by their prey species, including juvenile trout (Brown and Moyle 1991; Brown and Brasher 1995).

Smallmouth bass, first stocked in the Russian River in 1878 (Dill and Cordone 1997), are widespread throughout the mainstem. Optimal water temperatures for growth range from 26 to 29°C, and preferred temperatures overall range from 21.1 to 26.9°C. Smallmouth bass prefer DO levels in excess of 6.0 ppm (Edwards *et al.,* 1983). Smallmouth bass are spring spawners, and spawning is generally initiated after water temperature increases to 12.8 to 15.5°C (range 4.4 to 21.1°C) (Emig 1966). Preferred spawning substrate is gravel, but silt and sand can be utilized.

Nests are generally built at depths between 1 to 3 ft. Spawning generally occurs in quiet backwater areas of streams (Edwards *et al.,* 1983).

Smallmouth bass consume a wide variety of food items, including fish, crayfish, insects, and amphibians (Moyle 2002). Juvenile salmonids can constitute a significant portion of bass diet during the salmonid outmigration period (Fayram and Sibley 2000). Sub-yearling Chinook salmon comprised 59 percent of the diet of smallmouth bass in one Columbia River study (Tabor and Shively 1993). However, Poe *et al.,* (1991) found that sub-yearling Chinook salmon accounted for only 4 percent of smallmouth bass prey items. Sub-yearling Chinook salmon accounted for 12.4 to 25.8 percent of the diet of smallmouth bass collected in three sections of the Columbia River during a seven- year study. In another study, smallmouth bass consumed approximately four percent of the hatchery production in a given year (Fritts and Pearsons 2004). However, hatchery reared Chinook salmon are larger than their wild counterparts, and predation on wild fish was likely higher.

Sonoma Water began conducting studies to characterize the fish community and habitat conditions in Wohler Pool of the Lower River in 1999 (Cook 2003; Chase *et al.,* 2005; Sonoma Water unpublished data). Since that time, additional monitoring has continued for various purposes using different methods. Sacramento sucker and smallmouth bass dominated the catch, when all years and sites were combined (approximately 26.1 percent of the catch) (Table 17). Pikeminnow were the 5th most abundant species captured, accounting for approximately 5.9 percent of the total catch. Other predatory fish species, including largemouth bass, white catfish, channel catfish, and striped bass comprised a very low percent of the fish captured. Wild and hatchery salmonids have been collected in relatively low numbers, primarily in reaches above the dam (Wohler Pool).

Table 17. Average number of predatory fish by reach in the Wohler Pool from a 1999 study. Reaches are shown in Figure 38 below (ESA, Inc. 2023).

Site	Sacramento Pikeminnow	Smallmouth Bass	Largemouth Bass	Striped Bass
Reach 1	20	420	61	0
Reach 2	69	366	6	0
Reach 3	86	363	1	0
Reach 4	86	324	2	0
Reach 5	12	8	0	1

All five reaches sampled provide suitable habitat conditions for the two predatory species of concern (Figure 38, Table 17). Based on a review of habitat requirements for smallmouth bass and catch data, reaches 1 through 4 appear to provide the most suitable habitat. The stream gradient in the Russian River declines below the dam, and there is a higher frequency of pool type habitats compared to the above dam habitat (Chase *et al.,* 2000). The greater depth and lower current velocity associated with pool habitats is preferred by centrarchids (which include smallmouth). Not surprisingly, smallmouth bass dominate the predatory fish population in these reaches.

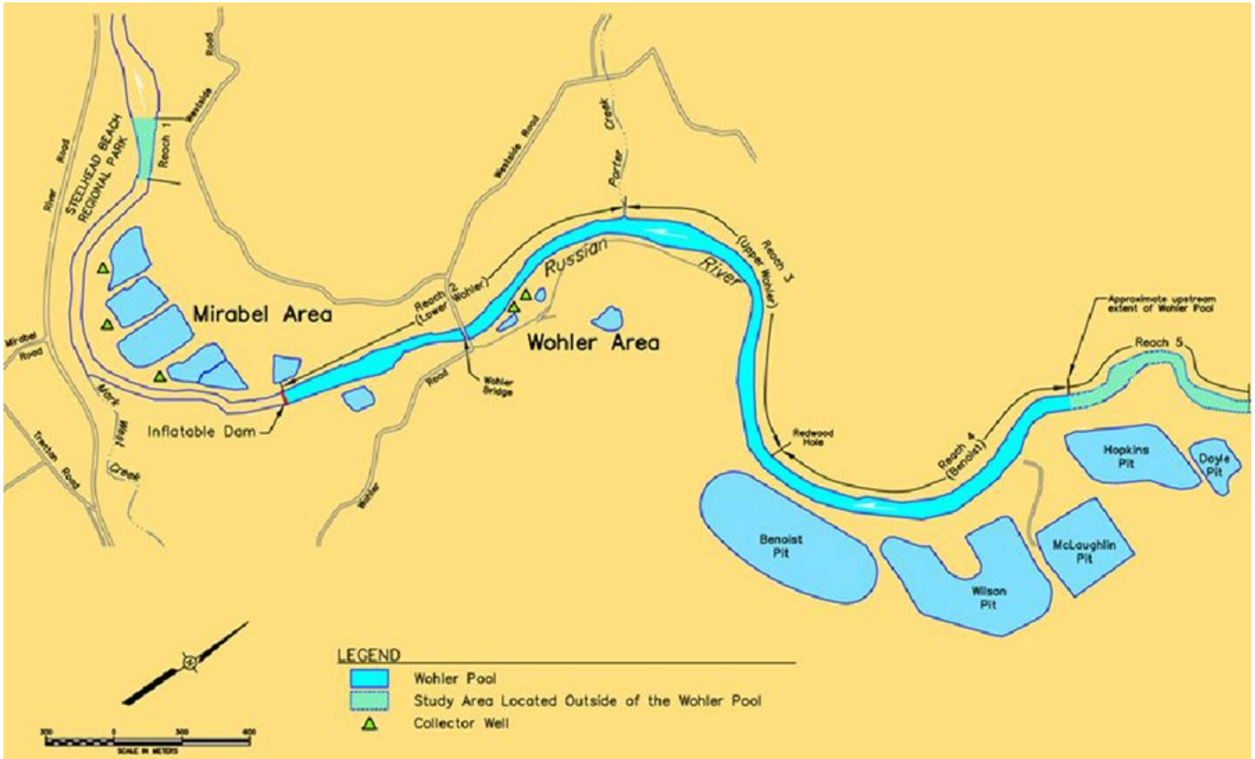

Figure 38. Reach locations across the Wohler Pool area (ESA, Inc. 2023).

Smallmouth bass and pikeminnow attain a size sufficient to prey on salmonid smolts by the start of their third year of life (age 2+). As noted above, smallmouth bass are the most abundant predatory fish species inhabiting the Wohler Pool; however, the majority of smallmouth bass captured were YOY (ESA, Inc. 2023), which are too small to eat salmonid smolts. Similarly, pikeminnow catch was dominated by fish that were age 0+ and 1+, based on size class (<9.8 in), which are not likely sufficient size to eat salmonid smolts. It is not known if the relatively low number of older smallmouth bass and pikeminnow is due to a high rate of mortality, or a high rate of dispersal by young fish to areas outside of Wohler Pool. Winter habitat conditions (i.e., when the dam is deflated) may at least partially explain the poor recruitment to older age classes, which may be due to higher flow rates and colder water temperatures.

2.4.4.6 Smolt Migration Survival Estimates and Potential Predation

As described in detail in 2.4.3.2 Status of Salmonids in the Action Area, CCC coho salmon, smolt survival was studied in 2021 and 2022 via PIT tagged coho salmon. Preliminary survival estimates have been developed for coho from these data. Trends in survival were identified by release group with survival decreasing from first to last release. Further, Dry Creek and the Estuary were identified as segments with higher survival compared to the segment between Dry Creek and Mirabel Dam, where tagging studies identified high rates of predation resulting in low coho smolt survival. Additional analysis of environmental factors (flow, turbidity, and temperature) was also conducted to identify potential relationships between these factors and survival. In general, these analyses found positive relationships between higher survival and higher flow, and between higher survival and higher turbidity. It is likely that the relationship of survival with turbidity here is driven mostly by the positive relationship of turbidity with flow, rather than suggesting a benefit of turbidity, given the known negative relationship between turbidity and survival. Survival estimates as a function of flow are detailed in the BA (ESA, Inc. 2023). Additional details of the studies conducted can also be found in the BA.

2.4.4.7 Estuary Management and Habitat Enhancements

The frequent artificial breaching of the barrier beach disrupts the conversion processes described above and the value of habitat for estuarine species. As noted above (Section 2.4.1.4), artificial breaching of the barrier beach that periodically forms at the mouth of the Russian River has been performed regularly since the 1960's by Sonoma County. Estuary management and monitoring of conditions was deemed necessary, and deemed the responsibility of Sonoma Water, due to the elevated flows in the summer for water supply.

During the period since the 2008 Opinion, from May 15 through October 15, Sonoma Water has monitored and, when indicated, implemented bar breaching to minimize flood risk and enhance estuarine salmonid rearing habitat. While maximizing habitat has been the priority during this period, minimizing flood risk and preserving water quality remain parallel obligations which can override beach management if warranted. In addition to required monitoring, a series of studies designed to improve understanding of the physical processes in the Estuary and to identify routes for improving management were completed. Below we identify the elements of management, studies and actions completed from 2008-2023, the effective period of the 2008 Opinion, which inform the Environmental Baseline for the Estuary.

Monitoring data collected by Sonoma Water since 2009 in the Estuary and on the barrier, beach have generated a wealth of information on the beach and river mouth morphology, and the resulting hydrology, water quality, physical processes, and habitat conditions in the Estuary. In recent years, beach management practices have been updated as a result of the adaptive management process and the availability of new monitoring data on the beach collected by Sonoma Water. These updates have been reflected in annual spring updates to the AMP. Annual monitoring reports have documented the change in the beach geometry from year to year and have considered the implications of beach morphology on Estuary water levels across a range of wet and dry years.

In response to continued challenges with beach management and continued review of monitoring data, including the recent summary on juvenile steelhead rearing habitat requirements provided by Boughton *et al.,* (2017), NMFS provided feedback that successful management of juvenile salmonid habitat could be better achieved by encouraging longer closure events. In response to this, the 2019 update to the AMP included a revision to the conceptual model of beach morphology and addition of a decision tree for planning beach management (Sonoma Water 2024e). This followed a multi-year review of data in the Estuary, which indicated that outlet channel conditions were unlikely to be maintained for significant periods of time and that any partial artificial breach to attempt perched conditions resulted in a full breach or closure, depending on ocean conditions. Future proposed Estuary management incorporates this "decision tree" which provides more planning flexibility to allow the inlet to remain closed, rather than implementing an outlet channel immediately when water levels are anticipated to reach the lower target water level threshold of 7 ft NGVD. Though the upper threshold of 9 ft NGVD29 remains unchanged as a trigger for artificial breaching to minimize flood risk.

As a part of the adaptive management process, during each year, monitoring data from the prior year is reviewed with the resource agency team in the month of March, prior to adopting a plan for the next year. The decision tree was intended to incorporate both seasonal and recent data collected by Sonoma Water and publicly available data collected by other agencies, including some real time monitoring data. This process allows monitoring data to be incorporated into the decision-making process, so that decisions about outlet channel implementation are based on recent habitat conditions for salmonids in the lagoon. To facilitate supporting salmonids utilizing the habitat in different ways during different seasons, the management season was split into three segments, reflecting different salmonid life stages and tolerance to salinity in the lagoon. Other considerations, such as environmental conditions, beach accessibility to equipment, safety, and harbor seal constraints were also incorporated.

The importance of effective beach management is reflected in the 2008 Opinion's RPA Element 2: Alternatives to Estuary Management. Several of the actions in the RPA, including Management of Estuarine Water Surface Elevations and Investigation of Jetty Impacts on Permeability and Lagoon Formation ('Jetty Study'), called for maximizing freshwater habitat for juvenile steelhead in the lagoon through beach management practices. This was drawn in part from a review of historical conditions on the Russian River, and review of a number of estuarine reference sites, including Scott Creek and the Carmel River.

Sonoma Water completed the Feasibility Study of Alternatives to Goat Rock State Beach Jetty for Managing Lagoon Water Surface Elevations ('Jetty Study') in 2017 (ESA, Inc. 2023). In accordance with the RPA, the purpose of this evaluation was to determine whether the jetty could be modified or removed to help achieve the water surface elevation objectives of the RPA. The Jetty Study was useful for understanding the dynamics of the beach between the Estuary and ocean. There are subsurface flows that occur between the ocean and Estuary in locations where jetty components are absent from the beach, seepage from the Estuary to the ocean intensifies during low tides, and seepage can be 3.7 times faster in sections where the jetty is absent, compared to areas where it is present. The study also found that the groundwater flows through the beach are layered; with a lower saltwater wedge that moves toward the Estuary while the freshwater lens at the surface moves toward the ocean through the porous beach. Finally, during inlet closure, persistently higher water levels in the Estuary than the ocean result in a hydraulic gradient that pushes near-bottom water through the beach. Due to this hydraulic gradient, it was observed that over time the groundwater within the beach gradually converts to freshwater, suggesting the lagoon would convert to freshwater over time during a closed beach.

A component of the Jetty Study was to create a Quantified Conceptual Model to predict the potential effects of removing all or parts of the jetty, or notching the jetty. The modeling results found that removing some or all of the jetty would not meaningfully contribute to attaining more frequent or sustained lagoon conditions and a corresponding increase in Estuary water levels. Modeling the act of notching the jetty suggested this may facilitate longer lagoon conditions in some years, but this action would have other feasibility constraints (e.g., managing channel erosion, impacts to public safety, or to the environment) that preclude its utility for the purposes of achieving Estuarine water surface elevation objectives.

2.4.4.8 Russian River Coho Salmon Captive Broodstock Program

In 2021, CDFW and USACE finalized an HGMP for the RRCSCBP in support of their application for ESA Section 10(a)(1)(A) permit coverage. The HGMP describes pertinent hatchery activities, including the collection of NOR broodstock, artificial spawning, hatchery rearing, marking and tagging, health maintenance and disease control, program releases, and post-release monitoring. At present, the RRCSCBP has the capacity to accommodate up to 500,000 coho salmon eggs, 250,000 progenies (age 0^+ to age 1^+), and 1,500 adults. To operate at this capacity, the broodstock program annually collects up to 1,500 NOR YOY and NOR adult coho salmon for artificial propagation and/or rearing and release. Table 18 below contains a summary of annual release targets as outlined under the HGMP.

Since 2004, the RRCSCBP has released over two million juvenile coho salmon into the mainstem Russian River and tributary streams. Under this program, annual returns of coho salmon adults (predominantly HOR) have increased (Figure 32) and the program has substantially increased the genetic diversity of Russian River coho salmon. Additionally, the abundance of adult coho salmon has also increased from a low of 5-10 in the early 2000’s into the hundreds over the last decade (Figure 31). The program has also increased the distribution of program coho salmon into numerous tributaries, expanding from the three tributaries observed in the early 2000’s. Unlike most non-conservation hatchery supplemented populations, the wild Russian River coho salmon population has benefited substantially from the conservation program.

Table 18. RRCSCBP maximum annual release targets by life stage (CDFW and USACE 2017).

Life Stage	Release Number	Release Location	Release Date
Unfed fry and/or eyed eggs	250,000	Russian River tributaries or out-of-basin streams	Feb – Apr
Juveniles (fingerlings, yearlings, and smolts)	250,000	Russian River tributaries or out-of-basin streams	Feb – Mar
Adult	700[a]	Russian River tributaries or out-of-basin streams	Jan – Jun; Oct - Dec

NOTE: Only 500 adults may be released in natal or non-natal out-of-basin streams.

After 20+ years of the RRCSCBP being in place, the ratio of NOR to HOR is still concerning (at least in 4 LCM tributaries). Few NOR are completing their life cycle. Data also shows that smolt to adult ratios and freshwater survival is very low for CCC coho in the Russian River watershed. One note of promise is that NOR juvenile coho are found in streams throughout the lower watershed where broodstock are not released (Figure 39). Although most of these tributaries are outside of the Action Area, presence of NOR represents the potential to boost our assumptions about poor NOR/HOR ratios and shows that the population is benefiting from RRCBCSP outside of release streams.

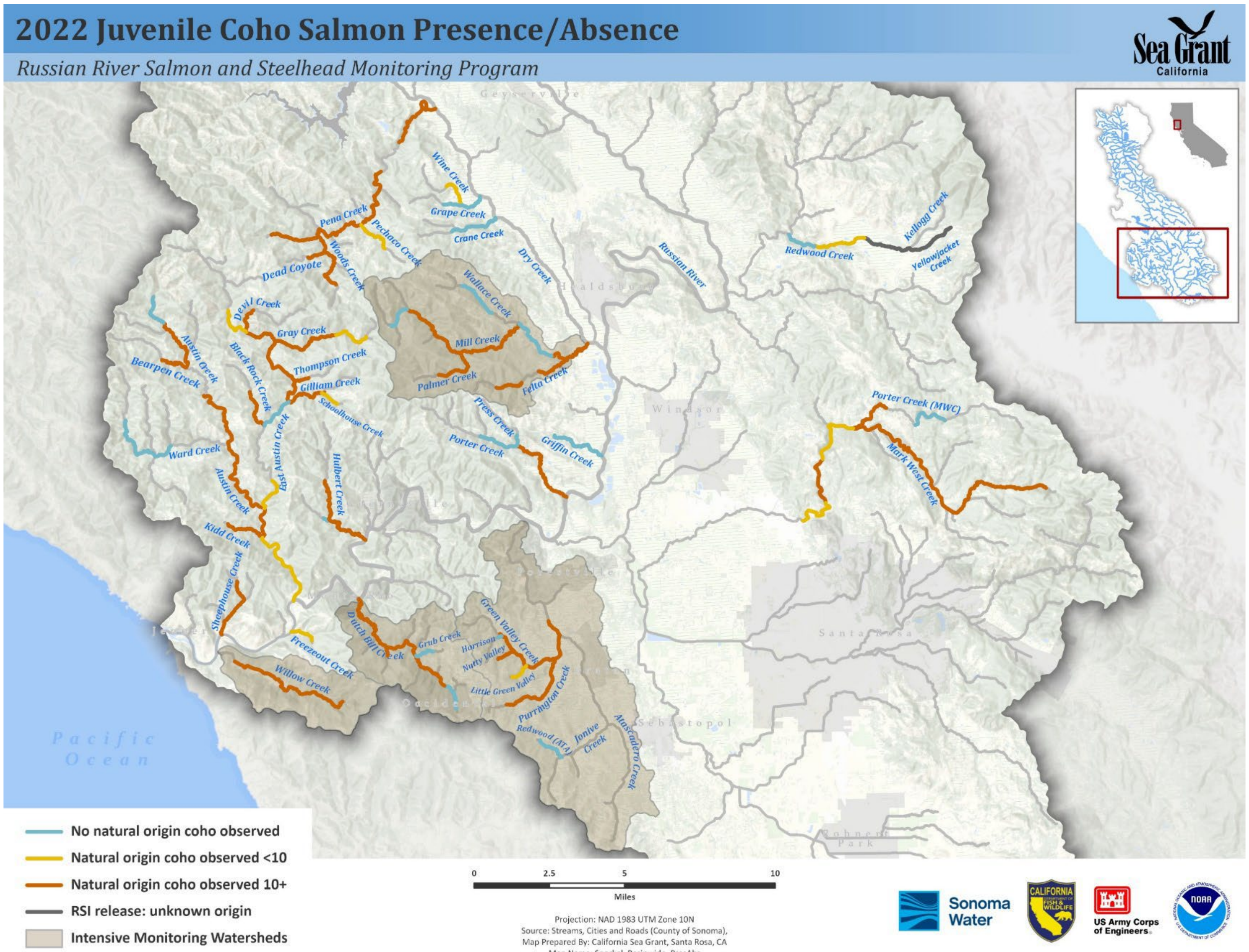

Figure 39. Map showing results from 2022 juvenile coho salmon snorkeling surveys and NOR coho salmon counts in the Lower Russian River watershed (CSG and Sonoma Water 2023b).

Meanwhile, recently the invasive New Zealand Mudsnails (*Potamopyrgus antipodarum)* have been found in the source waters for the two fish facilities (DCFH and CVFF), which has led to CDFW decreasing the stocking of juvenile coho via the broodstock program. Now, CDFW policy only allows stocking to five mudsnail-positive tributaries out of 22 historically stocked. Until changed, this alteration in program focus has the potential to have significant repercussions to the success of the RRCSCBP.

The current population of CCC coho salmon have been also exposed to impacts of the two steelhead hatchery facilities that have been releasing from 300,000 to 500,000 smolts into the Russian River since the early 1980's. The past impact of HOR steelhead on coho salmon is through competition and predation on coho salmon smolts and juveniles, and harvest impacts to adult coho salmon from fisheries targeting hatchery steelhead (CDFW and USACE 2021b). The HGMP for the steelhead program (discussed below) has minimized the competition and predation effects via modification of release numbers, size, timing and location.

2.4.4.9 Steelhead Hatchery Program

Hatchery practices have also impacted steelhead populations within the Action Area. Since the 1870's, millions of hatchery-reared salmonids have been released into the Russian River Basin. The combination of planting out-of-basin stocks, hatchery broodstock selecting processes, and interbreeding have led to a decrease in salmonid genetic diversity and loss of local adaptations (SEC 1996). Prior to the construction of the DCFH and CVFF nearly all stocking of steelhead into the Russian River used broodstock from out-of-basin sources. These historical transfers are recorded as early as the 1890s and included a variety of origins. In the early 1900s, steelhead from Scott Creek (Santa Cruz County) were released throughout the Russian River basin. Significant numbers of steelhead from the Mad River Hatchery (Humboldt County) were released into the Russian River basin prior to the construction of the hatchery. Other reported historical plant sources (FishPro and Entrix 2000) include: Eel River (1972), Prairie Creek (1927), Mad River/Eel River hybrids (1974), San Lorenzo Creek (1973), Scott Creek (1911), and Washougal River, Washington (1981).

The primary purpose of the modern-day steelhead hatchery program is to compensate for lost habitat due to the construction of WSD and CVD. Hatchery production is required to "mitigate" for the loss in natural steelhead production estimated to have occurred prior to construction of the dams. Although hatchery production CCC steelhead are included in the DPS listing, unlike the conservation hatchery programs for CCC coho salmon, the primary purpose of CCC steelhead hatchery programs is to supplement recreational angling opportunities. Therefore, HOR steelhead are not included in the abundance target of the viability criteria and recovery targets and take of these hatchery fish is not prohibited (considered "surplus" fish). Since the implementation of the steelhead programs at DCFH (1981) and CVFF (1992), broodstock have been collected solely from fish returning to the WSD and CVD, respectively.

Since completion of the HGMP in 2021, total fish production from the steelhead program has been reduced by 20 percent and capped at 400,000 fish (DCFH production will be reduced to 200,000 fish, Table 19). This reduction in DCFH hatchery production is expected to result in a 33 percent reduction in proportion of HOS for the DCFH program. Thus, until performance targets are met, the program will release up to 200,000 juveniles from DCFH and 200,000 from CVFF annually.

Table 19. A summary of annual release targets as outlined under the HGMP for steelhead in the Russian River (CDFW and USACE 2021a).

Life Stage	Release Location	Release Date
Smolt	Mouth of Dry Creek or Mainstem Russian River	Feb – Mar
Smolt	CVFF	Jan – Feb – Mar

In addition to outlining standard protocols for artificial spawning, hatchery rearing, and post-release monitoring, the steelhead HGMP includes a series of revisions to the release program aimed at increasing genetic diversity, reducing competition, and predation impacts on juvenile coho salmon, Chinook salmon, and wild steelhead. These revisions include releasing smaller steelhead to reduce the size of fish they can prey upon, and modifying release locations and times to reduce or eliminate predation and competition effects on other salmonids. For example, steelhead from both programs will now be released in February and March at the CVFF and January through March at the DCFH, prior to the emergence of coho salmon fry. This action is designed to reduce the probability that hatchery steelhead will prey on newly-emerged coho salmon. The HGMP also includes limiting the total number of releases from DCFH to reduce genetic risks to the natural steelhead population and the coho population.

As noted above, differentiation among steelhead within the Russian River basin has been substantially influenced by the widespread transfer of hatchery steelhead within the basin (Bjorkstedt et al., 2005). The HGMP describes a program incorporating NOR broodstock, primarily from independent populations, and ideally from dependent populations to be included into both Upper and Lower River hatchery programs. This is intended to promote the inclusion of wild genetics into the hatchery population, and to reduce the divergence between hatchery and wild populations.

2.4.4.10 Chinook Salmon Hatchery Stocking and Harvest

The history of hatchery stocking has likely had some effect on genetic diversity for CCC Chinook salmon in the Russian River watershed (Bjorkstedt *et al.,* 2005; Chase *et al.,* 2007). The stocking of Chinook Salmon in the Russian River basin was first reported between 1881 and 1907 and continued sporadically, until the 1950s and 1960s when planting efforts became more consistent, with plantings occurring nearly every year between 1982 and 1998. These hatchery programs for Chinook salmon ceased in 1996 due to low adult returns that failed to meet mitigation goals (Good *et al.,* 2005). The current run of Chinook salmon in the Russian River stems from natural production, and likely evolved as part of a diverse group of native coastal populations (Hedgecock *et al.,* 2002).

In the 2016 recovery plan (NMFS 2016d) fishing was identified as a medium threat for most of the populations of CC Chinook salmon because of freshwater fishing. While retention of Chinook salmon is prohibited in the freshwater areas of the ESU, poaching and encounters during steelhead fisheries (especially during low flow conditions) remain a concern (NMFS 2016d). To address this, CDFW has implemented low flow fishing closures, including additional closures in 2022, to reduce the impact on Chinook salmon across the ESU.

2.4.4.11 Steelhead Sport Angling

The Russian River watershed supports a popular year-round fishery. While take of Chinook and coho salmon is prohibited, hatchery reared and marked steelhead may be taken. Since public access is provided throughout the watershed, angling is common throughout accessible reaches from Jenner upstream to Cloverdale. The steelhead program assumes that some portion of hatchery steelhead releases will be captured by anglers and factors this into their release targets and broodstock management. The steelhead HGMP assumes anglers will harvest approximately

50 percent of the HOR steelhead adults returning to the Russian River each year. On average, anglers are expected to harvest approximately 3,500 adults each year.

While the harvesting of NOR fish is prohibited, they are still caught by anglers. The Steelhead Fishing Report-Restoration Card has been in place since 1993, and has collected angling information to estimate harvest and releases of wild and hatchery steelhead throughout the state, since 1999. The Steelhead Report and Restoration Card data estimates that approximately 1 NOR adult is caught for every 2 HOR steelhead caught by anglers (CDFW 2025). Although anglers are required to release all NOR adults, it is assumed that 5 percent of the caught NOR steelhead are killed due to hooking and handling. From 2006 to 2015, it is estimated that approximately 400 NOR steelhead were caught by anglers in the Russian River (CDFW and USACE 2021a). Assuming 5 percent of these fish were killed, then a total of 20 NOR steelhead are killed on average each year, equaling about 1 percent of the total Russian River NOR steelhead population.

The number of HOR and NOR steelhead kept and released in Russian River sport fisheries is shown in Table 20. From 2000 to 2016, a total of 7,967 adult HOR steelhead have been caught in the basin by anglers and an additional 6,765 released. Because released hatchery steelhead may spawn naturally and the management goal is to increase the number of NOR spawners, the HGMP includes a program to educate anglers to the need and rationale for keeping all hatchery fish caught. Anglers recruited to catch NOR fish for broodstock as part of the HGMP will be trained on proper handling procedures for transporting fish from capture point to adult holding facilities or hatchery trucks. Barbless hooks will be used to reduce injury to caught NOR fish.

Table 20. The number of NOR and HOR steelhead kept and released by anglers in the Russian River and tributaries (CDFW and USACE 2021a).

Year	NOR Kept	NOR Released	Total NOR	HOR Kept	HOR Released	Total HOR	Total HOR + NOR
2000	3	16	19	6	19	25	44
2001	2	101	103	99	128	227	330
2002	2	84	86	141	132	273	359
2003	6	95	101	234	139	373	474
2004	12	187	199	510	439	949	1,148
2005	1	109	110	129	93	222	332
2006	11	189	200	328	225	553	753
2007	94	1,296	1,390	1,568	1,254	2,822	4,212
2008	40	582	622	388	297	685	1,307
2009	14	284	298	323	418	741	1039
2010	6	275	281	162	178	340	621
2011	0	428	428	411	456	867	1,295
2012	0	880	880	1,087	846	1,933	2,813
2013	0	834	834	909	808	1,717	2,551
2014	0	441	441	542	411	953	1,394
2015	0	580	580	763	613	1,376	1,956
2016	0	202	02	379	309	685	887
Total	**191**	**6583**	**6,774**	**7,976**	**6,765**	**14,741**	**21,515**
Average	11	387	398	469	398	867	1,266

2.4.4.12 Other Restoration Actions

Many instream and near-stream restoration activities have occurred throughout the Russian River watershed. Many of these activities were undertaken specifically to improve aquatic and riparian habitat to benefit salmonids. Examples of recent restoration activities include: 1) placing large wood structures in streams; 2) replacing instream road crossings and undersized culverts with appropriately sized culverts or bridges; 3) contouring stream banks to recreate or rehabilitate flood plains; 4) removing riprap or other hardened surfaces using bioengineered techniques; 5) removing and replacing nonnative vegetation with native vegetation; 6) installing fencing to remove grazing in riparian zones; and 7) improving fish passage at dams, such as the Mill Creek and Yellowjacket Creek dams. These restoration projects were undertaken by NOAA's Restoration Center, Gold Ridge Resource Conservation District, Sonoma Water, and CDFW to fix chronic watershed problems that were degrading valuable habitat. Restoration objectives included: reducing erosion and minimizing sediment delivery to streams, stabilizing stream bed and grade, providing access to spawning and rearing habitat upstream by eliminating passage barriers, improving stream/floodplain connectivity, and providing cover and lower stream temperatures.

Nearly all instream and near stream restoration activities have environmental costs associated with their construction. Impacts included capture and relocation of fish, turbidity, or loss of riparian vegetation. However, those effects were generally small, localized, and of short duration. Restoration projects provide long-term habitat that provide salmonids with increased access to more spawning and rearing habitat, thereby facilitating recovery of salmonid populations. Also, restoration of hydrologic, geomorphic and sediment processes will lead to flood and groundwater retention and water quality improvement further improving the value of salmonid habitat in the Russian River watershed. These changes are expected to improve spawning, rearing, or migration success of Russian River salmonids in future years.

2.4.4.13 Climate Change

As described above in the Status of the Species and Critical Habitat section, the most relevant trend in global climate change is the warming of the atmosphere from increased greenhouse gas emissions. Global warming is likely to manifest itself differently in different regions. Impacts identified above for California include increase in the number of critically dry years (Cayan *et al.,* 2006). Many of the threats already identified for these salmonid populations are related to a reduction in surface flow of tributary streams. Future climate change may, therefore, substantially increase risk to the species by exacerbating dry conditions, especially toward the end of this Century.

For example, a major emergent habitat concern related to climate change is the increased frequency and severity of large, unprecedented wildfires that have affected the Russian River. The Russian River watershed was severely impacted by the 2017 Pocket, Tubbs, and Nuns Fires, the 2019 Kincade Fire, and the 2020 Walbridge and Glass Fires.[13] The Austin Creek, Mill Creek, Maacama Creek, and Mark West Creek watersheds experienced significant damage from these wildfires (Figure 40). Fires of this magnitude cause substantial damage to riparian habitat and instream wood shelter, and contribute to increased landslides and sediment input to streams. Roads and fire breaks cut by bulldozers to provide access and stop the fire's movement, respectively, can also cause unintentional impacts via vegetation removal and increasing sources of fine sediment input into streams.

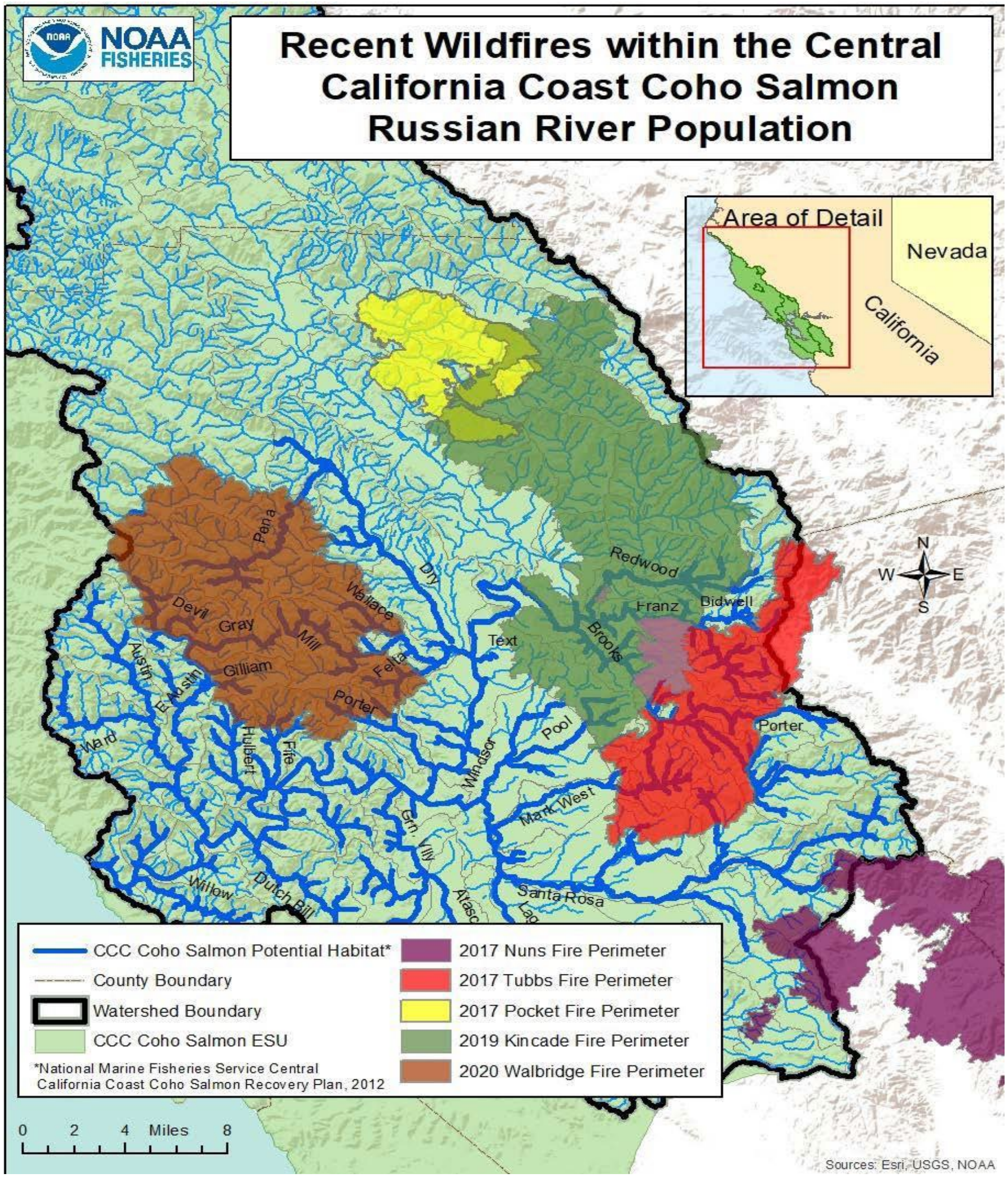

Figure 40. Map of recent wildfires within the CCC coho salmon population in the Russian River watershed.

[13] The 2020 Glass Fire occurred in the Russian River headwaters but is outside the CCC coho salmon recovery footprint.

NMFS expects that the increased frequency of large fires in the Action Area is likely to continue during the Proposed Action's 10-year duration and may cause additional sediment input as well as loss of vegetation in some parts of the Action Area. We cannot predict where and when these events will occur, nor their precise impacts. Stream temperatures and flows during the next ten years are also likely to be similar to the last ten years, with the potential for additional droughts similar to the recent past, as well as ARs and flooding.

Progress is being made on forecasting decadal changes of surface temperature due to global climate change on global and large regional scales (Smith et al., 2007). In addition, progress has been made in attributing some increases in the severity of recent weather and climate events such as flooding and droughts to climate change (see Section 2.2.5.2 above). However, predicting climate change impacts on scales of a decade or less remains at the early stages of scientific understanding (Done et al., 2021). Therefore, NMFS concludes the best approach to forecasting impacts from climate change in the Russian River watershed during the next ten years will be that these impacts will likely be similar to the previous 10 years, including increased drought, fire, and flood risk, as described above.

2.4.4.14 Previous ESA Section 7 Consultations in the Action Area

In addition to the consultations for issuance of HGMPs and research permits, numerous ESA Section 7 consultations have been completed in the Action Area for actions authorized, funded, or carried out by federal agencies. These include actions such as summer river crossings, bank protection, bridge repair and retrofits, and restoration of salmonid habitats. Except for the previously noted 2008 Opinion, all of these consultations either resulted in NMFS' concurrence with not likely to adversely affect determinations made by federal action agencies, or NMFS's finding in a biological opinion that the proposed action was unlikely to jeopardize listed species or destroy or adversely modify designated critical habitat. NMFS' biological opinions include terms and conditions to avoid or reduce the amount or extent of incidental taking anticipated to occur within the action area, or to minimize the impact of such taking.

2.4.5 General Ocean Habitat Description for Southern Resident Killer Whales

Critical habitat for SRKW includes approximately 2,560 mi^2 of inland waters of Washington as well as 15,910 mi^2 of marine waters along the U.S. west coast between the 20-ft depth contour and the 656.2-ft depth contour from the U.S. international border with Canada south to Point Sur, California (see Section 2.2.6 and Figure 20 for more details). SRKW are known to use the portion of critical habitat that overlaps with the Action Area (coastal waters off California and Oregon) most frequently during the late fall through the spring, with K and L pod found in this region more often than J pod (Hanson et al., 2013; Hanson et al., 2017; Emmons et al., 2019; Emmons et al., 2021).

2.4.6 Status of Southern Resident Killer Whales and their Critical Habitat in the Action Area

The three pods of SRKW use the Action Area in different ways. While K and L pod have been observed in the coastal waters off California and Oregon during the winter and spring months, J pod usually remain in northern waters during this time of the year (NMFS 2021c). But even though J pod usually remains in the northern portion of their range, SRKW are known to consume California-origin Chinook salmon far from their stream of origin (Hanson et al., 2021), so it is possible for all pods to be impacted by changes in availability of CC Chinook. As stated in the above Rangewide Status of the Species for SRKW (Sections 2.2.6 to 2.2.10), SRKW face multiple threats within the Action Area, including prey limitation, that likely interact to inhibit survival and recovery (Murray et al., 2021).

2.4.7 Factors Affecting Southern Resident Killer Whales and their Habitat in the Action Area

In Sections 2.2.1 and 2.4.3.1, we discussed the impacts of various activities and factors affecting Chinook salmon populations in the freshwater environment and, specifically, the Action Area for CC Chinook salmon in the Russian River. Given that the status and the factors that affect salmon in the freshwater environment of the Russian River Basin are discussed above, this section focuses on important factors for Chinook salmon and for SRKWs in the marine environment.

As described in Section 2.2.9 and assessed in the Final Recovery Plan (NMFS 2008b), 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 2008b). 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 5-year review (NMFS 2021a) 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 the Status of the Species and Critical Habitat Sections are also relevant to the Environmental Baseline and we refer to those descriptions or include only brief summaries in this section.

2.4.7.1 Prey and Prey Reductions

As described in the Quantity and Quality of Prey subsection within Section 2.2.9 Factors and Threats Affecting Southern Resident Killer Whales and their Critical Habitat, Chinook 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 many papers (Ford et al., 2005; Ford et al., 2010; Lacy et al., 2017; PFMC 2020; Murray et al., 2021; Ward et al., 2013; Williams et al., 2024). While specific stocks have not been correlated with SRKW vital rates (PFMC 2020), access to many stocks throughout their range, including within the Action Area, is essential to their recovery. Please refer back to Section 2.2.9 for more details on the impact of prey reductions on SRKW.

2.4.7.1.1 CC Chinook Salmon as Prey

As described in Section 2.4.3.1, the Russian River population of CC Chinook represents a considerable portion of the genetic and ecological diversity within the ESU (Myers et al., 1998) and thus the survival and recovery of the Russian River population of CC Chinook is important to the conservation of the ESU as a whole. It is important to note that Chinook in the Russian River are primarily CC Chinook: the contribution of non-listed salmon to the Russian River Chinook population has been observed to be negligible, with only occasional strays of non-listed Chinook from nearby rivers observed in recent monitoring studies (Mariska Obedzinski, personal communication, 2023). Additionally, as described above, there are no Chinook hatcheries in the Russian River.

As described in Section 2.2.6, SRKWs are known to reside in coastal waters along the west coast of the U.S. 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). Largely, our knowledge of the distribution of Russian River Chinook salmon in the Pacific Ocean in comparison to the distribution of SRKWs 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 Russian River Chinook salmon stocks is not as well known.

Recently, Shelton et al., (2019) did estimate the seasonal ocean distribution, survivorship, and aggregate abundance of fall run Chinook salmon stocks from California to British Columbia. While their analysis did not appear to reveal significant seasonal variance in the relative distribution of Chinook salmon stocks from California, they generally concluded that fall- run stocks tended to be more northerly distributed in summer than in winter-spring, and ocean distributions also tend to be spatially less concentrated in the winter-spring (Figure 3 in Shelton et al., 2019). Without any additional information available that would suggest the distribution of Russian River Chinook salmon shifts substantially seasonally, we assume the distribution of Russian Chinook salmon during the winter and spring is similar to what has been documented during the summer and fall. We also assume that data collected from hatchery fish (usually where CWTs are applied) are representative of the distribution of both wild and hatchery populations consistent with the approach used by federal and state agencies to manage salmon fisheries and populations using CWT data for many decades. The limited amount of available information suggests their distributions are similar (Weitkamp 2010).

The available data from CWT and GSI confirm that CC Chinook salmon from the Russian River region (fall-run) occur in small numbers as far north as the Columbia River, but are primarily encountered by ocean salmon fisheries in a relatively concentrated area ranging from North of

San Francisco Bay through the Klamath River region (Weitkamp 2010; Bellinger et al., 2015; Shelton et al., 2019) and follow a similar distribution as Chinook from Klamath (Satterthwaite et al., 2014). Unfortunately, current information is insufficient to forecast the ocean abundance of the stock of the specific CC Chinook ESU (PFMC 2021). A recent Opinion estimated adult Chinook salmon abundance using: 1) sonar-based estimates on Redwood Creek and the Mad and Eel rivers, 2) weir counts at Freshwater Creek (one tributary of the Humboldt Bay population), 3) trap counts at Van Arsdale Station (representing a small portion of the upper Eel River population), 4) adult abundance estimates based on spawner surveys for six populations on the Mendocino Coast, and 5) video counts of adult Chinook salmon at Mirabel on the Russian River (NMFS 2024e). The recent 5-year means for estimated CC Chinook adult return is 13,169 individuals (NMFS 2024a).

The final biological report supporting the 2021 coastal critical habitat designation found relatively high SRKW use occurred within some of the zones where CC Chinook and SRKW likely overlap (NMFS 2021c). Additionally, 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 (NMFS and WDFW 2018) (see Table 9 in Section 2.2.9 Factors and Threats Affecting Southern Resident Killer Whales and their Habitat, above). Also, factors contributing to the ranking of priority prey for SRKW reflect likely overlap between CC Chinook and SRKW (NMFS and WDFW 2018). 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 form a significant component of their diets (Krahn et al., 2007; Krahn et al., 2009; O'Neill et al., 2012). CC Chinook have not been observed in the SRKW diet during the limited prey studies and SRKW observation in California, and, therefore, are not high on the SRKW priority prey list (NMFS and WDFW 2018; Hanson et al., 2021). But, it is likely that CC Chinook have been a part of the SRKW diet given the overlap between SRKW and CC Chinook in the winter and spring months (NMFS and WDFW 2018). As a result, we conclude that SRKW could prey on CC Chinook salmon 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 the prey portfolio in California and Oregon (Hanson et al., 2021). This is especially true south of the Columbia River, which includes the times of SRKW potential reduced body condition and increased diet diversity that received additional weight during the NMFS and WDFW prey prioritization process described above.

2.4.7.1.2 Chinook Salmon Harvest, Hatchery, and Habitat

A more detailed description of the harvest, hatchery, and habitat impacts on Chinook salmon is available in NMFS (2024c; pg. 139-148) 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.

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 within the Action Area include PFMC-area salmon fisheries (NMFS 2008c; 2020; 2021d) and fisheries in Southeast Alaska (NMFS 2024c).

Analyses in previous Opinions discussed here and in NMFS (2024c) 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.

Hatchery Actions

Hatchery production of salmonids has occurred for over a hundred years. As noted in the Status of the Species section above (Section 2.2.9) there are over 300 hatchery programs in Washington, Oregon, California, and Idaho that produce and release juvenile salmon that migrate through coastal waters of the Action Area. Many of these fish contribute to both fisheries and the SRKW prey base in the Action Area.

NMFS has completed Section 7(a)(2) consultations on more than two hundred hatchery programs (NMFS 2021e). A detailed description of the effects of these hatchery programs can be found in the site-specific Biological Opinions referenced in Appendix C, Table C.1 of NMFS (2024c). Additionally, a description of the effects of hatchery production receiving federal funds to increase SRKW prey is included in the final environmental impact statement (NMFS 2021e) and the ESA consultation (NMFS 2024c) for the program, as well as the site-specific ESA and NEPA documents for the funded programs. 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. All of the completed analyses to date have determined that the hatchery programs will not jeopardize listed salmonids.

Habitat Actions

Habitat-altering activities such as agriculture, forestry, marine construction, levy maintenance, shoreline armoring, dredging, hydropower operations and development, both past and present, 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 recent activities have a federal nexus and have undergone Section 7(a)(2) consultation. 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. However, the Environmental Baseline is also influenced by many past actions 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 historical levels, largely due to these past activities. Since the SRKWs were listed, federal agencies have consulted on impacts to the whales from actions affecting salmon by way of habitat modification.

NMFS has consulted on many activities that affect salmon habitat within the Action Area, and, therefore, also likely limit prey available to SRKWs. Briefly, these include the National Flood Insurance program (NMFS 2008d), USFS program for the aerial application of long-term fire retardants (NMFS 2022b), stormwater discharge (NMFS 2022c; 2021g) and pollutant discharge (NMFS 2021h). NMFS has also consulted on activities that affect other populations of salmon (CV Chinook, Klamath Chinook) and sources of prey for SRKW, including hydropower projects such as the Daguerre Point Dam (NMFS 2024f), Central Valley Project and State Water Project Operations (NMFS 2019b), Klamath Project Operations (NMFS 2024g; 2019a) and Lower Klamath Project decommissioning (NMFS 2021f).

2.4.7.1.3 Metabolic Needs

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.

Though Chinook abundance 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 the Action Area.

2.4.7.1.4 Prey Quality

SRKW prey is highly contaminated, causing contamination in the whales themselves. 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 Chinook salmon populations (Krahn *et al.,* 2007; O'Neill and West 2009; Veldhoen et al., 2010; Mongillo *et al.,* 2016; Holbert et al., 2024). These contaminants are accumulating in SRKW. For example, L pod has also been found to have higher levels of DDT, consistent with these higher DDT concentrations in Chinook salmon off the coast of California (Krahn et al., 2007). Build-up of pollutants can lead to adverse health effects in mammals (see Toxic Chemicals Subsection in Section 2.2.1.4 of NMFS 2024c). 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).

2.4.7.2 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 (Alava et al., 2018).

2.4.7.3 Summary of Environmental Baseline for Southern Resident Killer Whales

SRKWs and their designated critical habitat are exposed to a wide variety of human activities and environmental factors in the Action Area. All the activities discussed above are likely to have some level of impact on SRKWs (specifically L and K pod) and their designated critical habitat when they are in the Action Area in the winter and spring months. No single threat has been directly linked to or identified as the cause of the small size and relative lack of growth of the SRKWs population over time, although three primary threats that have been identified are: prey availability, environmental contaminants, and vessel effects and sound (Krahn et al., 2002; NMFS 2016e; 2021a). 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 2008b; NMFS 2016e; NMFS 2021a). 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.

2.5. Effects of the Action

Under the ESA, "effects of the action" are all consequences to listed species or critical habitat that are caused by the Proposed Action, including the consequences of other activities that are caused by the Proposed Action 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). For a summary of adverse and beneficial effects to listed species and critical habitat, see Tables 32 and 33 in the Integration and Synthesis section below.

2.5.1 Effects of Reservoir Operations

2.5.1.1 Effects of Reservoir Operations at CVD

2.5.1.1.1 Effects of Reservoir Operations at CVD to Critical Habitat - Water Temperature

NMFS has analyzed the effects of proposed reservoir (flood control and water supply from Lake Mendocino) operations on Upper River water temperatures downstream of CVD.

Included in the 2020 FIRO Final Viability Assessment for Lake Mendocino, NMFS conducted an analysis to evaluate the potential benefits of increased water storage and cold-water pool availability that could support salmonids downstream of CVD. From 2015 to 2019, NMFS monitored the Upper River and reservoir water temperatures (Figure 41). Using these data, NMFS developed a machine learning-based modeling approach to estimate stream and reservoir water temperatures that influence the quality and quantity of summer rearing steelhead habitat and migratory water temperature conditions for fall-run adult Chinook salmon. Of the years monitored, 2015 was an extreme drought year, and 2019 was considered a wet year. These two water years were the primary focus of the study as they represented bookends for potential Lake Mendocino water storage scenarios with the potential benefits with the implementation of FIRO procedures during contrasting water year classifications and their associated water operations.

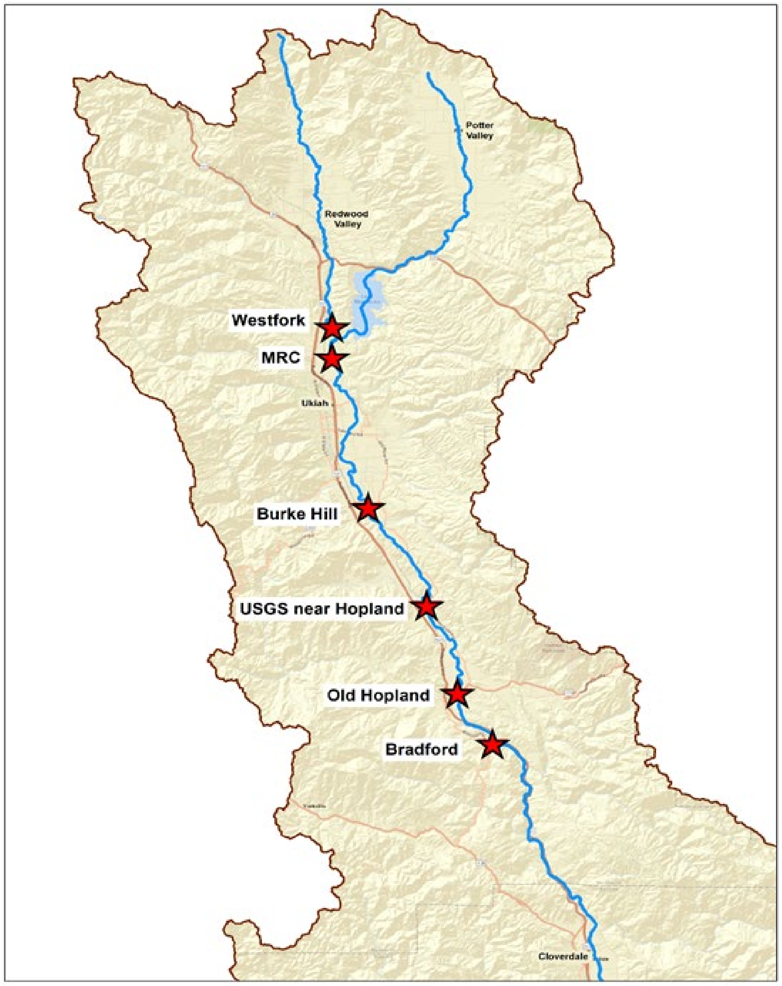

Figure 41. Upper River temperature monitoring locations, 2015 to 2019.

In general, coldwater storage within Lake Mendocino remains available for a longer duration when reservoir storage levels are higher (Figures 42 and 43). Consequently, water temperatures released from CVD into the Upper River tend to be lower during the summer and early fall months when storage levels are higher (Figures 44 and 45). Conversely, when reservoir storage levels are lower during this same dry-season period, temperatures within the reservoir—and subsequently in the Upper River—tend to be higher.

Figures 42 and 43 depict mean daily Lake Mendocino water temperatures at different depths for 2015 and 2019, respectively.

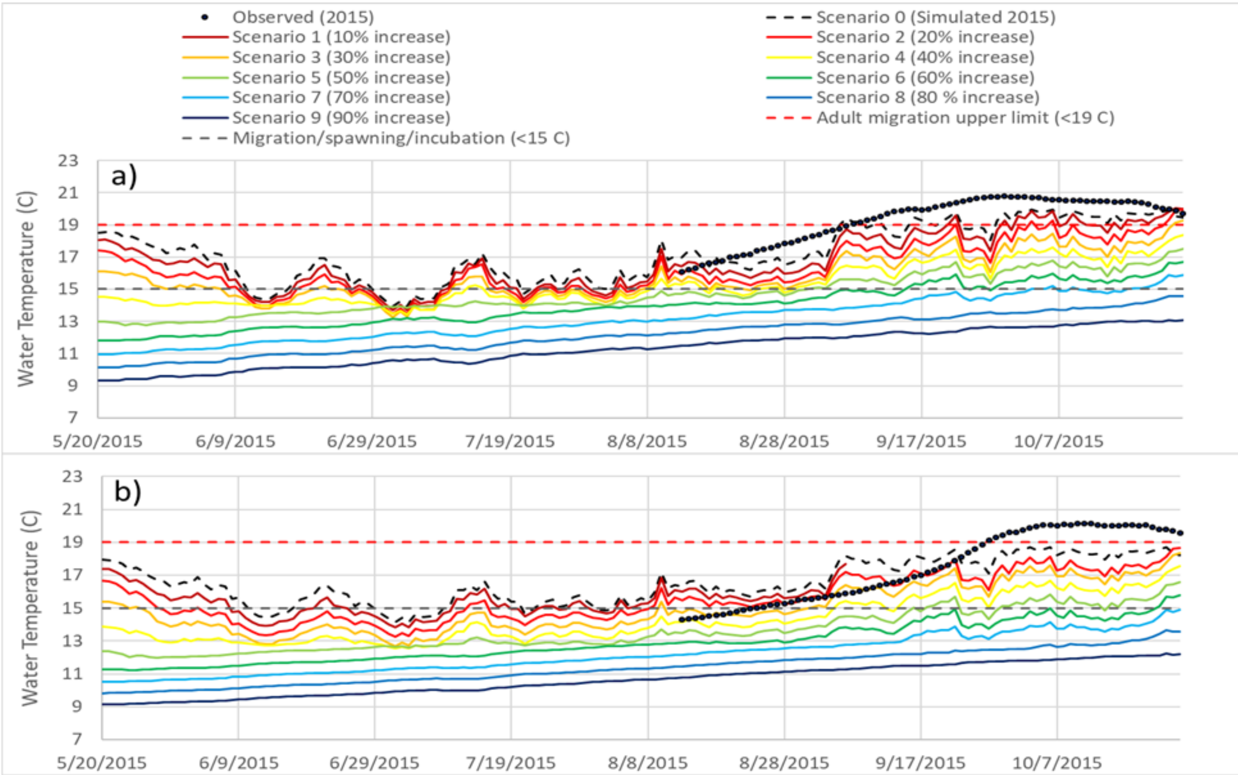

Figure 42. Scenario results for Lake Mendocino water temperatures at depths: a) 40 to 80 ft, and b) reservoir bottom depth, WY 2015.

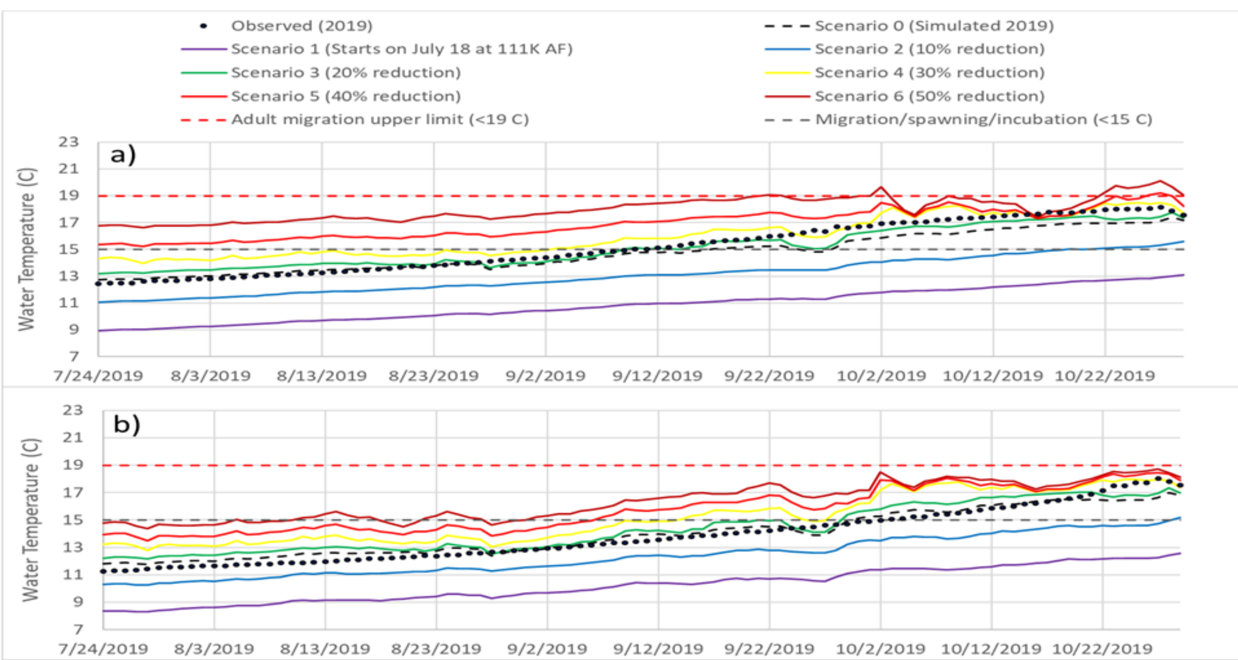

Figure 43. Scenario results for Lake Mendocino water temperatures at depths: a) 40 to 80 ft, and b) reservoir bottom depth, WY 2019.

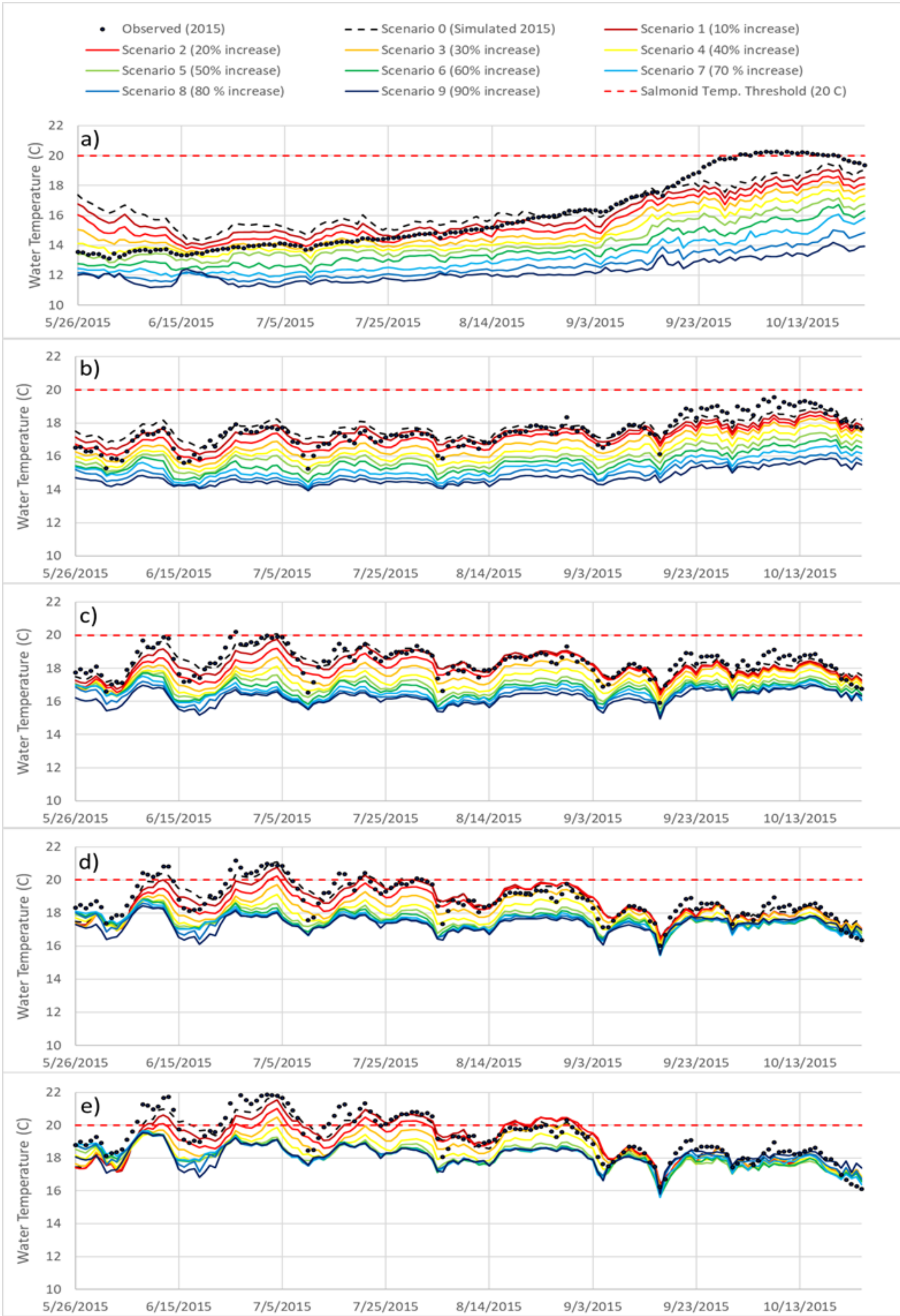

Figure 44. Scenario results for Upper River water temperatures at: a) MRC, b) Burke Hill, c) USGS gage at Hopland, d) Old Hopland, and e) Bradford, WY 2015.

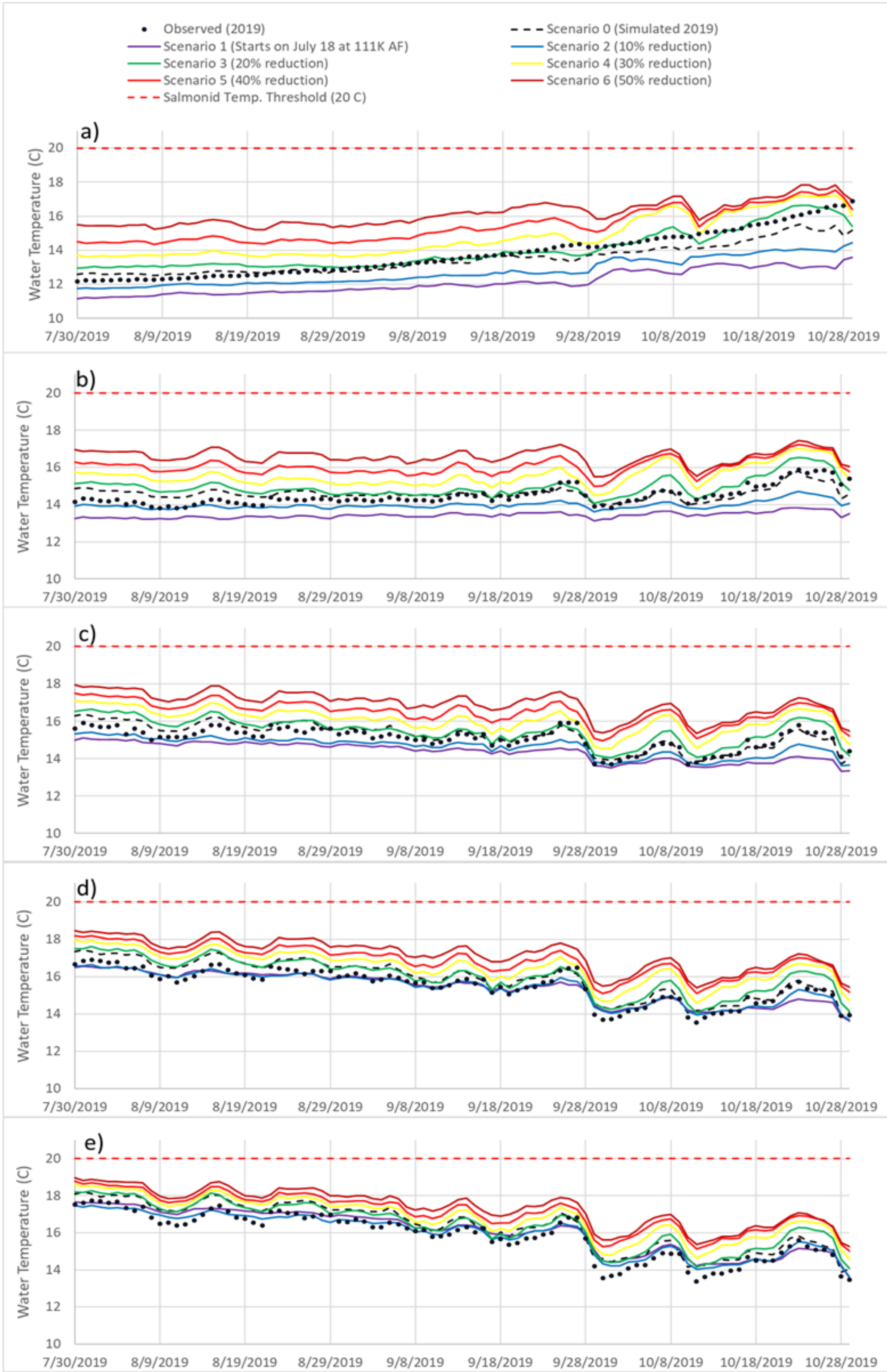

Figure 45. Scenario results for Upper River water temperatures at: a) MRC, b) Burke Hill, c) USGS gage at Hopland, d) Old Hopland, and e) Bradford, WY 2019.

Under the Proposed Action of implementing FIRO at Lake Mendocino, the benefits of higher reservoir storage levels in maintaining cooler water temperatures during the juvenile steelhead summer rearing season through the adult Chinook salmon fall migration period will be maintained regardless of operations associated with contrasting WY classifications (2015 critically dry and 2019 wet). For instance, implementation of FIRO procedures in 2019 and 2020 resulted in the conservation of approximately 11,175 ac-ft of water volume, an approximate 19 percent increase in storage available for releases later in the year compared to operations without the implementation of FIRO. This example further validates the NMFS modeling results, as elevated storage conditions during WY 2019 maintained suitable summer rearing habitat water temperature conditions for juvenile steelhead while providing more reliable migratory flow conditions for adults in the Upper River. Therefore, NMFS anticipates that the Proposed Action, including proposed FIRO procedures, will continue to benefit temperature conditions of rearing habitat PBFs of salmonid critical habitat below CVD.

2.5.1.1.2 Effects of Flood Control Operations at CVD

Proposed CVD flood operations include both water storage and water releases. Water storage reduces the magnitude of flood peaks, while flood releases have the potential to scour the streambed, erode banks, increase turbidity, and create dewatered stream channel conditions during down-ramping activities in the Upper River. NMFS' analysis found adverse effects on Chinook salmon spawning critical habitat from scour and bank erosion, and severe impacts on the PBFs of Chinook and steelhead critical habitats, specifically migration, spawning, and rearing habitat, from the release of turbid waters at CVD. Down-ramping of flows are expected to create intermittent flow and/or dewatered conditions in rearing and spawning habitats used by Chinook salmon and steelhead eggs, pre-emergent fry, fry, and juveniles during the winter and spring. Pre-flood and periodic inspections during the fall (September) can cause dewatered channel conditions, potentially adversely affecting juvenile steelhead rearing habitat. We also assessed the implications of the Proposed Action's continued implementation of FIRO procedures on water temperature conditions (a PBF), migratory cues, and habitat and flow relationships.

Proposed flood control releases are likely to result in the scour of Chinook salmon redds in the Upper River, immediately downstream of CVD to Ukiah. Impacts to Chinook salmon and steelhead from bank erosion, such as the entombment of eggs due to increased sedimentation and effects on juvenile rearing habitat are also likely to occur further downstream to Hopland. Down-ramping for flood control and water supply would occur in the late winter and spring and is most likely to affect Chinook salmon and steelhead fry and juveniles. Pre-flood and periodic inspections would occur in the fall and are most likely to adversely affect juvenile steelhead. These fall inspections should not affect juvenile Chinook salmon as they are not expected to be present during the fall. Lastly, we determined that turbidity-related effects from CVD flood and water supply operations are likely to have the greatest impact on spawning, egg, pre-emergent fry, and juvenile CC Chinook salmon in the Upper Russian River, as well as on many individual summer-rearing juvenile steelhead belonging to the Upper Russian River CCC steelhead independent population. Our effects analysis of these impacts is described below.

2.5.1.1.2.1 Effects of Flood Control at CVD to Critical Habitat - Streambed Scour

Proposed CVD flood control operations are designed to reduce the magnitude of flood peaks in the Upper River. Although the proposed CVD flood operations would mute peak flows generated by winter storms, the magnitude of some flood releases from CVD can be sufficient to cause streambed scour that can adversely affect salmonid spawning habitat. Studies conducted within the Upper River, near the City of Ukiah (Ukiah Reach) indicate that streambed scour sufficient to affect salmonid redds occurs when flows meet or exceed 4,200 cfs (Florsheim and Goodwin 1993). Further downstream at Hopland, such streambed scour flows are in the vicinity of 9,500 cfs (USACE and Sonoma Water 2004). Such flows are termed channel-forming flows.

The risk of increased streambed scour during the flood season can be driven by flow release sequencing during proposed flood control operations at CVD. For example, during large storms, when discharge in the Russian River exceeds channel-forming flows (4,200 cfs), USACE proposes to generally release lower flows from CVD to minimize flooding in Ukiah and Hopland. Once the Russian River discharge begins to fall, CVD flow releases would increase to evacuate water stored during storm events. These post-storm flood releases range between 1,000 to 6,400 cfs, depending on reservoir storage elevations, and can independently or in combination with contributing unregulated runoff from tributaries equal or exceed channel-forming flows. These CVD flood control releases can prolong channel-forming flows and could subject salmonid redds to more streambed scour than would otherwise occur without flood operations, particularly during periods of frequent rainfall when Chinook salmon and steelhead are actively migrating and spawning. Moreover, flood control releases during high reservoir water storage years can lead to even larger and prolonged flood releases, further increasing the duration and magnitude of streambed scour.

To analyze the potential for streambed scour from the Proposed Action, the threshold of 4,200 cfs was used by Sonoma Water and USACE to evaluate contributing flood control release flows from CVD that increase the duration of channel-forming flows over those that would occur otherwise within the Ukiah Reach. The period of record evaluated was from water year 1986 through water year 2017 (31 years) during the months of December through March (ESA, Inc. 2023). Hydrologic information from 2017 to current was not readily available during the time of this analysis, as hydrologic modeling efforts were completed up to 2017. This evaluation was conducted for simulated proposed flood control operations with FIRO procedures implemented. Additionally, an analysis of the duration of scouring flows based on an estimate of stream flow without CVD (unregulated flows) was developed by Sonoma Water and USACE to provide more context of the potential benefit of flood risk management and the reduction of streambed scour events associated with CVD (ESA, Inc. 2023).

The number of days in each water year exceeding 4,200 cfs at the Ukiah gage for each flow record were calculated to determine the duration, in days, of flows meeting the criteria. The duration (days) for flows greater than 4,200 cfs was calculated for the following scenarios:

a. Ukiah Flow minus CVD releases: Representing flows in the Ukiah Reach near the Ukiah Gage (USGS Ukiah Gage 11461000), located below the East and West fork confluence, without contributions from CVD flood control releases.

b. Unregulated Ukiah Flow: Combined flow from the Ukiah and the Calpella (above CVD, USGS Calpella Gage 11461500) gages, representing estimated unregulated flows (minus CVD water storage or PVP contributions).

c. Proposed Operations Ukiah Flow: Simulated CVD flood control releases, including FIRO procedures, summed with Ukiah Flow (a).

To determine the total number of days that exceeded 4,200 cfs during the period analyzed, the sum of flow duration by water year for the period of record for each scenario was calculated. The difference in duration *with* FIRO procedures (simulated for the entire period of record; FIRO procedures were implemented starting in 2018) was calculated to evaluate the duration and subsequent effect of flood control operations on channel forming flows for each case (Table 21). Summary statistics including the average, maximum, and minimum duration in days were also calculated (Table 22).

The duration of channel forming flows observed for the Ukiah Flow, independent of the influence of CVD releases (a. above) ranged from 1 to 6 days over the period of record and 1 to 15 days under unregulated conditions (b. above). For the simulated Proposed Action, including the implementation of FIRO procedures (c. above), the duration of channel forming flows was 1 to 11 days compared to 1 to 15 days under unregulated flows (b. above) (Table 21). Therefore, under the *with FIRO* procedures, channel forming Ukiah Flows (a. above) in the Ukiah Reach would have receded earlier had flow releases for flood control not been made. However, under the *with FIRO* procedures scenario, the duration of channel forming flows was 1 to 6 days shorter than the unregulated scenario (b. above). The total duration of channel forming flows was 119 days for the unregulated scenario (b. above), while it was 72 days under the *with FIRO* scenario, a decrease of 47 days (Table 22). Hence, the adverse effect of redd scour due to increased duration of channel forming flow was reduced in the *with FIRO* procedures scenario, versus the unregulated flow scenario (b. above), and similar to the Ukiah Flow scenario (a. above). Based on the 31-year data set, NMFS anticipates that under the Proposed Action, including implementation of FIRO (scenario *c* above), CVD flood control releases may contribute to 25 additional days of streambed scour events over the next 10-year period, as estimated by the difference between the 10 highest annual values for scenarios *a and c* (Table 21). Alternatively, on an annual basis, CVD flood releases may extend the duration of streambed scour events (≥4,200 cfs at the Ukiah gage in the Upper River) by up to 10 days, based on the difference in maximum annual duration between scenarios *a and c* (Table 21).

Table 21. Number of days in each water year that equal or exceed 4,200 cfs, December through March based on observed Ukiah Flow (a. above) at the Ukiah Gage, Unregulated Ukiah Flow, Ukiah Gage summed with Calpella Gage (b. above), and Proposed Project Flow, including FIRO procedures, summed with Ukiah Flow (c. above) during the period of record, water years 1986 to 2017 (ESA, Inc. 2023).

Water Year	Number of Days Ukiah Flow minus CVD releases (a)[1] ≥ 4,200 cfs	Number of Days Unregulated Ukiah Flow (b)[1,2] ≥ 4,200 cfs	Number of Days Proposed Project Flow (c)[3] ≥ 4,200 cfs
1986	2	No Data	7
1987	None	No Data	None
1988	None	2	None
1989	None	1	None
1990	None	None	None
1991	None	None	None
1992	None	None	None
1993	2	5	4
1994	None	None	None
1995	6	15	10
1996	None	4	3
1997	3	8	7
1998	1	15	11
1999	None	3	None
2000	None	2	None
2001	None	1	None
2002	None	2	0
2003	None	9	0
2004	1	8	4
2005	None	1	None
2006	3	9	11
2007	None	1	None
2008	1	4	2
2009	None	None	None
2010	1	4	1

Water Year	Number of Days Ukiah Flow minus CVD releases (a)[1] ≥ 4,200 cfs	Number of Days Unregulated Ukiah Flow (b)[1,2] ≥ 4,200 cfs	Number of Days Proposed Project Flow (c)[3] ≥ 4,200 cfs
2011	None	7	2
2012	None	None	None
2013	1	3	2
2014	None	None	None
2015	1	1	1
2016	None	4	2
2017	1	10	5

NOTES:
1 Daily data from USGS Ukiah Gage 11461000.
2 Daily data from USGS Calpella Gage 11461500 (period of record starts in water year 1988).
3 Daily data based on simulations with FIRO flood control operations.

Table 22. Summary statistics of the number of days in each water year that equal or exceed 4,200 cfs, December through March based on observed Ukiah Flow (a. above) at the Ukiah Gage, Ukiah Gage combined with Calpella Gage (b. above), and Proposed Project Flow, including FIRO procedures, summed with Ukiah Flow (c. above) during the period of record, water years 1986 to 2017 (ESA, Inc. 2023).

	Number of Days Ukiah Flow minus CVD releases (a)[1] ≥ 4,200 cfs	**Number of Days Unregulated Ukiah Flow (b)[1,2] ≥ 4,200 cfs**	**Number of Days Proposed Operations Flow (c)[3] ≥ 4,200 cfs**
Total Duration (days)	23	119	72
Average Annual Duration (days)	0.7	3.7	2.3
Max Annual Duration (days)	6	15	11
Minimum Annual Duration (days)	0	0	0

NOTES:
1 Daily data from USGS Ukiah Gage 11461000.
2 Daily data from USGS Calpella Gage 11461500 (period of record starts in water year 1988).
3 Daily data based on simulations with FIRO flood control operations.

This analytical approach included a ‘no-CVD’ condition and the amount of flows coming from the East Fork in an unregulated scenario (b. above), essentially a pre-CVD and PVP setting. While such information may be helpful in determining impacts at the population and ESU or DPS scale, it is not appropriate for the exposure and response analysis we report here when evaluating the Proposed Action added to baseline conditions. The USACE controls how flood releases are managed at CVD, and critical habitat and salmonids are exposed to the results of those releases, regardless of pre-CVD and PVP conditions and what they may have experienced in an unregulated flow environment.

The Ukiah Reach is a major Chinook salmon and steelhead spawning area. The analysis above focused on whether CVD releases resulted in channel-forming flows in the Ukiah Reach that would not have occurred due to flows entering this reach from the Russian River mainstem directly above the confluence with the East Fork. The results indicate that in years when channel-forming flows occur in the Ukiah Reach, the annual duration in days of these events can be increased due to flood control operations (c. above) versus the Ukiah Flow scenario (a. above; Table 22). However, CVD also reduces the magnitude of large to very large storms (those that raise Russian River flows far above channel-forming thresholds), likely reducing the scour potential of those events, particularly now with the Proposed Action’s continued implementation of FIRO procedures at Lake Mendocino.

Given this streambed scour evaluation and that CVD increases the duration of channel-forming discharges from December through March, we conclude that the Proposed Action’s winter flood operations are likely to contribute to the scour of salmonid spawning gravels during this time period. Because Chinook salmon spawn and their eggs incubate during this time, the critical habitat PBFs of Chinook spawning critical habitat are likely to be adversely affected by the Proposed Action. Some steelhead spawning habitat may also be adversely affected. However, most steelhead use spawning gravels later in the year, when scour from proposed flood operations is less likely to occur (after February 15).

Studies suggest that Chinook salmon are well adapted for reproductive success in flood-prone river systems. May *et al.* (2009) found that site selection preferences by Chinook salmon correspond to areas of the streambed that are least likely to become mobilized or be at risk for deep scour. Several studies cited by May *et al.* (2009) found that the average probability of Chinook salmon redd scour, defined as net scour greater than 9.0 to11.8 inches in riffles (Evenson 2001), ranged from as little as 5 percent during annual floods to 20 percent for extreme, multi-century recurrence floods.

Baseline channel conditions in the Upper River likely increase the potential for streambed scour during 1.5 to 2-year flood events. Channel incision, dense mature riparian vegetation, and the lack of complexity in the form of LWD or other roughness elements help to concentrate shear stress on the channel's streambed. Present channel conditions are likely to increase the potential for streambed scour due to the uniform distribution of shear stress along the channel bottom.

Therefore, we expect that the increased duration (16 days over the 10-year term of this Opinion) of channel-forming flows caused by CVD is likely to cause slightly higher scour in riffles used by Chinook salmon for spawning than the 5 percent reported above for annual storm events. We estimate that the scour of these riffles in the mainstem below CVD may approach 5 to 10 percent for annual storm events (more details below). Scour, as defined above, diminishes the physical function of critical habitat PBFs in these spawning areas until additional gravel is deposited during subsequent storm events. We do not anticipate meaningful changes in streambed scour rates caused by the Proposed Action's CVD releases during extreme, multi-century recurrence floods because these events will have similarly long streambed scour durations, regardless of CVD operations.

2.5.1.1.2.2 Effects of Flood Control at CVD to Species - Streambed Scour

CVD flood control releases under the Proposed Action are likely to result in some scour of salmonid redds downstream of the dam. The construction of redds by adult Chinook salmon from October to mid-December makes them susceptible to CVD flood releases from December through February (flood control season). Flood releases that contribute to flows greater than 4,200 cfs in the 5 miles immediately below CVD (Ukiah Reach) are expected to mobilize the streambed and adversely affect some Chinook salmon redds.

Due to limited site-specific data in the Upper River, a review of May *et al.* (2009) was conducted to inform our understanding of the relationship among river discharge, bed mobility, and scour depths in areas used by spawning salmonids. May *et al.* (2009) evaluated high flow releases from Lewiston Dam on the Trinity River to determine the level of bed mobility that may scour Chinook salmon redds and impact redd viability. We relied on May *et al.* (2009) to understand the potential effects on salmonids within the Upper River. More recent reviews have concluded that May *et al.* (2009) remains the best available science associated with this specific topic area (Harrison *et al.* 2019; Munsch *et al.* 2020). Based on May *et al.* (2009) and baseline channel conditions in the Upper River, and our best professional judgement, NMFS estimates that 5 to 10 percent of the Chinook salmon redd areas in the Ukiah Reach may be scoured by CVD flood releases.

To estimate the number of Chinook salmon redds that potentially could be scoured by proposed CVD flood control operations, we utilized site-specific Chinook redd counts reported by Sonoma Water (2008). Sonoma Water (2008) reports that the Ukiah Reach of the mainstem is an important spawning area for Chinook salmon, with redd densities ranging from 12 redds per mile in 2006 to 25 redds per mile in 2002. Based on these densities, 60 to125 Chinook redds could be exposed to total or partial scouring within the Ukiah Reach. Based on our estimate of 5 to 10 percent of Chinook redds expected to be scoured by CVD flood releases, we expect that between 3 and 13 redds are likely to be scoured during each year that CVD extends the duration of streambed scour events exceeding 4,200 cfs (approximately every one to two years under the Proposed Action). Scour of Chinook salmon redds is expected to decrease the survival of embryos and pre-emergent Chinook fry by physically dislodging them from the protection of the redd during high flow events.

Although CVD can increase the duration of flows capable of causing streambed scour, Chinook salmon and steelhead redds are typically constructed in stable areas of the river channel, such as channel margins, where both bed mobility and redd scour are less likely to occur due to lower velocities and reduced shear stress (May 2009). Consequently, the risk of these redds being scoured to the depth of the egg pocket or where individual pre-emergent fry may reside is lower. Therefore, adverse effects on individual embryos and pre-emergent fry Chinook salmon and steelhead due to streambed scour from CVD flood control operations are anticipated to be within the ranges discussed above in years with high flood releases, and lower during normal to critically dry years when prolonged flood control releases are expected to be less frequent under the Proposed Action.

Due to the timing of steelhead redd construction, fewer steelhead redds than Chinook salmon redds are expected to be adversely affected by streambed scour resulting from proposed CVD flood control operations. Most steelhead spawning in the Ukiah Reach occurs from March through mid-April. Therefore, steelhead redds constructed in February (or any time before March) have a higher likelihood of exposure to redd scour by CVD flood control releases. However, the majority of steelhead redds constructed after March in the Ukiah Reach are less likely to be adversely affected by redd scour events, as the frequency of CVD flood control releases is expected to decrease after February 15, when the water conservation pool (water supply storage) begins to increase incrementally into the spring. Additionally, the water storage capacity has been expanded by the implementation of FIRO procedures, further reducing the likelihood of steelhead redd scour events (those greater than 4,200 cfs) within the Ukiah Reach after February 15.

2.5.1.1.2.3 Effects of Flood Control at CVD to Critical Habitat - Bank Erosion

Flows of 6,000 cfs or greater at the Hopland Gage have been previously determined to initiate bank erosion along the Upper River down to Hopland (USACE and Sonoma Water 2004). During storm events, when unregulated Russian River flows are elevated, CVD outflow is usually low to avoid contribution to flood flows downstream. However, during some winters with high rainfall, CVD flood control releases' contributions to flows at Hopland can extend the duration of flows that cause bank erosion. The impacts of bank erosion due to CVD flood operations were analyzed using hydrologic data from the USACE, focusing on the magnitude and frequency of stream flows exceeding 6,000 cfs at Hopland.

Similar to streambed scour, the risk of increased bank erosion during the flood season can be influenced by the sequencing of flow releases during flood control operations. For instance, during large storms when discharge in the Russian River exceeds bank-eroding flows, the USACE typically releases low flows from CVD to minimize flooding in Ukiah and Hopland. Once Russian River discharge begins to recede, CVD flow releases are increased to evacuate water stored during winter storms. These post-storm flood releases range from 1,000 to 6,400 cfs, depending on the reservoir elevation, and can either alone or in combination with mainstem flows equal or exceed bank-eroding flows. Longer durations of bank-eroding flows likely increase the potential for bank erosion. Additionally, flood control releases during the wettest years may lead to higher flows and prolonged durations.

Bank erosion criteria developed by USACE and Sonoma Water (2004) were applied to assess whether flow releases from CVD during proposed flood control operations could extend the duration of bank-eroding flows over those that would occur within the Hopland Reach during the same 31-year period of record used for streambed scour (1986 to 2017). This evaluation was conducted for both simulated proposed CVD flood control operations, including FIRO procedures, and flows at the Hopland gage independent of CVD releases. To calculate flows independent of CVD at Hopland under observed conditions, flows measured at CVD are subtracted from flows measured at the Hopland gage, accounting for flow accretion and routing in the reach below CVD. To calculate flow at the Hopland gage under the Proposed Action, the calculated independent flows at the Hopland gage were combined with flows from CVD under simulated proposed operations.

In summary, the bank erosion analysis flow scenarios are as follows:

a. Hopland Flows minus CVD releases: Representing flows in the Hopland Reach near the Hopland gage (USGS Gage at Hopland 11462500), without contributions from CVD flood control releases, and

b. Proposed Operations Flow: Simulated CVD flood control flow releases, including FIRO procedures, summed with Hopland Flow (a).

For Hopland Flow (a. above), bank-eroding flows occurred 1 to 11 days within a given water year. In contrast, under the Proposed Operations Flow scenario, including FIRO procedures (b. above), flows exceeded bank-eroding levels 1 to 21 days within a given water year during the same period of record (Table 23). Therefore, under the Proposed Operations Flow, bank-eroding flows upstream of Hopland are likely to occur more often and for longer durations due to CVD flood control releases. Over the 31-year period of record, the total duration of bank-eroding flows was 148 days under the Proposed Operations Flow scenario, compared to 100 days with independent Hopland flows (Table 24). Based on the 31-year data set, NMFS anticipates that under the Proposed Action, including implementation of FIRO (scenario *b* above), CVD flood control releases may contribute to 28 additional days of bank erosion events over the next 10-year period, as estimated by the difference between the 10 highest annual values for scenarios *a and b* (Table 23). Alternatively, on an annual basis, CVD flood releases may extend the duration of bank erosion events (≥ 6,000 cfs at the Hopland gage in the Upper River) by up to11 days, based on the difference in maximum annual duration between scenarios *a and b* (Table 23).

Table 23. Number of days in each water year that equal or exceed 6,000 cfs December through March based on Hopland Flow minus CVD flood control releases (a. above) and Proposed Operations Flow, including FIRO procedures (b. above) during the period of record, water years 1986 to 2017.

Water Year	Number of Days Hopland Flow minus CVD releases (a)[1] ≥ 6,000 cfs	Number of Days Proposed Operations Hopland Flow (b)[2] ≥ 6,000 cfs
1986	7	9
1987	None	None
1988	None	1
1989	None	None
1990	None	None
1991	None	None
1992	None	None
1993	5	5
1994	None	None
1995	11	17
1996	3	8

Water Year	Number of Days Hopland Flow minus CVD releases (a)[1] ≥ 6,000 cfs	Number of Days Proposed Operations Hopland Flow (b)[2] ≥ 6,000 cfs
1997	6	9
1998	10	21
1999	3	4
2000	1	1
2001	1	None
2002	1	1
2003	6	7
2004	7	8
2005	1	1
2006	9	14
2007	None	None
2008	4	4
2009	None	None
2010	3	4
2011	4	7
2012	None	None
2013	3	4
2014	None	None
2015	1	1
2016	2	5
2017	12	17

Notes:
1 Daily data from USGS Gage at Hopland 11462500 minus observed daily data from CVD
2 Daily data from USGS Gage at Hopland 11462500 plus simulated CVD daily data (with FIRO)

Table 24. Summary statistics of the number of days in each water year that equal or exceed 6,000 cfs December through March based on Hopland Flow minus CVD flood control releases (a. above) and Proposed Operations Flow, including FIRO procedures (b. above) during the period of record, water years 1986 to 2017.

	Number of Days Hopland Flow minus CVD releases (a)[1] ≥ 6,000 cfs	Number of Days Proposed Operations Hopland Flow (b)[2] ≥ 6,000 cfs
Total Duration	100	148
Average Duration	3	5
Max Annual Duration	12	21
Minimum Annual Duration	0	0

Notes:
[1] Daily data from USGS Gage at Hopland 11462500 minus observed daily data from CVD.
[2] Daily data from USGS Gage at Hopland 11462500 based on simulations with FIRO flood control operations.

Bank erosion and sediment deposition are natural geomorphic processes essential for forming and maintaining riparian and aquatic habitats for various organisms, including salmonids. There is a well-established link between episodic disturbances due to channel evolution and habitat diversity. Such diversity enhances riverine ecosystem resilience by creating multiple floodplain and channel habitats that support diverse communities. However, the Proposed Action's regulated CVD flood control releases and water storage operations are expected to cause small to moderate amounts of prolonged unnatural bank erosion. Direct effects may include bank sloughing and increased sediment bed loading, potentially impacting aquatic biota during a flood. Large bank failures due to CVD flood releases are unlikely, as channel adjustments have occurred since the construction and flood operations of CVD. These adjustments include relatively dense riparian vegetation along much of the upper mainstem, which makes the banks of the Russian River more resistant to erosion. Bank erosion from CVD flood releases is expected to be minimal, with sediment and riparian vegetation input affecting only a few sites along the mainstem when erosion occurs.

Consequently, bank erosion resulting from proposed CVD operations is expected to have a small to moderate impact on critical habitat PBFs that provide quality spawning habitat directly downstream of erosion sites. Because of the small and limited nature of sediment inputs, the adverse effects on PBFs of spawning habitat from sedimentation of redds in the Upper River are expected to be minimal under the Proposed Action.

2.5.1.1.2.4 Effects of Flood Control at CVD to Species - Bank Erosion

Bank erosion resulting from sustained moderate to large flow releases from CVD during proposed flood control operations has the potential to lead to the loss of salmonid embryos and pre-emergent fry due to sedimentation of redds in the Upper River. Bank erosion contributed by CVD flood control operations may cause some reduction in the survival of embryos, pre-emergent fry, and emergent fry in spawning areas immediately downstream of bank erosion sites. As noted above, these failures are expected to occur at few locations, given the relatively dense riparian vegetation that exists along most of the upper mainstem. Chinook salmon eggs and pre-emergent fry are at higher risk than other life stages because bank erosion is more likely to occur from late December through February (the likely period of highest CVD releases), when successful redds are anticipated to be active and more susceptible to sedimentation. However, these effects on Chinook salmon and steelhead redds are expected to be confined to short reaches below bank erosion sites, during high flood release years, resulting in adverse effects to very small numbers of individual redds relative to the total number in the Upper River. Adverse effects are expected to be less, if at all, to individual redds during normal to critically low water years to these species. NMFS anticipates that the small number of redds that experience sedimentation from bank erosion would have a higher percentage of eggs that do not survive to hatch.

2.5.1.1.2.5 Effects of Flood Control at CVD to Critical Habitat - Ramping Rates

Flow down-ramping can cause intermittent surface flow and may, at times, completely dewater portions of streams (Hunter 1992). Intermittent and dewatered areas are likely to be found in rivers with many side channels, potholes, and low gradient bars. Conversely, confined channels with steep banks have less potential for dewatered and intermittent areas. Under the Proposed Action, CVD flood control operations would incrementally ramp flows to manage flood risk objectives, USACE would also reduce or shut off stream flow from CVD to conduct inspection activities.

CVD flow down-ramping impacts are likely to be most pronounced in the Ukiah Reach where changes in stage elevation are most pronounced. This reach has low gradient gravel bars with cobble substrates and backwater pools that are likely to become disconnected from the main channel and/or dewatered during down-ramping (USACE and Sonoma Water 2004). The USACE and Sonoma Water (2004) note that elevated storm runoff from the upper watershed may dampen this effect during late winter and spring, but that under some flow conditions, CVD down-ramping, as proposed, may cause bar areas or off-channel pools to become dewatered or disconnected from the main river channel from January through May (flood control season), elevating the risk of juvenile salmonids getting trapped in isolated pools or beached in completely dewatered areas.

Downramping for Flood Control

In 2016, flow ramping rates for releases of 4,000 cfs or lower were modified to minimize effects on salmonids from CVD flood releases, as recommended by NMFS (2016a). As part of the Proposed Action, USACE included down-ramping rates for CVD consistent with NMFS' 2016 recommendations, which recognize ongoing concerns with stranding mortality of juvenile salmonids in the Ukiah Reach. Studies conducted by NMFS and USACE in December 2012 (NMFS 2016a) found that the potential for stranding salmonids in the Ukiah Reach was highest when down-ramping occurred following CVD flood releases that were between 1,000 and 2,500 cfs. Given the high potential for stranding in the Ukiah Reach when CVD releases are less than 2,500 cfs, protective ramping criteria specify that down-ramping rates should be no greater than 100 cfs per hour prior to March 15th. After March 15, CVD releases of less than 250 cfs should not ramp-down in excess of 25 cfs per hour to protect egg incubation, pre-emergent fry, and young weaker swimming juvenile salmonids. This is consistent with NMFS (2016a) ramping recommendations and those that are included as part of the Proposed Action.

Some CVD flood control releases under the Proposed Action would require more expedient water evacuation (>2500 cfs).[14] In these scenarios, the 2016 down-ramping rates would not apply, and releases under the Proposed Action could be expected in excess of 100 cfs per hour to meet Lake Mendocino WCM operational criteria for flood management downstream. A comparison of the frequency and duration of unregulated down-ramping at the Ukiah gage was conducted by Sonoma Water and USACE, between 2011 and 2021, and their analysis shows that CVD operations reduce the number of potential stranding events from what would occur in unregulated conditions.

The frequency of unregulated-occurring down-ramping rates greater than 100 cfs per hour for flows less than 2,500 cfs was higher in all months for the period of record, ranging from as few as 4 events in the first half of November to as many as 61 in the second half of December (Figure 46). In contrast, down-ramping rates greater than 100 cfs per hour from CVD flood control operations ranged from as low as zero in the second half of November to as many as 29 in the second half of March (Figure 46). Given these findings, if CVD flood control operations maintain the frequency of down-ramping events greater than 100 cfs per hour for flows below 2,500 cfs at or below the frequency of unregulated conditions shown in Figure 46, impacts on juvenile salmonid rearing conditions are within the range of natural variability within the Ukiah Reach and are anticipated to be limited. Stranding risk remains when expedited water storage

[14] Impending storm forecasts and Lake Mendocino surface water elevation can result in the need to release water faster than the ramping objectives above in order to protect life and property downstream. USACE has committed to the ramping objectives above as long as enough lake storage is available to protect life and property.

flood releases occur. Under the Proposed Action, when expedited water storage releases are not needed, USACE will continue implementing the down-ramping criteria recommended by NMFS (2016a). Therefore, the continued implementation of NMFS (2016a) recommended down-ramping criteria, with relatively rare variances when expedited releases are required, is anticipated to have minimal adverse effects to critical habitat PBFs within the upper River, and most notably, the Ukiah Reach, where early life-stages of Chinook salmon and steelhead are most at risk.

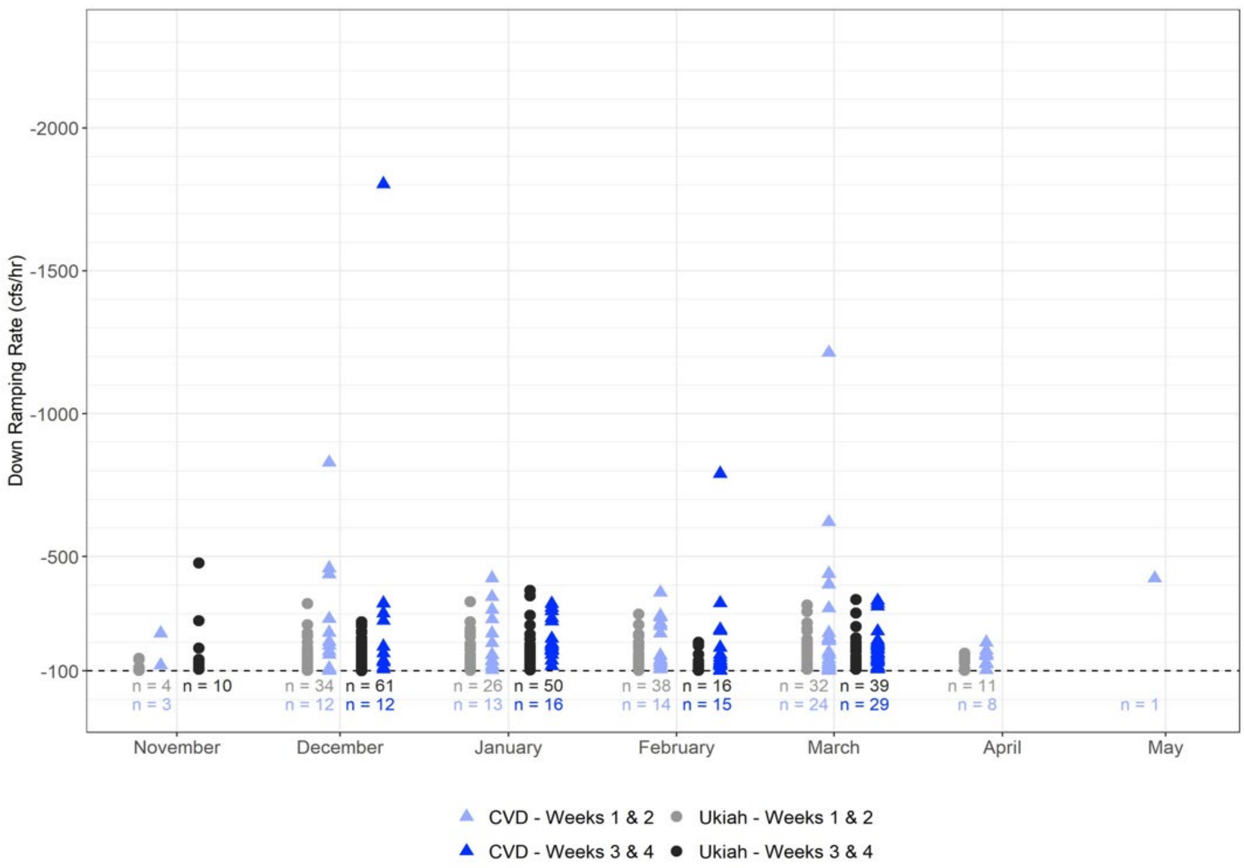

Figure 46. Sonoma Water and USACE unregulated-rate of stage change occurring at the Ukiah gage at greater than 100 cfs per hour (gray or black) and CVD release down-ramping rates greater than 100 cfs per hour (light blue or blue) for flows less than or equal to 2,500 cfs at the Russian River near the Ukiah gage for WYs 2011 through 2021.

Downramping for CVD Inspection Activities

Annual pre-flood and 5-year periodic inspections will be conducted during September to ensure CVD flood control facilities are operational for the upcoming winter storm season. The down-ramping and complete shut-off of water from CVD for these inspections will create intermittent and/or dewatered conditions in some areas of salmonid rearing habitat in the East Fork and to a lesser degree below the West Fork confluence. Annual inspections take approximately two hours to complete, after which normal operating flows are restored. Additionally, a comprehensive outlet tunnel inspection (periodic inspection) is required at least every 5-years to comply with required infrastructure safety standards. Periodic inspections also involve ramping-down CVD releases to zero flow, followed by a four-hour inspection period, after which normal operating releases are restored. However, periodic inspections will only occur when flows in the unregulated West Fork of the Russian River are in excess of 300 cfs and CVD hatchery operations are inactive (prior to the hatchery steelhead season), ensuring that flow conditions in critical habitat are suitable for rearing salmonids within the Upper River.

NMFS and USACE have worked to minimize impacts to habitat from the pre-flood and periodic inspections. In 2004, USACE installed Remote Automated Gate Controllers that allow for releases in increments of about 10 cfs. Using the Hunter stage elevation criteria (Hunter 1992), USACE and NMFS agreed in 2017 that a 12 cfs per hour and no more than 24 cfs per day ramp down increment during maintenance and inspection activities, which greatly minimizes or completely avoids creating habitat conditions that could potentially strand juvenile steelhead. Given that the Proposed Action would continue these practices, the impacts on critical habitat (loss of rearing space) are expected to be minimal during pre-flood and periodic inspections.

2.5.1.1.2.6 Effects of Flood Control at CVD to Species - Ramping Rates

Both Chinook salmon and steelhead emergent fry and juveniles have the potential to be stranded in isolated pools or beached in dewatered areas created during flood control flow down-ramping events. Fry, which are more vulnerable than older juvenile salmonids, are poor swimmers and are known to inhabit shallow margins of rivers where flow reductions are likely to have greater effects on aquatic habitat, as these areas typically drain first. Down-ramping rates that result in river stage changes of one-inch or less per hour are recommended by Hunter (1992) to protect steelhead fry, and two-inches per hour or less to protect larger juvenile salmonids. Based on a review of the Ukiah gage data conducted by NMFS, down-ramping rates of 100 cfs per hour at CVD are expected to produce river stage changes of approximately 3.3 inches per hour for discharges ranging between 1,000 cfs and 2,500 cfs. These stage changes could potentially strand fry and juvenile salmonids, although some reduction of stranding effects may occur due to late winter and spring storm runoff preventing stream reaches from becoming disconnected. Any juvenile salmonids potentially trapped in isolated pools could experience an increase in predation risk, as they become more susceptible to avian and terrestrial animals. However, under the Proposed Action these habitat conditions are expected to be rare and short in duration, resulting in the loss of few individuals.

NMFS staff biologists have surveyed much of the Upper River during the winter months (and during previous fall pre-flood inspections) and concluded that, based on the number of low gradient bars and other cover that exist for Chinook salmon and steelhead fry and juveniles, only a very small portion of fish residing in the upper four to six miles below CVD are at risk of stranding (trapped) in isolated pools or being beached by CVD down-ramping activities (NMFS 2011b). For example, past observations by NMFS and USACE indicate that fewer than 20 juvenile steelhead were stranded in disconnected pools during pre-flood or periodic dam inspections. Observations by NMFS and USACE survey teams also noted that the build-up of gravel bars has confined the wetted stream, thereby reducing the potential for fishes to become stranded in disconnected pools (NMFS 2011b).

The creation of intermittent and dewatered areas of the channel downstream of CVD during proposed pre-flood and periodic inspections is expected to potentially strand, but not injure or kill, juvenile steelhead within the short reach of the East Fork and mainstem Russian River during down-ramping activities. Surveys conducted by NMFS and USACE personnel during inspections from 1998 to 2004 documented juvenile steelhead stranded in disconnected pools (NMFS 2011b). Past monitoring by NMFS staff also found that isolated pools with trapped juvenile salmonids are reconnected with the wetted river channel when flow is quickly restored during the up-ramping phase of the action (NMFS 2011b). No mortalities of stranded juvenile steelhead in isolated pools have been detected during any of the stream monitoring surveys conducted during fall pre-flood inspections since the issuance of the 2008 Opinion.

Proposed periodic inspections will only occur when West Fork flows exceed 300 cfs, limiting the impacted area to the short East Fork reach immediately below CVD. However, within the East Fork, intermittent pools will still be available for juvenile steelhead during the four-hour flow shutdown period. Additionally, USACE proposes to conduct biological surveys and fish relocation efforts if needed. The effects on juvenile steelhead during proposed relocation activities are described in the monitoring section of this Opinion. These fall inspections should not affect juvenile Chinook salmon, as they are not expected to be present when pre-flood or periodic inspections occur.

2.5.1.1.2.7 Effects of Flood Control at CVD to Species - Water Temperature

As described above, modeling results have demonstrated the benefits of higher reservoir storage levels on the cold-water pool volume associated with the Proposed Action. This includes the continued implementation of FIRO procedures, which significantly contribute to maintaining cooler water temperatures within Lake Mendocino (cold-water pool). These cooler water release temperatures subsequently provide suitable thermal conditions below CVD throughout the juvenile steelhead summer-rearing season and the fall adult Chinook salmon migration period. Therefore, we expect that the Proposed Action, including the ongoing implementation of FIRO, will help sustain cooler water temperatures in the Upper River for summer-rearing juvenile steelhead and fall-run adult Chinook salmon when water supply releases are made from CVD.

2.5.1.1.2.8 Effects of Flood Control at CVD to Critical Habitat - Migration Flows

There is some uncertainty regarding whether the Proposed Action, including the ongoing implementation of FIRO procedures associated with CVD flood control operations, may negatively influence migratory cues and flow habitat conditions in the Upper River that are necessary for the successful upstream movement of fall-run adult Chinook salmon. To a lesser extent, this concern may also apply to steelhead, given their later run timing in the winter, and to coho salmon, whose migration patterns are further differentiated by their later run timing and primary distribution in the Lower River, where CVD operations have minimal influence on their migratory habitat conditions.

One of the main objectives of the Proposed Action's FIRO-informed CVD flood control operations is to reduce the frequency, duration, and magnitude of moderate to high hydrologic events during the flood control season (wet season). This could result in fewer moderate to high flow releases from CVD, which are important for supporting salmonid spawning migrations, particularly in the fall when unregulated river hydrology, such as accretion flows from adjacent tributaries, may be limited. Additionally, CVD flood operations are expected to further reduce hydrologic variability in the East Fork that would otherwise occur downstream of CVD in the absence of FIRO, whether for flood storage or water supply purposes within Lake Mendocino.

To assess the potential effects of the Proposed Action's FIRO-informed CVD operations on salmonid migration during the flood control season, the passage conditions of critical habitat for Chinook salmon were analyzed by comparing the percentage of time that flows are expected to be sufficient for Upper River passage (interim petitions; Table 25). The Chinook salmon passage threshold in the Upper River has been determined to be 105 cfs at Healdsburg (Sonoma Water 2023). This threshold is considered the most conservative, as Chinook salmon are the largest of the salmonids in the Russian River and require the most flow for upstream passage.

Table 25. Percent occurrence of upstream migration flows in the Upper River at the Healdsburg gage (Sonoma Water 2025, unpublished).

Scenario	**Passage Flows (cfs)**	**Oct 15 - 31**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**
Baseline	105	65%	86%	95%	97%	97%	100%
Proposed Interim Petitions	105	41%	81%	92%	96%	98%	100%

This evaluation concluded that CVD flood control operations under the Proposed Action are expected to result in only a minor reduction in the percentage of time that migratory PBFs are supported, except during the latter part of October, when a more noticeable reduction in passage flows may occur (Sonoma Water 2025, unpublished; Table 25). These reductions are most likely to take place in Dry and Critical Dry years, when CVD flood control operations are not being implemented and water supply operations control CVD releases. During these dry water year classifications, the Lake Mendocino Pulse Flow Adaptive Management Plan, which is part of the Proposed Action, would ensure targeted releases to support passage conditions for adult salmonids (see Section 2.5.1.1.3.5).

Therefore, we conclude that the Proposed Action's CVD flood control operations are unlikely to negatively influence the migratory PBFs of critical habitat for Chinook salmon and steelhead as they ascend the Upper River toward their spawning grounds. Additionally, proposed CVD flood control operations are expected to have only a minor to negligible influence on the migratory PBFs of critical habitat for all three species in the Lower River, as flow and habitat conditions are primarily influenced by releases from WSD.

2.5.1.1.2.9 Effects of Flood Control at CVD to Species - Migration Flows

Our assessment of the effects of flood control at CVD on critical habitat, specifically Upper River migration flows, concluded that CVD flood control operations under the Proposed Action are unlikely to have more than a minor to negligible influence on migratory habitat conditions for adult salmonids ascending the Upper River. Potential minor effects on individual adult salmonids include alterations in migratory cues that influence critical run timing into the Upper River due to reduced hydrologic variability resulting from FIRO-informed CVD operations. These effects are likely limited to a few Chinook salmon arriving early in the spawning season or during dry and critically dry years, as the Proposed Action results in little change to the availability of passage flows later in the wet season compared to baseline conditions (Table 25).

Migratory cues that promote the timely upstream movement of Chinook salmon are of greater concern than those for steelhead and coho salmon, as discussed above. As the earliest seasonal migrants in the Russian River, Chinook salmon are the most likely to experience disruptions in migratory cues and run timing in the Upper River due to FIRO-informed CVD flood control operations. However, primary environmental migration cues appear to be more strongly associated with seasonal changes, breaching of the barrier beach at the river mouth, fluctuations in river stage, and rain events. Seasonality, particularly photoperiod shortening and decreases in stream temperature, likely plays a key role in initiating upstream migration.

Salmonid counts at Mirabel Dam indicate that rain events serve as the strongest environmental cues for migration. Potential mechanisms associated with these events include changes in water temperature, chemistry, turbidity, and barometric pressure. Even small rain events that do not significantly increase flow appear to strongly influence migration. Flow and water depth over shallow riffles in the Upper River can also influence Chinook salmon run timing, or more so, their migration rate upstream. Using flow as a proxy for stage, evidence suggests that flows below 105 cfs at the Healdsburg gage may limit Chinook salmon movement through the Upper River (Sonoma Water 2023). However, flow in this section of the river rarely falls below this threshold later in the wet season and is expected to affect only a few Chinook salmon during the earliest part of the spawning migration season, with little to no impact on subsequent spawning success.

Therefore, the proposed continued implementation of FIRO procedures under the Proposed Action is unlikely to have more than a minor influence on migratory cues critical for the run timing of adult salmonids, particularly fall-run Chinook salmon, as they ascend the Upper River toward their spawning grounds before heavy rains generate more favorable passage flows throughout the Russian River watershed.

2.5.1.1.3 Effects of Water Supply Operations at CVD

The Proposed Action will continue to manage CVD for purposes of water supply during the low flow season (generally late May through October), significantly altering flow volume and water quality in the Upper River (above Dry Creek). Juvenile Chinook salmon and steelhead are the primary species and life-stages impacted by CVD water supply operations, although adult Chinook salmon (via cold-water pool releases in early fall) and post-spawn adult steelhead (emigrating back to the ocean in late spring) can also be impacted by releases during certain years. Habitat conditions within the Upper River down to Dry Creek are considered ill-suited for coho salmon spawning and rearing primarily due to warmer water temperatures.

The following habitat elements potentially impacted by reservoir operations are listed as PBFs of CCC steelhead and CC Chinook salmon critical habitat: 1) freshwater spawning sites with adequate flow, water quality, and substrate; 2) freshwater rearing sites with suitable water quantity, water quality, and cover; and 3) unobstructed freshwater migration corridors with adequate water quality, water quantity, and cover (the fourth element, estuarine habitat, is considered in the Estuary Effects Section 2.5.3). Although CCC coho salmon are not thought to inhabit the Upper River, critical habitat is designated within all accessible portions of the watershed. The PBFs of CCC coho salmon critical habitat closely follow those for CCC steelhead and CC Chinook salmon listed above, and, therefore, impacts to coho salmon critical will be considered correspondingly where applicable. Critical habitat impacts are discussed below, except for turbidity. Critical habitat impacts resulting from turbid water released from CVD are discussed separately in Section 2.5.1.1.4.1.

Proposed water supply operations at CVD have the potential to impact Chinook salmon and steelhead individuals due to habitat degradation. The operations in question have little chance of directly killing or injuring individual fish. The expected impact to individuals of each species are discussed below.

2.5.1.1.3.1 Effects of Water Supply Operations at CVD to Critical Habitat - Spawning

CCC coho salmon, CCC steelhead, and CC Chinook salmon all use spawning habitat predominantly during late fall, winter, and early spring, and these periods are typically outside of water supply operations. Effects to spawning habitat resulting from flood control operations (e.g., redd scouring) are considered above. If CVD water storage is in control of the USACE during the dry season (typically in wet water years), analysis conducted by Sonoma Water suggests predicted flows under the Proposed Action would be suitable for spawning 72 percent of the time during November, and 86 percent of the time during December; months when Chinook salmon spawning typically peaks in the Upper River (Sonoma Water 2023). For Chinook salmon that are able to access Upper River spawning habitat prior to the onset of fall rains, the proposed flow schedule has the added benefit of maximizing preservation of the reservoir cold-water pool, affording Sonoma Water, in coordination with NMFS and CDFW, the ability to fine tune releases to maximize water quality, migration, and spawning and egg incubation success.

2.5.1.1.3.2 Effects of Water Supply Operations at CVD to Critical Habitat - Rearing Habitat

Proposed water supply management will likely have little adverse effects on the quality of rearing habitats for salmonids between Cloverdale (Upper River) and Monte Rio (Lower River), because in this river segment, summer water temperatures typically exceed thermal tolerances of rearing salmonids (USACE and Sonoma Water 2004). Thus, this segment provides both minimal amounts and marginal quality rearing habitats for these species. Sonoma Water's proposed flow management at CVD will continue to influence the quality of PBFs of critical habitat for rearing of steelhead and Chinook salmon in the 34-mile segment of the Upper River above Cloverdale.

For purposes of analyzing water supply operations, simulated flows resulting from the Proposed Action were generated for four study sites in the Upper River using the Russian River Reservoir Simulation Model (Russian River ResSim) developed by Sonoma Water. This is currently the best available data to evaluate the effect of proposed reservoir operations on designated critical habitat by using flow/habitat components of the Russian River ResSim outputs for the Upper River. Additionally, Sonoma Water developed a two-dimensional hydraulic model (Russian River River2D) to assess project-related impacts to steelhead and Chinook salmon fry and juvenile rearing habitat at four study sites within the river reach most impacted by reservoir releases (from highest to lowest position in the upper watershed: Ukiah, Hopland, Comminsky Station, and Cloverdale).[15] The model estimated depths and velocities within reaches of the river (study sites) over a range of simulated flows. These predicted depths and velocities were then linked to a Habitat Suitability Index for different salmonid species and life stages to quantitatively estimate the quantity and quality of habitat in each reach. The quantity of habitat expressed as Weighted Usable Area (WUA), the amount of habitat in a reach adjusted, or "weighted," by habitat quality. The amount of WUA can be compared at different simulated flows to inform how habitat changes with discharge. Generally, the model indicates which flow levels under the Proposed Action maximize available Chinook salmon and steelhead fry habitat in the Upper River (Figure 47 and 48). We thoroughly evaluated Sonoma Water's modeling efforts and concur with their conclusions.

As shown in Figures 47 and 48, fry habitat for both Chinook salmon and steelhead is greatest at lower flows (<125 cfs) at the Hopland, Comminsky Station, and Cloverdale sites. Under the Proposed Action, minimum flows in the Upper River range from 25 to 150 cfs, depending on the water year classification (critically dry, dry, or normal). During normal water years, the prescribed flow is 125 cfs. Unlike downstream sites, the Ukiah site shows little variation in habitat as flows increase from 50 to 300 cfs. This stability may be due to the relatively unconfined nature of the river in the Ukiah Valley compared to lower study sites.

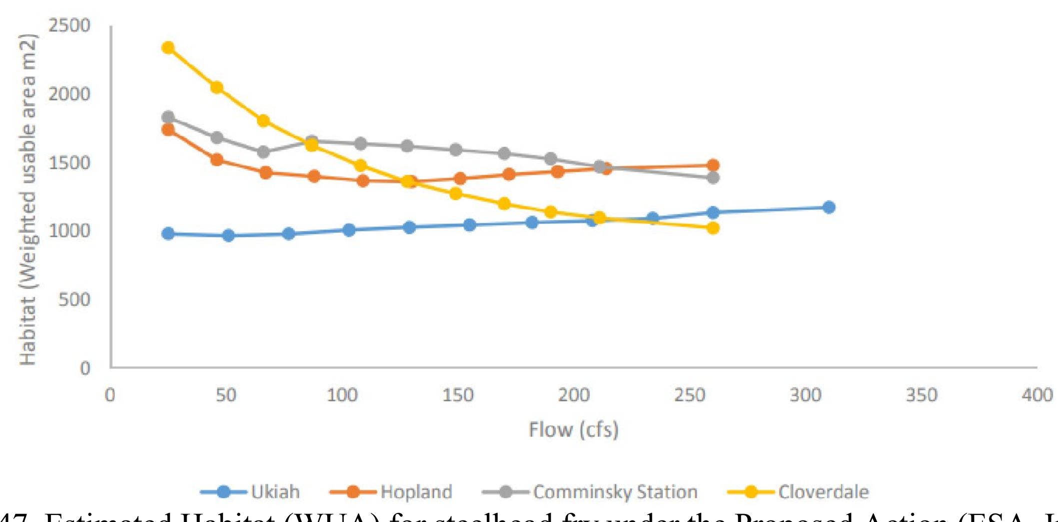

Figure 47. Estimated Habitat (WUA) for steelhead fry under the Proposed Action (ESA, Inc. 2023).

[15] Data suggests the effect of dam releases on flow levels and water quality typically dissipates before the Russian River enters Alexander Valley at Cloverdale (BA).

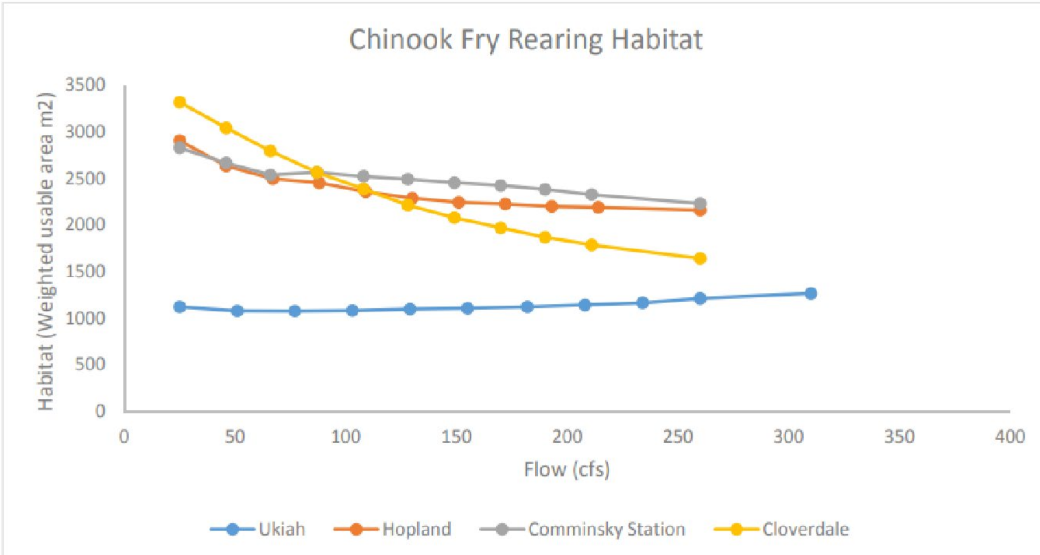

Figure 48. Chinook salmon fry WUA under the Proposed Action (ESA, Inc. 2023).

Juvenile steelhead occupy rearing habitat within the Upper River year-round. Juvenile steelhead WUA increases at all four study sites as flows increase from 25 cfs to approximately 125 cfs (Figure 49). Above that flow, WUA values either decrease slightly (Hopland and Cloverdale) or undergo little change (Ukiah and Comminsky Station) as flows approach the upper limits of the study. In contrast, Chinook salmon juveniles only rear within the Upper River for a relatively short period (i.e., 2 to 4 months) in spring before migrating downstream as smolts. Rearing habitat within the Upper River appears to peak at approximately 100 cfs at all four study sites during their limited freshwater residency (Figure 50). Habitat area then slowly diminishes as flows increase to 300 cfs, the upper limit of analysis.

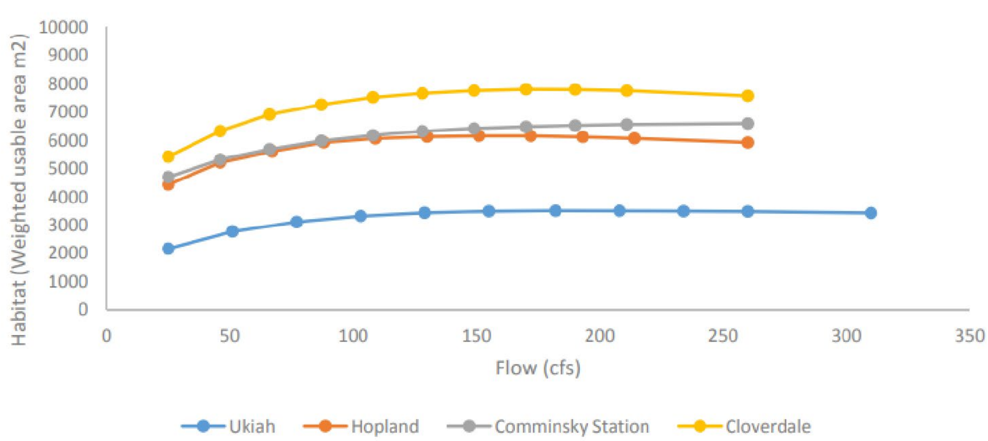

Figure 49. Estimated steelhead juvenile habitat under the Proposed Action (ESA, Inc. 2023).

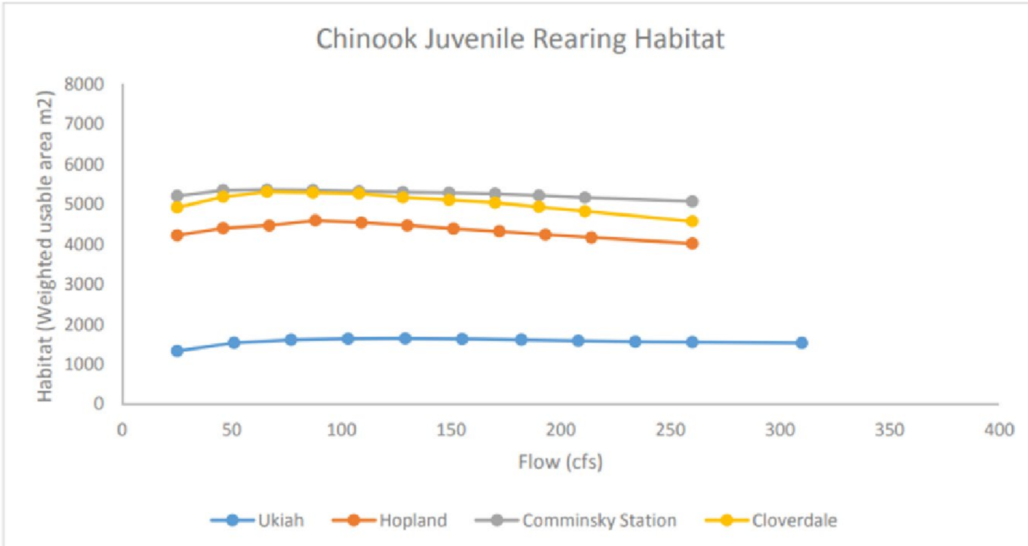

Figure 50. Estimated Chinook salmon juvenile WUA resulting from the Proposed Action (ESA, Inc. 2023).

In addition to habitat characteristics controlled by structure, channel morphology, and flow rate (e.g., cover, water depth, water velocity), rearing juvenile salmonids also require a specific level of water quality, most importantly cold, well oxygenated water. Where water temperatures are above preferred ranges but below lethal thresholds, rearing juveniles may survive if abundant prey is available to meet the concomitant higher bioenergetic demand (Lusardi *et al.* 2020). Figure 6-19 of the BA (Figure 51 below) shows predicted mean maximum daily temperature for modeled flows under the Proposed Action, plotted by month for nine locations on the Russian River and Dry Creek. The plots show Russian River temperatures during the summer/early fall rearing period remain coldest near CVD and warm progressively downstream until Cloverdale, owing to reservoir releases from the cold-water pool below the thermocline. Modeled temperatures at Cloverdale routinely remain below the 21.9°C threshold (tolerable conditions), and modeled temperatures improve to suitable or optimal conditions at the Hopland and Forks (Ukiah Valley) study sites located further upstream. Water temperatures downstream of Cloverdale generally do not support juvenile rearing, except possibly locations where significant cold-water accretion occurs (e.g., Dry Creek confluence).

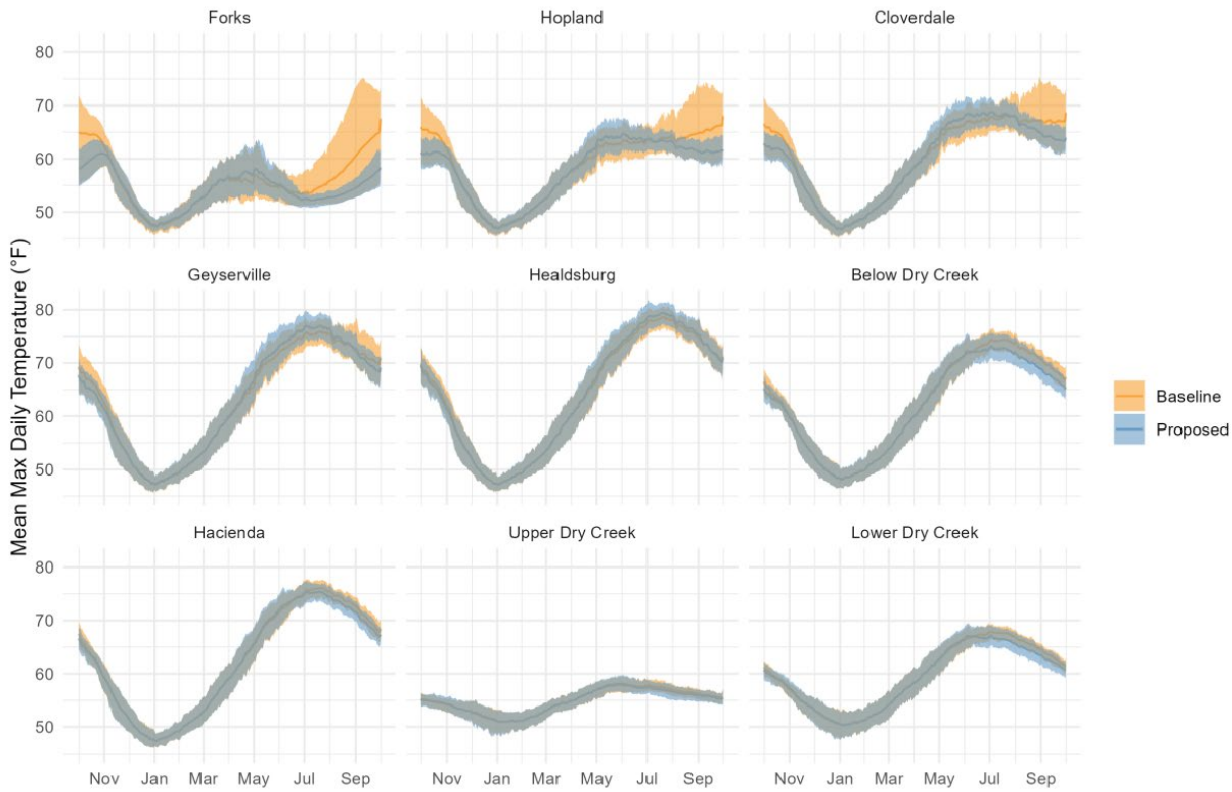

Figure 51. Range of predicted average daily maximum temperature at select locations on the Russian River and Dry Creek (ESA, Inc. 2023).

2.5.1.1.3.3 Effects of Water Supply Operations at CVD to Critical Habitat - Migration

During CVD water supply operations, the flow rate released from CVD primarily influences water depth at critical riffles[16] in the Upper River and has only a minor influence on the Lower River as flow moves downstream toward the Estuary. This, in turn, can influence whether upstream-migrating adult Chinook salmon or downstream-migrating smolts and kelts of all three species[17] can successfully complete these life-stages.

While CVD reservoir water supply operations could theoretically influence adult coho salmon and steelhead migratory habitat in the Lower River, both species typically migrate well after the onset of the winter storm season, when CVD dam releases have little influence on Lower River flow volumes. Therefore, the following discussion focuses on the influence of CVD reservoir

[16] Critical riffles are the shallowest points along a river or stream longitudinal profile where water depth limits fish passage as flows diminish. Four critical riffles were identified in the Russian River (from downstream location): Casini Ranch near Duncans Mills, at Monte Rio, at Badger Park near Healdsburg, and Geyserville (near Hwy 128).

[17] Unlike Pacific salmon that die shortly after spawning, a small but significant fraction of adult steelhead survive following spawning and, after returning to the ocean, can migrate upstream and spawn again in future years. These post-spawn, or "kelt", steelhead migrate downstream shortly after spawning, and reservoir operation impacts to their migration is considered similar to that of upstream migrating adults.

water supply operations on adult Chinook salmon migration. Whether CVD is being operated under water supply operations (managed by Sonoma Water) or flood control operations (managed by USACE), releases have the greatest influence on migratory habitat conditions within the Upper River. The minimum passage threshold is 105 cfs at the Healdsburg gage in the Upper River, a threshold that is almost always exceeded during the latter half of the adult spawning migration period (November to June).

During September and early October, CVD water supply releases may be insufficient to allow upstream migration beyond Healdsburg under the driest flow conditions. However, delaying adult migration past Dry Creek (Lower River) until winter storms augment reservoir releases can often be beneficial. Modeling by Sonoma Water suggests that water temperatures can exceed 67°F (the point at which conditions become suboptimal) during late September and October. Adult salmon that enter the river but are unable to migrate upstream of Hacienda are likely to hold within deep pool habitat in the Lower River or Estuary, where waning summer heat, cooler coastal conditions, and cold-water releases from WSD help maintain suitable water quality. However, while holding in the Lower River likely improves individual survival due to favorable water quality, it can also increase predation pressure from pinnipeds (see below for our analysis of predation and habitat enhancements in the Estuary to reduce pinniped predation risk).

To minimize potential water depth and temperature impacts on migrating adult Chinook salmon in the Upper River, Sonoma Water has proposed a CVD "pulse flow" release strategy as part of the Proposed Action. This strategy can only be implemented during dry water years and is contingent on predicted impacts to reservoir storage and real-time monitoring of Chinook salmon presence in the Lower River (via salmonid counts at the Mirabel/Wohler fish counting station). Under the Proposed Action, the pulse flow strategy could also be coordinated with "blockwater" releases from Lake Sonoma via WSD.

CVD water supply operations typically do not begin to influence river flow and critical riffle depth until sometime in May, when tributary inflows recede. During May and June, critical riffle depth is predicted to meet smolt passage requirements under nearly all simulated reservoir operations. Similarly, suitable water temperatures are expected throughout the Chinook salmon smolt migration period in the Upper River reach influenced by CVD water supply operations. Modeling performed by Sonoma Water predicts water temperatures below 20°C upstream of Cloverdale through June under almost all simulated water years (see Figure 6-19 of the BA).

Steelhead smolt migration is more sensitive to temperature, as steelhead have a lower tolerance for temperatures exceeding 15°C. Temperature modeling suggests that suitable water temperatures for steelhead smolt emigration will persist under almost all scenarios analyzed near CVD (i.e., Forks), but temperatures rise steadily further downstream. Water temperatures at Cloverdale, the lowest point influenced by CVD reservoir operations, are projected to exceed 15.6°C sometime in May. However, as the peak migratory period for both Chinook salmon and steelhead smolts ends in May, the majority of migrating smolts are expected to encounter suitable migration conditions within the Upper River.

Under the Proposed Action, when surplus water is available in Lake Mendocino, pulse flows will be released to address flow-related issues affecting steelhead and Chinook salmon migration. These pulse flows will be adaptively managed in coordination with CDFW and NMFS and will depend on reservoir storage projections developed during fall (October–December) and winter/spring (February 1 to May 31). Fall pulse releases, which can occur once annually during dry water supply conditions, can last up to 14 consecutive days and will increase the required minimum flow for the Upper River from 75 cfs to 105 cfs, facilitating migration into the Upper River.

Additionally, up to two late winter/early spring pulse releases, each lasting up to 14 days, may be implemented to facilitate downstream smolt migration, increasing minimum flow requirements from 75 cfs to 150 cfs. Like the fall pulse flow, these releases can only occur during a dry water year when surplus water is forecasted. When implemented, pulse flows are expected to improve the migratory PBFs of critical habitat within the Upper River.

2.5.1.1.3.4 Effects of Water Supply Operations at CVD to Species - Predation

Juvenile and smolt salmon and steelhead are exposed to various forms of predation during their freshwater residency. Juveniles, particularly recently emerged fry, are vulnerable to stranding and increased predation when sudden flow changes isolate shallow edge-water habitat (see predation discussion under CVD flood control operations). Studies suggest that smolt predation risk is inversely proportional to discharge; in other words, higher flow rates accelerate migration and reduce predation risk. However, little is known about how flow management at CVD influences smolt predation risk.

To minimize this risk, Sonoma Water, currently, and under the Proposed Action would supplement scheduled water supply releases with additional "pulse flows" to accelerate downstream smolt migration and reduce predation risk for steelhead smolts released from CVFF. These releases likely also minimize predation risk for natural-origin steelhead and Chinook salmon smolts. The late winter and early spring pulse releases discussed above can be coordinated with hatchery smolt pulses to further reduce predation risk.

Adaptively managing both pulse flow opportunities to maximize their benefits is likely to appreciably reduce predation risk in the Upper River. However, estimating the precise level of risk, and its repercussions on individual Chinook salmon and steelhead, as well as their populations, is challenging due to the lack of watershed-specific data. To address this uncertainty, Sonoma Water has proposed additional studies (Sonoma Water 2024a) beginning in the first year after this Opinion is issued (i.e., 2026). These studies will investigate predation risk for downstream-migrating steelhead smolts in the Upper River, as well as for migrating coho salmon smolts in the Lower River.

Based on preliminary survival study results, we anticipate that the proposed studies will show elevated predation risk during low-flow scenarios (e.g., dry and critically dry water years), with many individuals being preyed upon due to low CVD releases in some years. By implementing "pulse releases" with more precise flow thresholds, it is likely that predation risk can be significantly reduced or ameliorated, bringing it closer to more natural or adequate levels.

2.5.1.1.3.5 Effects of Water Supply Operations at CVD to Species - Adult Chinook salmon and Steelhead

Under the Proposed Action, a few early-arriving adult Chinook salmon may experience delayed upstream migration during dry water years when low releases from CVD could potentially prevent passage beyond critical areas in the Upper River. Potential migration delays in the Upper River are expected during dry years when fall rains do not materialize or are limited. However, these delays could be beneficial, as instream conditions upstream of the Dry Creek (Lower River) confluence are typically more stressful during the early part of the Chinook salmon spawning migration. Additionally, during dry periods, reduced discharge from WSD (and to a lesser extent CVD) into the Estuary will lower the likelihood of premature breaching before winter storms begin. This, in turn, reduces the chance that adult Chinook salmon will encounter unfavorable water quality conditions.

In most circumstances, delayed upstream migration caused by reduced CVD dry-year releases during the first month or two of the migration periods is likely beneficial. It prevents adult salmon from being artificially lured into the Upper River, where water quality conditions during dry years may be detrimental to their spawning success and survival. Once further upstream, Chinook salmon will likely benefit from colder water releases at CVD, which have been improved in frequency and volume under the Proposed Action.

The few Chinook that arrive early may experience reduced spawning success due to increased stress from suboptimal water temperatures during drought years. However, this situation is likely rare, as NMFS anticipates that most individuals will likely stage in cooler areas of the Russian River mainstem until suitable conditions are available in the Upper River. Therefore, we expect few, if any, adverse effects on Chinook salmon during their spawning migrations specifically due to proposed CVD water supply operations when combined with timely and strategic pulse flows releases.

Most adult steelhead typically migrate into the Upper River after winter rains have begun and CVD flood operations have commenced. Therefore, we expect few, if any, adverse effects on migrating adult steelhead. A very small number may experience brief migration delays in some drought years under the Proposed Action. However, these individuals would likely be able to spawn after resuming their migration when flows increase from fall rains, water releases, or both.

2.5.1.1.3.6 Effects of Water Supply Operations at CVD to Species - Chinook salmon and Steelhead Fry

Fry within the Upper River can encounter poor habitat quality or quantity directly resulting from CVD reservoir operations, since releases from CVD often significantly influence physical habitat volume, water temperature, and fry stranding potential. However, the Proposed Action for CVD includes flow ramping rates (water supply and flood control operations; NMFS 2016a) that are anticipated to recede slowly enough to avoid fry stranding, since that lifestage is most at risk due to its preference for shallow, edge-water habitat.

2.5.1.1.3.7 Effects of Water Supply Operations at CVD to Species - Juvenile Steelhead

The Proposed Action will implement flow conditions targeted in the 2008 Opinion, which are expected to enhance rearing conditions for steelhead in the Upper River. Juvenile steelhead rearing in the Upper River may experience occasional episodes of stressful water temperatures (i.e., >23.9°C), primarily late in the summer during dry and critically dry water years. These conditions are typically limited to areas downstream of Cloverdale. While steelhead occupying these reaches will likely be displaced, the loss of this habitat is not expected to significantly influence individual fish growth or survival. Fish excluded from habitat directly below CVD will likely find rearing habitat further downstream. Chronic turbidity from CVD releases is likely the primary factor degrading habitat conditions and potentially displacing summer-rearing steelhead, as discussed below (See Section 2.5.1.1.4.4).

2.5.1.1.4 Overview of Effects of Flood Control and Water Supply Operations at CVD - Turbidity

CVD flood control and water supply operations can significantly affect the flow dynamics of the Upper River during all seasons (fall, winter, spring, summer). As described earlier, Lake Mendocino, impounded by CVD, serves as a flood control reservoir, storing and regulating water, particularly during the wet season to mitigate downstream flooding risk to life and property. However, as winter progresses and the reservoir nears capacity (as governed by Lake Mendocino WCM), regulated releases are initiated to manage Lake Mendocino water storage elevations effectively. As river conditions transition to the dry season, water supply operations become the primary influence on the Upper River's hydrology. Regulated flood control releases and subsequent water supply releases alter the river's natural (unregulated) flow patterns and noticeably contribute to elevated turbidity levels throughout all seasons.

While statistical significance may not always be observed, the available data[18] suggests a correlation between flow discharge rate and turbidity levels, with downstream turbidity often higher and persisting longer within the East Fork below the CVD Outlet compared to background observations in the West Fork, where CVD has no hydrologic influence. As detailed below, NMFS expects that turbid water discharged from CVD will remain elevated during all flow releases, even when flood control operations reduce the magnitude of high flood flows downstream of the dam. Furthermore, NMFS anticipates the extended duration of flood control releases following large storm events exacerbate chronic turbidity levels in the river, compared to the more natural (unregulated) episodic river conditions, where higher peak flows likely

[18] In addition to the studies cited throughout this section and the Opinion regarding effects of turbidity, NMFS considered the value of data collected by the Plaintiff in relation to his claims in *White v. United States Army Corps of Eng'rs, 3:22-cv-06143-JSC (N.D. Cal.)*. As summarized during that litigation in a declaration by NMFS (Declaration of Robert M. Coey, Sept. 20, 2023, Doc. 51-1), "Plaintiff's limited sampling effort is not scientifically robust and can be considered potentially representative of only the one small area sampled in the one year in which Plaintiff took the samples…" We concluded that the data "should not be utilized to make assessments regarding the condition of habitat, nor the impacts to salmonids, rather the Corps gauge data and sampling locations should be utilized for this analysis, where the Corps has been monitoring for over 10 years…"

transport greater volumes of sediment, but clear up within a much shorter timeframe (e.g., West Fork Russian River).

The results of our analysis, described below, indicate turbidity-related effects resulting from flood control and water supply pool operations at CVD are likely to adversely affect a substantial number of individuals from all populations of the CCC steelhead Interior Diversity Stratum that utilize the Upper River during various stages of their life cycle. This encompasses the Upper Russian River essential population and four supporting populations (Crocker Creek, Gill Creek, Miller Creek, and Sausal Creek), identified in the NMFS Multi-Species Recovery Plan (NMFS 2016d). However, among these populations, individuals from the Upper Russian River steelhead population are likely to experience the greatest adverse effects from chronic turbidity levels discharged from Lake Mendocino through the CVD Outlet; as these individuals can no longer access habitat above CVD and are confined to the area below CVD and a few adjacent tributaries. This population encompasses the Upper Russian River mainstem reach (above Dry Creek) to CVD, which historically included the entire East Fork Russian River, above Lake Mendocino.

Prior to construction of CVD, the East Fork above CVD and its tributaries contained a high percentage of the most productive spawning and rearing habitat in the entire Russian River watershed (Prolysts 1984; SEC 1996). Because NOR steelhead can no longer ascend to the upper East Fork above CVD, we now expect a large portion of Upper Russian River steelhead to inhabit the Upper River. Additionally, within the CC Chinook salmon Central Coastal Diversity Stratum, there is one essential population that inhabits the Russian River watershed: the Russian River Chinook salmon population (NMFS 2016d). Similar to steelhead, individuals from the Russian River Chinook salmon population that use the Upper River are likely to be adversely affected by turbidity-related effects associated with flood control and water supply operations at CVD. Most of the Russian River Chinook salmon spawning typically occurs in the Upper River and Dry Creek (Martini-Lamb and Manning 2024); with a high density of redds (spawning nests) occurring with the Ukiah Reach (Sonoma Water 2008, 2024c). Overall, there has been a substantial decrease in the number of adult Chinook salmon observed in the Russian River watershed between 2014 and 2020 (Martini-Lamb and Manning 2024), with the lowest recorded number occurring in 2020 (n=626); however, the number of returning adults has steadily increased since that time (Figure 29). Critical habitat PBFs for both CC Chinook salmon and CCC steelhead extend through the Upper River and are adversely affected by chronic turbidity levels from CVD operations throughout all seasons (fall, winter, spring, and summer).

USACE – Russian River Turbidity Assessment 2023

RPM4 in the 2008 Opinion required the USACE to undertake measures to assist NMFS in determining the amount of take resulting from turbidity releases at CVD. Toward fulfillment of RPM4's requirements, the USACE completed the Russian River Turbidity Assessment and Proposed Plan for Sonoma County and Mendocino County, California (Russian River Turbidity Assessment or RRTA) (USACE 2023). During the duration of the 2008 Opinion, the USACE was to collect turbidity data for 10-years at five locations, in addition to the three existing USGS turbidity gages in the Russian River downstream of CVD. Deliverables were to include annual reports and a final report documenting the data and analyses, and the development and implementation of a plan to avoid or minimize project-related turbidity. However, all required data collection did not occur due to staff turnover and difficulties in deploying and maintaining equipment.

The following turbidity sources and durations of available data were used in the RRTA analysis for the Upper River (USACE 2023):

- West Fork, Ukiah at Lake Mendocino Drive Bridge, 2012-2014: USACE data collected near USGS gage #1146100;

- East Fork, Calpella above Lake Mendocino, 2013-2018: USACE data collected near USGS gage #11461500; also, from the USGS gage #11461500, 2019-2021;

- East Fork, Ukiah at CVD Outlet, 2011-2018: USACE data collected near USGS gage #11462000;

- Hopland: USGS gage #11462500, 2002-2021;

- Jimtown: USGS gage #11463682, 2009-2021.

The main objective of the RRTA was to document the turbidity data collected in the Russian River and provide data analysis alongside the USACE interpretation for selected seasons and locations. However, significant data gaps were observed by the USACE in both the USACE and USGS datasets used in the analysis, particularly during winter when turbidity gages may have been damaged or removed during high flows. Some instances only had low-flow records available, likely during dry periods, exacerbating the data gaps. Moreover, certain USACE data points recorded unusually high values, reaching up to 3,000 NTU, possibly due to sensors being either out of the water or covered in bottom sediment (USACE 2023). To address this issue, the USACE omitted all data exceeding 930 NTU, the highest value recorded at the Hopland gage.

We reviewed the information provided in the RRTA (USACE 2023) and summarize it as follows to inform our turbidity-related effects analysis:

NMFS' summary of information provided in the RRTA 2023:

- Lake Mendocino has a sediment pool (sediment basin), where fine sediments deposit and later mobilize.

- Sloughing of benthic sediments occurs around the CVD Outlet tower due to a suction or funnel effect toward the intake, which can occur at high and low flow ramp-up release rates during flood control or water supply pool operations.

- Turbidity data for the CVD Outlet (East Fork Russian River), West Fork Russian River, and Hopland were collected concurrently for a total of 477 days from 2012 through 2014. During this period, the CVD Outlet recorded turbidity levels exceeding those of the West Fork by 10 NTU or more 85 percent of the time, while Hopland exceeded the West Fork by 10 NTU for 14 percent of the time.

- Turbidity levels at Hopland are more correlated with the West Fork turbidity gaging location during the winter season, whereas Hopland is more correlated with the CVD Outlet during drier seasons (summer and fall) when CVD has the greatest influence on hydrologic conditions in the Upper River.

- Turbidity values at the CVD Outlet tended to be higher and remained high for longer periods compared to those at Calpella (above Lake Mendocino), indicating that turbidity downstream of the CVD Outlet declines at a slower rate following winter storms. However, during extended dry periods (e.g., summer), the minimum turbidity values at the CVD Outlet remain much higher than those at Calpella.

- All gage locations recorded turbidity levels less than 1 NTU within the duration of data used for the analysis, except for the CVD Outlet, where turbidity values never reached that threshold. Instead, values were typically much higher, with approximate turbidity levels over 12 NTU occurring 75 percent of days, indicating persistent release of turbid water from CVD.

- The median turbidity value at the CVD Outlet (20.9 NTU) was more than two times higher than the next highest median turbidity value among all turbidity gaging locations (Hopland, 6.3 NTU). The West Fork gaging location had the lowest median turbidity value (0.84 NTU).

- The Jimtown gage (44 miles downstream of CVD) is thought to be the limit of influence of added turbidity from CVD. Among the turbidity gaging locations influenced by CVD, Jimtown had the lowest observed median turbidity value (1.0 NTU) in the Upper River.

- The RRTA (USACE 2023) confirmed that over 70 years of informal assessments, photographic documentation, anecdotal observations, and past studies indicate that prolonged high turbidity levels occur more frequently at the CVD Outlet and Hopland compared to Jimtown and the West Fork turbidity gaging locations.

NMFS' summary of potential turbidity-related effects to salmonids as provided in the RRTA 2023:

Lethal effects kill individual fish, cause overall population reductions, and damage the capacity of the system to produce future populations (Newcombe and Jenson 1996; Bash *et al.,* 2001).

Sub-lethal effects relate to tissue injury or alteration of the physiology of an organism. Effects are chronic in nature and while not leading to immediate death, may produce mortality and population decline over time (Newcombe and Jenson 1996; Bash *et al.,* 2001).

- Using scientific publications, USACE established two alternative turbidity-related effect ranges for sublethal and lethal thresholds to address uncertainties with NTU levels while evaluating the effects on rearing juvenile salmonids. In this process, the USACE developed a relationship equation to convert suspended sediment concentrations (SSC) to NTU, based on turbidity-related effect values from Servizi and Martens (1992), Newcombe and Jenson (1996), and Bash *et al.* (2001).

- Alternative 1: Sublethal values between 1.7 to 490 NTU and lethal values greater than 490 NTU, sourced from Newcombe and Jensen (1996), to assess turbidity-related effects on rearing juvenile salmonids.

- Alternative 2: Sublethal values between 10 and 872 NTU and lethal values greater than 872 NTU, sourced from Servizi and Martens (1992) and Bash *et al.* (2001) to assess turbidity-related effects on rearing juvenile salmonids.

- USACE utilized sublethal effects values between 0.6 and 28 NTU and lethal values greater than 28 NTU, sourced from Newcombe and Jensen (1996), to assess turbidity-related effects on spawning and incubation (eggs, embryos to pre-emergent fry).

- Sublethal turbidity effects levels occurred consistently during all seasons (fall, winter, spring, and summer) at the CVD Outlet and Hopland for both alternative turbidity values. Lambert Bridge (Dry Creek) and the West Fork exhibited notably lower sublethal turbidity values across seasons. Although turbidity data was unavailable for Jimtown during the winter, sub-lethal values occurred throughout all other seasons.

- The CVD Outlet occasionally reached lethal turbidity levels for rearing juvenile salmonids under both alternative turbidity values in all seasons except for spring. Similarly, the gage near Calpella (above CVD and Lake Mendocino on the East Fork) reached lethal turbidity values in all seasons, although to a lesser extent than those recorded at the CVD Outlet, except for the spring. Conversely, all other gaging stations experienced at least one season where lethal turbidity levels were not recorded.

- Sublethal turbidity-related effects values for salmonid spawning and incubation were observed at all turbidity gaging locations across all seasons.

- The CVD Outlet consistently reached lethal turbidity values for salmonid spawning and incubation across all spawning seasons (fall, winter, spring). The CVD Outlet exceeded lethal levels the highest percent of days in the summer, however, salmonid spawning and incubation does not occur during this period. Hopland and the West Fork reached lethal levels, but to a much lesser extent. Conversely, Jimtown rarely reached lethal turbidity values across all seasons.

2.5.1.1.4.1 Effects of Reservoir Operations at CVD to Critical Habitat - Turbidity

Chinook salmon and steelhead critical habitat PBFs of migration, spawning, and rearing habitat, all occur within the Upper River and are impacted by chronic turbidity released from CVD throughout the year. The extent of turbidity impact from CVD on salmonid habitat varies with the magnitude, duration, and frequency of discharge from CVD and the salmonid life stages present at that time.

Under the Proposed Action, highly turbid flood control releases from CVD, including FIRO procedures, are expected to affect the pattern of fine sediment deposition in the Upper River. The magnitude, duration, and chronic turbid water discharged from CVD during flood control and water operations cause fine sediment to distribute downstream; eventually settling out of the water column and depositing into the coarse sediment substrate. The distance that CVD discharged turbid water flows downstream varies with river flow levels. Consistent and prolonged (chronic) delivery of turbid water with fine sediment occurs at all flows, while larger amounts of coarse materials (gravel) are trapped behind CVD. This leads to increased embeddedness and degrades the quality of gravel substrates available for salmonid spawning along the main river channel (thalweg) below CVD.

Embeddedness impacts the spawning gravel quality which leads to a reduction of the abundance and diversity of prey items for juvenile salmonids (Everest 1987). Intragravel survival of salmonid embryos and pre-emergent fry depends on porous gravel that facilitates oxygenation of interstitial spaces and removal of waste products needed for embryo and pre-emergent fry development (Bash *et al.* 2001). High levels of fine sediment (turbidity) can reduce intragravel permeability, impairing the necessary exchange of oxygen for embryonic development. This causes both indirect and direct mortality, impacting fry emergence (Cederholm and Salo 1979; Bash *et al.* 2001). Moreover, the presence of fine sediment in the substrate affects the invertebrate community, negatively impacting salmonids by decreasing prey abundance and the diversity of important food sources, ultimately affecting growth rates (Newcombe and Jensen 1996; Bash *et al.* 2001). Additionally, the magnitude and prolonged duration of highly turbid flood control releases from CVD reduce water quality and clarity, thereby impacting the migratory habitat conditions of juvenile and adult Chinook salmon and steelhead as they ascend the Russian River to their spawning grounds.

Limited data are available to reliably quantify the magnitude of turbidity-related effects directly impacting Chinook salmon and steelhead habitat in the Upper River, including increased embeddedness, reduced hyporheic (groundwater) inputs, loss of refugia, decreased habitat complexity, and reduced prey abundance and diversity. Given the extended history of photographic accounts, anecdotal observations, and both informal and formal reports (Ritter and Brown 1971; USACE 2023), along with the sharper decline in Chinook salmon redd abundance in the Upper River compared to Dry Creek (Lower River) since 2014 (Martini-Lamb and Manning 2024), we conclude that highly turbid flood control and water supply releases are likely to cause moderate to severe degradation to the migration, spawning, and rearing PBFs of Chinook salmon and steelhead critical habitat in the Upper River; especially from the CVD Outlet to Hopland. However, we acknowledge that multiple factors also contribute to these population trends, such as drought and ocean conditions. Additionally, the number of adult Chinook salmon has more than doubled since the historic observed low of 2020, when 626 individual adults were counted at Mirabel (1,553 adult Chinook salmon counted in 2024, Figure 29), which indicates an increase in abundance in recent years.

2.5.1.1.4.2 Effects of Turbidity from Reservoir Operations at CVD to Species - Adult Chinook Salmon and Steelhead

The turbidity variations described above have significant implications for Chinook salmon and Upper River steelhead populations that rely on the Upper River for migration and spawning. Adult Chinook salmon, in particular, spawn at high densities between Cloverdale and the confluence of the West and East Forks, shortly downstream of CVD (Sonoma Water 2008; NMFS 2016d), making them particularly susceptible to prolonged exposure to higher turbidity levels as they attempt to complete their life cycle. Additionally, adult steelhead are expected to migrate through the Upper River as they ascend to spawning tributaries. Steelhead are also frequently observed spawning in the mainstem below the confluence of the East and West Forks, particularly during drier water years when many tributaries are hydrologically disconnected from the mainstem, limiting fish passage opportunities to tributary spawning habitat (T. Daugherty, NMFS personal communication, 2023).

Elevated turbidity levels in the Upper River, particularly during storm events and subsequent CVD flood control releases, may hinder salmon homing and delay migration as they ascend toward their spawning grounds. Although specific turbidity-related effect thresholds for adult salmonids are not precisely determined, chronic turbidity levels anticipated from CVD flood control releases, are expected to impact Chinook salmon and steelhead migration and spawning success at a sublethal level, as defined by Newcomb and Jensen (1996) and Bash *et al.* (2001). Therefore, the persistent altered flow patterns from CVD flood control operations, during the fall and winter seasons are expected to contribute to high chronic turbidity levels, which, while not likely to kill adult salmonids, are likely to severely affect adult salmonid spawning success in the Upper River; with the greatest adverse effects likely occurring in the Ukiah Reach, where Chinook spawning densities are high relative to other spawning areas in the watershed (Martini-Lamb and Manning 2024). In this reach, we expect that spawning success will decrease greatly given that turbidity levels and duration of exposure are high.

2.5.1.1.4.3 Effects of Turbidity from Reservoir Operations at CVD to Species - Embryos and Pre-emergent Fry

The RRTA (USACE 2023) assessed turbidity impact thresholds for the deposition of fines (embeddedness) into salmonid redds (nests) containing salmonid eggs, embryos, and pre-emergent fry using turbidity data collected from the Russian River watershed and a model developed by Newcombe and Jensen (1996). Turbidity measurements ranging from 0.6 to 28 NTU were considered sublethal, while values greater than 28 NTU were deemed lethal to these life-stages. However, there is a moderate level of uncertainty within published scientific literature associated with these thresholds, specifically regarding the threshold between sublethal and lethal effect levels. The range of values selected for the RRTA analysis were based on Newcombe and Jensen (1996). We agree with the RRTA’s use of Newcombe and Jensen (1996) and expect it represents the best available science for establishing certain turbidity-related effect thresholds based on current scientific literature.

The results presented in the RRTA (USACE 2023) indicate that turbidity values exceeded lethal levels on more than 50 percent of days (based on the percentage of days with available data) during the fall (51 percent), winter (54 percent), and spring (56 percent) at the CVD Outlet (Table 26). Chinook spawning typically occurs in the fall and winter, while steelhead spawning occurs in the winter and spring. Additionally, lethal turbidity levels were observed downstream at least as far as Hopland (12 miles downstream of CVD), where they occurred on 16 percent of days in the fall, 35 percent in the winter, and 16 percent in the spring (USACE 2023). In comparison, the West Fork (uninfluenced by CVD) reached lethal turbidity levels less frequently than at the CVD Outlet, occurring on 6 percent of days in the fall, 23 percent in the winter, and

17 percent in the spring (USACE 2023). Thus, turbidity was highest at the CVD Outlet, though lethal levels occurred much less frequently further downstream at Hopland.

Sublethal turbidity levels at the CVD Outlet were present on 34 percent of days during the combined fall (37 percent) and winter (31 percent) seasons, which correspond to the Chinook salmon spawning season, and on 40 percent of days during the combined winter and spring (43 percent) seasons, which align with the steelhead spawning season. However, the pattern at Hopland differed somewhat, with a higher proportion of sublethal days compared to the CVD Outlet, but significantly fewer lethal days, indicating an improvement in turbidity levels further downstream of CVD.

Consequently, while lethal turbidity levels occurred more frequently at the CVD Outlet, the occurrence of sublethal days was higher at Hopland (Table 26), suggesting that turbidity discharged from the CVD Outlet dissipates further downstream, likely contributing to high fine sedimentation rates within the upper Ukiah Reach. Turbidity conditions in the West Fork, upstream of the East Fork confluence and outside the influence of CVD, more closely resembled those at Hopland, with sublethal levels occurring more frequently than lethal levels. Specifically, sublethal turbidity was observed on 64 percent of days during the fall and winter and on 66 percent of days during the winter and spring seasons.

These sublethal and lethal turbidity results, derived from the RRTA (USACE 2023), indicate that the highest concentrations (NTU) of chronic turbidity are associated with turbid water discharged from CVD. Additionally, episodic high-turbidity flow events occur in the more unregulated reaches of the Upper River, such as the West Fork, Hopland, and downstream, during the fall, winter, and spring seasons.

Table 26. Number of days of which turbidity data was available, and the percent of days that had turbidity measurements of 0.6 to 28 NTU, which represent potential sub-lethal and lethal thresholds, respectively, obtained from Newcombe and Jensen (1996) for spawning (i.e. salmonid embryos and pre-emergent fry in redds). Note: The Calpella gage is located in the East Fork Russian River above Lake Mendocino and is outside the Action Area (USACE 2023).

	Season											
	Winter			Spring			Summer			Fall		
Gage	Days Count	% Sublethal	% Lethal	Days Count	% Sublethal	% Lethal	Days Count	% Sublethal	% Lethal	Days Count	% Sublethal	% Lethal
Dam Outlet	349	31%	54%	428	43%	56%	328	20%	70%	451	37%	51%
Hopland	788	65%	35%	957	82%	18%	874	92%	8%	834	84%	16%
Calpella	217	59%	41%	282	60%	39%	160	79%	21%	319	84%	16%
West Fork	144	56%	23%	195	65%	17%	187	90%	3%	78	69%	6%
Jimtown	0	0%	0%	412	93%	7%	704	98%	0%	550	99%	1%

Due to the ongoing CVD flood control operations as part of the Proposed Action, Chinook salmon redds located in the Upper River are expected to be exposed to extended periods of higher turbidity at sublethal and lethal levels during late fall and winter. Due to the consistently high proportion of Chinook salmon redds located within the Ukiah Reach compared to the Russian River in any given year, we anticipate that a considerable percentage of redds will be degraded and unsuccessful, and eggs, embryos, pre-emergent fry will be lost due to the high concentrations of fine sediment resulting from turbid water discharged from CVD. Similarly, individuals from the Upper Russian River steelhead population are also expected to encounter adverse turbid water conditions throughout the winter and spring, albeit to a lesser extent, as they have a broader spawning distribution, utilizing upper basin tributaries when access is available. This wider habitat range provides steelhead with a greater ability to avoid unsuitable spawning areas affected by lethal turbidity levels below CVD, but some steelhead redds are still anticipated to be located within the influence of CVD turbid water discharge annually. During drier water years when access to tributary spawning areas uninfluenced by CVD is limited, we expect a higher number of steelhead redds, eggs, embryos, and pre-emergent fry to be lost due to turbid water discharged from CVD, as these individuals will likely be forced to spawn in the Upper River mainstem.

Extended exposure to elevated lethal turbidity levels, as presented in the RRTA (USACE 2023), underscores the likelihood of substantial losses of salmonid eggs, embryos, pre-emergent fry, and overall spawning success downstream of CVD. These losses are expected to extend through the Ukiah Reach, potentially reaching Hopland (12 miles downstream) and possibly even further downstream to Jimtown (44 miles downstream). The mainstem reach from CVD to Jimtown likely contains the highest number of Chinook salmon redds (Sonoma Water 2008 and Martini-Lamb and Manning 2024) and mainstem steelhead spawners in the entire Russian River. Therefore, continued chronic turbidity exposure under the Proposed Action decreases the likelihood of spawning success, particularly for these sensitive life stages, and may cause harm, severe injury, or mortality to a considerable number of individuals associated with these salmonid populations.

2.5.1.1.4.4 Effects of Turbidity from Reservoir Operations at CVD - Rearing and Outmigration

Juvenile Chinook salmon and multiple juvenile age classes of steelhead (0+, 1+, 2+, smolts) rearing and migrating through the Upper River during winter and spring are expected to be exposed to elevated and prolonged turbidity levels due to the proposed CVD flood control and water supply pool operations. As the dry season approaches and natural tributary accretion recedes, hydrologic conditions in the mainstem become increasingly dominated by CVD water supply releases, making the corresponding turbidity levels from CVD more apparent.

As summarized above, the analytical approach developed by the USACE and presented in the RRTA used two alternative turbidity-related effect ranges (Alternative 1 and Alternative 2) to capture potential sublethal and lethal effects on rearing juvenile salmonids. The USACE developed these alternatives to address discrepancies in the published literature regarding sublethal and lethal turbidity thresholds for rearing juvenile salmonids. We agree with this approach.

Alternative 2 (sublethal: 10 to 872 NTU; lethal: greater than 872 NTU; Table 27) represents a broader range of sublethal and lethal effects, with minimum threshold values for both categories significantly higher than those in Newcombe and Jenson (1996) and Alternative 1 (sublethal: 1.7 to 490 NTU; lethal: greater than 490 NTU; Table 28). We further examined Alternative 2 to provide greater certainty regarding potential adverse effects on rearing juvenile salmonids in the

Russian River. This wider range of sublethal and lethal thresholds helps reconcile discrepancies in turbidity-related effects across different river and stream types. Thus, we determined that Alternative 2 would provide more certainty in assessing the degree of sublethal and lethal effects on rearing juvenile salmonids and outmigrating smolts in the Upper River.

Table 27. Alternative 2 results from the RRTA (USACE 2023). Number of days for which turbidity data were available, and the percent of days that had turbidity measurements of 10 to 872 NTU and greater than 872 NTU, which represent potential sublethal and lethal thresholds, respectively, obtained by USACE from Newcombe and Jenson (1996) for rearing juvenile salmonids.

	Season											
	Winter			Spring			Summer			Fall		
Gage	Days Count	% Sublethal	% Lethal	Days Count	% Sublethal	% Lethal	Days Count	% Sublethal	% Lethal	Days Count	% Sublethal	% Lethal
Dam Outlet	349	76%	1%	428	89%	0%	328	88%	2%	451	87%	1%
Hopland	788	72%	1%	957	61%	0%	874	68%	0%	834	66%	0%
Calpella	217	56%	5%	282	73%	4%	160	65%	11%	319	61%	3%
West Fork	144	32%	4%	195	13%	8%	187	4%	0%	78	10%	0%
Jimtown	0	0%	0%	412	11%	0%	704	0%	0%	550	2%	0%

Table 28. Alternative 1 from the RRTA (USACE 2023). Number of days for which turbidity data was available, and the percent of days that had turbidity measurements of 1.7 to 490 NTU and greater than 490 NTU, which represent potential sublethal and lethal thresholds, respectively, obtained from Newcombe and Jenson (1996) for rearing juvenile salmonids.

	Season											
	Winter			Spring			Summer			Fall		
Gage	Days Count	% Sublethal	% Lethal	Days Count	% Sublethal	% Lethal	Days Count	% Sublethal	% Lethal	Days Count	% Sublethal	% Lethal
Dam Outlet	349	79%	3%	428	100%	0%	328	81%	9%	451	86%	2%
Hopland	788	98%	2%	957	99%	0%	874	100%	0%	834	99%	0%
Calpella	217	76%	10%	282	89%	8%	160	85%	14%	319	96%	3%
West Fork	144	53%	8%	195	32%	8%	187	36%	0%	78	38%	1%
Jimtown	0	0%	0%	412	81%	0%	704	63%	0%	550	77%	0%

The RRTA (USACE 2023) provided results indicating the potential magnitude and duration of turbid flow releases from CVD during the winter and spring (Table 28) (winter and spring juvenile salmonid rearing season). For the combined winter and spring periods influenced by CVD operations, at the CVD Outlet, 83 percent of days fell within the sublethal range, with only 0.05 percent (4 days) exceeding the lethal threshold based on available data. Similarly, at Hopland, 66 percent of days during the winter and spring were considered sublethal, with 0.5 percent (8 days) exceeding the lethal threshold. In comparison, the West Fork, unaffected by CVD operations, experienced sublethal and lethal percentages of 21 and 7 percent of days, respectively. This indicates that Hopland turbidity levels are strongly influenced by CVD discharge during these seasons, particularly in the spring, as Upper River hydrologic conditions become more influenced by CVD releases, and less accretion flow from tributaries is expressed downstream.

Individual juvenile steelhead from the Upper Russian River population, along with those from supporting populations (i.e., Crocker Creek, Gill Creek, Miller Creek, and Sausal Creek), enter the mainstem from adjacent tributaries. Additionally, Chinook salmon and steelhead offspring in the Upper River are likely to utilize the upper extent of the Russian River until river conditions become unsuitable or other environmental cues further encourage their seaward migration. Due to the elevated turbidity levels resulting from the continuation of CVD water release operations as proposed, individual foraging behavior and migration patterns are likely to be adversely affected, potentially leading to altered habitat use and increased stress levels.

The literature review conducted by Bash *et al.* (2001) identified two major themes regarding the effect of turbidity on foraging behavior. Many studies indicate that as visual feeders, salmonids' effectiveness at obtaining food is reduced in turbidity levels as low as 20 NTU (Berg 1982). Conversely, other research suggests that several species of juvenile salmonids appear to prefer moderately turbid water for foraging, possibly as a strategy to reduce predation risk (Bash *et al.* 2001). NMFS expects this behavior dynamic may represent trade-offs between predation risk and the bioenergetic demands and benefits of increased growth as suggested by Bash *et al.* (2001), which could be relevant in the Russian River where numerous invasive predatory fish species are present throughout the mainstem.

Within the context of the Proposed Action, we anticipate that turbid water releases from the CVD will persist in both magnitude and duration, as indicated by the RRTA (USACE 2023). Consequently, juvenile salmonids exposed to elevated turbidity during winter and spring will likely exhibit avoidance behavior. They may retreat to accessible areas with lower turbidity near hydrologically connected, clearer-water tributary confluences or migrate downstream from the more turbid mainstem reach of the Upper River. However, these avoidance strategies would likely be adopted by a smaller proportion of rearing juvenile salmonids (non-smolts), as their migratory capacity limits access to turbidity refugia. In contrast, outmigrating smolts, having developed the physical capacity for longer migrations, are more likely to find refugia further downstream. In either case, unnatural energy expenditures are expected, more substantial for rearing juvenile steelhead and, to a lesser extent, smolts, as both life stages likely respond behaviorally to elevated and prolonged turbidity from CVD releases.

A significant portion of the literature (reviewed or summarized in Newcombe and Jensen 1996, Bash *et al.* 2001) attests to the occurrence of sublethal effects within the turbidity values identified in the RRTA (USACE 2023). These effects encompass both physiological impacts, such as gill trauma, alterations in blood physiology, osmoregulation, and growth, as well as behavioral changes, including shifts in territoriality, avoidance, foraging behavior, and prey selection abundance and diversity.

Therefore, despite minimal observed lethal turbidity-related effects on winter and spring-rearing juvenile salmonids at all turbidity gaging locations influenced by CVD releases[19], the expected chronic discharge of turbid water from the CVD, as part of the Proposed Action, combined with the high percentage of sublethal exposure days, poses a considerable risk to winter and spring-

[19] Due to the turbid conditions themselves, the large size of the upper Russian River compared to the very small size of juvenile salmonids, and the presence of numerous predators and scavengers, all make observing dead juvenile salmonids very unlikely.

rearing and outmigrating juvenile salmonids. Given this, NMFS expects that elevated and prolonged turbidity levels resulting from CVD releases likely adversely affect a large portion of individuals at these various life stages in the Upper River.

CVD water supply operations, including water storage and releases, are managed by Sonoma Water and typically take place between April and October, contingent upon Lake Mendocino water storage elevations. During the late spring and early summer seasons, the transition between CVD flood control operations controlled by USACE and water supply operations managed by Sonoma Water typically becomes more apparent. The water supply operations season becomes more evident as CVD releases increasingly dominate hydrologic conditions in the Upper River.

The Upper Russian River steelhead population is considered essential for the recovery of CCC steelhead and represents the highest percentage of summer rearing juvenile steelhead in the mainstem below CVD (NMFS 2016d). Furthermore, while individuals from the other four Upper Russian River supporting populations (Crocker Creek, Gill Creek, Miller Creek, and Sausal Creek) are likely to be present, their numbers are expected to be lower than the number of individuals from the Upper Russian River steelhead population. This is because the supporting populations are significantly further downstream of CVD and inherently less numerous, given their role within the recovery population structure. Juvenile Chinook salmon are not expected to be present in the mainstem Russian River during the summer months, as juvenile Chinook salmon become smolts throughout the spring and migrate to the ocean before summer (typically by June 15).

The USACE's turbidity-related effect ranges used in the RRTA to assess impacts on summer-rearing juveniles from CVD water operations are consistent with those applied to winter- and spring-rearing juvenile salmonids. As noted above, we agree with the percent-of-days approach used in the RRTA (USACE 2023) report and further analyzed turbidity values in the USACE assessment by examining the percent-of-days presented for each life stage (Alternative 1 (Table 28), Alternative 2 (Table 27)), and spawning through pre-emergent fry (Table 26) to gain deeper insight into observed turbidity levels and potential impacts on summer-rearing juvenile steelhead. This approach was not applied to other life stages because summer-rearing conditions are less variable, as they are primarily influenced by CVD releases into the East Fork rather than by unregulated runoff from the West Fork. Additionally, we referenced Newcombe and Jensen (1996) and Bash *et al.* (2001), as cited in the RRTA (USACE 2023), to further describe potential behavioral effects (e.g., changes in territoriality, exposure avoidance, foraging behavior, and prey abundance and diversity) and physiological effects (e.g., gill trauma and reduced growth rates) on individual summer-rearing steelhead in the upper Russian River mainstem. Newcombe and Jensen (1996) and Bash et al. (2001) remain the most comprehensive reviews of published literature on turbidity-related effects in salmonid ecology.

Combining the percentage-of-days analysis from the RRTA (USACE 2023) at the CVD Outlet for rearing juvenile salmonids (Alternatives 1 and 2) and spawning (embryos and pre-emergent fry) indicates that 20 percent of days exhibited turbidity levels below 28 NTU, while 61 percent of days fell within the range of 28 to 490 NTU, and seven percent of days ranged from 490 to 872 NTU during the summer months. Using the same approach, turbidity levels exceeding lethal effect thresholds were observed on 12 percent of days, with turbidity surpassing 490 NTU (capped at 930 NTU per USACE 2023). This exceeds the lethal threshold defined under Alternative 1 (490 NTU). At Hopland (12 miles downstream of CVD), turbidity levels appeared to dissipate as turbid water moved downstream, with 92 percent of days below 28 NTU during the summer season (USACE 2023). Similarly, in the West Fork, upstream of CVD's influence, 90 percent-of-days remained below 28 NTU, with only three percent exceeding this threshold (USACE 2023), which is likely a good habitat surrogate for summer background conditions in the Upper River. Thus, the greatest percentage-of-days with the highest turbidity levels occurred at the CVD Outlet during the summer season.

These findings further highlight that the highest turbidity levels, including those during the summer months, consistently occur closest to the CVD Outlet (Table 27). Conversely, water temperatures released from CVD create suitable summer-rearing habitat conditions for juvenile steelhead below the dam. As ambient temperatures rise and cold-water refugia from adjacent tributaries diminish later in the dry season, water temperatures become considerably warmer and less suitable further downstream. This warming trend independently restricts the extent of suitable temperature conditions in the Upper River, with the most favorable temperatures occurring nearest to the CVD Outlet. Furthermore, these conflicting habitat conditions, cooler water near CVD combined with high turbid water, likely trigger avoidance behavior in juvenile steelhead, forcing them into more marginal habitats where turbidity is more tolerable for foraging, but water temperatures are less suitable. As a result, summer rearing occurs in suboptimal habitat conditions. Consequently, the dynamic interplay between temperature suitability and turbidity levels limits the full extent of the beneficial cold-water releases from CVD, likely reducing the overall growth and fitness potential of many summer-rearing juvenile steelhead in the Upper River.

Proposed fisheries monitoring associated with the turbidity discharged from CVD (as detailed in Section 1.3.1.3.4) will assist managers in fulfilling a longstanding knowledge gap for Chinook salmonid abundance and juvenile steelhead habitat use in the Upper River. This commitment to fisheries monitoring and annual reporting will aid future evaluations of the magnitude and extent of turbidity impacts associated with CVD operations, while ensuring that population productivity persists as future long-term turbidity determinations and/or potential solutions are implemented. Pilot surveys would begin in 2026, and methodologies will be finalized in 2027 with continued monitoring over the 10-year duration of this Opinion. This proposed timeline would allow NMFS to continue to track turbidity effects on Chinook salmon and steelhead populations to ensure there are no significant declining trends while solutions to decrease turbidity in the Upper River are explored and implemented.

2.5.1.2 Effects of Reservoir Operations at WSD

Under the Proposed Action, USACE will manage water releases at Lake Sonoma when water levels exceed the top of the water supply pool (245,000 acre-ft) and enter the flood control pool. Additionally, the USACE will oversee releases during annual inspections, maintenance, and repairs. Meanwhile, Sonoma Water will continue to manage releases from the water supply pool (below 245,000 acre-ft). Flood control operations at WSD will follow procedures outlined in the WSD WCM and subsequent USACE approved deviations (minor or major), while the USACE and the Russian River FIRO Steering Committee evaluate potential FIRO alternatives for Lake Sonoma.

2.5.1.2.1 Effects of Flood Control Operations at WSD

The USACE and the Russian River FIRO Steering Committee are currently evaluating Minor Deviations to the WSD WCM with the application of FIRO procedure alternatives at Lake Sonoma. These specific actions regarding flood control operations, including the incorporation of FIRO procedures for WSD and Lake Sonoma, are still to be determined. Any potential deviations will comply with proposed flow requirements, and their effects are included in this analysis. This includes flood control release requirements that stipulate minimizing releases when flows in the Lower River near Guerneville exceed 35,000 cfs. We anticipate advanced weather forecasting tools similar to those used under FIRO at Lake Mendocino will be utilized at Lake Sonoma. FIRO operating procedures at Lake Sonoma will be developed in coordination with NMFS to ensure that any future proposed FIRO procedures will result in effects consistent with those analyzed in this Opinion.

Flood management operations at WSD, along with annual pre-flood and 5-year periodic inspections of the outlet works, have the potential to reduce flood peaks, contribute to streambed scour and bank erosion, raise turbidity levels, and cause dewatering or disconnection of off-channel areas in portions of the Dry Creek mainstem. Effects resulting from WSD flood control operations are not anticipated to impact salmonid habitat within the mainstem of the Russian River below Dry Creek beyond those of unregulated flood flow conditions generated from the greater watershed; flood control operation seeks to minimize flood flow effects to Lower River flow conditions. The extent of impacts to salmonids and their designated critical habitat is anticipated to be within Dry Creek with the greatest risk occurring closest to WSD and dissipating further downstream as the flood flow energy from releases recedes.

2.5.1.2.1.1 Effects of Flood Control at WSD to Critical Habitat - Streambed Scour

Coho salmon, Chinook salmon, and steelhead PBFs of spawning critical habitat occur within the Dry Creek mainstem and are potentially impacted by streambed scour influenced by WSD flood control operations. Sonoma Water’s 2023 Lake Sonoma Release Metrics memorandum (Sonoma Water 2023) indicates flood releases (1,000 to 4,000 cfs and above) from WSD during the winter and spring are sufficient to cause streambed scour of Chinook salmon, coho salmon, and steelhead spawning gravels in the mainstem of Dry Creek. NMFS agrees with Sonoma Water's assessment and understands that current WSD flood operation releases provide tradeoffs between periodic streambed mobilization needed to clean spawning gravel, and the risk of extended high-flow streambed scour events that can dislodge established redds. WSD flood releases that exceed 3,000 cfs can cause streambed scour in Dry Creek, upstream of the confluence with Pena Creek, and flows greater than 4,000 cfs can cause streambed scour of salmonid spawning habitat throughout the Dry Creek mainstem.

To further evaluate the influence of WSD flood control releases on streambed scour events, Sonoma Water compiled a summary of annual events that exceed 3,000 cfs and 4,000 cfs, both with and without WSD flood control release contributions, as realized at the Lambert Bridge gaging station approximately 7 miles downstream of WSD (Table 29). The gaging station at

Lambert Bridge was used because it includes the watershed area where WSD operations have the most influence on Dry Creek flow conditions without major contributions from other tributaries in Dry Creek.

Table 29. Summary of the annual number of days in each water year from 2008 to 2024 that exceed 3,000 cfs and 4,000 cfs at the Lambert Bridge gaging station, located approximately seven miles downstream of WSD. Simulated flows include total watershed area inflows (Sonoma Water 2024, unpublished).

Water Year		Simulated Lambert Bridge Flow without WSD Releases Flow > 3,000 cfs (days)	Simulated Lambert Bridge Flow with WSD Releases Flow > 3,000 cfs (days)	Simulated Lambert Bridge Flow without WSD Releases Flow > 4,000 cfs (days)	Simulated Lambert Bridge Flow with WSD Releases Flow > 4,000 cfs (days)
2008		8	2	3	0
2009		3	0	1	0
2010		7	0	7	0
2011		8	5	4	0
2012		2	0	1	0
2013		6	0	4	0
2014		0	0	0	0
2015		4	1	3	1
2016		11	2	6	0
2017		22	29	16	10
2018		1	0	0	0
2019		28	26	18	16
2020		1	0	1	0
2021		0	0	0	0
2022		4	0	2	0
2023*		***24***	***9***	***18***	***4***
2024*		***19***	***11***	***12***	***9***
Average		**9**	**5**	**6**	**2**
Total		**148**	**85**	**96**	**40**

*Minor Deviation years with preliminary FIRO procedures at Lake Sonoma.

The results provided in Table 29 show that WSD flood operations typically reduce the overall frequency and magnitude of scouring flows in Dry Creek at Lambert Bridge. However, during relatively rare, abnormally wet water years (e.g., 2017), WSD flood control releases can extend the duration (consecutive days) and total number of days scour events occur. Over the full spectrum of water-year types, WSD flood operations are expected to decrease the frequency and magnitude of high-flow redd scour events throughout the mainstem of Dry Creek down to the confluence with the Russian River. Additionally, when FIRO procedures are fully incorporated into WSD flood control operations, a further reduction in the overall frequency, duration, and magnitude of streambed scour is likely, as occurred in 2023 and 2024 with the implementation of the USACE approved Minor Deviations using preliminary FIRO procedures for Lake Sonoma (Table 29).

When streambed scour events occur, spawning habitat located within the 3-mile reach immediately downstream of WSD is at the highest risk of degradation from WSD releases due to proximity and no other major tributaries enter Dry Creek in this reach. Below Pena Creek, scouring flows are likely dominated by unregulated inflow from Pena Creek, Grape Creek, and other downstream tributaries.

Although a portion of the spawning habitat will likely be adversely affected due to WSD flood control releases, the expressed high flow conditions in Dry Creek are dynamic and temporal, falling within the range of variability observed in both natural and other managed systems. Based upon research conducted on Trinity River in Northern California (May et al. 2009) and similar to the effects to spawning habitat for CVD flood control releases, we expect approximately 5 to 10 percent of spawning habitat above Pena Creek, and zero to five percent downstream of Pena Creek, will likely experience streambed scour sufficient to destroy salmonid redds located in those areas.

2.5.1.2.1.2 Effects of Flood Control at WSD to Species - Streambed Scour

Once a redd is scoured by high flow, the eggs or developing embryos contained within the redd are lost. Past redd monitoring in Dry Creek estimated approximately 200-400 Chinook salmon redds were constructed per year, with the majority of observations occurring within lower Dry Creek (Sonoma Water 2008; Martini-Lamb and Manning 2023). Assuming up to a 10 percent loss of available spawning habitat, and that constructed redds are equally distributed spatially throughout that available habitat, a rough, conservative approximation of 20 to 40 Chinook salmon redds may be lost to scour events during abnormally wet winters, when WSD flood control releases are likely to prolong high-flow events. . Estimating steelhead and coho salmon redd loss is much more difficult, since these species typically spawn later than Chinook salmon, when high flows and poor visibility make redd observation challenging. As a result, redd density estimates for coho salmon and steelhead are unavailable for the mainstem of Dry Creek. Furthermore, whereas the vast majority of adult Chinook salmon entering Dry Creek spawn within the Dry Creek mainstem, both steelhead and coho salmon can, and do, also spawn within the Dry Creek tributaries, suggesting a much lower redd density in the mainstem creek than that estimated above for Chinook salmon. Given the relatively lower numbers of steelhead and coho salmon expected to spawn directly in the Dry Creek mainstem, we anticipate no more than a few coho salmon redds and several steelhead redds may also be lost to scour, primarily during wet water years.

2.5.1.2.1.3 Effects of Flood Control at WSD to Critical Habitat - Bank Erosion

Coho salmon, Chinook salmon, and steelhead PBFs of spawning and rearing critical habitat occur within the Dry Creek mainstem, and those PBFs may be impacted by bank erosion influenced by WSD flood control operations. WSD flood control releases of 1,000 to 6,000 cfs are likely to contribute to flows that could initiate bank erosion in some years (2008 Opinion). Based on the analysis of hydrologic data by the USACE and Sonoma Water (2000), it appears

WSD flood control operations are not a significant factor contributing to bank erosion in Dry Creek during most years. Bank erosion in Dry Creek typically initiates at flow releases of 2,500 cfs or greater (USACE and Sonoma Water 2004). During most storm events, WSD reduces bank erosion potential by decreasing flow releases, which increases water supply storage in Lake Sonoma. Capturing a portion of winter high flow behind WSD, in turn, reduces flood peaks realized below WSD. Conversely, managing reservoir releases to remain below the WSD "flood pool" can sometimes lead to infrequent periods where high dam releases can artificially accentuate and extend the natural storm recession rate consistent with Dry Creek tributaries. In these relatively rare circumstances, WSD releases can potentially initiate bank erosion processes. NMFS's review of WSD releases suggests bank erosion is initiated on average approximately once every two years (NMFS 2008a). Therefore, we expect that some bank erosion will continue to occur along Dry Creek due to the contribution of WSD flood control releases during the Proposed Action. Based on the analysis period of ten years, we anticipate a maximum of approximately five bank erosion events as a result of WSD flood control releases. However, when FIRO procedures are applied to Lake Sonoma, as part of the Proposed Action, we anticipate a further reduction in the frequency, magnitude, and duration of bank erosion events.

Aside from the lower two miles of Dry Creek, the streambanks bordering the creek channel are largely protected from erosion, either via streambank armoring implemented by adjacent landowners, or the mature riparian tree corridor established following WSD construction. Therefore, when bank erosion occurs, it is expected to be confined to relatively small, localized areas of unprotected streambank along the Dry Creek mainstem. Small bank erosion failures are likely to deliver sediment and organic debris to the channel, which can impair spawning habitat quality by increasing fine sediment concentrations within available spawning gravels. Elevated inter-gravel fine sediment concentrations can alter flow dynamics within the redd egg pocket that deliver oxygen-rich water and carry away metabolic waste from the developing embryos (Quinn 2005). These bank failures also have the potential benefit of increasing habitat complexity for juvenile salmonids through the addition of large woody debris and other organic material that support desirable critical habitat PBFs. In case of Dry Creek, the infrequent occurrence of erosion-inducing flows, and the limited spatial area where erosion can currently occur, suggests large impacts or benefits to critical habitat PBFs, such as those discussed above, are unlikely to accrue to an appreciable extent in Dry Creek. Thus, NMFS expects only small areas of salmonid PBF of spawning and rearing critical habitat will be adversely affected by bank erosion from WSD flood control releases in some years, and some small benefits may also occur at some locations affected by bank erosion.

2.5.1.2.1.4 Effects of Flood Control at WSD to Species - Bank Erosion

Bank erosion influenced by WSD flood control operations may lead to some reduction in embryo and emergent fry survival in spawning areas where mobilized fine sediment settles immediately downstream of erosion sites. However, as noted above these potential bank failures are expected to occur infrequently, and at minimal sites given the relatively dense riparian vegetation, bank protection, and recent habitat enhancements along most of Dry Creek. Any impact on salmonid redds are expected to be confined to short reaches below bank erosion sites at a minimal number of locations. Spawning gravel is abundant in Dry Creek, and instream sediment concentrations are typically well below levels that may impair egg and fry survival (Inter-Fluve 2010). Also, female salmonids frequently construct a number of “tests” redds, cavities smaller than an actual redd, to gage the suitability of the site and substrate composition. If a female finds unsuitable substrate composition (i.e., high concentration of fines) at a given location, the likely response would be shifting to a better site, which are in ample supply in Dry Creek. Thus, the limited bank erosion that may result from, or be influenced by, WSD flood control operations is not expected to significantly influence spawning success or egg to pre-emergent fry survival.

Conversely, juvenile salmonids may benefit from bank failures within the Dry Creek mainstem. These failures typically deliver vegetation in the form of small and large organic debris, which improves winter habitat for all salmonid species and enhances rearing conditions for juvenile steelhead and coho salmon during the summer months. Dry Creek, in particular, has been found to have limited high-flow refugia, and the introduction of organic debris from bank failures is anticipated to increase habitat complexity, providing more opportunities to avoid high-velocity flow areas. These benefits will only occur infrequently in limited areas, as described above.

2.5.1.2.1.5 Effects of Flood Control at WSD to Critical Habitat - Winter Habitat

Although WSD flood control operations reduce flood peaks in Dry Creek, the subsequent prolonged higher flow releases, mostly in wet water years, following storm events can reduce the quantity and quality of lower-velocity winter-rearing habitat in Dry Creek. Flood control releases at WSD may range from 1,000 to 6,000 cfs and can last longer than the naturally receding limb of storm events. While these extended releases are a lower discharge than the preceding flood peaks, they are still large enough to force salmonids to seek refuge from high-velocity areas to avoid being swept downstream into even higher flows in the Lower River. Salmonids are known to seek cover from high-velocity flows during winter-rearing periods (Quinn 2005).

Winter refugial habitat volume in Dry Creek is limited by channelization and the muting of channel forming flows by WSD. However, habitat conditions have greatly improved with the implementation of extensive habitat enhancements throughout much of Dry Creek, as described in the Environmental Baseline section. Prolonged high flood control releases can reduce the capacity of both naturally occurring and constructed high-velocity refugia, reducing the availability of areas where adult and juvenile salmonids can escape high water velocities during storm events.

High flows can mobilize bedload and reconfigure channel morphology through the process of aggradation and deposition. In Dry Creek, extended flood control releases above 3,000 cfs limit the usefulness of constructed habitat enhancement areas by reconfiguring their original design (Sonoma Water 2023). Several enhancement sites have needed repair after the winter flood season. This recurring cycle of habitat degradation and rehabilitation of recently enhanced habitat features hinders the long-term viability of these critical lower-velocity winter-rearing habitat areas, particularly for juvenile coho salmon. Additionally, these constructed habitat areas are also essential for dry-season summer-rearing critical habitat PBFs in Dry Creek (see WSD Water Supply effects section below). Extensive maintenance is sometimes needed to restore damaged habitat enhancement areas to meet targeted performance criteria. Under the Proposed Action, Sonoma Water in coordination with the USACE, have committed that these habitat enhancements will be maintained and repaired to design criteria following any high-flow reconfiguration, ensuring consistently available lower-velocity winter-rearing habitat areas that provide adequate refugia for juvenile salmonids during the WSD flood control season.

With the planned full implementation of FIRO procedures at Lake Sonoma as part of the Proposed Action, the overall frequency, magnitude, and duration of flood control releases exceeding 3,000 cfs are expected to decrease. This reduction may, in turn, lessen the need for habitat-enhancement maintenance activities in the future. However, in years when prolonged WSD flood control releases result in habitat degradation and maintenance of constructed features becomes necessary, repairs will be promptly implemented following proper evaluation and planning to minimize future maintenance needs.

2.5.1.2.1.6 Effects of Flood Control at WSD to Species - Winter Habitat

Juvenile salmonids use different habitats during winter and summer (Bustard and Narver 1975, Quinn 2005). Salmon typically seek off-channel habitats in low-velocity areas with substantial cover during high flow events (Tschaplinski and Hartman 1983). Quinn (2005) notes that during winter, salmon, particularly coho salmon, move from inhospitable main channel areas to flooded wetlands, beaver ponds, tributaries, and various off-channel habitats. Bell (2001) documented increased fidelity and survival of winter-rearing juvenile coho salmon in alcoves and backwaters in a Northern California stream. Others have observed increased densities of coho salmon in side-channel pools (Bjornn and Reiser 1991). Juvenile salmonids (Chinook salmon, coho salmon, and steelhead) that are unable to utilize the limited lower-velocity refugia available in Dry Creek during high-flow storm events are likely to be swept downstream during WSD flood control releases, posing a risk to their survival if individual salmonids are unable to find adequate winter refugia. Those that are able to find winter refugia will have their feeding opportunities limited to those areas until high flows recede to more adequate conditions, allowing them to exploit other feeding and winter refugia opportunities. A reduction in feeding opportunities and the overexertion of energy in high-velocity habitat conditions may impact their overall fitness if high WSD flood control releases continue for prolonged durations (weeks).

To alleviate this problem, Sonoma Water and USACE have implemented extensive habitat enhancements throughout Dry Creek which significantly increase the amount of available lower-velocity winter-rearing habitat for juvenile salmonids, especially juvenile coho salmon. These areas were originally designed to enhance juvenile coho salmon rearing habitat during the summer, but the same features likely provide refugia from winter base flows. Salmonids experiencing water velocities that exceed their swimming ability will likely be displaced downstream. During summer months, this outcome would be fatal for some juvenile steelhead and coho salmon if they cannot find the available refugial habitat further downstream in Dry Creek because of poor water quality and high predation risk in the Russian River. However, juvenile salmonids displaced during winter are more likely to encounter more favorable habitat conditions elsewhere. Hence, displaced salmonids likely have more opportunity to find suitable habitat in other areas of Dry Creek and the Russian River mainstem during winter (e.g., inundated floodplain, non-natal tributary confluences, estuary habitat), water temperature and dissolved oxygen levels in the Russian River are typically suitable, and predator density and success rate are reduced by higher flows and decreased visibility, respectively. Fall and winter "redistribution" into new habitat areas is a life-cycle adaptation commonly employed by juvenile coho salmon (Lestelle 2007). For these reasons, the anticipated infrequent periods when prolonged high-velocity WSD releases displace winter-rearing juvenile salmonids are unlikely to appreciably decrease the survival of juvenile salmonids rearing in Dry Creek during winter months.

2.5.1.2.1.7 Effects of Flood Control at WSD to Critical Habitat - Ramping Rates

Accelerated streamflow reductions due to WSD operations are most likely to influence salmonid fry habitat, given their limited swimming ability and preference for shallow, edgewater environments (Hunter 1992). A rapid decrease in flow can dewater or isolate fry habitat, exposing stranded fish to increased predation or desiccation as occupied habitat dries quickly (Nagrodski et al. 2012). The risk of stranding due to rapid flow recession is not exclusive to regulated river systems; habitat isolation and dewatering can also occur naturally in watersheds with unaltered hydrology and pristine conditions (Nagrodski et al. 2012). In both Dry Creek and the Upper River, natural fluctuations in tributary inflows also contribute to stranding risk, independent of reservoir releases.

We evaluated the potential for down-ramping flows associated with WSD flood releases and inspections to adversely influence PBFs of spawning and rearing critical habitat in the Dry Creek mainstem. Additionally, we assessed potential down-ramping effects on critical habitat conditions in the Russian River mainstem, downstream of the Dry Creek confluence. However, flow contributions from the Upper River and Dry Creek are expected to maintain habitat connectivity within the Lower River.

As part of the Proposed Action, USACE will continue applying ramping rates of 250 cfs per hour when WSD releases range from 250 to 1,000 cfs and 25 cfs per hour when releases are below 250 cfs. When WSD releases reach or exceed 1,000 cfs, down-ramping rates will be limited to a maximum of 1,000 cfs per hour, while up-ramping rates (increased releases during WSD flood control operations) will be limited to no more than 2,000 cfs per hour. Current down-ramping rates of 250 cfs per hour and 125 cfs per hour result in river stage changes of approximately 6 inches per hour within the first 1.5 miles downstream of WSD (USACE and Sonoma Water 2004). Ramp-down rates between 250 and 1,000 cfs per hour are expected to produce stage changes exceeding six inches per hour, likely having a greater influence on salmonid fry and juvenile PBFs of spawning and rearing critical habitat in the Dry Creek mainstem.

Although USACE and Sonoma Water did not survey stage changes in the 1.5-mile reach between Pena Creek and WSD, NMFS field observations suggest that channel conditions in this reach are similar to those in the surveyed 1.5-mile reach downstream of Pena Creek. Consequently, stage changes within the first three miles downstream of WSD are likely to create conditions conducive to fry and juvenile stranding during flow down-ramping. Beyond Pena Creek, cross-section evaluations generally met Hunter’s criteria (USACE and Sonoma Water 2000), and natural tributary inflows are expected to dampen and mitigate the effects of WSD down-ramping operations on PBFs of spawning and rearing critical habitat.

The evolution of recently constructed habitat enhancement areas in the Dry Creek mainstem, which provide increased low-velocity backwater channels, may elevate stranding risk in isolated off-channel habitats during down-ramping events. Although each enhancement area is designed to provide ingress and egress opportunities for juvenile salmonids as flows fluctuate, evolving channel dynamics, shifting construction features during high-flow events, and potential gravel aggradation may create higher-risk stranding locations in the future. As described in the Proposed Action, Sonoma Water, in coordination with USACE, will monitor and maintain constructed habitat enhancement sites to minimize stranding risk and ensure that PBFs of spawning and rearing critical habitat are maintained in the Dry Creek mainstem.

Additionally, WSD flood control operations are unlikely to appreciably influence fry PBFs of spawning and rearing critical habitat in the Lower River (i.e., downstream of the Dry Creek confluence with the Russian River mainstem), given the relatively minor influence of WSD winter discharges on Lower River stage elevation and flow compared to accretion flows from tributary sources and the Upper River.

2.5.1.2.1.8 Effects of Flood Control at WSD to Species - Ramping Rates

The likelihood of Chinook salmon, coho salmon, and steelhead fry and juveniles becoming stranded in the Dry Creek mainstem during proposed down-ramping operations (February–June) is low, with the highest risk occurring downstream to Pena Creek. Down-ramping will follow Hunter's (1992) recommended rates: one inch per hour or less to protect steelhead fry and two inches per hour to protect juvenile salmonids below Pena Creek, where accretion flows from contributing tributaries will mitigate WSD down-ramping effects.

As described above, the Dry Creek mainstem's steep banks and limited natural side channels and backwater features generally do not create conditions conducive to high stranding rates. Consequently, we expect relatively few juvenile salmonids to become stranded in isolated pools or experience habitat desiccation (fewer than 200 juvenile steelhead, 100 juvenile coho salmon, and 50 juvenile Chinook salmon). These occurrences will likely be concentrated between WSD and Pena Creek due to down-ramping over the 10 year-period of the Proposed Action. Additionally, no spawning is expected in the Lower River below the Dry Creek confluence, eliminating risks to pre-emergent fry and reducing risks to weaker-swimming juveniles. See nd shall timely provide thorough updates on progress on these items at NMFS' request Section 2.5.2.2 for anticipated stranding within enhanced habitat restoration reaches of the Dry Creek mainstem.

Annual pre-flood and 5-year periodic inspections at WSD are unlikely to strand or kill listed salmonids in Dry Creek because: 1) inspections are proposed to occur in September to avoid impacts on adult spawning and allow juvenile fish time to grow, reducing their stranding risk; and 2) USACE will maintain a continuous 25 cfs minimum bypass during inspections. Additionally, during these periods, USACE will closely monitor instream conditions to minimize stranding. If necessary, USACE will implement fish capture and relocation efforts as described in the Monitoring Section. The effects of salmonid relocation associated with down-ramping are discussed in the Monitoring Effects section.

2.5.1.2.2 Effects of Water Supply Operations at WSD

2.5.1.2.2.1 Effects of Water Supply at WSD to Critical Habitat – Spawning and Migration Flows

Chinook salmon spawning in Dry Creek peaks between November and January but can begin as early as late September and extend through February (Sonoma Water 2023). Steelhead and coho salmon typically spawn later in the winter (December through April for steelhead and December through February for coho salmon) and are unlikely to be influenced by proposed WSD water supply operations, which generally occur from May through October. However, these operations have the potential to influence PBFs related to spawning and migration within critical habitat.

In years when the onset of fall and winter storms is significantly delayed (during prolonged dry fall periods), Chinook salmon spawning habitat in Dry Creek may be influenced during October and early November, as these storms typically cue migration. WSD water supply releases primarily influence water depth, velocity, and temperature in the Dry Creek mainstem, shaping habitat conditions encountered by spawning and migrating adult salmonids.

Under the Proposed Action, the frequency of upstream migration flows in Dry Creek is expected to provide adequate passage flow opportunities through the fall and winter months (Table 30). Based on surveys and hydrologic evaluations conducted by Sonoma Water, 90 cfs is considered the minimum passage flow for Dry Creek (Sonoma Water 2016; ESA, Inc. 2023). We concur with Sonoma Water's assessment of this passage flow for Dry Creek. While this change could influence early-migrating Chinook salmon in drier years, peak migration for steelhead and coho salmon is anticipated to remain largely unaffected due to the likelihood of wetter conditions later in the winter season. During most migration periods, proposed WSD flow releases are expected to provide suitable temperature and velocity conditions for both adult and juvenile salmonid migration within Dry Creek.

Table 30. Percent occurrence of upstream migration flows in Dry Creek (ESA, Inc. 2023).

Scenario	Passage Flows (cfs)	Oct 15-31	Nov	Dec	Jan	Feb	Mar
Baseline	90	98%	96%	97%	89%	95%	99%
Proposed Interim Petitions	90	82%	71%	77%	88%	95%	99%

The flow rate released from WSD, combined with discharges at CVD, also influence water depth at critical riffles[20] in the Lower River, which, in turn, can determine whether upstream-migrating

[20] Critical riffles are the shallowest points along a river or stream longitudinal profile where water depth limits fish passage as flows diminish. Four critical riffles were identified in the Russian River (from downstream location): Casini Ranch near Duncans Mills, at Monte Rio, at Badger Park near Healdsburg, and Geyserville (near Hwy 128).

adults or downstream-migrating smolts and steelhead kelts[21] can successfully complete their journey. Hydrologic analysis and visual observations conducted by Sonoma Water have documented that flows greater than 110 cfs in the Lower River (at Hacienda) provide suitable water depth and velocity, with large numbers of Chinook salmon adults successfully migrating up to and through the fish counting station at the Mirabel/Wohler fish ladder (Sonoma Water 2024 email).[22] Therefore, we recognize 110 cfs as the minimum flow needed to adequately support fish passage conditions for adult salmonids in the Lower River.

Under the Proposed Action, the percentage of upstream migration flows in the Lower River during late October increases from 12 to 20 percent in critically dry water years compared to baseline flow conditions (Table 31). However, in normal and dry water years, migration opportunities meeting the minimum passage flow of 110 cfs in the Lower River are ample (Table 31). As noted for the Upper River (Section 2.5.1.1.2.9), delaying adult migration under these conditions until wetter, cooler periods (e.g., storm events) augment reservoir releases may benefit adult salmonid survival. Modeling by Sonoma Water suggests that water temperatures in the Lower River are often unfavorable for adult salmonids in late September and October before fall rains (ESA, Inc. 2023). Additionally, the Estuary sandbar typically prevents adult Chinook from entering when fall river flows are limited.

Table 31. Percent occurrence of upstream migration flows in the Lower River (Sonoma Water, unpublished data 2024).

Scenario	Passage Flows (cfs)	Water Year Class	Oct 15-31	Nov	Dec	Jan	Feb	Mar
Baseline	110	Critically Dry	12	67	100	90	83	98
Baseline	110	Dry	97	100	100	100	100	100
Baseline	110	Normal	98	100	100	100	100	100
Proposed	110	Critically Dry	20	45	73	86	85	99
Proposed	110	Dry	100	99	100	100	100	100
Proposed	110	Normal	97	100	100	100	100	100

Adult salmonids that enter the Estuary and Lower River may be constrained from migrating upstream due to unfavorable water quality and are likely to hold within deep pool habitats. In these areas, adult salmonids (particularly Chinook) can survive in the cooler coastal climate as late summer heat recedes, waiting for suitable water quality (i.e., temperature) conditions for migration. Flows from Dry Creek also help accelerate the cooling of the Lower River during the summer-to-fall transition. While holding in the cooler reaches of the Lower River may improve

[21] Unlike Pacific salmon that die shortly after spawning, a small but significant fraction of adult steelhead survive following spawning and, after returning to the ocean, can migrate upstream and spawn again in future years. These post-spawn, or “kelt”, steelhead migrate downstream shortly after spawning, and reservoir operation impacts to their migration is considered similar to that of upstream migrating adults.

[22] Note that 110 cfs was identified as adult passage flow in Lower River in recent TUCOs, and recent empirical data shows that adult Chinook Salmon passed up to Mirabel on spawning migrations with flows less than 110 cfs.

salmonid health by providing better water quality, it could also increase pinniped predation pressure (see Section 2.5.3.4).

As described in the Proposed Action, Sonoma Water will commit 2,500 acre-feet of blockwater on an annual basis to augment releases from Lake Sonoma into Dry Creek and the Lower River to support salmonid migration and survival under adverse conditions, such as poor spawning and migration flows during prolonged fall drought conditions. In addition to potential blockwater releases, during dry and critically dry water supply conditions, Sonoma Water will release water from Lake Sonoma to maintain a minimum adult passage flow of 110 cfs in the Lower River if Chinook salmon monitoring indicates that augmented flows are needed (e.g., Estuary inlet conditions, adult Chinook salmon observations in the Estuary and/or Lower River, observations at Mirabel). The appropriate blockwater release strategy and flow augmentation operations plan will be adaptively managed in coordination with NMFS during the Chinook salmon migration season (October 15 through December 31).

With the inclusion of these flow augmentation procedures as part of the Proposed Action, we anticipate that timely and adequate passage flow conditions will be provided, benefiting adult salmonids, particularly Chinook salmon, when dry conditions extend late into the spawning season. These flow augmentation strategies will also be coordinated with potential Lake Mendocino fall pulse releases, providing additional benefits to migratory habitat conditions in both the Lower and Upper River. Therefore, WSD water supply operations are likely to have a minimal adverse effect on salmonid PBFs of spawning and migration critical habitat in Dry Creek and the Lower River.

2.5.1.2.2.2 Effects of Water Supply at WSD to Critical Habitat - Rearing

The fry life stage (i.e., juveniles recently emerged from the redd) of all three species generally prefer similar habitats, characterized by shallow, low-velocity edge-water areas with gravel (cobble) substrates unembedded by fine sediment. This type of PBFs of rearing critical habitat is relatively limited within the Dry Creek mainstem and, to a lesser extent, in the Lower River below its confluence with Dry Creek. In Dry Creek, habitat availability is constrained because much of the channel has been modified, reducing connectivity to low-velocity edge-water habitat. In the Lower River, natural topography limits the extent of such habitat, and portions of the river have also been channelized.

Where fry habitat does occur downstream of WSD, proposed water supply operations are unlikely to significantly influence its physical quality or extent, as these characteristics are primarily determined by channel configuration, flow volume and velocity, and fine sediment transport (i.e., factors influencing channel sinuosity and shallow habitat formation, such as point bars). The Dry Creek channel is currently incised, largely due to the infrequent occurrence of effective channel-forming flows, as winter flood operations prioritize water storage. In the absence of such flows, a mature riparian corridor has developed over the decades. Along with extensive floodplain encroachment and bank stabilization efforts by adjacent landowners, this has effectively prevented lateral channel migration and point-bar development in Dry Creek. Similarly, fry habitat volume in the Lower River appears to be constrained by a combination of natural and anthropogenic factors, including high valley confinement, widespread floodplain encroachment and disconnection, and limited alluvial reaches where suitable fry habitat could form. Given these conditions, the relatively low discharge typically associated with WSD water supply operations (compared to inflows from upstream sources) is unlikely to meaningfully influence the extent or quality of shallow edge-water habitat preferred by salmonid fry.

The three anadromous salmonid species considered in this Opinion differ in their preferred juvenile rearing habitat characteristics and the duration of freshwater residency. Unlike Chinook salmon, both coho salmon and steelhead exhibit extended freshwater rearing phases, typically 1.5 years for the former and up to several years for the latter. Thus, both species require adequate habitat (e.g., areas with suitable water velocity, temperature, depth, and cover) to survive the summer low-flow period. While WSD water supply operations reduce water temperatures, they also increase flow volume and velocity throughout the entire 14-mile stretch of Dry Creek. Summer releases from WSD are drawn from the bottom-most layer of Lake Sonoma, where water temperatures are generally suitable for coho salmon juvenile growth and survival throughout most of Dry Creek, except in the lowermost section influenced by Russian River flow dynamics.

Water temperatures in Dry Creek under the Proposed Action are expected to support high-quality juvenile rearing habitat. The 2008 Opinion concluded that flow releases of 110 to 175 cfs at CVD resulted in poor coho salmon summer habitat quality (NMFS 2008) due to high water velocities. Consequently, the associated RPA required constructing several miles of habitat optimized for rearing. Under the Proposed Action, Sonoma Water's WSD releases will generally be limited to 175 cfs or less throughout most of the summer rearing season (June 1–October 15), with occasional short-term exceedances (i.e., less than 24 hours).

While these flows will maintain suitable low-velocity conditions within the 275,745 ft^2 of enhanced side-channel habitat, other portions of Dry Creek will likely remain largely unsuitable for juvenile coho salmon and all but the largest steelhead when flows exceed 90 cfs and approach 130 cfs (Entrix 2004). Thus, in the unrestored sections of Dry Creek, PBFs of rearing critical habitat will begin to be adversely affected when flows exceed 90 cfs, with much of the available juvenile rearing habitat temporarily lost to inundation as flows continue to rise. However, NMFS considers that, given the estimated densities of steelhead and coho salmon currently occupying refugial habitat in Dry Creek remain well below suspected carrying capacity, the restored refugial habitat is likely sufficient to support juvenile salmonid growth.

Smolts of all three species begin migrating downstream to the Estuary during February and March, before WSD water supply operations typically commence. Water quality modeling predicts tolerable water temperature and dissolved oxygen levels throughout Dry Creek during nearly all of April, May, and June—the peak smolt migration months (Sonoma Water 2023). During infrequent dry spring periods when precipitation is scarce and tributary accretions are low, WSD releases could theoretically influence flow dynamics (i.e., water velocities) and, by extension, predator-prey interactions further downstream in the Russian River, including the Wohler Pool. During these dry spells, to meet increased water demand, WSD flow releases are expected to be relatively high, which may mitigate any negative effects of WSD operations on predation risk in the Lower River. Therefore, the proposed WSD water supply operations are expected to have only minor adverse effects on smolt PBFs of rearing and migratory critical habitat in Dry Creek and the Lower River.

2.5.1.2.2.3 Effects of Water Supply at WSD to Species – Adult Chinook Salmon, Coho Salmon, and Steelhead

In some years and under certain watershed conditions, WSD water supply operations may contribute to delays in the spawning migration of adult salmonids. This is most likely during the Chinook salmon spawning migration season, from late September through November in dry and critically dry years. Delayed salmonids attempting to reach upstream spawning habitat (Dry Creek or the Upper River) may experience increased stress due to poor water quality (elevated temperatures) and higher predation risk (e.g., pinnipeds, fishermen), potentially reducing reproductive success.

As described above, timely flow augmentation, either independently from Lake Sonoma (blockwater) or through combined pulse flow releases from Lake Mendocino and adaptively-managed blockwater releases from Lake Sonoma, will provide adequate passage flows in both the Lower and Upper River, including access to Dry Creek. Therefore, we anticipate minimal adverse effects on individual adult salmonids migrating through the Lower River into Dry Creek or ascending to the Upper River toward their spawning grounds.

2.5.1.2.2.4 Effects of Water Supply at WSD to Species - Chinook Salmon, Coho Salmon, and Steelhead Egg Incubation and Emerged Fry

Unlike the other two species, steelhead egg incubation can extend into late May, meaning late-incubating eggs could be exposed to dry-spring water operations starting around that time. The primary mechanisms by which steelhead eggs could be influenced by WSD water supply operations include turbid water releases and fine sediment deposition, redd scour from elevated discharge, and poor water quality (e.g., unsuitable water temperatures). However, while only a small portion of eggs from the later part of the steelhead spawning period would be present during water supply releases, none of these mechanisms are likely to manifest within the affected reaches of Dry Creek.

Water released from WSD is generally "sediment-starved," as most coarse and fine sediment is captured within Lake Sonoma. Tributaries serve as the primary source of both fine and coarse sediment in the lower 14-miles of Dry Creek (Inter-Fluve 2010). In contrast, fine sediment input from Pena Creek, which enters approximately 3 miles downstream of WSD releases, is likely insignificant. Gravel is the dominant substrate directly below the dam, with fine sediment relatively absent (Inter-Fluve 2010).

Scour-inducing flows exceeding 1,000 cfs are highly unlikely during proposed WSD water supply operations, as Sonoma Water aims to maximize storage by avoiding excess releases above those necessary to meet minimum flow requirements at the mouth of Dry Creek. Additionally, late-spring releases from WSD typically fall within suitable water quality ranges, including appropriate water temperatures for egg incubation and survival (Sonoma Water 2023). Therefore, we anticipate that only a small number of individual salmonids (eggs and fry) would be adversely impacted by proposed WSD water supply operations.

2.5.1.2.2.5 Effects of Water Supply at WSD to Species – Summer Rearing Steelhead and Coho Salmon

As described in the discussion of critical habitat effects (Section 2.5.1.2.2.2), the proposed high-flow releases for water supply will degrade rearing habitat outside the enhanced habitat areas. As flows exceed 175 cfs, areas that have not undergone enhancement will become increasingly unsuitable for juvenile salmonids. Water velocity will surpass the swimming capacity of juveniles, making it energetically demanding for them to maintain a fixed position. Depending on the magnitude and duration of high-velocity flows, overwhelmed fish are likely to be swept downstream and must locate low-velocity refuge habitats before reaching the Russian River, where summer water temperatures can approach lethal levels (see Section 2.5.2.1).

When Dry Creek flows exceed the upper design limit of the constructed habitat enhancements (175 cfs; some areas up to 210 cfs), the availability of suitable water velocity within enhanced off-channel habitats will likely decrease. This will initially displace smaller, weaker-swimming juvenile coho salmon, with larger individuals being affected as flows continue to rise. However, we anticipate that Dry Creek flows during proposed WSD water supply operations will not exceed 175 cfs.

Because the loss of low-velocity refugial habitat will be gradual as flows increase, and since available slow-velocity, off-channel habitat remains well below carrying capacity, most displaced salmonids will likely find suitable, underutilized rearing habitat further downstream, either in other enhanced habitat areas or naturally suitable locations, before being flushed into the Lower River, where water quality conditions are inhospitable during the summer months due to high water temperatures. Thus, a small number of juvenile salmonids unable to find suitable habitat before reaching the Lower River will likely perish. Therefore, we expect a minor annual loss of individual rearing juveniles each of the 10-year duration of the Proposed Action.

2.5.1.2.3 Effects of WSD Operations - Turbidity

RPM4 in the 2008 Opinion required the USACE to undertake measures to assist NMFS in determining the amount of take resulting from turbidity releases at CVD. As partial fulfillment of RPM4, the USACE completed the RRTA 2023, which provides turbidity level information below WSD. However, limited data was available during the winter (90 days) and spring (140 days) due to gage outages. More robust datasets were available for the summer (832 days) and fall (549 days).

In Section 2.5.1.1.4 above, we explained the data available to assess turbidity from USACE and Sonoma Water's proposed operation of CVD. Here, we use some of that data to assess turbidity from WSD.

- Dry Creek at Lambert Bridge: USGS gage #11465240, 2012-2021.

Of the salmonid species present in Dry Creek, CC Chinook salmon embryos and pre-emergent fry are likely the most adversely affected in terms of numbers of individuals, as Chinook salmon spawn in high densities in the mainstem Dry Creek (Sonoma Water 2007, ESA, Inc. 2023). CCC steelhead and CCC coho salmon are also known to spawn within the Dry Creek mainstem, but likely to a lesser extent, as they are frequently observed spawning in its tributaries (SWFSC 2023). Other life stages of all three salmonid species are likely exposed to elevated turbidity contributions from WSD water operations, but at much lower levels and for shorter durations than those experienced in the Upper River below CVD.

2.5.1.2.3.1 Effects of Turbidity from Reservoir Operations at WSD to Critical Habitat

Coho salmon, Chinook salmon, and steelhead critical habitat PBFs of migration, spawning, and rearing critical habitat occur within the Dry Creek mainstem and can be influenced by turbidity discharged from WSD throughout the year. The extent of turbidity influence from WSD on salmonid habitat varies depending on the magnitude, duration, and frequency of discharge from Lake Sonoma, as well as the salmonid life stages present at the time.

During proposed operations during the WSD flood control season, turbidity contributions from Lake Sonoma and WSD releases are likely most pronounced in the 3-mile reach upstream of the confluence with Pena Creek. Below this point, turbidity contributions become commingled with inputs from tributaries. In contrast, during WSD water supply operations, turbidity contributions from WSD are more easily discernible, as Dry Creek's summer hydrology is dominated by reservoir releases.

Potential turbidity effects on PBFs of migration, spawning, and rearing critical habitat in Dry Creek are consistent with those observed in the Upper River associated with CVD. Elevated turbidity levels can degrade spawning gravel quality, increase streambed embeddedness, and reduce intra-gravel permeability, which is essential for embryo and pre-emergent fry development. Additionally, increased turbidity may cause juvenile salmonids to avoid certain habitats, displace them from preferred rearing areas, reduce prey abundance and diversity, and impact overall water clarity and quality, potentially affecting adult migration.

Limited data are available to reliably quantify the magnitude of turbidity-related effects from WSD releases on salmonids in the Dry Creek mainstem downstream to Lambert Bridge. Existing data suggest that median turbidity levels are very low (1.9 NTU; USACE 2023). One important caveat regarding this monitoring data is the location where it was collected. Lambert Bridge is approximately 7 miles downstream of WSD, and significant tributary accretion and sediment input occur upstream of this location (e.g., Pena, Dutcher, and Grape creeks). Thus, turbidity recorded at Lambert Bridge likely results from a combination of relatively large tributary inputs and a smaller component sourced from WSD releases.

Finally, past studies identified gravel as the predominant substrate throughout the Dry Creek mainstem, with fine sediment concentrations typically below 10 percent across the 14-mile reach. These conditions support optimal salmonid spawning, egg incubation, and rearing (Inter-Fluve 2010). This suggests that despite limited turbidity data for Dry Creek, and specifically contributions from WSD releases, gravel quality appears to be of high quality. Therefore, turbidity contributions from proposed WSD flood control and water supply releases are unlikely to significantly degrade coho salmon, Chinook salmon, and steelhead PBFs of spawning, egg incubation, and rearing critical habitat in Dry Creek.

2.5.1.2.3.2 Effects of Turbidity from Reservoir Operations at WSD to Species

Given the documented low turbidity and optimal fine sediment concentrations observed in the Dry Creek streambed, it is anticipated that individual spawning and rearing salmonids, or deposited eggs, will not be impacted by turbid water releases from WSD.

2.5.1.2.4 Effects of Water Diversion Operations at the Mirabel Facility

As noted previously, Sonoma Water's diversion facilities along the Russian River include an inflatable dam, the Mirabel diversion and fish ladder facility, a screened surface water intake and infiltration ponds, and the Wohler diversion facility. During high flows, the inflatable dam remains deflated and lays flat on the river bottom. During the low flow period of late spring/early summer, the dam is inflated, creating a 3.2-mile-long impounded river section (Wohler Pool) that facilitates recharge into the alluvial aquifer. Mirabel Facility operations may affect juvenile and adult migration habitat, and juvenile rearing habitat. We do not anticipate spawning to occur within this reach, as documented spawning occurs in tributaries throughout the greater Russian River watershed and the Upper River.

2.5.1.2.4.1 Effects of Mirabel Facility Operation to *Critical Habitat – Passage*

Fish passage at the Mirabel Dam has been monitored since 2000 to ensure that it does not inhibit the upstream adult or downstream smolt migration of salmonids. After reviewing the available data on fish passage at Mirabel Dam (Sonoma Water unpublished data, 2024), NMFS has concluded that adult salmonid migrants prefer the newer vertical slot ladder, delays when the dam is inflated are minimal, and fish can pass the site easily when the dam is deflated. There are no known dam passage effects for outmigrating smolts. The ladder is configured to accommodate fish passage while the Mirabel Dam is inflated and river flows range from 125 to 1,000 cfs. While not the primary focus of the design, fish passage is also facilitated when the Mirabel Dam is deflated. Monitoring data showed that fish passage when the Mirabel Dam was inflated occurred primarily through the new vertical slot fish ladder on the west bank. Therefore, adverse effects on PBFs or migration critical habitat are anticipated to be negligible.

2.5.1.2.4.2 Effects of Mirabel Facility Operation to Critical Habitat – Water Quality

The aquatic habitat at the inflatable dam site and within the Wohler Pool does not provide high-quality rearing habitat for salmonids and instead provides habitat suitable for salmonid predators, as described in the Environmental Baseline. Pools and riffles will also be inundated when the dam is inflated, further reducing habitat complexity.

We have also considered the effects of the Mirabel Dam on water quality. Sonoma Water's monitoring of DO in the Wohler Pool has found that DO levels typically range from 6.0 ppm to 9.0 ppm, which is slightly lower than DO levels at the upstream control sites. Initial distress symptoms in salmonids were observed at DO levels of 6.0 ppm to 7.0 ppm (Barnhart 1986; Hassler 1987; Bjornn and Reiser 1991). Low DO levels can negatively affect metabolic function, swimming, and overall survival in salmonids. Small to no temperature increases above natural warming occur in the Wohler Pool impoundment (upstream of the dam), which would be most critical during the summer months. Importantly, summer water temperatures upstream of the impounded area are already high, leading to poor rearing conditions for juvenile salmonids, regardless of the presence of the Wohler Pool. Although artificial structures can exacerbate stream warming and degrade habitat quality, this does not appear to be the case for the Wohler Pool, where temperature conditions generally reflect seasonal changes throughout the Russian River mainstem.

Before the dam is raised, it is sometimes necessary to remove gravel that has accumulated on top of the dam and in the fish ladders due to bed movement during the winter. Under the Proposed Action, grading and gravel removal will only be required after large depositional events following high-flow periods. Gravel removal will occur only in areas that are not inundated by the active flow of the Russian River or in areas that can be isolated from it. Similarly, all equipment will remain outside the active channel. Since no grading will occur in the active channel, the temporary increase in turbidity is unlikely to impact water quality. Therefore, we do not anticipate that the PBFs of rearing critical habitat associated with water quality will be significantly impacted by the presence of Wohler Pool as a result of Mirabel Facility operations.

2.5.1.2.4.3 Effects of Mirabel Facility Operation **to** *Species – Stranding*

Juvenile salmonids may become stranded when abrupt inflation or deflation of the dam causes rapid changes in river stage within the impounded area. The rate of river stage change in these areas depends on how quickly the dam is raised or lowered. Rapid fluctuations can dewater habitat occupied by juvenile and adult salmonids. Mortality may occur if salmonids become desiccated or suffocate when trapped in isolated pools. Additionally, stranded salmonids face a higher risk of predation.

Vulnerability to stranding appears to be size-dependent, with juvenile salmonids more susceptible than adults. However, the dam is deliberately inflated and deflated at a slow rate to minimize stranding risk. Salmonid stranding during dam inflation and deflation has not been documented by Sonoma Water staff. Under current protocols, dam inflation takes approximately three to ten days, while deflation requires one to five days. River stage change upstream of the dam occurs at approximately 0.10 feet per hour (ft/hr) during inflation (depending on river flow) and 0.20 ft/hr during deflation, aligning with established stage-change guidelines designed to prevent juvenile stranding below CVD and WSD. Adult salmon and steelhead generally hold in deeper portions of the river channel and are unlikely to be in the shallow channel margins where stranding occurs.

The viewing chamber at the Mirabel Facility is expected to flood every winter, and Sonoma Water anticipates rescuing stranded fish from the chamber multiple times per season. Based on past stranding events at the Wohler Facility, up to 45 juvenile salmonids may require capture and relocation to the mainstem river annually. Under the Proposed Action, Sonoma Water will attempt to capture stranded fish using seines and will only employ electrofishing if necessary to recover fish that remain after seining efforts. Recently spawned adult steelhead kelts may enter the facility and require rescue and relocation, but the likelihood is low, as kelts are presumed to prefer migrating downstream within the deeper thalweg of the channel. In contrast, juvenile salmonids likely favor shallow habitats along the riverbank, where they find greater cover from predators and higher food availability. Therefore, it is anticipated that no more than one steelhead kelt will require capture and relocation from the viewing chamber annually.

2.5.1.2.4.4 Effects of Mirabel Facility Operation **to** *Species - Predation*

NMFS is concerned about how predation rates may be affecting survival of juvenile salmonids through this reach of the Lower River (see Section 2.4.4.6, 2.4.3.2 for a detailed discussion). Little is known about how flow management at WSD influences the predator-prey relationship affecting smolt survival in the Lower River. Studies from other watersheds (e.g., Tiffan et al. 2009; Cavallo et al. 2013; Michel et al. 2019) suggest that predation risk for migrating smolts is inversely proportional to discharge (i.e., higher flows increase juvenile salmonid migration rates and decrease predation risk). Since 2021, Sonoma Water has conducted preliminary survival studies focused on coho salmon smolts. Preliminary results indicate that survival rates are higher in Dry Creek and the Estuary compared to the Lower River.

Reach-specific survival estimates and loss rates developed for the 2022 releases identified marked decreases in survival near the Dry Creek confluence (from the mouth to Syar Ponds) and at Mirabel Dam. The highest estimates of tagged coho loss (likely mortality) were observed in the later (May) release groups. Additional analyses of environmental factors (flow, turbidity, and temperature) were conducted to assess potential relationships between these factors and survival. In general, Sonoma Water's analysis found a positive correlation between higher survival and increased flow, but more information is needed to conclude specific flow targets that ensure adequate survival rates (Sonoma Water 202d4a).

As described in the Proposed Action, Sonoma Water will annually reserve 2,500 acre-feet of “blockwater” from WSD, to be used at NMFS’s discretion. Blockwater release strategies can be combined with scheduled releases to improve migratory habitat conditions, accelerate downstream smolt migration, reduce piscivorous fish density per unit of water, and minimize overall predation risk for migrating steelhead, Chinook salmon, and coho salmon in the Lower River. Sonoma Water will coordinate annually with CDFW, SWRCB, and NMFS to optimize blockwater use to support salmonid migration and improve survival rates. Blockwater release strategies will be integrated with smolt survival studies to evaluate the effectiveness of flow augmentation. Thus, it is anticipated that blockwater and other flow augmentation strategies (such as pulse flows from Lake Mendocino) will significantly improve juvenile salmonid survival rates, particularly during drier years. However, fine-tuning flow rates will require additional data and refinements as part of the Proposed Action.

Another concern for salmonid loss in Wohler Pool is predation by avian species. While no studies or targeted monitoring efforts have been conducted to quantify this concern, several avian predators, including mergansers, have been observed in the pool and near the dam (Chase et al. 2005). Salyer and Lagler (1940) estimated from observations and stomach content analysis that an adult merganser consumes between one and one-and-a-half pounds of fish daily, approximately one-third to one-half of its body weight. Additionally, monitoring in the Yakima River Basin identified avian predation as a significant factor contributing to the loss of migrating juvenile salmonids. Specifically, estimates indicated that common mergansers in the upper Yakima River consumed between 15,196 pounds of fish in the spring and 9,500 pounds in the summer (Sonoma Water 2023).

Quantifying the number of coho salmon, Chinook salmon, and steelhead smolts lost to predation in Wohler Pool and the Lower River remains unattainable at this time. However, preliminary assessments by Sonoma Water suggest that moderate to high numbers of juvenile salmonids are lost between the Dry Creek confluence and the area just downstream of Wohler Pool. The dynamic relationship between flow volume and habitat conditions complicates efforts to discern the extent to which Mirabel Facility operations contribute to these losses. It is likely that the greatest losses occur during dry and critically dry years, while losses in normal water years are much lower. As part of their ongoing multi-year study (initiated in 2021) and under the guidance of the Survival Studies Work Group, if results indicate that Sonoma Water operations or facilities negatively impact salmonid survival, measures such as blockwater releases will be implemented to minimize these effects.

2.5.2 Effects of Dry Creek Habitat Enhancements

2.5.2.1 Effects of Dry Creek Habitat Enhancements on Critical Habitat

When comparing the estimated total area of habitat restored (275,745 ft^2), with the area of the entire wetted channel (672,572 ft^2) of Dry Creek, it is apparent that this large-scale restoration effort has addressed the lack of low water velocity areas and provided a significant increase in cover and water depth and, therefore, increased habitat suitability for rearing juvenile salmonids, particularly coho salmon. According to Roni et al., (2010), it may take a considerable length of time and a considerable amount of habitat enhancement to produce and detect a measurable biological response. Once established, and if maintained properly, the restoration sites in Dry Creek and its tributaries will continue to enhance juvenile rearing habitat suitability (by providing adequate PBFs including velocity, cover, and depth) primarily for juvenile coho salmon and steelhead, but also for juvenile Chinook salmon.

As described above in the Proposed Action, Sonoma Water and the USACE will jointly monitor and adaptively manage these existing habitat enhancement sites for 10 years post-construction. After 10 years, Sonoma Water will assume long-term maintenance responsibility for the entire project footprint. The habitat sites will be restored to their as-constructed condition and adaptive management will result in changes to the as-constructed project design to better meet project objectives.

The degree of beneficial habitat impacts realized from the previously constructed restoration sites in Dry Creek depends on the duration, magnitude, and frequency of high flows that occur during flood control releases as well as the water supply flow regime (see Section 2.5.1.2). As discussed in the Environmental Baseline Section, Dry Creek transports high quantities of sediment. This high sediment load combined with sustained elevated flows from WSD releases result in a high risk of compromising the structural integrity and, therefore, the effectiveness of enhancement reaches. As part of their feasibility studies, Inter-Fluve (2010) concluded there is a high risk of off-channel habitat in the lower reaches of Dry Creek becoming compromised through sedimentation. caused by frequent and moderately high flows, (750 to 1500 cfs). However, Sonoma Water and USACE have since found that all reaches are prone to such compromise. For instance, immediately after a sustained, week-long, flood control release of 4,000 cfs in the spring (April to May) of 2024, the USACE reported that a newly constructed side channel in the upper reach of Dry Creek (just below the confluence of Pena Creek) had been completely filled in with approximately three to four ft of gravel (Church 2024). During flow ramp-downs after this event, several isolated pools containing stranded fish were discovered at this site where approximately 902 juvenile steelhead and 14 Chinook salmon smolts were rescued by USACE and moved into more suitable habitat nearby.

2.5.2.2 Effects of Dry Creek Habitat Enhancements on Species

The significant increase of area of habitat enhanced since 2008 should reduce the percentage of fish that will be flushed downstream during typical summer flows in Dry Creek (110 to 175 cfs). Due to fish monitoring challenges in Dry Creek, there is no way to discern exactly how many juvenile salmonids are displaced.

As described under Section 4.4.4 of the BA, 4.5 miles of the 6 miles of habitat enhancement that were included as an RPA in the 2008 Opinion were completed by Sonoma Water and USACE within the allotted 12-year period. Previous enhancement targets were designed to ensure adequate availability of winter and summer rearing habitats for juvenile steelhead and coho salmon. Satisfying the enhancement targets is needed to ensure adequate available habitat and to avoid increased competition for resources within the otherwise limited amounts of winter and summer rearing habitats available, which could further impair juvenile survival rates for both species over several generations.

Monitoring conducted in Dry Creek suggests that coho salmon and steelhead abundance is not currently limited by the availability of instream rearing habitat. Based on the results of recent validation monitoring, there is clear evidence that juvenile salmonids and steelhead are utilizing the completed 4.5 miles of habitat enhancements in Dry Creek (Table 4-19 of the BA). Nearly all life stages of all 3 species have been observed using the enhanced habitat reaches. Additional analysis of this data estimates that juvenile steelhead occupy newly constructed side channels at average densities of 1.0 fish/ft^2 (range 0.62 fish/ft^2 to 1.7 fish/ft^2) and in the mainstem of Dry Creek at 0.62 fish/ft^2. Although the density estimates are uncertain due to sampling challenges, the average population density for enhanced sites was greater than for unenhanced sites. The densities of juvenile steelhead and coho salmon observed within the enhancement sites do not appear to be near carrying capacity or at a level that would suggest impacts on survival from increased competition for resources (see Table 4-18 of the BA).

Restoration features such as LWD, side channels, and back water alcoves will provide habitat refuges for juvenile coho salmon and steelhead to avoid predators, escape high water velocities, and find food. Although Chinook salmon juveniles spend a relatively short time (compared to coho salmon and steelhead) rearing in freshwater before migrating to the ocean, they will likely benefit from habitat enhancement in Dry Creek as well because of the increased shelter opportunities the habitat features provide.

While it is clear that completed enhancements have met habitat metrics (Table 16), and have resulted in the presence of salmonids in most reaches, and increases in the density of juvenile steelhead and coho salmon in the enhanced habitats (Sonoma Water 2024c), uncertainties remain regarding the benefits to coho salmon. Coho smolt and juvenile stocking into Dry Creek, and Dry

Creek enhanced habitats respectively (as part of the RRCSCBP) have not resulted in the expected returns to the DCFH. The enhanced habitats were not specifically designed to provide smolt habitat rearing benefits and juvenile stocking into enhanced habitats have not provided the expected adult coho salmonid return. While survival studies conducted by Sonoma Water have documented fair coho salmon survival in Dry Creek, survival between the confluence of Dry Creek and Mirabel Dam has been documented as low, indicating that other factors (substantial predation of juvenile coho salmon within the Wohler pool) may be limiting the survival of juvenile and smolt coho salmon, negating the benefits of increased habitat potential in the enhanced Dry Creek habitats (Sonoma Water 2024a).

Based on the available information, NMFS concludes that maintaining the functionality of these restored habitat reaches in Dry Creek (and Dry Creek tributaries) is vital to the survival and recovery of Russian River coho salmon. Not only do these enhancement reaches mitigate the effects of high flows and lack of suitable rearing habitat within Dry Creek, they also provide adaptive management flexibility for the RRCSCBP. During drought years, many of the Lower River tributaries that contain suitable habitat (habitat with the PBFs necessary to sustain CCC coho salmon) dewater in early summer, and become a series of disconnected pools. This creates a situation where there are limited release locations for coho salmon broodstock and the newly restored Dry Creek with its suitable water temperatures, and higher survival rates than those in the mainstem Russian River, becomes the primary alternative for releasing smolts and optimizing their chances of survival. The recent discovery of New Zealand mud snails in the Russian River watershed has further restricted stocking locations, with Dry Creek remaining one of the primary release site alternatives for coho salmon smolts.

Due to the complex climate, hydrology, and sediment dynamics in Dry Creek, continued monitoring and adaptive management of constructed habitat enhancement reaches, as described above, will be conducted. Many enhanced reaches are prone to compromise in unpredictable ways. For example, extensive monitoring will be required to further understand the evolving dynamics between constructed habitat-enhanced features and the pool isolation/stranding that can occur as a result of down-ramping activities. Most beached fish will die in less than 10 minutes due to asphyxiation, although smaller fish can survive in interstitial spaces between the substrate if subsurface flow exists (Nagrodski et al., 2012). Stranded fish are more likely to be eaten by predators or harmed by poor habitat conditions in the relatively small pools to which they are confined.

Therefore, while it is anticipated that the 4.5 miles of restored habitat in Dry Creek will provide significant benefits for all life stages of coho and Chinook salmon and steelhead populations, there may also be instances where juveniles and fry become trapped during or after ramping operations and require rescue and relocation. Based on the stranding event that occurred in the spring of 2024 discussed above, NMFS estimates that up to 50 juvenile coho salmon, 200 juvenile Chinook salmon and 1,000 juvenile steelhead may require rescue and relocation from isolated pools, within habitat enhancement reaches in Dry Creek during downramping releases from WSD in late winter/early spring. The frequency of these stranding events depends on climatic conditions and the application of FIRO at Lake Sonoma. Based on historical data, NMFS expects these rescues could be necessary in up to 5 of the 10 years covered by this Opinion.

2.5.2.3 Effects of Proposed Phase III Alternatives - Within Dry Creek and/or in Lower Tributaries on Critical Habitat and Species

The USACE and Sonoma Water propose to complete Phase III of the Dry Creek Project. However, as detailed in the Proposed Action, completion of this phase is dependent on acquisition of real estate interests and is unlikely at this time. Due to this uncertainty, the USACE and Sonoma Water have agreed to form an inter-agency decision-making group (a technical advisory committee, separate from the TAC established by USACE to advise on turbidity issues) to either: 1) finalize the approval processes required to make changes to the existing Dry Creek Project, and/or 2) to participate in the development and implementation of alternatives, including funding a habitat enhancement project(s) in the Lower River tributaries.

As discussed in the Proposed Action, due to fiscal and process constraints, the USACE may not be able to pivot their original restoration funding to efforts outside of Dry Creek. Therefore, another alternative being considered (in addition to restoration in the Lower River tributaries) is to make changes to the existing Dry Creek Project. Changes considered would maintain the intent of the original Project and could include additions or modifications to existing enhancement sites to ensure habitat enhancement performance and/or increase habitat value. All decisions will be based on empirical data from post-implementation monitoring and fully vetted through the TAC with final review and approval by NMFS.

NMFS expects all decisions to be finalized and funding mechanisms to be in place for implementing larger restoration project(s) no later than 5 years from the signing of this Opinion. Therefore, any expected habitat benefits provided by the selected project(s) would not be realized for at least an additional five to seven years. Because of the critically endangered status of coho salmon and due to the delay in implementing past and future restoration activities that will contribute to recovery of this species, it is important that Sonoma Water take actions to promote recovery prior to year five of the Proposed Action. A smaller-scale habitat enhancement project in one of the tributaries will be funded within one year that will provide smaller-scale benefits in a shorter period of time. These proposed projects are all in the early stages of development and quantitative metrics, such as square meters, linear feet restored, or miles of reconnected habitat, will not be finalized until project designs are available, thus cannot be definitively evaluated here. However, based on NMFS' familiarity with the results of similar projects (see Cederholm et al., 1997; Solazzi et al., 2000; Roni and Quinn 2001; Roni et al., 2005), NMFS expects that selected projects will increase the potential numbers of juvenile coho salmon and steelhead that can rear within a unit area of these enhanced stream segments.

As with the goals and objectives of the original Dry Creek Project (see below), the primary benefits provided by completed restoration projects would be summer and winter habitat improvements for juvenile coho salmon and steelhead, and to a lesser extent, Chinook salmon. All of the projects currently being considered for implementation as part of the Proposed Action will address priority actions identified in Recovery Plans (NMFS 2012, 2016d). The overall goal for the Dry Creek Project remains: to reconnect the channel to the floodplain and to restore the quality and diversity of aquatic and riparian habitat along lower Dry Creek, below WSD. NMFS expects the restoration of aquatic and riparian habitat will assist with the recovery of CCC coho salmon and CCC steelhead. Specific project objectives are:

- restore instream and habitat floodplain complexity and increase cover to benefit aquatic species;
- improve lateral instream-floodplain connectivity;
- reduce non-native vegetation and increase native riparian vegetation successional complexity in order to promote habitat diversity for riparian wildlife, to provide food and cover for aquatic wildlife, and to shade Dry Creek and associated floodplain features such as backwaters and side channels; and
- restore high quality instream, riparian, and floodplain habitat conditions along areas of Dry Creek's mainstem to benefit native and special status fish and wildlife species throughout their life cycle.

Based on the available information, NMFS expects that these new habitat enhancement reaches will help ameliorate the reduction in available rearing habitat PBFs caused by high summer flow releases in Dry Creek. Sonoma Water and/or the USACE will contribute to habitat enhancement projects that other restoration specialists will implement and manage based on the quality of summer and winter rearing habitat for individual sites. The project design for the chosen habitat enhancement project(s) will include geomorphic, hydraulic, biologic, and engineering analyses. In an attempt to estimate an equivalent quantitative area that will be selected and restored as part of the Phase III Alternatives, NMFS is expecting that at least all six miles of the RPA included in the 2008 opinion (see above) of habitat that would have been completed in Dry Creek (roughly 82,020 ft^2, see above) will be pursued. However, a specific project(s) will be decided upon based on more comparative and qualitative metrics during the TAC decision-making process. For example, less overall area may be restored if similar or greater benefits to salmonids can be achieved and maintained.

Maintaining existing enhancement sites in Dry Creek as well as implementing additional restoration sites that meet the same objectives as the original project as part of Phase III alternatives will significantly enhance rearing habitat PBFs for the coho salmon and steelhead populations in the Dry Creek watershed as well as the broader Russian River watershed. These enhancements will likely also increase the abundance and population growth rates of CCC coho salmon and CCC steelhead in the Russian River watershed.

2.5.2.4 Short-term Adverse Effects of Dry Creek Habitat Enhancements (including Phase III Alternatives) to Critical Habitat and Species

Detailed descriptions of BMPs and conservation measures that are part of the Proposed Action can be found in Sections 3.4.2.1 through 3.10 of the BA and are hereby incorporated into the Proposed Action by reference. NMFS has collated a list of these measures and included it as Appendix B of this Opinion. The Proposed Action includes implementation of these BMPs to further avoid and minimize impacts to listed fish and their designated critical habitat due to impacts that are likely to occur as a result of activities under the Proposed Action. BMPs include such measures as: June 15 to October 15 work windows, length limitations for streambank stabilization, herbicide use restrictions, erosion control measures, salmonid protection measures during dewatering/relocation.

Water Quality

Implementing restoration activities in and near streams has the potential to cause turbidity and sedimentation, as well as the release of contaminants into aquatic habitat, resulting in impacts to water quality. NMFS anticipates that juvenile Chinook salmon, coho salmon, and steelhead would be exposed to small, short-term, pulses of turbidity in relatively small portions of the Action Area affected by the maintenance of current and future Dry Creek habitat enhancements, including implementation and maintenance of Phase III alternatives that meet the same objectives as the original project. These pulses may occur either: 1) immediately during construction activities that require dewatering; or 2) when sediment from construction activities is remobilized after settling in a dry channel.

Deposition of fine sediments can reduce incubation success (Bell 1991), interfere with primary and secondary productivity (Spence et al., 1996), and degrade cover for juvenile salmonids (Bjornn and Reiser 1991). Chronic, moderate turbidity can harm newly-emerged salmonid fry, juveniles, and even adults by causing physiological stress that reduces feeding and growth and increases basal metabolic requirements (Bjornn and Reiser 1991; Servizi and Martens 1991; Spence et al., 1996). Sedimentation leads to increased substrate embeddedness and a reduction in the depth, volume, and frequency of pools. The overall effect of high levels of sediment input is a substantial reduction in the quality and extent of spawning gravels and deep-water refugia for adults and reduced survival of eggs and alevin (Meehan and Bjornn 1991). Sediment deposition can alter macroinvertebrate community composition and reduce the density, biomass, and diversity of aquatic invertebrates available to foraging juveniles. As visual predators, turbid conditions can reduce the foraging efficiency of salmonids thereby reducing growth rates if conditions continue for long periods (Shaw and Richardson 2001).

Based on the likely magnitude of the sediment and turbidity generated during construction of the restoration actions described above, NMFS anticipates that coho salmon, steelhead smolts, and rearing juvenile salmon and steelhead within the Action Area may be affected by short-term increases in turbidity and sedimentation. For example, these pulses of turbidity may cause fish to temporarily move downstream or upstream of the project area to avoid the turbidity. Based on our review of the scientific literature and familiarity with the levels of turbidity likely from these types of projects, NMFS does not anticipate these pulses of increased turbidity will reach lethal levels described in the literature, but may result in salmon and steelhead temporarily vacating preferred habitat areas and temporarily reducing their feeding efficiency (Berg and Northcote 1985; Servizi and Marten 1992; Sigler et al., 1984; Humboldt County 2002, 2003 and 2004; Gregory and Northcote 2003; Harvey and White 2008). Similarly, the amount of sediment likely generated by these restoration actions is unlikely to result in impairing PBFs of salmonid habitat to the point of reducing habitat volume or meaningfully reducing aquatic invertebrate production.

The behavioral modifications affecting juvenile fish will likely result in temporary occupation of less suitable habitat, temporary reduced feeding, and potentially greater intra- and interspecific competition for short periods of time. Along with the potential for a short-term negligible increase in predation risk, these temporary behavioral modifications are unlikely to have meaningful impacts on the fitness of individual fish.

Construction operations in, over, and near surface waters have the potential to release debris, hydrocarbons, concrete, wood preservatives, fuels, and similar contaminants into streams. Spills, discharges, and leaks of these materials can enter streams directly or via runoff. If introduced into streams, these materials could impair water quality by altering the pH, reducing oxygen concentrations as the debris decomposes, or by introducing toxic chemicals such as hydrocarbons or metals into aquatic habitat. Oils and similar substances from construction equipment can contain a wide variety of polynuclear hydrocarbons and metals. Polynuclear hydrocarbons can be acutely toxic to salmonid fish and other aquatic organisms at high levels of exposure and can cause sublethal adverse effects to aquatic organisms at lower concentrations (Heintz et al., 1999; Incardona et al., 2004; Incardona et al., 2005; Incardona et al., 2006).

As proposed, USACE and Sonoma Water have committed to apply BMPs to address spills and prevent the introduction of contaminants into Dry Creek (and Lower River tributary) waters. The proposed dry season work window from June 15 to October 15 will limit hazardous materials exposure to juvenile salmonids and eliminate potential for contaminants to adversely affect more sensitive life stages. As proposed, proper storage, treatment, and disposal of construction materials and discharge management is expected to substantially reduce or eliminate contaminants entering streams from runoff. Due to these measures, conveyance of toxic chemicals into waters from implementation of any proposed projects will be minimized.

We cannot estimate the precise number of individual juvenile CCC coho salmon, CCC steelhead, and CC Chinook salmon that will experience adverse effects from exposure to contaminants. Furthermore, not all exposed individuals will experience adverse effects. However, available information indicates that impaired water quality that would likely occur as a result of restoration or channel maintenance activities will be limited to a few small, localized areas. Although it is not possible to estimate precisely how many, we expect that only a very small proportion of juvenile salmonids and steelhead will experience harm (injury or mortality due to poor water quality) in these dispersed locations or across the broader Action Area.

Water Quantity

Implementing proposed restoration actions in the Action Area will, in some cases, require temporarily dewatering small stream segments. Dewatering may affect juvenile salmonids and steelhead by temporarily preventing them from accessing the work area for cover and forage. Benthic (bottom dwelling) aquatic macroinvertebrates, a salmonid food source, may be killed, or their abundance reduced when creek habitat is dewatered (Cushman 1985). However, effects to aquatic macroinvertebrates resulting from streamflow diversions and dewatering will be temporary because construction activities will be relatively short-lived. Rapid recolonization is expected following re-watering and typically occurs within one to two months (Cushman 1985; Thomas 1985; Harvey 1986). For this reason, we expect the function of benthic habitat will return to pre-project levels before adults and smolts use the Action Area for migration. The effect of macroinvertebrate loss on juvenile salmonids is likely to be negligible because food from upstream sources (via drift) would be available downstream of the dewatered areas via streamflow diverted around the project work sites. Thus, NMFS expects fish will be able to find food and cover outside of project work sites as needed to maintain their fitness during construction activities.

Fish Collection, Relocation, and Dewatering

If stream reaches are dewatered to facilitate habitat restoration activities, capturing and relocating fish would be conducted as part of the Proposed Action to minimize injury and death to listed salmonids. Whether or not an individual project requires dewatering (and, therefore, fish collection and relocation) depends on the location, timing, and type of proposed project. As proposed, in instances where dewatering is necessary, streamflow will be diverted around the project site and fish will be captured and relocated to a stream reach outside of the work area. The Proposed Action restricts the work window for these activities to June 15 through October 15. This work window, along with the location of these projects in relatively small tributary streams, will largely limit the effects to stream rearing juveniles. Smolts and adult salmonids are unlikely to be present based on their life history timing. Additional BMPs proposed for fish capture and release, including avoidance of work when stream temperatures are high, are based on standard NMFS guidance to reduce the adverse effects of these activities.

Fish collection and relocation activities pose a risk of injury or mortality to rearing juvenile salmonids. Any fish collecting gear, whether passive (Hubert 1996) or active (Hayes et al., 1996) has some associated risk to fish, including stress, disease transmission, injury, or death. Given the variable densities of salmonids and steelhead throughout the Action Area, the number of fish encountered will vary with project location, timing, and magnitude. NMFS notes, however, that potential restoration sites are very small relative to the size of the Action Area, and the number of juvenile fish affected is likely to be a small portion of those present in the Action Area. Based on NMFS's review of fish capture and relocation efforts associated with similar project types (Collins 2004; CDFG 2005, 2006, 2007, 2008, 2009, 2010), NMFS estimates injury and mortality to juveniles from these activities to be no greater than 3 percent of the fish captured and relocated at each activity site. Juvenile salmonids that avoid capture in a project work area would likely die during dewatering activities due to desiccation or thermal stress, or by being crushed by heavy equipment during construction operations. However, due to the BMPs that will be used, NMFS expects that the number of juvenile salmonids that would be killed as a result of desiccation or crushing during dewatering and construction activities would be less than one percent of the fish within the dewatered area.

Although sites selected for relocating fish will likely have similar water temperature as the capture site and should have ample habitat, in some instances relocated fish may endure short-term stress from crowding at the relocation sites. Relocated fish may also have to compete with other native and non-native fishes for available resources such as food and habitat. Some of the fish at the relocation sites may move and reside in areas that have more suitable habitat and lower fish densities. As each fish moves, competition is expected to remain localized to a small area or quickly diminish as fish disperse. NMFS cannot accurately estimate the number of fish affected by competition, but does not anticipate that this impact will be large enough to affect the survival chances of individual fish. For example, the use of multiple release sites will help facilitate fish dispersion limiting competition. Once construction is complete, juvenile rearing space will return to the dewatered area with the likely improvements described above.

2.5.3 Effects of Estuary Management and Habitat Enhancements

Under the Proposed Action, when lagoon water surface elevations are in the target range for possible breaching for flood risk management, Sonoma Water will follow the Estuary AMP (Sonoma Water 2024e) to determine whether breaching is appropriate and perform adaptive beach management (artificial breaches) following the decision tree shown in Figures 8-10. The goals of the decision tree are to aid in making decisions to breach or not breach, to maximize habitat conditions for juvenile steelhead acclimating to salinity in spring months, enhance habitat conditions for steelhead rearing in summer, and promote adult migration conditions for all salmonids in fall and winter, while continuing to maintain water levels below the flood risk threshold during closed-inlet conditions throughout the year. Specific considerations for beach management vary throughout the year and are summarized in the Proposed Action (1.3.4.1). One important change since the 2008 Opinion is the recommendation to allow beach closures to persist after water levels reach 7 ft NGVD29 (Sonoma Water 2024e); allowing more prolonged lagoon conditions, which provide enhanced habitat for juvenile salmonid rearing in the lagoon. In addition, the AMP includes annual evaluation to refine management for subsequent years.

Given the adaptive management strategy being employed, NMFS cannot precisely predict the amount and timing of future Sonoma Water breaching actions because surface water elevations in the Estuary and storm conditions are variable throughout the winter, spring, and fall months. Based on the frequency of artificial breaching in recent history, we do not expect that artificial breaching would happen every year or during every season. Information on breaching since the 2008 Opinion indicates artificial breaching actions would typically be conducted in the summer and fall. Artificial breaching occurs, on average, once per year based on recent history. In order to analyze the impacts of the proposed Estuary breaching, NMFS assumes that artificial breaching during the next 10 years would occur at roughly the same frequency as in the recent past.

To perform adaptive management as proposed, monitoring activities will be conducted to understand the conditions in the Estuary and salmonid utilization of the habitat (see 1.3.4); some monitoring activities may affect salmonids. Salmonid monitoring activities that occur in the Estuary include unique tagging (telemetry and PIT tagging), maintaining stationary antenna arrays, seining, and DSMT. Habitat monitoring includes stationary water quality monitoring and intermittent boat-based vertical profiling of water quality. Effects of monitoring salmonids are the same across the whole Action Area; additional information on the effects of monitoring and research on salmonids are described in Section 2.5.6, Effects of Monitoring and Research Activities.

2.5.3.1 Effects of Estuary Management to Critical Habitat- Migration

Effects of artificial breaching on migration habitat from the proposed adaptive management strategy depend primarily on: 1) the timing of breaching relative to natural breaching events, and 2) estuary and river flow conditions that would be available to salmonids at the time.

Artificial breaching changes the amount of time the Estuary is open to ocean tides. As described above in the Environmental Baseline Section 2.4.4.7, the USACE and Sonoma Water's proposal to breach the Estuary bar following the Estuary AMP would result in the Estuary being open to ocean tides: 1) earlier in the fall, 2) intermittently during the summer to promote favorable water quality conditions for juvenile steelhead rearing, and 3) on a limited basis in the spring to maximize migration for salmonid smolts or rearing conditions for juvenile steelhead.

Overall, considering the expected timing and frequency of artificial breaching based on recent history, negative impacts are primarily expected to include negative effects on PBFs of CC Chinook salmon migrating in the fall. However, if Sonoma Water follows the Adaptive Management Plan's decision tree, those negative impacts may be avoided if they delay the breach until passage conditions are favorable (>110 cfs at Hacienda). No effects are expected on CCC coho or CCC steelhead adult migration PBFs. Negative effects of artificial breaching also include increased predation risk by pinnipeds.

Tagging studies of Chinook migration behavior in the Klamath River suggest that as long as passage is not impeded, adult fish make rapid upstream progress through the estuarine lagoon, often in less than 24 hours (Strange 2013). This rapid travel observed through the Klamath Estuary may be due to direct or indirect pinniped predation pressure (Williamson and Hillemeier 2001; Wright et al., 2007). It is unclear whether the salmonids in the Russian River exhibit similar behavior when passage upstream is not impeded.

As described in 2.2.5.5 predation pressure on ESA-listed salmon and steelhead from seals and sea lions has been increasing over the last few decades. Under a closed mouth condition, seals and sea lions forage off the coast of the beach and prey on adult fish holding in offshore waters prior to breaching. Conversely, under open mouth conditions, seals and sea lions may anticipate seasonal migration events and opportunistically prey on salmonids migrating upstream. The number of pinnipeds in the Estuary increases quickly after breaching (NMFS 2008a). Greater numbers of harbor seals (*Phoca vitulina*) are observed in and near the Estuary when the mouth is open (RREITF 1994). Post-breach pinniped monitoring by Sonoma Water has rarely observed pinniped predation on salmonids (Martini-Lamb, Sonoma Water, personal communication, 2025). However, post-breach observations are only made during daylight hours; harbor seals are known to primarily feed from dusk to dawn and rest during the day (Allen *et al.*, 2011).

Increased pinniped presence in the Estuary during open conditions and immediately after breaching may impact salmonid survival or residence time in the Estuary. The amount of increase in predation on migrating salmonid adults by pinnipeds likely depends on the duration that adult salmonids stage in the Estuary due to low river inflows (passage flows), and whether they have sufficient refuge habitat (e.g., LWD) to use as shelter from predation. Currently the Estuary has limited refuge habitat along the mainstem and tributaries; breaching may both increase the pinniped predation for salmonids immigrating through the mouth of the Estuary and for those stuck staging in the Estuary when upstream passage is impeded.

Utilizing the AMP decision tree to prioritize waiting for natural hydrology to drive breaches during fall to optimize adult upstream migration conditions will likely result in habitat benefits for migrating salmonids. Estuarine monitoring has shown that in the weeks following bar closure, the saltwater wedge becomes increasingly anoxic and bottom temperatures begin to increase (ESA, Inc. 2023). Chinook migrating through the Klamath Estuary have been observed to travel within the cold thermo-halocline in the estuarine salt wedge, where water temperatures are lower, presumably to maintain low body temperatures (Strange 2013). Thermal conditions and flow conditions for passage upstream prior to October are generally unsuitable and stressful for adult salmonids in the Russian River. If breaching in the fall is necessary, timing estuarine breaching to promote circulation of cooler and oxygen rich ocean water in the Russian River Estuary would provide beneficial migration conditions to immigrating adult salmonids in the fall and winter.

Based on studies by Sonoma Water (ESA, Inc. 2023) since the 2008 Opinion, increasing flows in the mainstem during the fall usually overtop the bar within 2 to 3 weeks of bar closure (Table 11), which naturally opens the migration route. Adult salmonids typically immigrate upstream following winter storms, when the Estuary would be open due to natural or artificial breaching. Adult salmonids may be delayed from entering the Estuary when relying on natural breaches if drought conditions result in lower inflows to the Estuary that extend closures into the migration season (generally mid-October through March). Natural or artificial breaching that occurs before October is unlikely to impact immigrating adult salmonids because this timing is outside of the period of time when the bulk of adult salmonid migration occurs.

One beneficial effect of artificial breaching for all three salmonids species will be potential increase in upstream migration or downstream critical habitat migration PBF availability. Adult salmonids intending to migrate upstream in the late summer or fall are less likely to find their way blocked by a closed bar at the mouth of the Russian River. Similarly, smolts migrating to the sea in the spring will have more opportunity to enter the open ocean when they arrive in the Estuary if breaching occurs. However, given recent breaching history and seasonal ocean and beach conditions (Section 2.4.2.6), the need for artificial breaches during the spring is expected to be rare and unlikely to provide a net positive impact on outmigrating salmonids, and as noted above, breaching too early in the fall could have negative impacts if upstream flows are too low for passage or water quality negatively impacts migration habitat quality. Thus, these potential benefits may not result in an overall net benefit.

2.5.3.2 Effects of Estuary Management to Critical Habitat- Rearing

As noted above, the information available indicates breaching actions as proposed by Sonoma Water would typically be conducted in the spring, summer, and fall. Steelhead juveniles are most likely to be rearing in the Estuary for extended periods during this time, and are the main focus below. Some coho salmon juveniles may rear in the Estuary for long time periods (Section 2.2), and impacts on these coho salmon are similar to impacts on steelhead. Potential impacts to Chinook salmon juveniles are also expected to be similar; whether a large number of Chinook juveniles utilize the Estuary is unknown. There may also be some increased predation on juvenile salmonids by harbor seals.

Adaptive management to maximize lagoon conditions during the rearing period for salmonids (Figure 7) will provide benefits to the rearing critical habitat PBF for all salmonids in the Estuary as long as lagoon conditions can be maintained with minimal artificial breaching during the summer rearing period. Artificial breaching during the summer rearing period without carefully considering potential impacts on habitat conditions would result in the loss of rearing habitat for an important life history component of steelhead (and likely some coho and Chinook) in the Russian River watershed. Poorly timed breaching promotes cycling of the Estuary as an open and closed system between late spring through early fall, which would perpetuate dynamic conditions that are not conducive for the survival and growth of freshwater-acclimated juvenile steelhead. Section 2.2.3 describes the life history of steelhead in detail, including stages of acclimation. Specific water quality conditions that occur during open and closed estuary states are discussed below (Section 2.4.2.6).

Coho salmon smolts can also utilize the Estuary for high productivity rearing habitat. A recent study demonstrates that hatchery-raised coho released to upper Willow Creek exhibit two distinct life history strategies, with some rearing in upstream habitat while others rear downstream in estuarine habitat (Baker *et al.,* 2025); this has been found to be a strategy of coho in other Northern California estuaries as well (Koski 2009; Wallace *et al.,* 2015). Chinook salmon juveniles may utilize the Estuary for rearing habitat to some extent, however, the population sizes are too small for this to have been assessed to date, and may be a result of limited wetland rearing habitat availability in the Estuary (see 2.5.3.4).

As pinnipeds increase within the Estuary as a result of breaching (described above in 2.5.3.1), a greater number of rearing smolts and juvenile salmonids are potentially eaten by the pinnipeds, although the overall observed predation rate remains low. Each time the Estuary is breached, pinniped haul-out attendance increases; in a prior study pinniped abundance increased from about 15 before to about 95 seals after breaching (Mortenson 1996).

To quantify the effects of beach management on availability of habitat type and quality, ESA, Inc. compared the change in availability of steelhead rearing habitat between open (as a result of managed breaching) and closed conditions between 2000 and 2022 (Sonoma Water 2024f) using the Habitat Viewer (Boughton *et al.,* 2017). Changes in the availability of habitats is reflected as the number of acre-days to reflect both the spatial (acres) and temporal (days) dynamics of inundation. Habitat acre-days is defined as the number of days that an area (acres) of suitable habitat type (littoral, epibenthic, limnetic) is inundated over the model period of record (Figure 52). In this analysis, available acre-days of habitat was compared between modeled beach management described in the AMP and a no beach management scenario. The time estimate was calculated by looking at the stage of the Estuary and beach elevation at the time of the managed breach and estimating the difference time (in days) from that date to when natural breach would be expected to occur. A natural breach was predicted when the Estuary stage would exceed the beach elevation (CDFW 2020, 2023; NMFS 2021i).

A

B

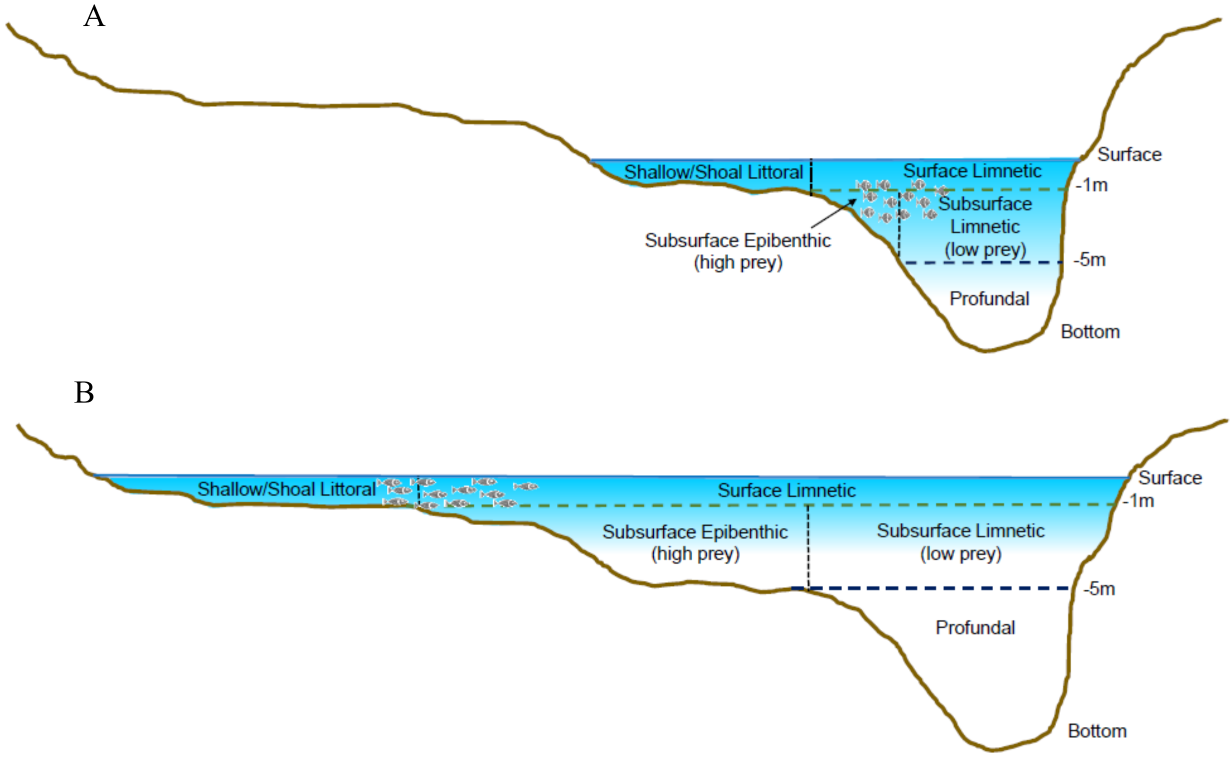

Figure 52. Foraging zones during (A) open conditions and (B) closed/perched conditions in the Russian River Estuary (Boughton *et al.,* 2017).

The habitat analysis supported the notion that there would be an increase in the duration of closure events without beach management actions. Comparing beach management with AMP and no beach management scenarios, under closed inlet conditions there are expected to be reductions in available littoral habitats across all months (Figure 53; Sonoma Water 2024f).

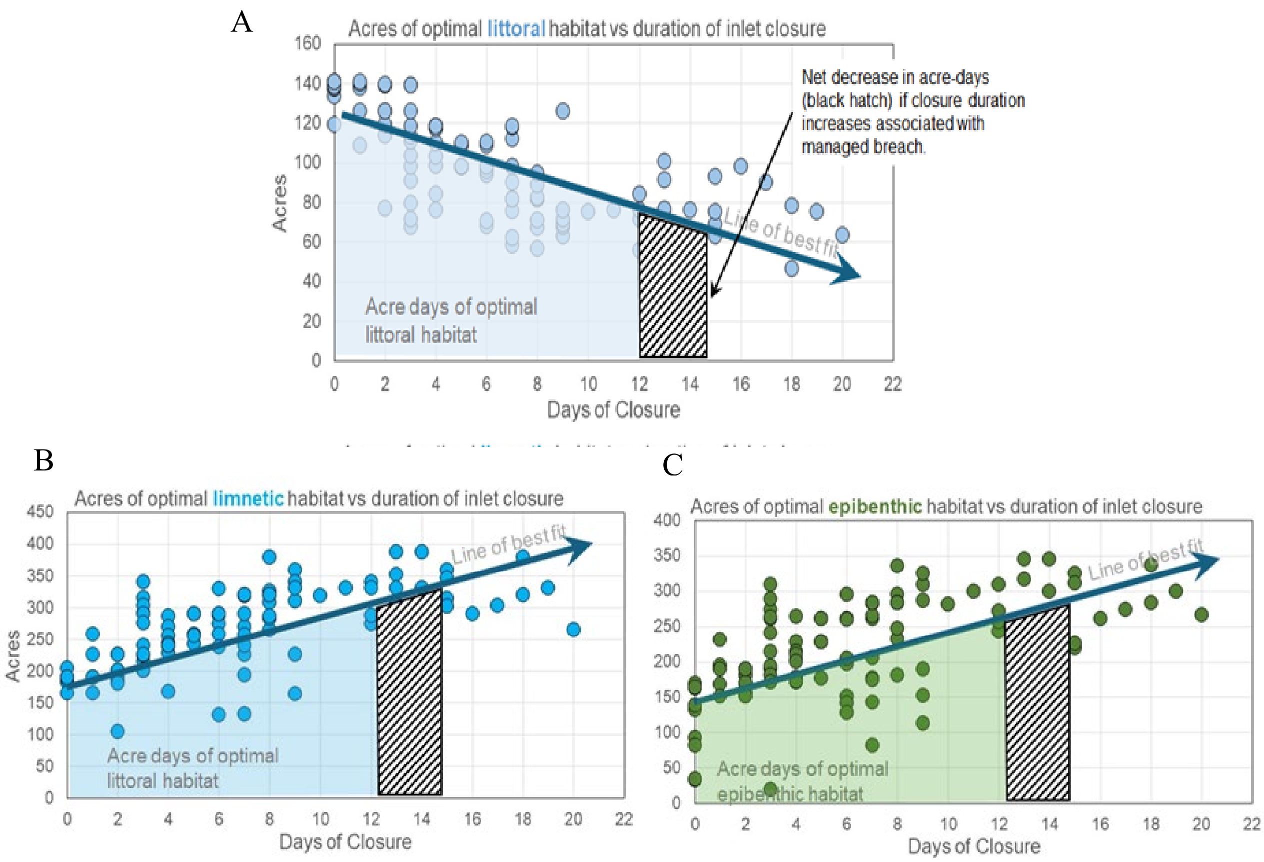

Figure 53. Acres of optimal habitat accessible to salmonids compared to the duration (days) of bar closure for existing (A) littoral, (B) limnetic, and (C) epibenthic habitats. Hatched area under each curve represents the theoretical difference in accumulated acre-days of each habitat type between a managed breach (reduced closure duration) and a natural breach (extended closure duration).

Habitat enhancement has been identified as a management strategy to balance predicted losses in habitat type availability under closed conditions. Results of the analysis show how a conceptual 3 to 5 acres of restored tidal habitat within the Estuary would result in improved conditions under the current management approach (Figure 54). Specifically, the habitat losses identified in Sonoma Water 2024d would be fully mitigated with resulting net gains in habitat acre-days with the addition of the proposed 3 to 5 acres of enhancement for all months except October, where net deficits in the epibenthic habitat type remains under closed inlet condition. Given the bathymetry of the Estuary (see Boughton *et al.,* 2017), there is limited potential for enhancement to provide increases in the availability of habitats beyond the littoral zone. However, littoral habitat offers high prey availability for juvenile salmonids and along with a limited risk of aquatic predators relative to the other habitat zones outlined above.

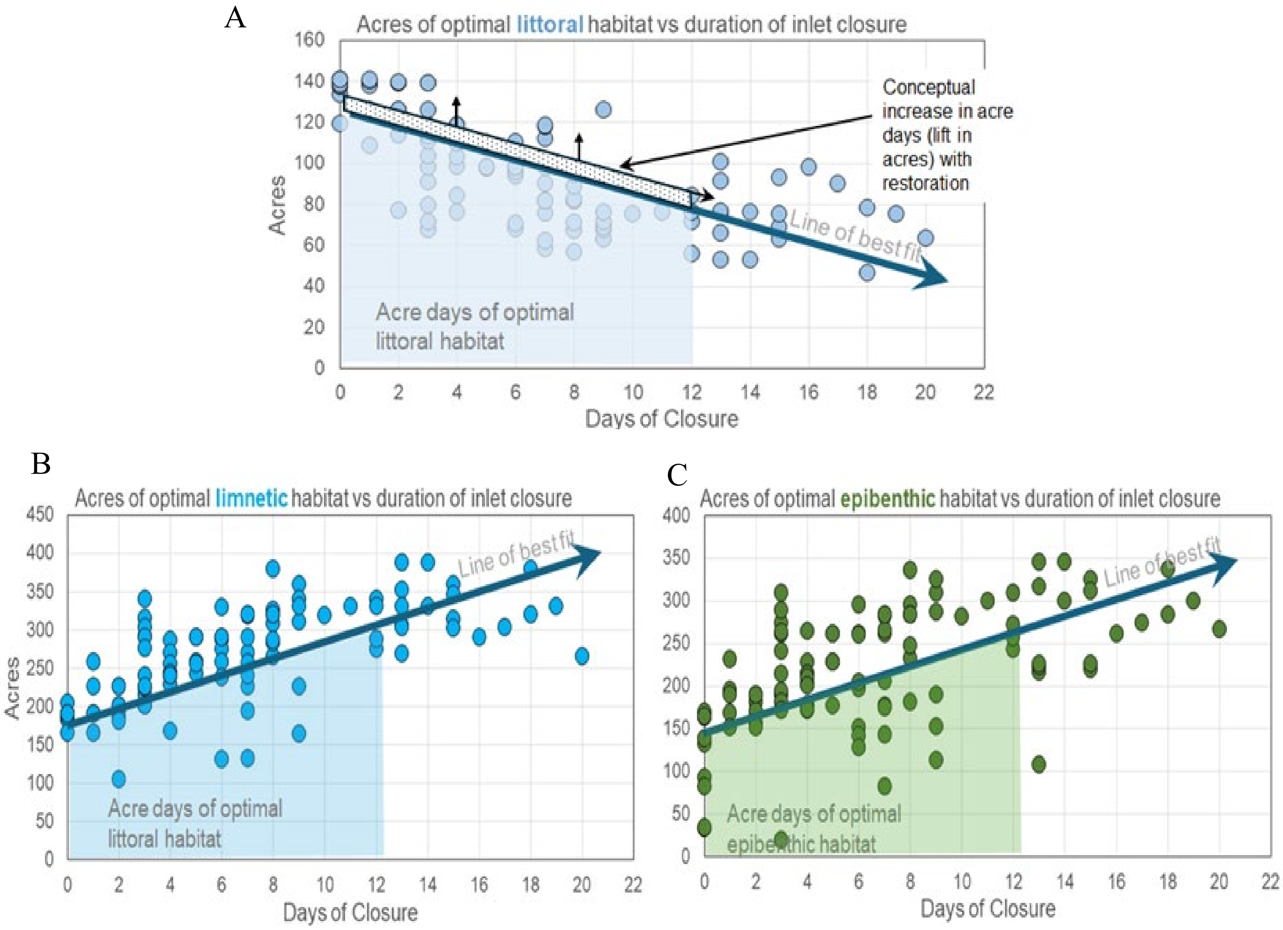

Figure 54. Acres of optimal habitat accessible to salmonids compared to the duration (days) of bar closure for existing (A) littoral, (B) limnetic, and (C) epibenthic habitats. Hatched area above each curve represents the theoretical difference in accumulated acre-days of each habitat type between existing habitats and a conceptual increase in habitat provided through habitat enhancements.

The likelihood of artificial breaching in the spring is low based on recent history. If it is necessary for the Estuary to be breached in the spring or summer, conditions would be created that likely: 1) sweep small juvenile steelhead (and possibly juvenile coho salmon) out to sea before they are ready for the ocean environment, 2) increase salt levels in the estuary to amounts above the tolerance levels of freshwater-acclimated steelhead, 3) expose juvenile steelhead to adverse water quality conditions (DO, temperature), 4) expose juvenile steelhead (and possibly juvenile coho salmon) to greater levels of predation as the freshwater lens at the top of the estuary shrinks, 5) reduce the availability of high-quality littoral rearing habitat. Most of the small juvenile salmonids exposed to these conditions will die. Following the decision tree in the Estuary AMP will help Sonoma Water minimize detrimental impacts, but will not be able to entirely avoid negative impacts to rearing salmonids.

Overall, NMFS concludes that the proposed breaching framework would minimize negative impacts of artificial breaching on the freshwater-acclimated salmonids rearing in the Estuary during the spring and summer. In late summer and early fall, artificial breaching reduces quality littoral habitat that expands the carrying capacity of the Estuary and can result in detrimental impacts to water quality (see 2.5.3.2.2 for details).

2.5.3.2.1 Effects of Estuary Management to Critical Habitat - Water Quality

Changes in water quality as a result of artificial breaching are most likely to negatively impact salmonids rearing in the Estuary and the effects are discussed in detail below. Water quality changes will also stress immigrating salmonids but to a lesser degree so the focus here is on rearing habitat; adults are more physiologically resilient to short term stressors if water quality conditions are not suitable.

Steelhead are the primary salmonid that utilizes the Estuary for prolonged periods for rearing habitat during the summer and early fall when water quality conditions are most prone to change depending on the state of the Estuary (open or closed). Since most information is available about water quality impacts on steelhead, we use what is known about steelhead to reflect water quality impacts on the habitat for all salmonids rearing in the Estuary.

DO, water temperature, and salinity conditions in the Estuary are important to monitor because they can change rapidly after bar closure and these changes can negatively impact salmonid rearing habitat (Section 2.4.2.6). DO concentrations in water affect habitat quality and use, physiological stress, and mortality of fish and other aquatic organisms (Boughton *et al.,* 2017). Utilizing the decision tree to determine when to breach a closed bar will maximize water quality conditions and promote survival of salmonids in the Estuary.

As a component of the habitat rating scheme developed in Boughton *et al.,* (2017) for the Estuary, freshwater and marine-acclimated steelhead juveniles were determined to be minimally, or unimpaired, by DO levels >6 ppm, moderately impaired by DO between 4 and 6 ppm, severely impaired by DO between 3 and 4 ppm. DO below 3 ppm is considered unsuitable under any circumstances, eventually causing death. However, complex interactions between the impacts of variable temperature, salinity, and DO on salmonid energetics mean that these ranges should be applied with caution; for example, moderate DO at high temperatures could result in severe impairment for fish that cannot find suitable thermal or oxygen refuge over time.

When the Estuary is open, DO typically ranges from approximately 7 to 10 ppm in the surface layers, and varies, on average, from 4 to 9 ppm in bottom areas of Estuary pools. Deeper waters of the Estuary can experience hypoxic or anoxic conditions even during open Estuary conditions. However, deep waters most often develop anoxic to hypoxic conditions (<5 ppm) in the weeks following inlet closure, when oxygen is used up by biological processes in the deeper waters and water column stratification prevents mixing between bottom waters and overlying oxygen rich waters. When the Estuary opens after closure, conditions can initially decline throughout the water column when anoxic bottom waters and anoxic waters that accumulate in wetlands (e.g., Willow Creek) are mixed, temporarily reducing water quality (DO) for any fish in the lower Estuary, which can result in fish mortality. This is referred to as an “anoxic mixing event” and requires careful planning of artificial breach timing following the framework described in the Estuary AMP and monitoring for changes in water quality conditions, to avoid rapid degradation of rearing PBFs due to low DO.

As summarized in Section 2.2.3.1, water temperature also influences salmonid growth rates, metabolism, and physiological processes. Rearing steelhead juveniles prefer water temperatures of 7.2-14.4ºC and have an upper lethal limit of 23.9ºC. However, they can survive short periods up to 27ºC with sufficient oxygen and abundant food. Due to the important influence of the cooler marine environment on estuary water temperatures, particularly during the late summer and early fall when mainstem temperatures are relatively high (Section 2.4.2.6), artificial breaching can be beneficial to the thermal component of the habitat required by salmonids that migrate through or rear in the Estuary.

Overall, water quality conditions in the Estuary habitat for salmonid rearing or migration are substantially influenced by the state of the barrier beach. Suitable rearing habitat for salmonids can occur during both open and closed conditions; which condition is more favorable depends most on what the overall state of the habitat conditions are. In general, open conditions promote mixing of cold, oxygen-rich marine water with brackish water in the lower Estuary and a well-mixed water column, but limit the extent of available PBFs of freshwater rearing habitat in the Estuary for freshwater-acclimated salmonids. A closed beach promotes PBFs of lagoon-based rearing habitat in the upper water column for freshwater-acclimated salmonids, but can also enhance poor-quality anoxic bottom water conditions and accumulate lower-quality warm surface waters. As described in 2.5.3.1, breaching too early in the fall may also negatively impact estuarine water quality during Chinook migration.

2.5.3.2.2 Effects of Estuary Management to Critical Habitat - Prey Availability and Foraging

The loss of high quality littoral freshwater habitat as a result of artificial breaching may reduce the carrying capacity of the Estuary habitat for juvenile salmonid rearing. However, studies of prey composition and feeding of the salmonids that rear in the Estuary suggest prey is not limiting their growth rates, regardless of the state (open, closed) of the Estuary bar (Seghesio 2011).

Studies of the diet composition of both steelhead and Chinook salmon juveniles in the Estuary indicate that these fish feed on relatively few taxa of aquatic invertebrates, mainly epibenthic crustaceans and aquatic insects that are common in the Estuary (Seghesio 2011). Accola et al., (2021) also concluded that juvenile salmonid feeding ecology in the Columbia River Estuary is similarly relatively low diversity and primarily composed of epibenthic prey.

The composition of epibenthic prey is driven primarily by bottom salinity and substrate composition (ESA, Inc. 2023). Invertebrate monitoring during the Russian River Estuary Management Project (2010 to 2019) found that prey availability differed more across Estuary reaches (lower, middle, upper) with differing bottom salinity than it did over time, and epibenthic prey composition did not depend on inlet condition. While salinity in the upper and mid water column can change rapidly due to inlet condition, monitoring data show that the salinity gradient in contact with benthic habitat does not vary as much with respect to inlet condition. Under periods of extended bar closure, the increasing freshwater lens can push the lower saline layer further upstream for short periods of time; however, they found this did not change the prey availability after the bar reopened (ESA, Inc. 2023). Over a 10-year study, the annual composition and abundance of invertebrates in the Estuary did not change appreciably regardless of variation in inlet condition (Boughton *et al.,* 2017).

During inlet closure, enhanced littoral habitat formation along newly inundated shorelines was found to be rapidly occupied by epibenthic crustaceans and aquatic insects. The rapid colonization of newly inundated littoral zones is one major benefit of closed lagoon conditions: this enhanced habitat rapidly increases the carrying capacity of the system (Seghesio 2011).

Prey is abundant in the Estuary, and this component of the salmonid rearing PBF does not appear to be a clear limiting factor for any of the salmonids that use this portion of the Action Area based on diet studies and growth rates. Variation in fish growth rates are primarily driven by prey availability and water temperature (Seghesio 2011). Growth rates of individually-PIT-tagged and recaptured juvenile steelhead in the Estuary are high (0.03 to 0.04 inches per day) when compared to steelhead rearing in the upper watershed (Martini-Lamb and Manning 2015; Boughton *et al.,* 2017; Matsubu 2019). The highest growth rates have been found in steelhead recaptured in the lower Estuary (0.05 inches per day; Martini-Lamb and Manning 2015) and has been attributed to more favorable temperatures and abundant epibenthic prey (Fuller 2011 and references therein).

Less data is available for understanding the extent of differences in growth rates between estuary-reared and freshwater-reared Chinook and coho salmon. A recent nine-year study of coho salmon in Willow Creek found higher variation in the growth rates of coho rearing in estuarine habitat in lower Willow Creek than the coho rearing in freshwater reaches (Baker et al., 2025), which suggests there may be greater variation in favorable prey for coho that can increase growth rates. The Estuary also has a potential to serve as nursery habitat for juvenile Chinook salmon, but the population remains relatively small and there is not much data on Chinook salmon growth rates in the Estuary. For the few Chinook salmon measured in the Estuary (n=7, Martini-Lamb and Manning 2015), growth rates between Dry Creek and the Estuary were lower than for steelhead, about 0.02 inches per day. However, growth rates of Chinook salmon recorded in other Estuary systems (British Columbia) can be as high as 0.05 inches per day (Healey 1980), providing supporting evidence that estuaries can be important rearing habitats, capable of supporting high growth rates.

2.5.3.3 Effects of Estuary Management to Species - Chinook Salmon

As described in Section 2.5.3.1, artificial breaching can impact the timing of migration and staging duration of adult Chinook salmon in the Estuary. Fall artificial breaching (September through December) may result in Chinook adults entering the Estuary too soon, necessitating extended staging in the Estuary when poor river conditions (low flows or warm temperatures) impede upstream passage. When staging without shelter (e.g., LWD, boulders) the migrating adult Chinook are prone to higher rates of predation, primarily by pinnipeds (e.g., sea lions). Thus, take is likely to occur if an artificial breach must occur during Chinook migration season between October 15 and December 30th and the following occurs: Chinook migrants are detected in the Estuary after the breach, and the flow rate at Hacienda gage maintains a flow rate of less than 110 cfs for more than seven days post breach. Installation of habitat enhancements to provide shelter during adult migration (LWD/Boulders) will help to minimize passage and predation-related impacts on adult Chinook.

A study of predation by sea lions in the lower Columbia River Estuary found that as the sea lion population increased, the odds of Chinook survival were estimated to decrease by 32 percent for every additional 467 sea lions, in the absence of an increase in alternative prey (Wargo Rub et al., 2019). Extensive studies in the Columbia River in 2000-2002, found sea lions were responsible for mortality of 0.1 to 5.0 percent of returning spring or fall run Chinook, respectively (Scordino 2010). Habitat enhancements included as a Proposed Action in the form of structures (LWD) in the Estuary mainstem would increase survival of migrating Chinook until tributary flows are sufficient for continuing migration upstream.

Breaching is unlikely to have an impact on most juvenile Chinook salmon when they outmigrate through the Estuary during the spring and early summer months since they aren't expected to exhibit extended estuarine residency and the Estuary mouth is most often open during this time. Chinook life history can be found in more detail in Section 2.2.1.

Based on breaching history since the 2008 Opinion and the adaptive beach management plans, most closures and subsequent breaches are likely to occur during the summer and fall months. Russian River monitoring data suggests that few Chinook juveniles currently reside in the Estuary beyond July, and those in the Estuary in spring and early summer have likely smolted (marine-acclimated) and would be large enough to survive in the marine environment. Larger fish would be more resilient to any changes in water quality that may occur when the Estuary is breached.

2.5.3.4 Effects of Estuary Management to Species - Coho Salmon

Adult coho salmon upstream migration into the Estuary primarily occurs between November and January, therefore, artificial breaching would not be expected to negatively impact coho salmon adult migrants since there is a higher likelihood of favorable conditions in estuarine migration corridors and sufficient lower river passage flows during this time. However, prolonged critically dry fall and early winter periods may expose adult coho salmon to higher predation risk, similar to adult Chinook salmon, but likely to a lesser extent.

Coho salmon are most likely to enter freshwater streams to spawn after late-fall or winter rainstorms breach the barrier beach at the river mouth. Coho salmon migrants in the Russian River in early fall may arrive before enough flow is available for migration and spawning in certain tributary streams, and coho may get stuck staging in the upper Estuary until tributary flows signal the presence of spawning habitat. Habitat enhancements included as a Proposed Action in the form of structures (LWD) in the Estuary mainstem would increase survival of migrating coho salmon until tributary flows are sufficient for migration upstream. Should breaching occur later in the coho salmon migration period, adults are likely able to migrate into spawning tributaries because winter rains have increased flows, providing accessibility to the watershed. Additionally, closures during the adult coho salmon migration season (November through January) are historically shorter than those that occur earlier in the fall (September and October) because of the higher rates of increase in Estuary water surface elevation later in the season. This also limits impacts on adult coho salmon migrants.

Coho salmon smolts migrate through the Estuary in the spring. During spring periods, especially in high precipitation years, flow within the Lower River into the Estuary is controlled primarily by natural watershed hydrology rather than reservoir releases. Since smolt migration timing would primarily be driven by natural hydrology rather than the instream releases, any effects of the Proposed Action on coho or Chinook salmon smolt migration are expected to be negligible.

Coho salmon juveniles (freshwater-acclimated) rearing in the Estuary may be impacted either positively or negatively by artificial breaching actions, depending on conditions. As described in more detail above in Section 2.2.2.1, some coho salmon may remain in the Estuary to rear through the summer, while others (marine-acclimated smolts) spend only a few days in the Estuary on their way to the ocean (Koski 2009; Wallace et al., 2015). AMP implementation would promote high quality lagoon rearing conditions in the Estuary during the summer, and would be expected to benefit juvenile coho rearing in the Estuary similar to the benefits described below for steelhead.

2.5.3.5 Effects of Estuary Management to Species - Steelhead

Steelhead are the latest arriving of the three salmonid runs, with adult upstream migration peaking between December and March. The bulk of steelhead adult migration occurs over a period when the Estuary would be naturally open for extended periods in most years, closure events are rare or of short duration, and water quality conditions are generally favorable (e.g., low temperatures), based on observations from recent history (ESA, Inc. 2023). Impacts of artificial breaching on steelhead adults are expected to be negligible.

Under the proposed project, Estuary water surface elevation management may adversely affect steelhead juveniles and smolts depending on timing and conditions in the habitat during artificial breaching events. As described in 2.5.3.2.1, depending on water quality conditions, breaching during the late summer or early fall can trigger anoxic mixing events that can cause stress or mortality of salmonids rearing in the lower estuary (primarily steelhead); AMP implementation aims to minimize the potential for these detrimental impacts. Additionally, proposed habitat enhancements in the lower Estuary may mitigate negative impacts of the Proposed Action through improving water quality during late summer closures, particularly if enhancements focus on improvements to lower Willow Creek (2.5.3.6.1).

During the spring months (specifically the months of March through June) when freshwater-acclimated steelhead typically begin arriving in the Estuary from upstream, management actions will be limited, as described in the AMP, to maximally benefit habitat conditions for steelhead juveniles. Allowing the Estuary to remain closed, at this time, until lagoon water surface elevations approach the 9-ft NGVD29 stage, allows juveniles to acclimate to higher salinities and increase in size before reaching the ocean.

Baseline data in the Estuary demonstrates that juvenile steelhead growth and acclimation to salinity increases through the rearing season from May through October, with the highest growth rates observed in juveniles growing in the lower Estuary (Martini-Lamb and Manning 2015). Depending on the timing of closure and the juvenile steelhead's tolerance to salinity (freshwater- or marine-acclimated), maximizing opportunities for steelhead growth may involve allowing the inlet to remain closed for as long as possible before reaching flood risk stage, or breaching the barrier beach sooner to improve habitat water quality conditions that would benefit marine-acclimated juveniles. The effects of artificial breaching during this period depend on the conditions at the time of breaching: A poorly-timed breach can lead to anoxic mixing and die offs, or a well-timed breach can enhance water quality and improve rearing habitat conditions.

The ecological benefits of naturally functioning lagoons to juvenile salmonids have been documented extensively (see Section 2.4.2.6). NMFS (2008a) previously raised concerns that artificial breaches during the lagoon period may result in the Estuary not fully converting to freshwater conditions, promoting stratified conditions that may reduce habitat function and productivity. However, in the period since the 2008 Opinion, the duration of closure events even in the absence of artificial breaching is often not long enough to allow the lagoon to convert to fully freshwater conditions (ESA, Inc. 2023). These observations suggest that the current instream flow conditions in the Russian River, combined with seasonal changes in ocean conditions driving sandbar stability, do not promote conditions to fully convert the lagoon to freshwater before it naturally breaches (or water levels trigger adaptive management). To facilitate management of the Estuary as a summer lagoon, Sonoma Water has filed petitions with the SWRCB annually since 2010 to change minimum instream flow conditions to improve rearing habitat for steelhead in the Estuary and to provide more favorable conditions for outlet channel adaptive management by Sonoma Water.

The distribution of fish in the Estuary is, in part, based on whether they are freshwater- or marine-acclimated. Under open Estuary conditions, juvenile steelhead experience primarily brackish and saline water in the lower and middle reaches and warm freshwater in the upper reach. Under closed Estuary conditions steelhead experience warm freshwater in the middle and upper reaches. During closed conditions, juvenile freshwater-acclimated steelhead display behavior that suggests the ability to mediate stressful thermal conditions; specifically, they respond to closed conditions by moving greater distances and/or aggregating near thermal refugia (Boughton *et al.,* 2017, and references therein).

As described in 2.5.3.2.2, prey abundance has not been a limiting factor for growth of juvenile steelhead rearing in the Estuary even when water temperatures are high. Simulated growth rates under open and closed mouth conditions also suggest that fish grow fast enough to reach the size for smoltification and increased marine survival during both open and closed mouth conditions (Matsubu et al., 2019). Further studies show that young freshwater-acclimated individuals (e.g., YOY) are also achieving accelerated growth rates and successfully transitioning to the marine acclimated stage within a relatively short period of time as seen in Figure 55.

A. B.

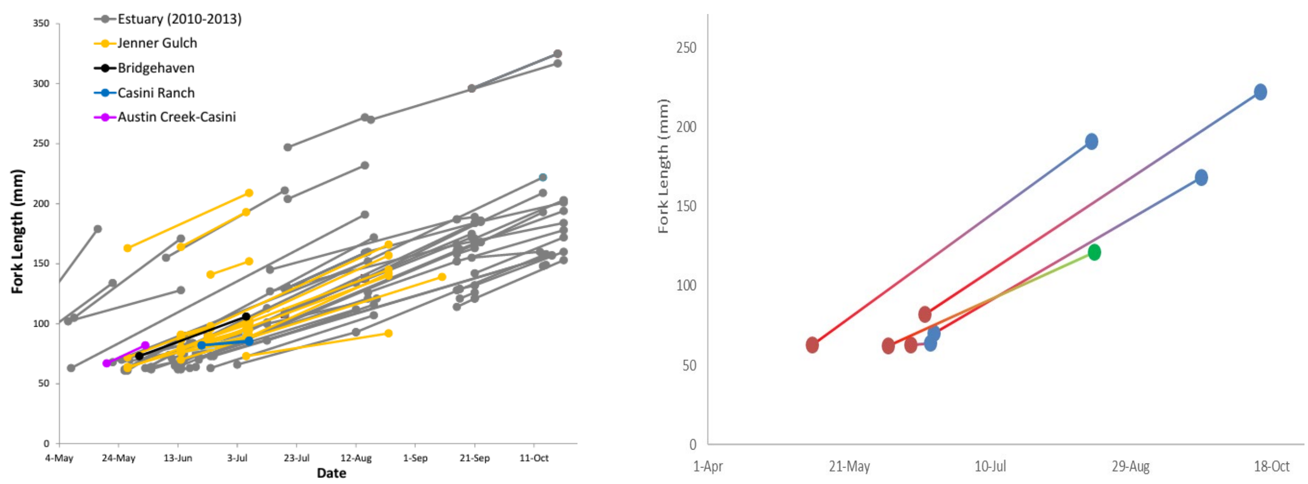

Figure 55. Size at initial capture (left point) and recapture (right point) of juvenile steelhead PIT tagged in the Estuary. (A) Aggregated data from 2010-2014 showing 2010-2013 data across the Estuary and specific sites (colors) from 2014 (Martini-Lamb and Manning 2015). (B) subset of data for 2010-2016 where fish were tagged in the middle or upper Estuary (red points) and then recaptured downstream in the middle (green) or lower (blue) Estuary (Martini-Lamb and Manning 2020).

Steelhead juveniles that rear in lagoons can have higher growth rates and can be a substantial portion of returning adult spawners (Bond et al., 2008; Seghesio 2011). Conservation of Russian River steelhead is likely to continue to depend, in part, upon an Estuary that can support large numbers of rearing juveniles (tens of thousands) with good growth rates that promote better chances of their returning from the ocean as adult steelhead migrants. As described in Section 2.2.3.1, the Russian River watershed is a key component of the CCC steelhead DPS.

The severity of impacts to salmonids in the Estuary depends most on timing of breaching relative to the conditions in the Estuary and species utilizing the Estuary at the time of the breach. Based on analysis of natural and artificial breaching under the current and proposed adaptive management decision tree framework, Sonoma Water may need to artificially breach the Estuary (in advance of a natural-breach).

Given the substantial negative impacts of breaching when freshwater acclimated juveniles from throughout the Russian River watershed would be rearing in the Estuary, Sonoma Water proposes to implement the AMP to minimize artificial breaching during the rearing period. To minimize impacts on freshwater-acclimated steelhead, take will be exceeded if an artificial breach occurs more than 10 days prior to a forecasted self-breach AND if it occurs more than once every 3 years between May 15 - October 15. Based on records of beach closure and artificial breaching since the 2008 Opinion (Sonoma Water 2024d), artificial breaching during this period is unlikely to occur in most years. During this same period (May 15 - October 15), the proposed adaptive management decision tree framework may also result in the implementation of artificial breaches that would be conducted to avoid and minimize naturally degrading water quality conditions for juvenile steelhead and coho salmon.

NMFS concludes that under the proposed breaching using the decision tree, as presented in the Estuary AMP, should minimize the potential for negative breaching impacts on steelhead during most years; however, there are likely to be occasional negative impacts of breaching on steelhead rearing in the Estuary. We anticipate that these negative effects of breaching will be ameliorated by the Proposed Estuary Habitat Enhancements (see below).

2.5.3.6 Effects of Estuary Habitat Enhancements to Critical Habitat

Sonoma Water has included habitat enhancements in the Estuary, as part of their Proposed Action, to mitigate the potential negative impacts of their Beach Management actions. Proposed habitat enhancements in the Estuary include two types: addition of structures to the Estuary (e.g., 2 to 4 LWD, boulders), and enhancing 3 to 5 acres (not to exceed 6 acres) of wetland and/or floodplain habitat (littoral habitat). Enhancement by the addition of structures to the lower, middle, and upper reaches of the Estuary mainstem would enhance habitat by providing shelter for migrating salmonids when they do not have access to passage upstream. These habitat structures will also likely benefit salmonids of all species and life history stages utilizing the Estuary throughout the year. Proposed littoral habitat enhancements targeting juvenile salmonid rearing may include grading areas adjacent to the Estuary, improving hydrologic connectivity, vegetation management, management of the riparian zone, or submerged aquatic vegetation (e.g., eelgrass) management and conservation.

Different benefits would be provided depending on which enhancement actions are implemented (Figure 23, candidate locations). Benefits to juvenile salmonids rearing in the Estuary may include: 1) providing access to inundated floodplain habitat for high flow refugia and expanded feeding opportunities, 2) providing complex low-flow shelter elements, and 3) connectivity to adjacent floodplains or constructed tidal channel habitats. The proposed habitat enhancements would provide connected, low-predation risk, high-forage opportunity habitats, many of which would benefit salmonids over the Estuary's full range of flow conditions. Such conditions are known to maximize juvenile steelhead growth and survival (Boughton *et al.,* 2017).

Floodplain and tidal channel enhancements would be designed to be stable and functional over time and under a wide range of site conditions. They would adapt to the natural fluctuations in tide and streamflow dynamics of the Estuary and would function through climate change driven shifts in sea level, flooding, and temperature. Long-term, these enhancement actions would provide additional climate resiliency for juvenile salmonids and their habitat by functioning across a wide range of potential tides and sea levels. Enhancements would provide critical refugia and feeding habitat for salmonids in the presence of rising sea levels and increased frequency of extreme weather events.

While the proposed enhancement actions will primarily benefit juvenile steelhead, NMFS anticipates that these habitat enhancements will also benefit habitat available to juvenile coho and Chinook salmon in similar ways to those outlined above. This is because all three species share many of the same or similar habitat needs in the Estuary.

Enhancement features using LWD will provide increased shelter/cover habitat at two to four locations, depending on the scale and locations chosen, from approximately the Duncans Mills Bridge to the middle or lower Estuary. Addition of LWD will improve juvenile rearing conditions and will also benefit staging adult salmonids (primarily early-entry Chinook salmon; to a lesser extent, adult coho salmon and steelhead, depending on inflow conditions), as they make their spawning migration.

Implementation of proposed BMPs would result in very small numbers of listed juvenile salmonids being injured or killed during placement of LWD or boulders if they are placed on top of their hiding places in streams. Sonoma Water will follow BMPs (See Appendix B and Sections 3.4.2.1 through 3.10 of the BA) to minimize impacts on salmonids when LWD and boulder structures are installed. NMFS cannot precisely calculate the number of juvenile salmonids that may be injured or killed, but expects the numbers to be small based on steelhead densities in recent surveys (Section 2.4.3.3). Anticipated harm may occur if structures are dragged more than 10 yards across or along stream beds in flowing or standing water, or if heavy equipment drives through flowing or standing water within stream banks to reach enhancement sites. Such activities may crush listed salmonids outside of the structure placement site. Similarly, digging in stream beds or stream banks with heavy equipment without relocating listed salmonids would also exceed anticipated take.

Preliminary evaluation of enhancement sites suggests most work will not occur in a wetted channel. For those sites requiring work within aquatic habitat, Sonoma Water will relocate any listed salmonids. Work in the intertidal zone will require use of construction equipment, and will require dewatering sections of habitat and fish relocation and exclusion. NMFS expects that juvenile steelhead and some coho salmon will be captured and relocated during enhancement activities requiring in channel work. Due to the lack of exact information on what site(s) will be selected for enhancement and the respective timing of work or salmonid densities at the project sites, NMFS cannot precisely determine the number of salmonids that will need relocation.

Beach Management utilizing the Estuary AMP and habitat enhancement of a 3 to 5-acre site (no more than 6 acres) is predicted to fully mitigate losses of optimal habitat conditions due to artificial breaching during primary months when juvenile Chinook salmon, coho salmon, and steelhead may be rearing in the Estuary (see Section 2.5.3.2). However, there are tradeoffs between net increases in littoral and net decreases in epibenthic habitat types. Net increases in acres days for optimal habitat types are predicted to occur in months when juveniles would be expected to be more dependent on estuarine rearing (May through September; less potential for steelhead only in October). Net losses in acre-days of epibenthic habitat function associated with closed inlet conditions in the month of October are not anticipated to result in significant habitat deficits because juvenile salmonids (steelhead and coho salmon) in the Estuary are known to be less reliant on Estuary rearing and able to re-distribute to other habitats as riverine temperature conditions begin to cool in the fall. Adult Chinook salmon would only occur in the Estuary during their upstream migration season, which requires an open estuary inlet condition.

A number of initial sites have been identified as potential areas to implement the 3 to 5 acres of habitat enhancement as part of the RRHFA and Sonoma Water's overview of potential enhancement activities are described in more detail below (Section 2.5.3.6). Impacts of construction activities to implement habitat enhancement/restoration activities to benefit adult salmonid migratory and juvenile rearing habitat in the Estuary are expected to be minimal, and measures will be taken to minimize impacts of construction activities in the Action Area. Details on the potential impacts of construction activities, dewatering, and fish relocation on critical habitats and species are discussed in Section 2.5.2.4 *Short-term Adverse Effects of Dry Creek Habitat Enhancements (including Phase III Alternatives) to Critical Habitat and Species,* and are applicable to habitat enhancements in the Estuary. Impacts specific to potential enhancement sites are included below, and a map of the enhancement sites is included in Figure 23.

2.5.3.6.1 Willow Creek Marsh and Lower Channel

As described above in Section 2.5.3.2.1, low oxygen levels negatively affect fish and other aquatic life, therefore, the goal of enhancement actions in Willow Creek Marsh would be to focus on improving the water quality (oxygen, thermal refugia) in the habitat to support juvenile steelhead and salmonids. Coho salmon are known to use the creek (CSG and Sonoma Water 2023b; Baker *et al.,* 2025), and would be the main co-beneficiaries of the habitat enhancements.

The floodplain along lower Willow Creek does not have a visible dendritic channel network like those commonly associated with tidal marsh geomorphology. High sedimentation from the creek's watershed may have filled in some historic channels. In the absence of such channels, the geomorphic suitability and stability of such channels should be considered as part of enhancement development. Habitat enhancements in Willow Creek could include excavating channels to increase the aquatic habitat for juvenile salmonids, as well as to improve hydraulic connectivity to the floodplain and reduce the potential for anoxic flushing events.

2.5.3.6.2 Patty's Rock Floodplain

The floodplain at Patty's Rock could provide enhanced littoral habitat and has capacity for enhanced habitat in response to sea level rise. Because a substantial portion of the site's area is at higher site elevations, the site has ample capacity for shoreward expansion of wetlands habitat in response to sea-level rise. Even with three feet of sea-level rise, about half the site would remain in the intertidal and supratidal ranges and about a fifth of the site would still be in the flood stage and upland ranges.

Connectivity could be enhanced by excavating a network of tidal channels to provide fish habitat and access to adjoining floodplains. A portion of the floodplain could be graded to lower elevations to increase its inundation frequency. The site's current vegetation, which is geared towards cattle grazing, could be replaced with native vegetation to create an ecotone from wetlands to uplands vegetation. This site is adjacent to Highway 1, which would require additional considerations for restoration design, such as the need to treat road runoff so as to not deliver impaired water to the restoration site, and the need to protect the highway from future flood and scour hazards that are exacerbated by sea-level rise.

2.5.3.6.3 Goat Hill Floodplain

The Goat Hill floodplain has potential to provide enhanced littoral wetland habitat supporting marine-acclimated (open conditions, most common) species and has some capacity for enhanced habitat in response to sea level rise. Given the frequent marine conditions at this location near the Estuary mouth, this site could also be a candidate for seagrass restoration. The site would be most beneficial to marine-acclimated species, but also benefit freshwater-acclimated species during beach closures and formation of the freshwater lens.

Since the site is aligned roughly parallel to the Russian River channel and is only at most a thousand ft wide, this site is well-situated for hydrologic connectivity with the lower Estuary. Existing channels into the site could be enlarged with excavation to extend the channel network, thereby enhancing limnetic fish habitat within and access to the adjoining littoral floodplain. In addition, the berm along the western portion could be breached or lowered to enable connectivity across this portion's border with the river over a wider range of water levels. The geometry of the enlarged channel network could be based on reference channel networks.

2.5.3.6.4 Penny Island

Penny Island is also close to the Russian River's mouth and has potential to provide enhanced littoral wetland habitat supporting marine-acclimated (open conditions, most common) species and has some capacity for enhanced habitat in response to sea level rise. Given the frequent marine conditions at this location near the Estuary mouth, this site could also be a candidate for seagrass restoration.

Tidal channels could be added to the site as enhancement measures to further increase connectivity. Such channels would enable connectivity through more of the tidal cycle and create additional habitat complexity for rearing salmonids. Non-native vegetation on the site could be replaced with native vegetation.

2.5.3.7 Effects of Estuary Habitat Enhancements to Species

As noted in Section 2.4.2.6 the Estuary currently has relatively limited wetlands. Estuarine wetlands in the Pacific Northwest provide habitat that can enhance subsequent ocean survival of rearing and migrating salmon (*Oncorhynchus* spp.) (Reimers 1973; Macdonald et al. 1988; Levings et al. 1989; Solazzi et al. 1991). Habitat enhancements focused on enhancing littoral and epibenthic habitat in the limited estuarine wetlands that are present in the Estuary should be considered as high priority enhancement areas for supporting Russian River populations of coho and Chinook salmon, in addition to steelhead. The 3-5 acres of habitat enhancements and the addition of structures to the Estuary mainstem (e.g., LWD, boulders), would benefit juvenile salmonid rearing, adult migrating salmonid survival rates as well as other life history stages throughout the seasons.

Steelhead juveniles utilize the Estuary for extended periods from spring through fall for rearing (Section 2.2.3). Providing enhanced habitat complexity for additional shelter from predators (LWD, boulders), improve habitat quality (e.g., water quality, riparian shade), or support prey and foraging opportunities (enhanced littoral habitat) would benefit juvenile steelhead as they rear within the Estuary.

Studies of coho salmon survival rates in 2021, 2022 (dry years), and 2023 (wet year) suggest that survival rates between Dry Creek and Patty's Rock (middle reach of the Estuary) can be low (Sonoma Water 2024a). Enhanced habitat complexity provides additional shelter from predators (LWD, boulders), improves habitat quality (e.g., water quality, riparian shade), and supports prey and foraging opportunities (enhanced littoral habitat), and overall, would broadly benefit coho salmon as they travel through or rear within the Estuary.

Currently, few Chinook are known to rear in the Estuary, likely due in part to the relatively low abundance that are found in the Russian River and due to the small contribution of what might be considered to be high quality estuarine habitat (wetland, riparian shade, in-water habitat structures). Chinook salmon survival rates in the Pacific Northwest have been found to be positively related to the percentage of estuary habitat in pristine condition (Magnusson and Hilborn 2003); therefore, the habitat conditions in the Estuary are important for supporting higher survival rates for Chinook salmon that utilize the Russian River. Restoration of estuary wetlands in other watersheds (e.g., Salmon River) provided important opportunities for expanded life history variation for Chinook salmon in the region, and after restoration there was a greater expression of estuarine-resident behaviors than was observed before wetland habitats were restored (Bottom et al., 2005). Habitat enhancements focused on restoration of wetlands in the Estuary are expected to have a similar effect on Chinook salmon in the Russian River, and provide opportunities for enhancing survival and expanding life history variation of Chinook rearing in the Estuary.

2.5.4 Effects of Channel Maintenance Activities

2.5.4.1 Effects of Channel Maintenance Activities in the Upper River to Critical Habitat and Species

MCRRFCD proposed to continue stream bank maintenance over a 36-mile reach of the Upper River in Mendocino county, just north of Cloverdale, upstream to the town of Calpella. MCRRFCD also is responsible for any channel maintenance actions over a 1-mile reach, in the East Fork Russian below CVD downstream toward the confluence with the Russian River. Many of the channel activities (described in the Proposed Action and Environmental Baseline sections) were implemented to prevent erosion and provide bank stabilization. Many have been covered with soil, brush, and trees, and continue to provide the protection they were designed for with little or no maintenance needed.

During the consultation process, MCRRFCD was unable to provide a summary of either past or proposed future channel maintenance activities. It is unclear to NMFS whether MCRRFCD has conducted any channel maintenance activities in the Upper River since the 2008 Opinion. Thus, the exact frequency and duration of disturbance due to implementing such activities is uncertain. However, MCRRFCD did confirm their desire to continue their maintenance obligations with the USACE (1997 MOU). Therefore, NMFS is assuming for purposes of analysis that these activities will be conducted and will have similar effects to designated critical habitat and listed salmonids as described below.

MCRRFCD has proposed minimization measures as described in the Project Description (Section 1.3.6). These minimization measures are likely to lessen the impact of channel maintenance on salmonid habitat. For example, a 25-ft vegetative buffer strip will be left on graded gravel bars to filter sediment and help maintain habitat complexity. In some cases, this vegetative strip may be mowed.

Gravel bar grading is expected to reduce channel sinuosity and development of pools at the affected stream sites. Loss of pools and habitat complexity is likely to reduce suitability for migration of salmonid adults and smolts, and habitat availability for juvenile salmonids throughout the year. Juvenile rearing habitat suitability during the summer and winter may be affected through the loss of hydraulic diversity at the various channel maintenance sites (USACE and Sonoma Water 2004). Bar grading at these sites will not be conducted in the wetted channel. However, spawning habitat may be adversely affected when rains and elevated river flows transport fine sediment from disturbed gravel bars (USACE and Sonoma Water 2004). Delivery of fine-grained sands is known to decrease spawning habitat quality and have the potential to reduce survival of incubating salmonid eggs.

Vegetation maintenance is proposed to occur at many of the gravel bar grading locations. In addition, vegetation removal is proposed at some sites for bank erosion control along the main stem channel. USACE and Sonoma Water (2004) state that this removal of vegetation in large swaths (250-400 ft wide) along the mainstem is likely to have adverse effects to salmonid habitat in the Upper River. MCRRFCD may also remove obstacles including LWD that spans the channel of the Upper River. The combination of gravel bar grading and vegetation maintenance is likely to further reduce the habitat complexity at the channel maintenance sites. The loss of complexity at these sites will make them less suitable for juvenile salmonids during the winter as refuge areas. Changes in the wetted portion of the channel as a response to vegetation and gravel bar grading may reduce the potential for summer rearing by juvenile steelhead, and reduce habitat for Chinook salmon and steelhead as they migrate to and from the ocean.

During any given year, the extent of impacts from channel maintenance will be limited. USACE and Sonoma Water (2004) reports that channel maintenance actions conducted in the past generally occur at sites 10 to 300 ft in length. Given the length of channel maintenance sites in the past and the maximum length that such activities may occur (2,000 ft in each county), the length of river affected by these actions is expected to range between 600 and 4,000 ft each year. Sites that are affected by channel maintenance activities will likely have impairment of habitat conditions for 1 or more years until stream dynamics restore natural habitat functions to baseline conditions.

Information is not available to allow NMFS to precisely determine the numbers of each species that will be adversely affected by channel maintenance activities in the Upper River. However, NMFS has used the linear extent of habitat affected, the likely habitat changes, the overall quality of habitat in the mainstem, and available fish survey data in the Russian River to determine that small numbers of juvenile steelhead will be injured or killed, as described below. No more than 30,000 linear ft of the mainstem Russian River will be affected by channel maintenance activities in the next 10 years. This represents about six percent of the entire mainstem. No more than 1,000 to 2,000 ft (1 to 2 bars) will be graded each year in each county. The loss of habitat complexity at the maintenance sites will make the habitat less suitable for adult, smolt, and juvenile Chinook salmon and steelhead during the winter and spring months, but the extent of the affected sites is limited and is not expected to affect the survival of individual fish as they migrate up or downstream. Enough suitable habitat is expected to be available upstream and downstream of the channel maintenance sites.

Although there may be an increase in the amount of fine sediments in the channel resulting from transport of fine sediment from disturbed gravel bars during winter storms, this increase is unlikely to affect migrating salmonids or eggs and alevins in the gravel. Analysis done in the Alexander Valley reach of the Russian River indicated fine sediments from gravel mining are limited and minor, with small impacts to eggs or alevins (NMFS 2003). Because the amount of gravel skimming proposed is smaller than the amount occurring in the Alexander Valley reach, NMFS expects the impacts to survival of eggs or alevins will be minimal.
Loss of habitat complexity at channel maintenance sites has the potential to affect juvenile steelhead rearing during the summer and winter. The limited number of sites affected by maintenance actions is not expected to reach a level that would adversely affect juvenile steelhead rearing during the winter, nor would it likely affect adult and smolt migrations; enough suitable habitat will remain to provide adequate food, rest, and cover in the winter and spring. Reduction in summer habitat suitability in up to 2,000 (and in some years, 4,000) ft of stream each year is unlikely to impact large numbers of juvenile salmonids because few juvenile salmonids inhabit the Upper River during the summers, due mainly to high flow releases and high-water temperatures. Some juvenile salmonids that cannot find suitable habitat in channel maintenance areas due to lack of complexity may find other suitable habitats nearby. Others may be lost to predation as they seek better areas of cover.

2.5.4.2 Effects of Channel Maintenance Activities in Dry Creek to Critical Habitat and Species

As described in the Proposed Action, Sonoma Water, via USACE authorization, maintains 14 bank stabilization sites in Dry Creek which have a total lineal extent of approximately 1 mile. In addition, Sonoma Water may work with local landowners to implement bioengineering projects to assist with streambank erosion problems in Dry Creek. These activities will be initiated only by a request from a private landowner after a washout threatens property or structures. Based on history, such activities occur approximately once every five to ten years. Typical project lengths under these circumstances are approximately 500 ft but could be up to 1,000 ft.

Salmonid habitat, including critical habitat, may be adversely affected due to bank stabilization work in these areas. Vegetative cover over and in the stream is likely to be reduced or eliminated, undercut banks are likely to be eliminated, and parts of mechanical equipment (excavator buckets) will temporarily enter aquatic habitat. These areas, and areas directly downstream, will experience temporary increases in turbidity levels and increases in sedimentation during and after bank stabilization work. Localized changes in channel hydraulics are also likely.

The main effects to migration habitat are limited vegetation removal and maintenance of riprap at some of the bank stabilization sites. Vegetation removal and riprap reduce the amount of vegetative cover available for adult salmonids to use as velocity refuges and to hide from predators during spawning migrations. Removal of undercut banks also reduces the amount of cover and velocity refuge available for migrating adults.

Similar losses to spawning habitat will occur. In addition, vegetation loss will likely reduce the sediment filtration capacity where vegetation removal occurs. This, combined with ground disturbance in maintenance areas, may cause localized sedimentation of spawning gravels. Increased fine sediments in spawning gravels reduce the quality of the substrate for incubating eggs by decreasing the amount of DO available to them. The barrier used to prevent downstream turbidity and sedimentation may increase these impacts in localized areas adjacent to the bank repair sites.

Channel maintenance is likely to adversely affect rearing habitat in several ways. Vegetation removal and bank hardening are likely to reduce or eliminate the recruitment of LWD to Dry Creek. The loss of complexity at these sites is likely to reduce cover from predators and velocity refugia from winter flows, and, over time, is expected to adversely affect winter and summer rearing habitat as bank protection work continues during the next 10 years. The removal of undercut banks will also eliminate habitat that provides hiding cover and velocity refugia. Instream cover needed by steelhead for velocity refuge and concealment from predators is already limited in the mainstem of Dry creek. Implementation of the proposed project will maintain these conditions, and may exacerbate them if cover is removed during maintenance activities. NMFS notes, however, that some of the bank protection methods themselves (jacks, for example) can provide cover and velocity refuge, and may ameliorate the loss of vegetation and undercut banks to some extent at some of the bank protection sites. Additional sediment entry to Dry Creek is likely to settle in pools, making them shallower, and eliminating aquatic insects that juvenile salmonids feed upon.

Additionally, the use of hard armoring techniques such as riprap can prevent the establishment of a native riparian corridor over the long term. This in turn affects rearing habitat by reducing canopy cover and increasing water temperatures for summer rearing. A reduction in canopy cover is likely to have the largest habitat impact in the lower section of Dry Creek where canopy cover is currently sparse.

Overall, managing the system of bank stabilization sites on Dry Creek is likely to continue to maintain reduced habitat suitability conditions for juvenile salmon and steelhead in portions of Dry Creek. The upper 3 miles of Dry Creek have a high number of stabilization sites that inhibit the function and development of optimal habitat. The middle and lower reaches of Dry Creek have a lower density of stabilization sites, and, therefore, maintenance of these sites is less likely to affect the overall condition of habitat for juvenile salmonids in those stream segments. Proposed continued channel maintenance activities in Dry Creek will contribute to armoring the stream banks, reducing velocity refuge areas for fishes during high flows, and simplifying stream channel morphology with potential degradation of both summer and winter rearing habitats for steelhead and coho salmon.

Information is not available to allow NMFS to precisely determine the numbers of each species that will be adversely affected by channel maintenance activities in Dry Creek. For example, there are no recent juvenile density estimates for the mainstem of Dry Creek. NMFS has used the linear extent of habitat affected (5,800 ft), the likely habitat changes and direct effects, and overall quality of habitat in Dry Creek to determine that small numbers of each species at specific life history stages will be injured or killed, as described below. The actual extent of effects are likely to be smaller, as many sites do not need maintenance on a yearly basis. Channel maintenance activities may result in short-term adverse effects during construction; however, these effects would be avoided and/or minimized through the implementation of BMPs (See Appendix B and Sections 3.4.2.1 through 3.10 of the BA).

Adult coho salmon, Chinook salmon, and steelhead will likely be adversely affected if they encounter spawning habitat that has been degraded as described above. For example, they may be lost to predators if pools or cover are degraded. The number of adults adversely affected is anticipated to be very low because: 1) the number and size of bank protection sites in Dry Creek (approximately 1 mile total, 600 ft per year) is limited compared to the 12 miles of known spawning habitat in Dry Creek, and 2) although some aspects of spawning habitats are already limited in Dry Creek, the relatively large numbers of Chinook salmon and steelhead that have been observed spawning this stream indicate that much of the mainstem of Dry Creek is suitable for spawning, regardless of the limited amount of instream cover for spawners.

Due to the abundance of Chinook salmon and steelhead spawners in Dry Creek, the limited extent of channel maintenance work during the next 10 years, and the availability of suitable spawning sites throughout Dry Creek, NMFS anticipates roughly no more than two Chinook salmon and steelhead adult spawners are likely to be unable to find appropriate cover for spawning in Dry Creek per year due to channel maintenance activities. These fish are likely to be lost to predators before they are able to spawn. There is limited ability to accurately detect and observe coho salmon redds in the mainstem of Dry Creek, though it is assumed that much better spawning habitat exists in the tributaries (Mill and Pena creeks) for coho salmon.

NMFS does not expect that many eggs and alevins of Chinook salmon or steelhead will be adversely affected by work at bank stabilization sites in Dry Creek. The size of bank stabilization sites are limited and females of both species' clean gravels prior to spawning. Impacts to steelhead eggs and alevins are not likely because this species spawns in late winter and spring, when high seasonal flows in Dry Creek will help clean fine sediments from spawning gravels. A few Chinook redds may be adversely affected. NMFS expects no more than two Chinook redds per year could have the survival of their eggs and alevins reduced. This estimate is likely high because work in any given year may or may not contribute sediment to Dry Creek.

Direct disturbance of flowing water by construction equipment may injure or kill juvenile coho salmon or steelhead at the bank protection sites. Some juveniles at the sites are likely to seek refuge in undercut banks or near other areas that will be disturbed or eliminated by heavy equipment. These fish may be injured or killed during bank protection repair operations. Sonoma Water's placement of barriers to prevent sediment and turbidity downstream of the repair sites may exacerbate injury to juvenile coho salmon or steelhead that remain at the sites by concentrating turbidity in the construction areas.

Juvenile steelhead and coho salmon are likely to be adversely affected by the loss of channel complexity at these sites once construction activities are completed. Juvenile steelhead and coho salmon in the lower section of Dry Creek are more likely to be adversely affected because habitat conditions in this area are less suitable due to more limited sheltering cover and shade. Coho salmon and steelhead attempting to rear in some of these sites are likely to be exposed to higher rates of predation and higher water temperatures that may be injurious. Juvenile coho salmon and steelhead forced to move because of habitat loss from bank stabilization may not be able to find cover from high flows and other resources they need to survive in Dry Creek.

NMFS expects that the number of juvenile coho salmon and steelhead adversely affected by these activities will be limited, because 1) the sites comprise only a relatively small portion of rearing habitat in Dry Creek, and Sonoma Water will only operate yearly on 10 percent of the total linear extent of the sites (roughly 600 ft per year), 2) not all sites or work at sites eliminate rearing habitat, 3) not all juvenile coho salmon and steelhead will remain at sites where work is conducted in flowing water, and 4) few juvenile coho salmon and steelhead are likely to be present at channel maintenance sites within Dry Creek due to the high summer water velocities, as described above.

Although channel maintenance activities will likely have some adverse effect on spawning and rearing habitats for Chinook salmon, these effects will probably be minor because each year, channel maintenance will affect only a small portion (less than one mile) of the 94-mile-long mainstem Russian River. This 94-mile segment effectively supports rearing habitat for juvenile Chinook salmon along its entire length and spawning habitat at riffles along the approximately 58-mile segment upstream from Healdsburg. Ongoing channel maintenance activities in Dry Creek will likely diminish available rearing habitat for coho and Chinook salmon and steelhead; however, the extent of rearing habitat loss in Dry Creek due to ongoing channel maintenance activities is likely minor given the availability of rearing habitat for this species throughout the mainstem Russian River. As noted above, we estimate very small numbers of salmonids will be injured or killed as a result of these channel maintenance actions in Dry Creek.

2.5.5 Effects of the Santa Rosa Creek Diversion

2.5.5.1 Effects of the Santa Rosa Creek Diversion to Critical Habitat

Under the Proposed Action, Sonoma Water will continue to operate the Santa Rosa Creek Diversion Structure. This reach of Santa Rosa Creek is designated critical habitat only for CCC steelhead. Due to the degraded habitat conditions that exist along the Santa Rosa Creek Diversion, the ability for CCC steelhead to occupy the Action Area has declined and that critical habitat within the Action Area will continue to be degraded. Overall, the area affected by the continued operation of the Santa Rosa Creek Diversion is small compared to the total number of miles of critical habitat available in CCC steelhead's recovery domain.

2.5.5.2 Effects of the Santa Rosa Creek Diversion to Species - Steelhead

The 2008 Opinion, and its preceding BA, included evaluations on whether operation of the Santa Rosa Creek Diversion Structure had been resulting in the entrainment and diversion of steelhead. These documents identified a low risk of entrainment and diversion of steelhead into Spring Lake during peak flow events (see Section 3.5.1). These operations are ongoing as part of the Proposed Action. The BA identified that storm events, with flows high enough to enter Spring Lake through the diversion structure, generally occur in January and February. However, after

March, storm events of this magnitude are less frequent. Importantly, only approximately one storm event per year would be high enough for water to spill through the diversion structure to Spring Lake. These events would occur only for a few days in most years, and many would occur prior to the steelhead downstream migration period. Thus, the risk to the population of steelhead is low because only a fraction of the smolt-sized fish that would migrate during a single storm would be affected. It is very unlikely that more than a few juvenile steelhead will be encountered during a single event due to the poor habitat conditions in engineered channels of the Santa Rosa Creek Diversion. There is a high likelihood that most rearing juvenile steelhead are outside the area, higher up in tributaries where cooler water and sufficient habitat is available. Therefore, the adverse effects of this element of the Proposed Action will be too short-term and limited to harm or kill no more than a small number of juvenile steelhead.

2.5.6 Effects of Monitoring and Research Activities to Species and Critical Habitat

This section analyzes the effects of monitoring and research activities conducted by Sonoma Water and the USACE within the Russian River watershed that are associated with the Proposed Action (See Table 8, Section 1.3.8). Sonoma Water proposed to continue to implement monitoring activities for coho salmon, steelhead, and Chinook salmon throughout the Russian River watershed to: monitor fish passage at Mirabel dam, monitor fish activity within Dry Creek, study salmonid survival in the mainstem and the Estuary, and conduct water quality monitoring. The USACE and Sonoma Water will coordinate monitoring, and fish relocation if necessary, below CVD and WSD during pre-flood inspection activities and down-ramping events as well as monitor/research turbidity impacts.

Sonoma Water utilizes sampling methods that are widely accepted in the fisheries community as inducing low mortality when properly implemented. As evidence, Sonoma Water has consistently displayed a very low incidence of mortality from the methods being proposed. Specifically, traps are checked daily and sometimes twice per day depending on flow/water quality conditions; all fish are kept in aerated live-wells during work-up and sampling is minimized (species ID and count) at temperatures in excess of 21°C; before measuring sizes, marking or tagging, juvenile salmonids are anesthetize using Alka-seltzer Gold; only a subset of the daily catch of juvenile salmonids collected each day at a given sampling location are measured/fin-clipped/tagged; backpack electrofishers are set to minimize the risk of fish injury (unpulsed DC), the timing and location of electrofishing is such that by-catch of adult salmonids is minimized and the NMFS 2000 Electrofishing Guidelines are followed; methods and fish sizes for gastric lavage and PIT/radio/acoustic tag implementation are based on procedures and size-thresholds from the published literature. All the staff are well trained and have extensive experience with a wide range of fisheries monitoring projects in the Russian River watershed and beyond. Sonoma Water also employs as many as 12 fisheries technicians each field season to ensure that all sampling is carried out in an efficient manner that minimizes the risk of injury to fish and delays or other changes to fish migration and behavior. Seasonal personnel are carefully screened prior to hire and intensive, hands-on training in fish handling and work-up procedures (including telemetry tagging) is provided in a hatchery setting prior to allowing individuals to handle fish in actual field settings.

All of these techniques are minimally intrusive in terms of their effect on habitat because they will involve very little, if any, disturbance of streambeds or adjacent riparian zones. Some fish collection activities involve seining/netting in marine or estuarine environments which may temporarily disturb substrate, displace benthic invertebrate prey, and increase turbidity just above the water surface. However, such actions affect small spatial areas and are brief in duration, so these effects are expected to be ephemeral and attenuate rapidly. Therefore, none of the proposed research and monitoring activities analyzed in this Opinion will have more than negligible effects on any habitat PBF function or value in the Action Area.

Impacts from research and monitoring activities on individual listed salmonids include temporary disturbance and potential short-term disruptions or changes in behavior such as feeding or social interactions with researchers in close proximity, and any minor injuries that may be associated with genetics samplings or attachment of tags for tracking movements and behavior. Electrofishing (boat and backpack) will likely result in minor injury (burns) or death to a small percentage of captured fish. Seining could also result in injury or death to a small percentage of captured fish. Risks to individual fish during work-up include possible stress/injury/direct and indirect mortality from anesthetization/handling, gastric lavage and from surgical procedures related to the implantation of PIT/radio/acoustic tags.

Most research activities will occur within a limited area over a short period of time, and the majority of impacts will occur at the juvenile life stage. No adverse effects are expected during proposed snorkel, spawning or passage surveys due to the non-invasive sampling techniques used (observe/harass only, no handling of live fish to occur). During these passive sampling techniques, approximately 25,500 Chinook salmon, 18,500 coho salmon, and 23,500 CCC steelhead are expected to be observed over the 10-year term of the Proposed Action and this Opinion (See Appendix A).

During out-migrant trapping, hook and line, electrofishing, and beach seining, some fish may experience minor injury and even some mortality. Juvenile salmonids caught in outmigrant traps (screw and fyke/pipe) where they will be detained for less than 24 hours in a flow-through live box may experience some stress. During PIT tagging and/or marking a subset of fish will experience minor stress but this is expected to be alleviated via anesthetization. Any adult mortality that does occur may cause short-term population abundance declines during the term of the Opinion but is unlikely to lead to long-term adverse effects to the population. Using these various methods for the capture, marking and sampling, approximately 96,700 CC Chinook salmon, 116,400 CCC coho salmon, and 88,560 CCC steelhead are expected to be handled over the 10-year term of this Opinion (See Appendix A). Mortality rates should continue to be one percent or less during each year's data collection. Any juvenile mortality that does occur is not likely to result in a reduction to the number of returning adults, both when considered separately and together.

During annual pre-flood and 5-year periodic inspection activities at CVD and WSD and down-ramping events below the dams, fish may need to be relocated. USACE will continue to conduct inspections during those times of the year that avoid adverse effects to juvenile and adult salmonids. Inspections in late August or September allow juvenile steelhead to reach a sufficient size to avoid stranding impacts during the ramp down of flow to the minimum stream levels maintained during inspection. Ramping rates in preparation for the inspection period are also designed to minimize effects on salmonids downstream. USACE anticipates that up to 50 juvenile steelhead and 50 juvenile Chinook salmon may be stranded and require relocation per dam inspection at CVD. No fish are expected to be stranded at WSD during pre-flood and 5-year inspections due to the schedule and ramping rates. USACE will coordinate the fish surveys with NMFS. At least one week prior to each dam inspection USACE will provide NMFS with a fish survey plan documenting the survey and fish handling methodology, including the number of survey crews and stream reaches to be surveyed. Survey crews will be present downstream of the dams at the start of flow ramp down, and remain until flows are entirely ramped back up. The number and species of fish encountered and moved will be reported to NMFS in person or by phone on the survey day, and documented by email within 24 hours. Habitat enhancement sites in Dry Creek will also be monitored during downramping events. Based on stranding that occurred in 2024, NMFS estimates that up to 50 juvenile coho and 200 Chinook salmon, and 1,000 juvenile steelhead may need to be rescued from isolated pools and relocated to suitable habitat during downramping events.

2.5.7 Effects due to Other Activities Reasonably Certain to Occur to Species and Critical Habitat

Sonoma Water proposes to continue to operate and maintain the offstream water transmission facilities (i.e., piping) and the WSD hydroelectric facility as done in the recent past. A substantial portion of Sonoma Water's water supply is consumed, eliminated as waste, treated as wastewater, and ultimately discharged back into the Russian River watershed or San Pablo Bay as treated effluent. We expect that operations of the offstream water transmission facilities will have minimal effects on critical habitat for listed salmonid species. The current wastewater discharges have minimal adverse effects on critical habitat for listed salmonid species, although high nutrient levels pose some potential adverse effect on steelhead in the Laguna de Santa Rosa, a stream that was not designated as critical habitat. We also conclude that the hydroelectric operations at WSD are not likely to adversely affect critical habitat for salmonids because they are dependent on-stream flows released from the project for water supply and flood control, and those effects have been analyzed above. The quality of water discharged by the hydroelectric facilities is suitable for salmonids. The effects of these other activities that are reasonably certain to occur for the 10-year duration of the proposed project are described in greater detail below.

2.5.7.1 Water Transmission

Sonoma Water's transmission system, which includes radial collector wells, disinfection and corrosion control (pH adjustment) facilities, pipelines, storage tanks, pumps, and conventional wells, conveys water from the diversion facilities on the Russian River to service areas in Sonoma County and northern Marin County.

Water is diverted from the Russian River after it is filtered through the alluvial aquifer below and adjacent to the streambed and infiltration ponds, and thus requires no further treatment other than disinfection and pH adjustment. Sonoma Water operates pH adjustment/corrosion control facilities to limit lead and copper content in drinking water. These facilities are located at the Sonoma Water Wohler maintenance yard and the River Road chlorination facility. The water is treated with caustic soda to raise the pH of pumped Russian River water. Although the water produced by the existing collector wells contains no detectable levels of lead and copper, the water is naturally moderately corrosive and can leach lead and copper from indoor plumbing and water fixtures. The pH control buildings are located about 200 yards from either the Russian River or Mark West Creek; however, the concrete masonry walls of the pH control buildings are designed to provide secondary containment to prevent the caustic soda from contaminating a large area if leaks occur within the pH control buildings.

Sonoma Water currently disinfects the water produced at the well facilities with chlorine. Chlorine gas is mixed with water inside three chlorine facilities to form a concentrated chlorine and water solution. This chlorine and water solution is transported through underground pipes to each collector well and is injected into the caissons to disinfect the water. The buildings used to store chlorine are equipped with leak detection alarm systems that send a signal to the operations and maintenance center indicating any leak locations. Additionally, scrubbers will be activated if chlorine gas is accidentally released. At the Occidental, Sebastopol Road and Todd Road wells, Tri-chlor is used on-site to generate an aqueous chlorine solution.

Presence of the pipelines or storage tanks are unlikely to affect salmonid species or critical habitat, though unplanned releases from the transmission system may affect salmonid species or critical habitat. The pipelines contain approximately 17 air relief valves, which may potentially discharge potable water to various creeks and drainage swales or ditches. These valves were installed to protect pipelines by relieving the pressure surges created when an abrupt change in flow occurs. Sonoma Water has taken measures to reduce the likelihood of corrosion on pipelines.

Maintenance of the water storage tanks includes periodic inspection, cleaning, recoating of the interior and exterior tank surfaces, structural repairs, and regulatory and safety upgrades which may require that the tanks be emptied. To the extent possible, the water in the tanks is drained into the water transmission system. The small amount of water remaining in the storage tanks after draining into the water transmission system is dechlorinated with sodium sulfite tablets to eliminate any chlorine residual and drained to the ground in accordance with the approved Non-Stormwater Discharge Best Management Plan. These controlled discharges occur approximately once every 5 years as part of maintenance activities. Overflow pipelines in each water storage tank are necessary to provide an emergency release route if water levels in the tank should rise too high. While automated control valves in the water transmission system have been installed to prevent this, overflow of chlorinated water may occur under certain circumstances.

Operation of Sonoma Water's Occidental Road, Sebastopol Road, and Todd Road wells can require discharging well water for sampling or flushing purposes. However, these discharges usually involve unchlorinated water and are conducted infrequently. The water at the Occidental well discharges into City of Santa Rosa's reclamation line, the Todd Road well discharge water goes into an on-site storage tank and then is trucked to City of Santa Rosa's Llano Road wastewater treatment plant, and the Sebastopol Road well water is discharged into City of Santa Rosa's reclamation line. NMFS expects these activities will have no effect on salmonids, regardless of chlorine content since facilities do not drain directly to salmonid streams.

2.5.7.2 Wastewater Treatment

NMFS is not aware of current receiving water issues associated with any of the WWTP discharges, with the possible exception of the Santa Rosa Subregional Wastewater Reclamation System in unusual circumstances. This latter facility has exceeded standards for nutrient concentrations in the past, which can cause low DO concentrations and algal blooms that can adversely affect stream pH in the Laguna de Santa Rosa. This stream is also listed under Section 303(d) of the Clean Water Act for having high levels of ammonium and low DO due to non-point source nutrient inputs from agriculture. Discharges that contribute to diminishing concentrations of DO in the Laguna de Santa Rosa potentially diminish the value of this stream as a migratory corridor for steelhead.

The Santa Rosa Subregional facility now recycles approximately 6.6 billion gallons of wastewater each year and during dry to normal water years, nearly 100 percent of the advanced treated effluent is beneficially used as recycled water. Approximately two-thirds of the recycled water is sent to recharge the Geysers stream fields to produce renewable energy for the region; the other one-third is used for urban and agricultural irrigation.

The City of Healdsburg wastewater treatment facility now produces disinfected tertiary recycled water as well. The Facility has two recycled water storage ponds, 25-million-gallon and 15-million-gallon capacity, with synthetic liners to provide storage for the disinfected tertiary treated recycled water and delivery of it to authorized recycled water users. In the past the facility discharged to the Basalt Pond, which is connected to the Russian River, all year but it now follows the seasonal restrictions for this discharge point. The facility delivers recycled water for agricultural, industrial, and construction uses, and approximately 1,170 acres of vineyards are directly connected to the pipeline. Additionally, the City operates two filling stations for the trucked recycled water program and that water is used for construction uses (primarily soil compaction and dust control), non-dairy livestock drinking water, and landscape and vineyard irrigation, consistent with agronomic demand. Irrigation occurs primarily during spring, summer, and fall and may occur during dry periods in the winter.

The City of Ukiah now seasonally recycles a significant amount of its wastewater as well. Phases 1-3 of the recycling project came on-line by 2019 producing approximately 1,000-acre feet per year used largely on agricultural properties and municipal fields. The Phase 4 expansion is currently underway and, once completed, it will increase the Project's capacity to 1,500 acre-feet per year.

Overall, wastewater discharges in the Russian River watershed are expected to have a negligible effect on salmonids and salmonid instream habitat due to tertiary treatment and the small amounts that may be discharged.

2.5.7.3 WSD Hydroelectric Facility

Flows through the hydroelectric facility at WSD are determined by water supply needs and minimum instream flow requirements. The turbines can operate at flows of 70 to 185 cfs. The facility does not impact flows downstream in Dry Creek. Water used in the facility is part of the water used for flood control and D1610 requirements and no flow releases are made solely for the benefits of hydroelectric generation. Some of this water is diverted through the turbine before traveling downstream to meet these needs and uses. Water tested at the inflow to the facility is at saturation level, meaning that the levels of nitrogen gas saturated in the water are at normal levels (USACE and Sonoma Water 2004). Operation of the WSD hydroelectric facility does not impact critical habitat or listed salmonids. There is no potential for entrainment of listed salmonid species in the turbine because they are not present upstream of the dam. Therefore, NMFS does not expect effects to occur to either individual species or critical habitat PBFs in the Action Area due to the operations of the small hydroelectric facilities at WSD.

2.5.8 Effects of the Proposed Action to SRKWs and their Critical Habitat

2.5.8.1 Effects to SRKW

The primary potential impact of the Proposed Action on SRKWs identified in the BA (ESA, Inc. 2023) and in this Opinion is the potential reduction in availability of preferred prey, Chinook salmon, in the coastal waters where CC Chinook salmon may be encountered by SRKWs.

Sections 2.2.6 and 2.2.9 describe 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. As a result, and based on evidence discussed in Sections 2.2.6 and 2.2.9, NMFS concludes that the best available science suggests that relative changes in Chinook salmon abundances are likely to influence the SRKWs population.

Here we review the prey reduction expected as an effect of the Proposed Action and 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 detrimentally 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 in Sections 2.2.6 and 2.2.9.

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 availability 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., 2019; 2021). While CC Chinook salmon have not been identified in the SRKW diet, CC Chinook and SRKWs are likely to overlap during the late winter and early spring along the outer coast (Hanson et al., 2021), during which time SRKW 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 percent of Chinook prey collected still originated from Puget Sound. In contrast, in mid-winter through early spring 93 percent of Chinook prey items were from outer coastal water stocks; most originating from the Columbia river (53.6 percent) followed by 19 percent from Central Valley Chinook stocks and 6.5 percent in the Fraser river.

The Chinook reductions from the Proposed Action would decrease the abundance of the CC Chinook ESU in the ocean and the availability of the CC Chinook ESU as prey for SRKWs in the southern portions of their coastal range. 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 2021a), where they are more likely to encounter and feed upon CC Chinook. 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 possible for all pods to be impacted by changes in availability of CC 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; 2009; O'Neill et al., 2012). SRKW typically consume larger fish (age three or older) thus any effects of the action would not occur immediately. Mortality of juveniles would translate to an effective loss of adult-equivalent Chinook salmon in this 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 adult salmon occurring as an effect of the Proposed Action would translate into a lower number of adult-equivalent Chinook salmon in this 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).

Because of the extent of the Effects of the Action on CC Chinook discussed above, and that the actions will continue to degrade critical habitat for CC Chinook spawning, rearing, and migration as well as result in lethal and sublethal effects to redds, fry, and juveniles, we assume there is potential for moderate reductions in the number of fish in the CC Chinook ESU. Based on the recent 5-year mean of the ESU of 13,169 fish (NMFS 2024h), we can compare this to the total abundance of ocean Chinook to estimate the relative amount of SRKW Chinook prey that could be potentially removed by this action.

We estimated the proportion of CC Chinook salmon relative to the total abundance of Chinook salmon that is available throughout the coastal range of SRKWs, assuming a CC Chinook abundance of 13,169 fish from NMFS 2024h and using FRAM-Shelton methodology to calculate total Chinook abundance in the region (see detailed methods in PFMC 2020; NMFS 2021d; 2024a). Briefly, we calculated pre-fishing coastwide adult (age 3 and older) abundance estimates for 1992-2020 for most Chinook salmon stocks using the Chinook FRAM (PFMC 2008) post-season runs (Salmon Modeling and Analysis Workgroup 2023).[23] Abundance estimates for

[23] i.e., Round 7.1.1 of base period calibration; 11.15.2023.

FRAM stocks are calculated using stock-specific terminal run size estimates by age and mark status provided by regional technical staff. Stock-specific terminal run sizes are then expanded by maturation rates, fishing mortality, and natural mortality estimates to derive a pre-fishing starting abundance. Coastwide pre-fishing ocean abundances were distributed among spatial boxes, including the California coast. Spatial abundances were based on estimates of the proportion of each stock found in each area each season, using combinations of FRAM and the state-space model from Shelton et al., (2021)[24], PFMC (2020) (and see NMFS (2021b)).

On average, between 2011-2020, total annual Chinook abundance off California is approximately 480,000 Chinook, and is approximately 2,147,000 off the entire U.S. West Coast (California, Oregon, North of Falcon – north of Cape Falcon, OR to the US-Canada border) using FRAM-Shelton methods. Comparing the 5-year mean adult return of 13,169 CC Chinook (NMFS 2024h) to abundance in these regions, CC Chinook made up ~0.7 percent on average of Chinook available annually to SRKW on the west coast from 2011-2020, and this proportion jumped to ~3.4 percent relative to Chinook off California. We assume here that abundances we have seen in the recent past (2011-2020) are representative of the future (where in abundances from earlier, specifically the 2000s, 13,169 in certain years would be as large as 9.8 percent of the available prey in California). According to the multispecies recovery plan, the recovery target for CC Chinook is 52,800 spawners (NMFS 2016d). Therefore, with the most recent population abundance of 13,169 (NMFS 2024h), the population is currently only at ~25 percent of its recovery goal. Given that many nearby Chinook populations face similar threats, it is difficult to predict how recovery of the CC Chinook would impact the relative percentage of the total prey available off California attributable to this ESU. But, should this ESU recover, the ESU has the potential to contribute tens of thousands of Chinook to the Action Area and contribute further to the availability of prey for SRKW.

As previously described in Section 2.4.7.1.1, while CC Chinook salmon have not been documented in the SRKW diet, they overlap with SRKW during any southerly movements along the coast of Oregon and California that may occur during the winter and spring when SRKW are more prey limited and more likely to have poor body condition. It is important to note that diet studies along the California coast are limited (limited sample size, limited temporal extent, and limited spatial extent). However, due to the overlap between SRKW and CC Chinook in the winter and spring months, CC Chinook are likely a part of the SRKW diet. During the winter and spring, the entire portfolio of prey along the coast is important to SRKW. Meaningful reductions to any of the ESUs along the coast, including CC Chinook, could cause a gap in the prey field available to SRKW. Reductions in the CC Chinook resulting from the Proposed Action could contribute to a localized loss of prey and create a gap in the prey portfolio in the regions where CC Chinook and SRKW overlap. Conversely, if the ESU recovers, CC Chinook have the potential to contribute significantly to the abundance of Chinook in the Action Area, and play a more important role in the SRKW diet.

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

[24] Pacific Fishery Management Council. November 2022 Decision Summary Document. Accessed March 2025. https://www.pcouncil.org/november-2022-decision-summary-document/

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; and abundance and body condition; Stewart et al., 2021).

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 (Trites and Donnelly 2003). Whales in poor body condition have a higher likelihood of mortality, some of which has been 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 and Satterthwaite 2020) and described in (NMFS 2021d), 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 seasons of prey limitation (winter), with wider-ranging distribution and poor body condition, California 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 in this Opinion (such as Noren 2011; Williams *et al.,* 2011; Chasco *et al.,* 2017a), 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 2021a) found that the probability of prey capture for SRKWs increased as prey abundance increased, 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 presents 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, 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 (NAS 2017). 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; Pelch 2011; 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 further for more abundant prey, which would result in whales expending more energy in search of depleted prey resources (NMFS 2021d). The potential increase in energy demand would likely have the same effect on an animal's energy budget as reductions in available energy that we 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 an 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). 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 prey species, increase energy expenditures in search of Chinook salmon, and/or reduce energy intake. Ford and Ellis (2006) also report that SRKWs engage in prey sharing about 76 percent 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).

Recent photogrammetry work by Fearnbach and Durban (2024) found that body condition has continued to decline in the population. In 2023, 32 percent of J pod and 40 percent of L pod were in the poorest body condition (out of five body condition groups); 48 and 67 percent 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 (Olson et al., 2018; NMFS 2021a; Stewart et al., 2023). Thus, current evidence suggests some degree of prey limitation may already be impacting SRKW health and they are likely vulnerable to continued reduction in Chinook salmon prey, particularly during winter and spring when they are more prey-limited.

In conclusion, the Proposed Action would result in small reductions in the abundance of the prey portfolio off the coast of California and Oregon for SRKWs during the winter and spring months when body condition is generally low. Adult CC Chinook mortality in a given year (e.g., 2025) will result in reduced adult offspring in the cohort four to six years later (e.g., 2029-2031). The result of reduced ocean abundance of CC 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. However, current loss of this ESU will often only represent <1 percent of total available prey on the coast (though greater for California availability only). Additionally, Chinook in the northern half of the SRKW range have been regarded as higher priority for SRKW population health than the Chinook in the southern half of their range (NMFS and WDFW 2018). Given the relatively small proportion of their SRKW prey the Proposed Action would impact and the lower relative importance of Chinook stocks in the southern half of the SRKW range to SRKW population health, we do not expect these effects from the Proposed Action to persist or be so large that they result in more than a minor change to the overall health of any individual whale. Based on the analyses that have been described above, the relative magnitude of adverse effects on SRKWs resulting from the reduced prey would likely be limited in extent and would not appreciably reduce the likelihood of survival or recovery.

2.5.8.2 Effects to SRKW Critical Habitat

In addition to the effects to SRKWs discussed above, the Proposed Action affects critical habitat designated for SRKWs off the U.S. West Coast. Based on the natural history of SRKW and their habitat needs, we identified three PBFs in designating critical habitat for SRKWs:

- Water quality to support growth and development;

- Prey species of sufficient quantity, quality and availability to support individual growth, reproduction, and development, as well as overall population growth; and
- Passage conditions to allow for migration, resting, and foraging (50 CFR 226.206).

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 (because the action occurs in-river). 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.

SRKW Critical Habitat (Figure 20) 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 (Area 6; NMFS 2021c). These three areas correspond to regions where CWT and GSI (data collected during the summer months) have confirmed CC Chinook are the most concentrated (Weitkamp 2010; Bellinger et al., 2015; Shelton et al., 2019). Each of these areas contains all three PBFs, including water quality, passage, and prey. Chinook salmon of three 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 percent of the ESUs in Area 4 and almost all of the Chinook salmon in Areas 5 and 6 (Shelton et al., 2019). 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 January, February, May, and December (Hanson et al., 2013). While the CC Chinook ESU was not documented in prey samples taken in any of these Areas, the limited nature of these studies could have missed contributions of CC Chinook to the SRKW diet.

As mentioned above, the CC Chinook salmon ESU is also likely a part of Critical Habitat in Oregon to some extent, though likely to a lesser degree. Prey is the primary PBF in Area 2 near northern Oregon whereas passage is the primary feature in Area 3 near central and southern Oregon. 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. 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 in January through May. Area 2 is considered a high use area by SRKW and has a mix of Chinook stocks from California to Canada. Shelton et al., (2019) suggest Area 2 has 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 the 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. But all ESUs in the region contribute to the prey field that SRKW depend on when in the region, and thus meaningful reductions in the CC Chinook ESU 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 CC 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 is 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. 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.

Additionally, if CC Chinook recover, this population could contribute tens of thousands of Chinook that will supplement the prey base for SRKW in the coastal waters of the Action Area. Given the reduction of CC Chinook, the overall effects to the prey PBF of designated critical habitat off the coast of Oregon and California will include adverse effects but the reduction in prey availability is likely to be small relative to the other Chinook prey resources in SRKW critical habitat.

2.6 Cumulative Effects

"Cumulative effects" are those effects of future state or private activities, not involving federal activities, that are reasonably certain to occur within the Action Area of the federal action subject to consultation. (50 CFR 402.02). 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.

2.6.1 Cumulative Effects on Salmonids

Some continuing non-federal activities are reasonably certain to contribute to climate effects within the Action Area. However, it is difficult if not impossible to distinguish between the Action Area's future environmental conditions caused by global climate change that are properly part of the Environmental Baseline *vs.* Cumulative Effects. Therefore, all relevant future climate-related environmental conditions in the Action Area are described earlier in the discussion of Environmental Baseline (Section 2.4).

Future state, tribal, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives. Government and private actions may include changes in land and water uses, including ownership and intensity, any of which could impact listed species or their habitat. Government actions are subject to political, legislative, and fiscal uncertainties. These realities, added to the geographic scope of the Action Area, which encompasses numerous government entities exercising various authorities, make any analysis of cumulative effects difficult and speculative. For more information on the various efforts being made at the local, tribal, state, and national levels to conserve CCC coho salmon, CCC steelhead and CC Chinook salmon, see any of the recent status reviews, listing Federal Register notices, and recovery planning documents, as well as recent consultations on issuance of Section 10(a)(1)(A) research permits.

Potential non-Federal actions affecting the Action Area in the future could include State angling regulation changes, voluntary or State sponsored upslope habitat restoration activities, discharge of stormwater and agricultural runoff, and continued development, including building of private roads, wells, and land use change. Urban development, including rural residential and agricultural development is likely to continue throughout the Action Area. The primary cumulative effects will arise from those water quality and quantity impacts that occur as human population growth and development shift patterns of water and land use, thereby creating more intense pressure on streams and rivers within this geography in terms of volume, velocities, pollutants, baseflows, and peak flows. Thus, non-Federal activities are likely to continue affecting listed species and habitat within the Action Area.

These cumulative effects in the Action Area are difficult to analyze because of this Opinion's large geographic scope, the different resource authorities in the Action Area, the uncertainties associated with government and private actions, and the changing economies of the region. Whether these effects will increase or decrease is a matter of speculation; however, it seems likely that they will continue to increase as a general pattern over time. Although many state, tribal, and local governments have developed plans and initiatives to benefit listed fish, they must be applied and sustained in a comprehensive way before NMFS can consider them "reasonably foreseeable" in its analysis of cumulative effects.

2.6.2 Cumulative Effects on SRKW

Many of the effects associated with activities that have occurred in the recent past that have affected the Status and Environmental Baseline of SRKWs as described in Sections 2.2.6-2.2.10 and 2.4.5-2.4.7, are expected to continue in the future and contribute to adverse cumulative effects on SRKWs. These are considered reasonably certain to occur in the future because they occurred frequently in the recent past, especially if authorizations or permits have not yet expired. Tribal, state and local government actions will likely be in the form of legislation, shoreline growth management, administrative rules, or policy initiatives and fishing permits. These actions may include changes in ocean policy and increases and decreases in the types of activities currently seen in the Action Area, including changes in the types of fishing activities, resource extraction, or designation of marine protected areas, any of which could impact SRKWs or their designated critical habitat. For example, Washington State increased the vessel buffer distance around SRKWs to 1,000 yards for all vessels as of January 1, 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 (Section 2.4) 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 2008b) informed by research. For example, the PCSRF was established by Congress in FY2000 to protect, restore, and conserve Pacific salmon and steelhead populations and their habitats. Under the PCSRF, NMFS manages a program to provide funding to states and tribes of the Pacific Coast region (including Oregon and California). Future projects funded by the PCSRF and conducted by states and tribes that will be implemented throughout the region will make important contributions to improve the status of ESA-listed salmon and protect currently healthy populations, which will help support the prey needs of SRKW in the Action Area. Additional actions by non-federal entities surrounding implementation of the SRKW recovery plan that are ongoing or expected to occur are described in the most recent 5-year review (NMFS 2021a).

Additional activities that may occur in the coastal waters off 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. Additionally, the state of Oregon recently listed SRKWs on the state endangered species list, so likely some actions will result from this but at this time are unknown. 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 the Status of the Species (Section 2.2) and Environmental Baseline (Section 2.4) characterize the type and magnitude of the effects these factors may be expected to have in the future during this Proposed Action.

2.7 Integration and Synthesis

The Integration and Synthesis section is the final step in assessing the risk that the Proposed Action poses to ESA-listed species and designated critical habitat. In this section, we add the Effects of the Action (Section 2.5) to the Environmental Baseline (Section 2.4) and the Cumulative Effects (Section 2.6), taking into account the Status of the Species and Critical Habitat (Section 2.2), to formulate the agency's Biological Opinion as to whether the Proposed Action is likely to: 1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution, or 2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

2.7.1 Summary of Project Effects on Salmonid Critical Habitat and Survival and Recovery

In this Opinion, we analyzed the effects that the Proposed Action's reservoir operations, Estuary management, monitoring, habitat restoration, channel maintenance, the Santa Rosa Creek Diversion, and other proposed activities may have on federally ESA-listed CCC coho salmon, CCC steelhead, and CC Chinook salmon and their critical habitats. Table 32 below provides an overview of the adverse effects, by life stage, for salmonids and location of critical habitat summarized in the text below. Effects of these activities were also analyzed for the endangered SRKW (see Section 2.5.8 above). The activities that are expected to have the most significant adverse impacts on ESA-listed species and their critical habitats are due to reservoir operations (with turbidity in the Upper River and reduced survival rates likely due to predation in the Lower River being of greatest concern) and Estuary management. Minimization measures are summarized in Table 33 and include: implementing FIRO, blockwater and pulse flow releases, down-ramping protocols, restoration projects in the Estuary and lower tributary(ies), maintaining existing habitat enhancement features in Dry Creek, monitoring, and conducting management focused research studies.

The effects of other proposed activities such as channel maintenance, maintaining the Santa Rosa Creek Diversion, and other activities are limited in scope and scale and/or effectively minimized via proposed implementation of BMPs. While these activities may cause a low level of harm or injury to a small number of individual juvenile salmonids and their localized critical habitats, they are not expected to affect them to the degree that they have a significant impact on the greater population(s) at the watershed, diversity strata, or DPS/ESU level. Thus, we expect the effects on the species due to these activities to be minimal and those impacts would only be seen in terms of slight reductions in juvenile and adult abundance and productivity. And because these reductions are so slight, the actions, even in combination, would have no appreciable effect on the species' habitat function and diversity or structure.

In evaluating the effects of the project on the function and role of critical habitat, we identified four PBFs of designated critical habitat for the three listed salmonid species. These PBFs are: freshwater migration corridors (safe passage conditions), freshwater spawning habitat, freshwater rearing habitat, and estuarine rearing habitat. Where appropriate, we have differentiated adult migration and smolt migration to better describe anticipated effects of the Proposed Action on the freshwater migration PBF.

We also address the effects of the Proposed Action on the likelihood of survival and recovery of federally listed CCC coho salmon, CCC steelhead, and CC Chinook salmon of sub-populations, the Russian River basin in total, and at the ESU/DPS scale. When analyzing impacts to these ESA-listed species, we considered changes in abundance, population growth rate, spatial distribution, and genetic and ecological diversity. We have considered potential project effects to each of the major life stages occurring in the riverine environment: adult migrations, adult spawning, egg incubation, fry stages, juvenile rearing, and juvenile outmigration to the ocean.

Table 32. Summary of Adverse Effects to specific life stages of CC Chinook salmon, CCC coho salmon, CCC steelhead, noted by location within the Action Area. Impacts to coho salmon are not applicable (NA) in the Upper River.

Adverse Effect	Location	CC Chinook salmon	CCC coho salmon	CCC steelhead
High Flow				
Turbidity	Upper River	a,b,c,d,e,f	NA	a,b,c,d,e,f
Streambed Scour	Upper River	c,d	NA	c,d
	Dry Creek	c,d	c,d	c,d
Bank Erosion	Upper River	c,d,e	NA	c,d,e
Habitat Refugia	Upper River	d,e	NA	d,e
	Dry Creek	d,e	d,e	d,e
	Estuary	NA	e	e
Low Flow				
High Temperature	Upper River[2]	d,e	NA	d,e
	Lower River	f	e,f	e,f
	Estuary	e,f	e,f	e,f
Passage	Upper River	a	NA	NA
	Lower River	a	a	a
	Estuary	a	a	a
Predation	Upper River	unknown	NA	unknown
	Lower River	f	f	f
	Estuary	a,f	a,e,f	a,e,f
Dewatering/Fish Relocation	Upper River	d,e,f	NA	d,e,f
	Lower River[3]	NA	e,f	e,f
	Dry Creek	d,e,f	d,e,f	d,e,f
	Estuary	e,f	e,f	e,f
Water Quality (DO, salinity, temperature)	Estuary[3]	a,f	a,e,f	a,e,f
Monitoring	Lower River[4]	d,e,f	d,e,f	a,d,e,f
	Dry Creek	d,e,f	d,e,f	a,d,e,f
	Estuary	e,f	e,f	a,e,f

[1]Primary life history stage affected: a = adult migration; b = adult spawning; c = egg incubation; d= fry stages; e= juvenile rearing; f= juvenile outmigration.
[2]High temperatures only affect the Upper River below Hopland. Releases from CVD provide cool water to the mainstem between Ukiah and Hopland.
[3]Including Lower River tributaries within the Action Area.
[4]Including the mouth and lower reach of Willow Creek.

Table 33. Summary of minimization measures affecting specific life stages of CC Chinook salmon, CCC coho salmon, CCC steelhead, noted by location within the Action Area. Impacts to coho salmon are not applicable (NA) in the Upper River.

Beneficial Effect	Location	CC Chinook salmon	CCC coho salmon	CCC steelhead
Flow Management				
FIRO[2]	Upper River	a,e,f	NA	a,e,f
	Lower River	a,e,f	a,e,f	a,e,f
	Dry Creek	a,c,d,e,f	a,c,d,e,f	a,c,d,e,f
	Estuary	a,e,f	a,e,f	a,e,f
Ramping rates	Upper River	c,d,e,f	NA	c,d,e,f
	Dry Creek	c,d,e,f	c,d,e,f	c,d,e,f
Blockwater/Pulse Flow	Upper River	a,f	NA	a,f
	Dry Creek	a,f	a,f	a,f
	Lower River	a,f	a,f	a,f
	Estuary			
Habitat Restoration	Lower River[3]	NA	a,b,c,d,e,f	a,b,c,d,e,f
	Dry Creek	a,b,c,d,e,f	a,b,c,d,e,f	a,b,c,d,e,f
	Estuary[3]	a,e,f	a,e,f	a,e,f
Monitoring and Survival Studies[4]	Upper River	a,b,c,d,e,f	NA	a,b,c,d,e,f
	Lower River[3]	a,b,c,d,e,f	a,b,c,d,e,f	a,b,c,d,e,f
	Dry Creek	a,b,c,d,e,f	a,b,c,d,e,f	a,b,c,d,e,f
	Estuary	a,b,c,d,e,f	a,b,c,d,e,f	a,b,c,d,e,f

[1]Primary life history stage affected: a = adult migration; b = adult spawning; c = egg incubation; d= fry stages; e= juvenile rearing; f= juvenile outmigration.
[2]FIRO has been implemented at CVD since 2018 and is planned to be implemented at WSD in the near future.
[3]Including Lower River tributaries within the Action Area.
[4]While monitoring and survival studies will not provide direct benefits, incorporating the outcomes of these activities into future management decisions is expected to provide conservation benefits for all listed species throughout the Action Area.

2.7.1.1 Summary of Effects of the Proposed Action on Critical Habitat

The condition of freshwater habitats for CCC coho salmon, CCC steelhead, and CC Chinook salmon has deteriorated from levels known to support viable populations. Major habitat concerns for these species, both across their broader ESU and DPS ranges and within the Action Area, include: (1) water quantity and quality associated with reservoir management, (2) fish passage, (3) impairment of estuary quality and extent, and (4) reduced habitat complexity.

Within the Russian River watershed, the completion of CVD in 1959 on the East Fork blocked access to up to 143 miles of high-value salmonid spawning and rearing habitat. The construction of WSD in 1983 further restricted anadromous salmonid access to 50 to 105 miles (approximately 60 percent) of the Dry Creek watershed. Additionally, the annual installation of the Mirabel inflatable dam (Mirabel Facility) impounds approximately 5 km of the Lower River. These anthropogenic activities have contributed to a baseline of degraded habitat conditions within the Action Area, including inadequate adult migration and spawning flows due to drought conditions and low reservoir storage levels, disruption of adult migratory cues and impaired water quality associated with artificial breaching of the Estuary, chronic high turbidity levels from CVD flow releases, reduced floodplain connectivity, increased predator densities, and diminished estuarine habitat quality. Many of these conditions would persist in the absence of the actions proposed under the Project.

Reservoir management for flood control and water supply operations in the Russian River has created habitat conditions in some areas that are more favorable to both native and non-native warmwater fish species, such as Sacramento pikeminnow and smallmouth bass. These piscivorous species likely prey on juvenile salmonids, with predation rates increasing during the spring and summer months, particularly in drier years between the confluence of Dry Creek and Mirabel Dam.

Salmonid spawning habitat in the mainstem Russian River has been negatively influenced by geomorphic changes. Summer rearing habitat conditions throughout the mainstem, particularly from Cloverdale downstream to the Estuary, are generally poor due to water temperatures exceeding the thermal tolerances of juvenile salmonids. Outside the summer season, the majority of suitable Chinook salmon spawning habitat is located in the Upper River and Dry Creek, as well as Pena Creek, a tributary to Dry Creek. Coho salmon primarily spawn and rear in Lower River tributaries and Dry Creek, using the mainstem Lower River primarily for migration. Due to degraded conditions in most Lower River tributaries, Dry Creek remains a key subwatershed for CCC coho salmon and CC Chinook salmon recovery.

Steelhead are distributed throughout the Russian River watershed, with most spawning and rearing occurring in tributaries. Some individuals from the Upper Russian River steelhead population spawn in the mainstem Upper River, particularly in drier years when tributary access is limited. The Estuary provides reliable migration opportunities for both adult and juvenile salmonids, as it is typically open during peak migration periods. However, no ESA-listed salmonids spawn in the Estuary. Instead, the Estuary serves as critical rearing habitat, particularly for steelhead, and to a lesser extent, for coho and Chinook salmon.

Since the 2008 Opinion, significant habitat improvements have been made in the Action Area through robust habitat enhancement efforts in the Dry Creek watershed, enhanced flow and reservoir management strategies, and adaptive management actions in the Estuary. Extensive adaptive management strategies aimed at optimizing estuarine conditions, including both open and closed mouth states, have continued to enhance lagoon habitat conditions during the rearing and migration periods for all Russian River salmonid species. These strategies will continue to support the rearing PBF of critical habitat in the Estuary, provided that lagoon water quality conditions can be maintained with minimal artificial breaching during important rearing periods. Additionally, extreme climate shifts, resulting in prolonged droughts, have led to more frequent low-flow conditions during the fall and spring across the species' ranges, limiting habitat productivity and reducing the effectiveness of habitat rehabilitation efforts necessary for full species recovery.

Habitat conditions for CC Chinook salmon, CCC coho salmon, and CCC steelhead within the Action Area are expected to improve due to proposed habitat enhancement efforts in the Estuary and the Dry Creek alternative(s) described in this Opinion. Once fully implemented, these beneficial effects will be long-term and influence all life history stages of ESA-listed salmonids in the Russian River.

Beach management under the Estuary AMP and habitat enhancements covering 3 to 5 acres (but not exceeding 6 acres) are anticipated to fully mitigate the loss of optimal habitat conditions caused by artificial breaching during primary rearing months for juvenile Chinook salmon, coho salmon, and steelhead. In addition, habitat enhancements using large wood structures will be installed at up to four locations, depending on the scale and location of the structures, to minimize potential impacts associated with artificial breaching on adult salmonids (primarily early-entry Chinook salmon) and other habitat effects most likely to occur in the fall. However, conservation gains may not be realized for several years due to the time required to develop and implement these habitat enhancement actions.

The continued implementation of FIRO procedures at CVD will greatly contribute to maintaining suitable water temperature conditions for adult Chinook salmon in the fall and juvenile steelhead during summer rearing, while also providing more reliable migratory and spawning flow conditions for adults in the mainstem Upper River. Similar benefits are expected in the Lower River as FIRO procedures are further implemented at WSD.

Proposed ramping rates and flow augmentation strategies (blockwater and pulse flow releases) are expected to mitigate reduced juvenile salmonid survival rates caused by increased predation risk and low-flow passage constraints. Additionally, ongoing monitoring and juvenile salmonid survival studies will help refine flow augmentation strategies to provide lasting benefits for ESA-listed salmonids in the Russian River watershed.

Despite these conservation actions, the effects of the Proposed Action are expected to continue decreasing the conservation value of designated critical habitat PBFs for all three species within the Action Area. The quantity and quality of critical habitat in the Action Area are highly dependent on flow volumes released from CVD and WSD. While proposed flood control and water supply operations at both facilities would enhance some PBFs, they would substantially degrade others.

The adverse impacts of the proposed flow management on listed salmonids and their critical habitat result from:

1. The extended duration and magnitude of high-flow releases, which lead to increased turbidity levels, streambed scour, bank erosion, and reduced rearing habitat refugia.

2. Low-flow conditions during drier water years, which reduce juvenile survival rates due to increased predation risk and impede adult passage.

3. Altered Estuary habitat quality and extent.

These changes influence all critical habitat PBFs for the three species by altering flow patterns, water quantity, and water quality.

Of primary concern is that persistent altered flow patterns from CVD flood control and water supply operations, particularly in fall and winter, are expected to significantly contribute to chronic high turbidity levels in the Upper River. These elevated turbidity levels are likely to severely influence spawning and rearing habitat used by Chinook salmon and steelhead., with the most adverse habitat effects occurring from the CVD Outlet to Hopland. Consequently, the Proposed Action is likely to appreciably reduce the conservation value of freshwater spawning and rearing habitat available for CC Chinook salmon and the Upper Russian River steelhead population. by creating conditions that hinder the formation and preservation of freshwater spawning and rearing habitats in the Upper River. However, as outlined in the Proposed Action, USACE is actively investigating and developing potential solutions to reduce turbidity levels resulting from CVD operations. Once effective treatments are identified, USACE will seek the necessary authorities to implement meaningful turbidity reduction measures within the 10-year timeframe of this Opinion.

Although PBFs of designated critical habitat for CC Chinook salmon and CCC steelhead in the Upper River are substantially degraded by high turbidity levels, adequate to high-quality critical habitat remains available elsewhere in the Russian River watershed. Alternative critical habitat areas exist in adjacent Upper River tributaries for steelhead and in Dry Creek (including Pena Creek) for Chinook salmon. In these areas, water quality and habitat quantity remain sufficient and are not influenced by chronic high turbidity from CVD discharges, ensuring that critical habitat in the Russian River is not adversely modified for these species.

While adverse impacts to critical habitat may occur due to other activities included in the Proposed Action, we do not expect them to rise to the level of adverse modification under the ESA. Several of these impacts are expected to be minor when considered alongside proposed flow releases, including adaptively managed flow augmentation procedures, improved Estuary management, associated habitat enhancements, and alternative Dry Creek habitat enhancement actions. Additionally, given baseline stochastic climate conditions (e.g., drought, fire, extreme precipitation) characteristic of the Russian River watershed, the cumulative effects of the

Proposed Action are not expected to appreciably degrade the overall value of designated critical habitat. We conclude that, if implemented, the Proposed Action would maintain the functionality of designated critical habitat for Chinook salmon, coho salmon, and steelhead, ensuring it continues to serve its intended conservation role.

A key factor influencing habitat conditions across all land and water ownerships is climate change. Summaries of national and international regulations and agreements governing greenhouse gas emissions indicate that, while the number and efficacy of such mechanisms have increased in recent years, global emissions have not yet deviated substantially from past trends. Upscaling and accelerating multilevel, cross-sectoral climate mitigation efforts will likely be necessary to further reduce future climate-related risks (IPCC 2014; IPCC 2018). These findings suggest that current regulatory mechanisms, both in the U.S. and internationally, remain insufficient to address the rate at which climate change is negatively influencing habitat conditions for many ESA-listed salmon and steelhead.

2.7.1.2 Summary of Effects of the Proposed Action on CC Chinook Salmon Survival and Recovery

CC Chinook salmon populations remain widely distributed throughout much of the ESU. However, smaller CC Chinook salmon populations outside the Eel River, both north and south of the Russian River, make this population one of the most isolated and essential for the recovery of the entire ESU. These small populations are vulnerable to natural stochastic processes, which may hinder recovery efforts. Recent population trends across the ESU have been mixed, with an overall moderate extinction risk (NMFS 2024a). The current 5-year mean estimate of CC Chinook salmon across the ESU is only 13,169 adult returns. However, since 2021, adult CC Chinook salmon returns in the Russian River and Eel River have increased considerably from historic low counts (2020), but still short of recovery levels (Martini-Lamb and Manning 2024; CDFW 2025a). The CC Chinook salmon ESU has low adaptive capacity and faces heightened extinction risk as existing threats are exacerbated by extreme droughts.

In the Central Coastal Stratum, including the Russian River, overall trends appear to be improving. The Garcia River population is critical for recovery and has shown a significant positive trend despite being at high risk due to depensation. As noted, the Russian River population is also essential to the recovery of the CC Chinook ESU. While this population appears relatively stable and has a low risk of extinction, adult Chinook salmon numbers have declined since the early 2000s through 2020 (NMFS 2024a, Figure 29). However, from 2021 to 2025, adult CC Chinook salmon returns in the Russian River have improved to an average of 1,570 per year from the historic minimum count in 2020 of 626 (Martini-Lamb and Manning 2024; J. Martini-Lamb, Sonoma Water personal communication, 2025).

All life stages of CC Chinook salmon will experience increased stress, injury, or mortality due to suspended sediment concentrations resulting in chronic high turbidity levels from CVD reservoir operations in the Upper River. The Ukiah Reach in the Upper River supports one of the highest densities of adult Chinook salmon redd abundance in the entire Russian River (Martini-Lamb and Manning 2024). Chinook salmon reliance on mainstem river conditions with constant subsurface flow increases the likelihood that prolonged high turbidity levels will have moderate to high adverse effects on Chinook salmon spawning success in the Upper River mainstem. Specifically, high turbidity levels are expected to reduce the spawning success of adult Chinook salmon and impair egg-to-fry development, However, alternative spawning and rearing locations within the watershed may enhance reproductive success over the next decade. For example, the relative contribution of Chinook salmon redds in Dry Creek is proportionately greater than in the Russian River mainstem, and some Chinook salmon successfully reproduce in tributaries throughout the watershed (e.g., Austin Creek, West Fork, Pena Creek, and other larger tributaries).

In the Upper River mainstem below CVD, adverse effects on individual embryos and pre-emergent Chinook salmon due to streambed scour and bank erosion are expected to be low to moderate, influencing approximately 5 to 10 percent of redds in years with high flood releases. These effects are expected to remain low during normal to critically dry years, when prolonged flood control releases are much less frequent, particularly with the continued implementation of FIRO procedures at CVD. Similarly, in the Dry Creek mainstem, high Chinook salmon spawning activity makes redds susceptible to scour and erosion from sustained flood control releases from WSD, with potential losses of 5 to 10 percent during wet years. However, the full implementation of FIRO procedures at Lake Sonoma is expected to further reduce the frequency, duration, and magnitude of flood control releases that could lead to prolonged streambed scour events in Dry Creek.

Down-ramping at CVD and WSD for flood control and water supply during late winter and spring is most likely to influence rearing habitat for salmonid fry and juveniles. Down-ramping may cause bar areas or off-channel pools to become dewatered or disconnected from the main river channel between January and May, increasing the risk of juvenile salmonids becoming trapped or stranded. However, the continued implementation of NMFS-recommended down-ramping criteria (2016a) is anticipated to result in minimal adverse effects on early life stages of salmonids and steelhead.

Reductions in adult passage flows in the Russian River mainstem during dry years (October–December) are anticipated to occur under the Proposed Action. While beneficial to rearing salmonids, these reductions would lower the frequency of passage flows during the early adult migration period, particularly for early-fall migrating Chinook salmon. However, the peak migration period would remain largely unaffected. Proposed flood control operations are unlikely to negatively impact coho salmon and, to a lesser extent, steelhead migration timing, as their runs occur later in the year. Additionally, adaptively managed augmented flows, such as blockwater releases from Lake Sonoma and pulse flows from Lake Mendocino, are expected to provide timely and sufficient passage flows at critical riffles during drier years, improving low-flow migration and spawning challenges for Chinook salmon in these years.

Artificially controlled flow regimes and degraded habitat conditions resulting from CVD, WSD, and Mirabel Dam water supply operations likely increase predation risk and reduce survival rates for outmigrating smolts of all three ESA-listed salmonids in the Upper and Lower River mainstem during drier years. This risk is particularly pronounced in the Lower River between the Dry Creek confluence and Mirabel Dam. Studies suggest that predation risk is inversely proportional to discharge (i.e., higher flow rates enhance migration speed and reduce predation risk). Proposed blockwater releases from WSD during drier years will aid Chinook salmon smolt outmigration in the Lower River. Although the extent of predation's impact on survival rates remains unquantified, proposed studies aim to estimate reach-specific smolt migration survival and timing under varying flow conditions, including drier hydrologic scenarios.

The Estuary is critical for the recovery of all Russian River salmonid and steelhead populations. Artificial breaching may negatively impact fall-migrating adult CC Chinook salmon. However, following the Proposed Action's Adaptive Management Plan's decision tree could mitigate these impacts by delaying breaching until passage conditions improve (>110 cfs at Hacienda). Migrating adult Chinook salmon, when staging without shelter (e.g., large woody debris, boulders), are more susceptible to predation, primarily by pinnipeds (e.g., harbor seals and sea lions). NMFS expects that proposed habitat enhancements, including installation of habitat complexity and shelter structures (LWD) in the Estuary mainstem, will improve survival rates by reducing predation risk for migrating adult salmonids, particularly Chinook salmon, until mainstem and tributary flows become sufficient for continued upstream migration.

In summary, while the Proposed Action is expected to reduce CC Chinook salmon abundance and viability within the Russian River population, these effects are not anticipated to extend across the entire ESU. The number of CC Chinook salmon projected to be lost due to the Proposed Action is small relative to the overall population and will be distributed across multiple year classes over the next decade, minimizing population-level impacts. Therefore, we do not expect the Proposed Action to significantly reduce the likelihood of survival or recovery of the CC Chinook salmon ESU.

2.7.1.3 Summary of Effects of the Proposed Action on CCC Coho Salmon Survival and Recovery

Most of the populations in the CCC coho salmon ESU are currently not viable, hampered by low abundance, range constriction, fragmentation, and loss of genetic diversity. Population abundance continues to decline, and many independent populations essential to the species' abundance and geographic distributions have been extirpated. These populations may not have sufficient abundance levels to survive additional natural or human caused environmental change and remain in immediate danger of extinction.

The Russian River watershed represents a third of the entire CCC coho salmon ESU and is, therefore, critical to the recovery of the entire population. Since the primary purpose of the DCFH is for conservation of the species (vs production for mitigation hatchery purposes and sport fishing), HOR coho salmon from the RRCSBP as well as NOR are included when NMFS considers viability criteria and recovery goals. Although the implementation of the RRCSCBP over the past 20+ years within the Action Area has been a life-line for CCC coho salmon in the Russian River, adult numbers are still only approximately three percent of the recovery target for this population. However, a strong cohort return in 2024/25 resulted in a record-breaking year with approximately 251 redds observed in the Lower River tributaries, with the majority of these found in Willow Creek (Sonoma Water unpublished data 2025).

Almost all of the current production of coho salmon in the Russian River watershed is sustained either by artificial production and planting of wild stock coho salmon via the RRCSCBP or by remnant natural spawning in a few tributaries in the Lower River that are not influenced by the Proposed Action. Spawning of wild adult coho salmon likely occurs in only a few Lower River tributaries, including the Dry Creek watershed. Because of the extremely small size of the Russian River coho salmon population and other coho populations in the Coastal Diversity Stratum, the RRCSCBP will likely remain an essential factor in maintaining the abundance, spatial distribution, and genetic diversity of coho salmon in the tributaries until sufficient quality habitats are rehabilitated or re-established and the population has ample time to respond to these potential improved habitat conditions.

Given that flows in Dry Creek and inflows and habitat conditions in the Estuary strongly influence the survival and abundance of juvenile coho in the Russian River watershed, any future flow management plan for WSD releases will affect population growth rates. Reservoir management at CVD has little bearing on the status of CCC coho salmon, other than contributing to necessary migration and survival flows in the Lower River. We anticipate that the Proposed Action will probably not directly reduce the overall abundance of coho salmon in the Russian River watershed relative to their recent population estimates, because coho salmon will be exposed to the same adverse conditions and experience the same rates of mortality as other year classes of coho salmon in recent years. Since the 2008 Opinion, impacts to ESA-listed salmonids due to flushing flood control releases from WSD have mostly been mitigated through a combination of: 1) intensive habitat enhancement efforts in the Dry Creek watershed, and 2) a reduction of sustained high flow events, both of which have significantly increased juvenile habitat refugia. However, we anticipate that many outmigrating juvenile coho salmon will die as the result of adverse habitat conditions resulting from the operation of Mirabel dam and Estuary management (e.g., habitat suitability in the Russian River mainstem, increased predation risk due to predator habitat availability, and the quality and extent of Estuary habitat conditions).

In order to counter anticipated losses of coho salmon, Sonoma Water and the USACE will implement additional habitat enhancement projects in the Lower River tributaries and Estuary and also adaptively manage flow augmentation strategies (i.e., timely blockwater and/or pulse releases) releases to increase survival rates for outmigrating juvenile coho salmon. Following the Estuary AMP to promote high quality rearing conditions in the Estuary during the dry season (spring through fall) is expected to benefit juvenile coho rearing in the Estuary similar to the benefits described below for juvenile steelhead.

Although the Russian River population of CCC coho salmon is considered at high risk of extinction, the Effects of the Proposed Action are not expected to appreciably contribute to the reduction in abundance, population growth rate, spatial structure, and diversity of this species in the Action Area or at the ESU scale. This is due to several factors, including: 1) most of the Lower River tributaries containing degraded habitat in which CCC coho salmon spawn and rear are outside of the Action Area or influence of proposed activities, 2) habitat enhancement efforts, including the previously constructed 4.5 miles of habitat in Dry Creek, combined with additional efforts to be implemented as part of the Proposed Action, will significantly increase high-quality rearing habitat availability, 3) it is assumed that CCC coho salmon mostly use the Estuary as a migration corridor and are not restricted by degraded habitat conditions there, 4) CCC coho salmon do not occupy the Upper River, so CVD operations only affect migration flows and survival in the Lower River, 5) and there are stronghold populations both north (along the Mendocino coast) and south (within Lagunitas Creek) of the Action Area, which continue to show positive trends (Sonoma Water unpublished data 2025; NMFS 2025)

2.7.1.4 Summary of Effects of the Proposed Action on CCC Steelhead Survival and Recovery

In California, ESA-listed coho and Chinook salmon are generally at greater risk (high to very high risk) than listed steelhead (moderate to high risk). CCC steelhead tend to be more widely distributed throughout their historic range and exhibit greater resilience throughout their life history. The Russian River contains multiple dependent and independent populations of CCC steelhead across two diversity strata (North Coastal and Interior Diversity Strata). Though population-level estimates of adult CCC steelhead are lacking throughout their DPS, they are not presently considered in danger of extinction, but likely to become at higher risk in the foreseeable future if population trends don't reverse over the next few generations. Concerns about interbreeding between hatchery and wild CCC steelhead and angling pressure in the Russian River are currently being addressed via adaptive management as part of the HGMP and future Fisheries Management and Evaluation Plan efforts.

Of the 16 populations of CCC steelhead from the North Coast and Interior Diversity Strata in the Russian River, the Upper Russian River independent population, and to a lesser extent, the four supporting dependent populations (i.e., Crocker Creek, Gill Creek, Miller Creek, and Sausal Creek) in the Interior Diversity Stratum, will be most-affected by high turbidity levels discharged from CVD, bank erosion, and streambed scour in the Upper River. The Dry Creek independent population will be affected by WSD operations, while all 16 populations will be affected by Estuary management). Although WSD and CVFF mitigation hatchery production of CCC steelhead are included in the DPS listing, unlike the conservation hatchery programs for CCC coho salmon, the primary purpose of these CCC steelhead hatchery programs is to supplement recreational angling opportunities due to construction of WSD and CVD. Therefore, HOR steelhead are not included in the abundance target of the viability criteria and recovery targets and take of these hatchery fish is not prohibited (considered "surplus" fish).

We do not anticipate that the Proposed Action will appreciably decrease the abundance of steelhead populations in the Russian River watershed relative to recent population abundances, because steelhead have adapted somewhat to high summer flows in the mainstem, Dry Creek, and Estuary and because proposed operations will either maintain or improve upon those conditions. Many tributaries of the Russian River that are unaffected by the Proposed Action will continue to provide functioning, albeit degraded, steelhead rearing habitat, and hundreds to thousands of wild steelhead will continue to return annually to spawn in the Russian River watershed during the 10-year life of this Opinion.

The DCFH will continue to contribute to the abundance of CCC steelhead in the watershed by producing and stocking hatchery steelhead that are genetically similar to wild stock. Although the Proposed Action is unlikely to reduce steelhead abundance relative to recent historic numbers, it will adversely impact the functionality of the PBF of critical habitat for freshwater spawning and rearing habitat in approximately 34 miles of the Upper River. Additionally, the Proposed Action will increase predation risk in drier water years for juvenile and smolt movement in the Lower River and alter rearing habitat in the Estuary, likely resulting in reduced production of juvenile steelhead and increased mortality. Consequently, juvenile steelhead production will be lower in these historically productive areas of the watershed. Given the degradation of critical outmigration habitat, we conclude that the steelhead hatchery program plays a substantial role in maintaining all Russian River steelhead populations.

The Proposed Action will also maintain longstanding conditions that constrain the ecological diversity of steelhead populations in the Russian River. Similar to CC Chinook salmon, the mainstem reach of the Upper River, from CVD downstream through the Ukiah Reach, likely supports a high density of adult steelhead spawners and redds, particularly in drier water years when access to adjacent tributaries may be limited. Consequently, some juvenile steelhead also rear year-round in the mainstem Upper River below CVD, where water temperature conditions remain suitable. Thus, the Upper Russian River steelhead population is expected to experience low to moderate impacts from heightened turbidity levels similar to those affecting Chinook salmon, though to a lesser extent in terms of spawning success and more significantly in relation to rearing conditions. Due to differences in spawning and incubation timing and a broader spawner distribution (including tributary spawners), fewer steelhead redds than Chinook salmon redds are expected to be impacted by streambed scour and elevated turbidity levels. Adverse effects on individual embryos and pre-emergent steelhead fry due to streambed scour are anticipated to be moderate in years with high flood releases, but lower in normal to drier water years, when prolonged flood control releases are less frequent.

Down-ramping for flood control and water supply during late winter and spring is most likely to affect rearing habitat for salmonid fry and juveniles, while pre-flood and periodic inspections in the fall are expected to adversely impact juvenile steelhead rearing habitat. Additionally, juvenile steelhead are expected to face increased predation risk in the mainstem Upper and Lower River during low-flow (drier) water years.

Steelhead populations exhibit diverse life history strategies, and in California, a significant portion of many populations rear in productive freshwater lagoons and estuaries during the dry season. Indeed, juvenile production in freshwater lagoons of smaller watersheds can contribute substantially to the number of adults returning from the ocean to California streams. Less is known about the role of larger open estuaries in steelhead productivity, but they likely provide important rearing habitat depending on the quality and extent of available estuarine habitat conditions.

The Proposed Action’s flow regime and Estuary breaching activities will likely adversely influence the natural ecological habitat diversity of steelhead populations in the Russian River watershed by continuing to alter Estuary dynamics that support resilient and diverse steelhead life histories. The quality and extent of rearing critical habitat for juvenile steelhead can be reduced in the Estuary during late spring, summer, and early fall due to mechanical breaching to prevent flooding in the town of Jenner.

Water quality dynamics during both open Estuary and closed lagoon conditions can limit both the quality and extent of juvenile steelhead habitat in the Estuary. Seasonal factors (spring, summer, and fall) and the ability of juvenile steelhead to osmoregulate and tolerate varying salinity levels influence habitat availability for specific life stages. In addition, water temperature and dissolved oxygen levels are critical elements of estuarine habitat quality and extent.

During spring and early summer, when mainstem inflows provide suitable water temperatures for salmonids, habitat conditions support all steelhead life stages. However, as mainstem conditions warm later in the summer and become less suitable for steelhead production (e.g., growth), cooler brackish water, resulting from tidal mixing, becomes more favorable for juveniles that have developed tolerance for higher salinity. This adaptability is particularly important during open-estuary conditions in late summer, when stratification becomes more pronounced between freshwater and saline layers of the Estuary. As the freshwater layer warms and becomes stressful, juvenile steelhead seek deeper, brackish water layers where mixing occurs with tidal exchanges, providing more favorable thermal conditions for growth potential.

By late summer, most juvenile steelhead rearing in the Estuary are expected to have transitioned to higher salinity tolerance and are equipped to capitalize on the highly productive brackish-water environment available in the Estuary. However, individuals with limited tolerance for increased salinity may experience reduced habitat availability and growth potential, likely restricting them to warmer, potentially more stressful freshwater areas.

Conversely, during late summer closed-lagoon conditions, a deeper freshwater layer builds within the Estuary, potentially expanding the availability of productive littoral habitat available in the Estuary. However, this freshwater layer can be dominated by warmer mainstem river water later in the summer, which may also limit steelhead production capacity in the Estuary. The duration of an estuary closure can further influence habitat conditions, as prolonged closures can lead to low or anoxic dissolved oxygen levels near the Estuary bottom, reducing suitable habitat for juvenile steelhead. Regardless of river mouth conditions (open or closed), the Estuary AMP and the habitat enhancements included in the Proposed Action seek to optimize habitat and water quality conditions to maximize foraging opportunities, supporting individual and population-level growth for steelhead in the Russian River.

As discussed above, the following conservation actions are expected to contribute to the CCC steelhead population within the Action Area: 1) previously completed habitat enhancement reaches in Dry Creek, 2) proposed habitat enhancement projects in the Lower River tributaries and Estuary, 3) adaptively managed flow augmentation procedures (e.g., blockwater and pulse flow releases from CVD and WSD), 4) continuing monitoring and research studies to inform future adaptive management decisions aimed to improve juvenile salmonid survival rates as they descend the mainstem Russian River, 5) investigations supporting future turbidity reduction efforts, and 6) continued implementation of FIRO procedures that further support sustaining cooler water released from CVD and WSD.

While the Effects of the Proposed Action are expected to result in a reduction in abundance and continue to reduce the likelihood of viability for the Upper Russian River population of CCC steelhead, we do not expect these effects to extend across the entire DPS. Although steelhead will be exposed to similar stressors as CCC coho salmon and CC Chinook salmon due to implementation of the Proposed Action, CCC steelhead generally have higher resilience against stochastic events, are widespread across their range, and are not as high risk for extinction as CCC coho salmon or CC Chinook salmon.

2.7.2 Summary of Effects of the Proposed Action on SRKW's Critical Habitat and Survival and Recovery

The Status of the Species and Environmental Baseline for SRKWs has been described in Sections 2.2.6-2.2.10 and 2.4.5-2.4.7 respectively. As described above in Section 2.5.8, our analysis of effects to SRKWs relies upon the expected impacts of the Proposed Action on the abundance and availability of Chinook salmon for SRKWs, 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 during the winter and spring months. Over the last 5 decades, the SRKW population has generally remained at a similarly low population size of about 70-90 individuals, and currently consists of 73 individuals. According to the most recent data available, J pod has 26 members, K pod has 14 members, and L pod has 33 members. Chinook salmon has been confirmed to be the preferred prey of SRKWs, and both the survival, fecundity, and body condition 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) 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 through 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 been linked to abundance of specific Chinook salmon stocks from Puget Sound and British Columbia 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 water operations in the Russian River and subsequent effects on habitat quantity and quality, the confinement of the river channel, limited riparian vegetation, ongoing sedimentation from roads, agriculture, and other developments and climate change. Water diversions, the confinement of the river channel, limited riparian vegetation, and ongoing sedimentation from roads, agriculture, and other developments remain important unresolved threats to the success of the CC Chinook salmon. 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 2.5.8 Effects of the Action*,* NMFS expects that the Proposed Action will reduce the amount of CC 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 by the time most of the juvenile Chinook production 5 years from now have fully matured and returned to spawn or otherwise been removed from the ocean through mortality. Based on the analyses that have been performed and the limitations of the available tools, the expectations for the absolute magnitude of these reductions in total cannot be precisely estimated. However, if a large portion of the ESU of 13,169 was lost, this would represent no more than a ~0.7 percent reduction of SRKW Chinook prey on the U.S. West Coast, or roughly 3.4 percent less prey off California. 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 off the coast of California and Oregon, and we expect that SRKWs will at times be harmed through impaired foraging behavior and success, requiring additional time spent foraging, which increases energy expenditures and the potential for nutritional stress, especially for members of K and L pods.

Increased energy expenditure and prey limitation can cause poor body condition and nutritional stress. 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 2.5.8 Effects of the Action Section*,* the overlap in distribution of SRKWs and CC Chinook salmon occurs throughout the SRKW range but are most likely when SRKW are in the southern part of their range along the coast of California and Oregon during the winter and spring. If prey availability is 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 reductions in Chinook resulting from this Proposed Action would occur in the southernmost part of the SRKW range, which is primarily used in the winter and spring months when SRKW have poor body condition, the magnitude of this reduction is generally low relative to the total magnitude of prey available to SRKW across the coast and CC Chinook are listed low on the priority prey list (see Section 2.4.7.1.1). Factoring in the Status of the Species, Environmental Baseline, and Cumulative Effects, NMFS concludes the Proposed Action would not be expected to appreciably reduce the likelihood of both the survival and recovery of the SRKW DPS over the next 5 to 9 years, or adversely modify critical habitat.

2.8 Conclusion

After reviewing and analyzing the current status of the listed species and critical habitat, the Environmental Baseline within the Action Area, the Effects of the Proposed Action, the effects of other activities caused by the Proposed Action, and the Cumulative Effects, it is NMFS' Opinion that the Proposed Action is not likely to jeopardize the continued existence of CCC coho salmon, CC Chinook salmon, CCC steelhead, SRKW, or destroy or adversely modify their designated critical habitat.

2.9 Incidental Take Statement

Section 9 of the ESA and federal regulations pursuant to Section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). "Harass" is further defined by guidance as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering." "Incidental take" is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and Section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this ITS.

2.9.1 Amount or Extent of Take

In the Opinion, NMFS determined that incidental take is reasonably certain to occur as detailed below. The precise number of salmonids that are likely to be taken cannot always be accurately quantified, however, because salmonids: 1) most often cannot be observed or counted, 2) are relatively small (especially as eggs, alevins, and juveniles), 3) live in aquatic environments where visibility is often low, hiding cover often available, and predators feed, 4) migrate long distances in short periods of time during some life history stages, and 5) naturally fluctuate in number between years due to short term environmental variation and other factors. Detection of lost redds and enumerating embryos/pre-emergent fry will be difficult because: 1) redds are created by salmonids in complex aquatic environments where they can be missed by observers, 2) redds can be obscured by high flow events without being destroyed, leading to incorrect counts of redds lost.

In cases where NMFS cannot specify a quantity of individuals that are expected to be incidentally taken by the action, NMFS uses surrogates to describe the extent or amount of incidental take. Thus, NMFS has used conditions or impacts, including habitat impacts, described below, as surrogates to describe the amount or extent of salmonids expected to be incidentally taken.

In this Opinion, NMFS determined that incidental take of CCC coho salmon, CC Chinook salmon, and CCC steelhead, and SRKW is reasonably certain to occur as follows:

2.9.1.1 Reservoir Operations at CVD - Turbidity

Proposed reservoir operations at CVD would release turbid water in a manner that is anticipated to result in take in the form of harm, injury, and mortality, resulting in moderate to high reductions in Chinook salmon and steelhead embryos, pre-emergent fry, and juvenile summer-rearing productivity from the CVD Outlet downstream to Hopland. These reductions may occur through entombment of embryos and pre-emergent fry, leading to poor spawning success within the Ukiah Reach. Juvenile steelhead are expected to be displaced when avoiding increased turbidity, and when combined with loss of prey, are likely to experience reduced overall growth and fitness potential below the CVD Outlet to Hopland, particularly during the juvenile steelhead summer season when turbidity levels are elevated.

As described in the Terms and Conditions below, NMFS is requiring turbidity and salmonid monitoring to more precisely assess the level of impact that turbid releases from CVD have on ESA-listed salmonids. However, until sufficient data are available to quantify take, NMFS will use the percentage-of-days that turbidity exceeds lethal thresholds, defined by 28 NTUs, as a surrogate for estimating the level of impact on specific salmonid life stages from CVD-related turbidity. This approach is appropriate because the turbidity thresholds are based on literature values that identify likely adverse effects to specific life stages of salmonids.

Based on the percent-of-days analysis in this Opinion, incidental take may be exceeded if, in any given year, CVD releases contribute to elevated turbidity levels at Hopland that exceed:

- 16 percent of days above the lethal threshold for embryos and pre-emergent fry (28 NTUs) during the fall months (October through December),

- 35 percent of days above the lethal threshold for embryos and pre-emergent fry (28 NTUs) during the winter months (January through March),

- 18 percent of days above the lethal threshold for embryos and pre-emergent fry (28 NTUs) during the spring months (April through May), or

- 10 percent of days above 28 NTUs during the summer months (June through September), potentially affecting juvenile steelhead during the summer rearing period.

2.9.1.2 Flood Control Operations at CVD – Streambed Scour

Streambed scour due to flood control flow releases at CVD is expected to result in take in the form of fry harm, injury, and mortality, and reduced egg survival by destroying a low number of Chinook salmon redds and even fewer steelhead redds in the Upper River. Due to the difficulty in observing redd loss downstream of the dam, NMFS will use the expected number of days that CVD flood control releases increase the duration of scour events above baseline channel conditions in the Upper River as a surrogate for the number of Chinook salmon and steelhead redds lost in the Upper River (as measured at the Ukiah gage). In this context, "baseline channel conditions" refers to Russian River flows in the absence of CVD flood control releases, reflected in the measurement at Ukiah gage.

During the next 10 years, NMFS anticipates years when CVD flood control operations will release flows over 4,200 cfs (scour events) above the baseline channel conditions in the Upper River. Based on the analysis of these scour events in the Opinion, incidental take will be exceeded if:

- CVD flood control releases extend the duration of scour events by more than 25 days ≥ 4,200 cfs at Ukiah during the next 10 years; or

- CVD flood control releases in any 1 year extend the duration of scour events by more than 10 days ≥ 4,200 cfs at Ukiah.

2.9.1.3 Flood Control Operations at CVD - Bank Erosion

Small, localized take of salmonid embryos and fry in the form of harm, injury, and mortality, from sedimentation due to bank erosion is expected as a result of Flood Control actions at CVD during some years. Similar to the issue of redd scour, it is difficult to detect resulting Chinook salmon and steelhead redd loss in the Upper River due to sedimentation from bank erosion downstream of CVD. Therefore, NMFS will use the number of days CVD is expected to release flood control flows above baseline channel conditions to greater than 6,000 cfs at Hopland as a surrogate for the number of redds lost and fish taken downstream of CVD due to bank erosion. This is an appropriate surrogate because flows of this magnitude have been known to cause bank erosion, which is documented in the literature to be directly related to the number of redds and fish exposed to the effects of resulting increases in sediment. Based on the analysis of these bank erosion events in the Opinion, incidental take may be exceeded if:

- CVD flood control releases extend the duration of bank erosion events by more than 28 days ≥ 6,000 cfs at Hopland over the course of the next 10 years, or

- CVD flood control releases in any 1 year extend the duration of bank erosion events by more than 11 days of flows ≥ 6,000 cfs at Hopland.

2.9.1.4 Water Supply Operations at CVD - Migration and Predation

NMFS anticipates some level of take in the form of harm and mortality to adult Chinook salmon is likely to occur if flows in the Upper River, which are largely determined by the Proposed Action, are too low to allow for adequate upstream passage. Low flows will also likely result in some level of take to out-migrating Chinook salmon and steelhead smolts due to predation (as discussed in Effects Sections 2.5.1.1.2.8 and 2.5.1.1.2.9). Passage condition of critical habitat is directly related to the amount of flow in the channel and is an appropriate surrogate for the amount of take anticipated because if adults are unable to migrate upstream, or if migration is severely delayed, they will be unable to spawn or spawning conditions will be too poor and the contribution of their eggs will be lost or severely compromised. Also, preliminary results from ongoing Sonoma Water studies indicate that survival of out-migrating smolts during low flow years may be significantly reduced due to predation impacts when compared with survival rates during normal water years. Therefore, incidental take will be exceeded due to Proposed water supply releases at CVD if the following do not occur:

- Sonoma Water will develop and test Lake Mendocino water supply pool pulse release strategies during dry and critical hydrologic conditions. The reservoir release strategy will be implemented on a trial basis during the first 2 years of this 10-year term of the Opinion. A finalized strategy will be implemented within 2 years of issuance of this Opinion, or if pulse flows at CVD are not made in accordance with NMFS guidelines and adaptively managed during dry water year conditions.

2.9.1.5 Flood Control Operations at WSD – Streambed Scour and Bank Erosion

WSD flood control releases that exceed 4,000 cfs can cause potential streambed scour of coho salmon, Chinook salmon, and steelhead redds in the Dry Creek mainstem below the Pena Creek confluence. This scour is expected to cause take to these salmonids in the form of harm, injury, and mortality. Similar to CVD above, NMFS will use the frequency of the WSD flood control releases that are likely to result in redd scour as a surrogate for numbers of salmonids taken. Based on the analysis of these scour events in the Opinion, take will be exceeded if:

- Releases from WSD of 4,000 cfs or greater occur on more than 15 consecutive days per year in any given 5 years during the next 10 years.

Small, localized take of salmonid embryos and pre-emergent fry in the form of harm, injury, and mortality, in the Dry Creek mainstem from sedimentation due to bank erosion is expected during some years. Similar to the surrogate used for take expected from scour effects, NMFS will use the frequency of WSD flow releases that are likely to produce bank erosion as a surrogate for numbers of fish taken. Bank erosion is expected when flood control releases exceed 2,500 cfs. Take will be exceeded if:

- Releases from WSD of 2,500 cfs or greater occur on more than 30 consecutive days per year in any given 5 years during the next 10 years.

2.9.1.6 Water Supply Operations at WSD - Elevated Summer Flows

NMFS anticipates take of juvenile coho salmon and steelhead in the form of harm, injury, and mortality, as a result of high flows in Dry Creek resulting from WSD water supply operations (typically May through October). Take levels will vary depending upon water year type and the flows released from WSD. Salmonid loss is expected to diminish over time as habitat conditions in Dry Creek become better established, creating areas where juvenile salmonids can escape high velocity flows.

NMFS will use WSD flow release data as a surrogate for estimating the numbers of juvenile rearing salmonids likely lost due to high flows. This is an appropriate surrogate because, based on analysis of these flows in this Opinion, the flow thresholds listed below conservatively capture the duration of exposure to adverse flow conditions that are expected to result in take. If these releases occur with greater duration/frequency than specified below, anticipated take may be exceeded.

- The median flow immediately below WSD during the low flow period (June 1 through October 15) exceeds 175 cfs over any 7-day period in any given year.

- Daily average flows in excess of 200 cfs (i.e., between 200 and 210 cfs) will not occur more than 2 non-consecutive days per year during the 10-year term of this Opinion, with each exceedance lasting no more than 24 consecutive hours.

2.9.1.7 Water Supply Operations at WSD - Migration

NMFS anticipates take of adult Chinook salmon in the form of harm and mortality when water supply releases from WSD are not sufficient to achieve minimum adult migration passage flows in the Lower River, particularly when the onset of fall and winter storm season is significantly delayed or during Critically Dry water years. NMFS uses minimum adult fish passage flows for the Lower River of 110 cfs as a surrogate for such take. Therefore, take of adult Chinook salmon will be considered exceeded if the following conditions are not followed:

- During dry and critically dry water supply conditions, from October 15 through December 31, Sonoma Water will implement flow augmentation procedures (using blockwater and/or pulse release strategies) from Lake Sonoma to maintain a minimum adult passage flow of 110 cfs in the Lower River. These releases will occur if the Estuary inlet is open, allowing for adult Chinook salmon to enter the river, and if adult Chinook salmon are documented in the Estuary and/or Lower River.

Take will be exceeded if:

- If Chinook migrants are detected in the Estuary and/or Lower River between October 15 and December 31, <u>and</u>

- The flow rate at Hacienda gage remains less than 110 cfs for more than 7 days post breach (10 percent of days between October 15 to December 31).

2.9.1.8 Stranding due to Pre-flood Dam Inspection and Down-ramping Events

NMFS anticipates take of fry and juvenile Chinook salmon, coho salmon, and steelhead, in the form of mortality, downstream from WSD and CVD during down-ramping events. Changes in river stage during flood control ramping are likely to result in stranding between February and late June.

Previous monitoring of pre-flood inspection flow ramp downs shows that the Proposed Action's ramp-down rate of 12 cfs per hour, and no more than 24 cfs per day, will minimize the occurrence of intermittent and dewatered habitats near the dam, and still allow for adequate flow from the stilling basin to the river. This will maintain instream habitat for salmonids further downstream during the 2-hour flow release inspection and maintenance shutdown. However, some stranding may still occur. A take surrogate is not necessary given the limited geographic area and scope of the action during these operations and because the take that has been documented during past ramping events is expected to be similar to those implemented as part of the Proposed Action.

- Incidental take in the form of mortality of up to 50 juvenile steelhead and 50 juvenile Chinook salmon that may be stranded and require relocation during dam inspections at CVD is reasonably certain to occur. This take may occur during annual and 5-year inspections over the 10-year term of the Opinion. Take is exceeded above this amount.

- NMFS estimates that up to 50 juvenile coho salmon, 200 juvenile Chinook salmon and 1,000 juvenile steelhead may need to be rescued from isolated pools, (particularly in habitat enhancement reaches in Dry Creek) and relocated to suitable habitat during downramping flows released from WSD in late winter/early spring. The frequency of these stranding events depends on climatic conditions and the application of FIRO at Lake Sonoma. However, based on historical data, NMFS expects these rescues could be necessary in up to 5 of the 10 years covered by this Opinion. Take is exceeded above this amount.

    - NMFS does not anticipate take associated with pre-flood/periodic inspections at WSD conducted in late August or September.

2.9.1.9 Mirabel Facility Operation

It is reasonably certain that a low-level of incidental take of juvenile salmonids in the form of injury or mortality may occur depending on river levels at the fish gallery at Mirabel. A take surrogate is not necessary given the limited geographic area and scope of the action during these operations, and because the take that has been documented during past events is expected to be similar to those implemented as part of the Proposed Action. Take will be exceeded if:

- More than 45 juvenile salmonids are in need of rescue per year;

- More than 2 juvenile salmonids or more than 1 steelhead kelt are injured or killed during each year's relocation efforts.

The backwater effect of Wohler pool caused by Mirabel dam creates an environment that favors predatory fish survival and predation success. An unknown amount of take of juvenile salmonids in the form of harm, injury, and mortality, is likely to occur as a result. Results from studies discussed in this Opinion suggest that higher flows increase juvenile salmonid migration rate and decrease predation risk. Therefore, NMFS is using blockwater releases from WSD as a surrogate for incidental take of juvenile salmonids that will occur due to predation. Take will be exceeded if the following conditions are not met:

- Sonoma Water will annually reserve 2,500 ac-ft of "blockwater" from WSD to be used at the discretion of NMFS in coordination with CDFW and SWRCB. Blockwater release strategies can be used in combination with already-scheduled releases to improve migratory habitat conditions, accelerate downstream smolt migration, lower piscivorous fish density per volume of water, and minimize overall predation risk to juvenile steelhead, Chinook salmon, and coho salmon smolt migrating through the Lower River. Sonoma Water will annually coordinate with CDFW, SWRCB, and NMFS on how blockwater can be optimized to aid salmonid migration to ensure adequate survival rates. Blockwater release strategies will be coordinated with the smolt survival studies to evaluate the effectiveness of timely flow augmentation.

2.9.1.10 Dewatering and Fish Relocation

A low-level of incidental take of juvenile CC Chinook salmon, CCC coho salmon and CCC steelhead in the form of injury or mortality is reasonably certain to occur during dewatering and fish relocation events associated with: 1) channel maintenance, 2) restoration activities in Dry Creek, Lower River tributaries, and the Estuary, 3) stranding at the Mirabel fish gallery, and 4) maintaining enhancements in Dry Creek. A take surrogate is not necessary given the scope of the action during these operations, and because the take that has been documented during past events is expected to be similar to those implemented as part of the Proposed Action.

- Unintentional mortality of listed steelhead during capture, handling, and relocation is not likely to exceed three percent of the total CC Chinook salmon, CCC coho salmon, and CCC steelhead handled. The amount of incidental take during dewatering and fish relocation will be considered exceeded if more than three percent of the total fish handled are injured or killed during any dewatering and fish relocation event.

2.9.1.11 Artificial Breaching in the Estuary

NMFS anticipates small amounts of take, mostly in the form of injury or mortality to small juvenile salmonids, will occur when it is necessary for the Estuary to be breached in the spring or summer. In these circumstances, conditions are created that likely: 1) sweep small juvenile steelhead (and possibly juvenile coho salmon) out to sea before they are ready for the ocean environment, 2) increase salinity levels in the Estuary above the tolerance levels of freshwater-acclimated juvenile steelhead, 3) expose juvenile steelhead (and possibly juvenile coho salmon) to increased levels of predation as the freshwater lens at the top of the Estuary shrinks, and 4) set up conditions for subsequent closure of the bar and temporary adverse changes to water quality as described in this Opinion. Most of the small juvenile salmonids exposed to these conditions will die.

Only small amounts of incidental take are anticipated for Chinook salmon migrants because: 1) these fish are anticipated to be able to enter and exit the Estuary through the overflow channel that will be constructed, 2) the Estuary will be fully open to ocean tides prior to the peak of the adult Chinook migration (mid-October through mid-November), and 3) Chinook salmon smolts that enter the Estuary can tolerate salt water. Similarly, most coho salmon smolts in the Estuary are expected to move into the ocean prior to the summer and are not likely to be adversely affected by adaptive management or a limited number of spring or summer breaching events. Juvenile coho salmon that remain are expected to leave the Estuary and move upstream prior to fall breaching.

NMFS cannot accurately estimate the number of juvenile steelhead (and coho salmon to a lesser extent) that will be impacted by artificial breaching. The number may range, considerably, depending upon the timing and presence of freshwater-acclimated juvenile steelhead, and when the Estuary may close in the spring or early summer. Therefore, NMFS will use the number of times the Estuary may be artificially breached as a surrogate for the numbers of juvenile steelhead and coho salmon taken as described above.

Therefore, a low level of incidental take of juvenile steelhead (and coho salmon to a lesser extent) is reasonably certain to occur as a result of artificial breaching in the lagoon management period (May 15 to October 15). If artificial breaching occurs between January 1 and May 15, little to no take is expected for any species. Artificial breaching actions conducted by Sonoma Water between May 15 and October 15 that follow the AMP, and are intended to avoid or minimize degrading water quality conditions to benefit rearing salmonids, will not be counted against the take coverage limits.

Take will be exceeded if:

- Artificial breaching occurs more than 10 days prior to a forecasted natural breach, <u>and</u>
- Artificial breaching occurs more than once every 3 years from May 15 through October 15 for the 10-year duration of the Opinion.

2.9.1.12 Channel Maintenance Activities

A low-level of incidental take is reasonably certain to occur as a result of implementation of channel maintenance activities in the Upper River (MCRRFCD) and Dry Creek (Sonoma Water). This take is expected in the form of harm to all freshwater life stages of CCC coho salmon, CC Chinook salmon, and CCC steelhead from habitat-related impacts (permanent loss of benthic habitat; pollution from hazardous materials and contaminants; removal of riparian vegetation or LWD; and altered channel morphology and hydrology). NMFS expects this incidental take to be mostly localized and limited to the footprint of project sites.

The extent of incidental take will be considered exceeded if:

- Channel maintenance activities exceed any of the specific limits assigned for each project type presented in Sections 1.3.3 and 2.5.4 of this Opinion. These limits apply to individual projects conducted under the 10-year term of this Opinion.

2.9.1.13 Santa Rosa Creek Diversion

Maintenance at the Santa Rosa Creek Diversion Structure will require dewatering the Vortex Tube using cofferdams and operation of the bypass pipe that may take 1 to 2 weeks to complete. Incidental take of approximately 5 juvenile steelhead in the form of mortality each year is reasonably certain to occur as a result of these maintenance activities. Take will be exceeded if more than 5 juvenile steelhead are taken in a year during these maintenance activities.

2.9.1.14 Monitoring and Research

It is reasonably certain that monitoring and research activities associated with the Proposed Action will result in the incidental take in the form of harassment (observation surveys), harm, injury, and mortality, of the species and life history stages represented below in Table 34. Appendix A contains a complete list of the amount of take expected for each activity. The amount of incidental take of CCC coho salmon, CC Chinook salmon, and CCC steelhead due to monitoring and research activities will be considered exceeded if the number of fish observed, handled, or killed during monitoring activities such as snorkel and redd surveys, downstream migrant trapping, seining, electrofishing, etc. is greater than that listed in Table 34.

Table 34. Summary of total take (by species and life stage) expected due to implementing monitoring and research activities associated with the Proposed Action.

Species	Life Stage	Fish Observed (snorkel, video, redd survey)	Fish Handled (capture, tag, release)	Unintentional Mortality
Chinook Salmon	Adult (NOR)	24,000	—	—
	Juvenile/smolt (NOR)	1,500	96,700	2,900
Coho Salmon	Adult (NOR/HOR)	7,000	—	—
	Juvenile/smolt (NOR/HOR)	11,500	—	—
	Juvenile/smolt (HOR)	—	88,650	886
	Juvenile/smolt (NOR)	—	29,850	298
Steelhead	Adult (NOR/HOR)	12,000	—	—
	Juvenile/smolt (NOR/HOR)	11,500	—	—
	Adult (HOR)	—	30	0
	Smolt (HOR)	—	13230	397
	Adult (NOR)	—	30	0
	Juvenile/smolt (NOR)	—	107,800	3,234

2.9.1.15 Take Impacting Southern Resident Killer Whales

NMFS anticipates that the reduction in the abundance of CC Chinook salmon that will occur as a result of impacts to Chinook salmon during the Proposed Actions included in the 10-year term of this Opinion is reasonably certain to result in some level of harm to SRKWs; specifically, members of K and L pod (currently 49 individuals), during that period. The harm is a consequence of subsequent reduced prey availability causing impairment in foraging behavior, leading SRKWs to forage for longer periods, travel to alternate locations, and encounter increased risk of nutritional stress and related health effects.

Currently, we cannot readily observe or quantify impacts to foraging behavior or any changes to the health of individual SRKWs that may occur as a consequence of the general level of prey reduction that is expected as a result of the Proposed Action because we do not have the data or metrics needed to monitor and quantitatively establish relationships between the effects of the Proposed Action and individual SRKW health. Quantitative relationships between the health and productivity of the entire SRKW population and the changing abundance of prey species are complex, as described in Section 2.4.7 Environmental Baseline for Southern Resident Killer Whale DPS. As a result, we will rely on surrogates for the amount or extent of incidental take of SRKWs as a result of the Proposed Action in the form of the extent of effects to Chinook salmon described in the Chinook effects analysis (Sections 2.5.8.1 Effects to SRKWs and 2.7.2 Integration and Synthesis for SRKWs).

Exceedance of the extent of effects to Chinook salmon would be viewed as an exceedance of the anticipated take of SRKWs. Effects to Chinook salmon will be measured and monitored as part of the monitoring and reporting requirements contained within this Opinion.

2.9.2 Effect of the Take

In the 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 designated critical habitat.

2.9.3 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). Many of the conservation-oriented and habitat restoration actions proposed by USACE and Sonoma Water, developed with technical assistance from NMFS, may be expected to reduce and avoid or minimize the impact of incidental take if they are properly and timely implemented. The following RPMs include monitoring and reporting requirements and other measures to ensure that USACE and Sonoma Water are implementing these actions as described in and considered in this Opinion and, where feasible, to further minimize take.

The following reasonable and prudent measures are necessary and appropriate to avoid and minimize take of CCC coho salmon, CC Chinook salmon, CCC steelhead, and SRKW:

1. Ensure measures are undertaken to avoid and minimize take of juvenile salmonids during down-ramping at WSD.

2. Ensure measures are undertaken to avoid and minimize take of ESA-listed salmonids resulting from adaptive management and monitoring within the Estuary.

3. Ensure measures are undertaken to avoid and minimize take of ESA-listed salmonids resulting from diversion operations at Mirabel Dam (within Wohler Pool) and WSD and CVD water operations.

4. Ensure all restoration projects are designed and implemented to avoid and minimize take of ESA-listed salmonids.

5. Ensure measures are undertaken to more precisely determine the amount of take resulting from turbidity impacts and to improve understanding of turbidity impacts on ESA-listed salmonids in the Upper River.

6. Ensure adherence to turbidity-related measures, including goals, objectives, and timelines outlined in the Proposed Action.

7. Ensure measures are undertaken to satisfy goals and objectives for all proposed TACs and Working Groups and adhere to proposed timelines.

8. Prepare and provide NMFS with plans and reports describing implementation of the Proposed Action consistent with this Opinion, including annual monitoring and reporting on activities that are implemented or were proposed to be implemented, and any incidental take that occurs.

2.9.4 Terms and Conditions

In order to be exempt from the prohibitions of Section 9 of the ESA, the federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions. The USACE, Sonoma Water, MCRRFCD, 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.

All Terms and Conditions listed below shall be implemented following BMPs detailed in Appendix B.

The following terms and conditions implement reasonable and prudent measure 1:

1. Develop and implement a plan for monitoring surveys in Dry Creek, below the confluence with Pena Creek, to further understand the evolving dynamics between constructed habitat-enhancement features and down-ramping activities.

a. Within 6 months of the signing of this Opinion, Sonoma Water and the USACE will provide NMFS, for its review and approval, with a robust Monitoring Plan to survey the immediate area at and below the Pena Creek confluence with Dry Creek during down-ramping events. This Plan shall include the timing and scope of monitoring that will occur during ramp-down events, an emergency action plan for fish rescue and relocation during such events, and associated reporting. The Monitoring Plan will be implemented immediately following NMFS' review and approval.

b. Information from these monitoring efforts shall be considered to inform future adaptive management needs of established habitat enhancement reaches in Dry Creek.

The following terms and conditions implement reasonable and prudent measure 2:

1. Sonoma Water will deploy in situ sensors from spring through fall to monitor water quality in the lower Estuary, lower Willow Creek, and other locations identified by the Estuary AMP Team. These data will support adaptive management aimed at optimizing habitat conditions in the Estuary, particularly during inlet closure events.

2. Sonoma Water will continuously monitor dissolved oxygen (DO) levels in the Estuary and Lower Willow Creek Marsh prior to any artificial breaching events during the juvenile salmonid rearing season. If artificial breaching occurs when water surface elevations have exceeded 7 feet NGVD29 and the Estuary AMP Team determines that water quality conditions are limiting prior to breaching, Sonoma Water will conduct post-breach surveys within the Lower Willow Creek Marsh and its confluence with the Estuary mainstem within 24 hours (timing contingent on the tide cycle).

The following terms and conditions implement reasonable and prudent measure 3:

1. Sonoma Water will continue to evaluate relationships between smolt migration survival and adaptively manage outmigration flows accordingly throughout the life of this Opinion.

2. Upon completion of proposed survival studies in the Upper and Lower River, Sonoma Water will pursue contingency measures designed to increase juvenile outmigration survival rates throughout the life of this Opinion.

3. During critically dry years, Sonoma Water will monitor pools downstream of the lowest critical riffle in the Lower River from October 15 through December 3, to assess the presence of upstream-migrating adult Chinook salmon. If Chinook are observed and flows at Hacienda are below 110 cfs, Sonoma Water will immediately notify NMFS to facilitate implementation of flow augmentation strategies (e.g., pulse releases and/or blockwater use), as directed by NMFS, to promote the timely upstream migration of adult salmonids.

The following terms and conditions implement reasonable and prudent measure 4:

1. The USACE and Sonoma Water shall coordinate with NMFS as early as possible in the planning stage of habitat restoration actions so that NMFS can provide technical assistance.

2. For the Estuary, Dry Creek, and Lower River tributary habitat enhancement activities, the USACE and Sonoma Water will provide NMFS with complete project descriptions for our review and approval that include: the scope of the action, BMPs addressing any potential water quality impacts (including activities such as fish relocation, screening, filtering, dredge disposal), monitoring, and post-construction reporting. Project descriptions shall be provided to NMFS for review and approval at least 6 months prior to implementing any restoration-related construction activities. The following will also be implemented and provided:

    a. A feasibility study for the proposed habitat enhancements in the Estuary (both the 3 to 5 acres of habitat enhancement and the 2 to 4 Estuary mainstem LWD structures) will be initiated within 4 months and completed within 2 years of the issuance of this Opinion. Design and permitting to be completed within 5 years of the issuance of this Opinion. Construction of the enhancement sites will be completed within 8 years of the issuance of this Opinion.

    b. After completing the Estuary habitat enhancements, Sonoma Water will conduct monthly surveys for at least 2 years to evaluate the effectiveness of the habitat enhancements and verify the structural stability and durability over time. These surveys will include both the 3 to 5 acres of enhanced habitat and the 2 to 4 LWD structures designed for the Estuary mainstem. The surveys will assess water quality conditions and habitat use by ESA-listed species within the enhancement site(s) and will be included in Sonoma Water's annual report. Effectiveness objectives will be developed by the Estuary AMP Team and submitted to NMFS for review and approval prior to construction. If the habitat enhancement features do not meet the post-construction success criteria established by the Estuary AMP Team, particularly following significant flow events, adaptive management measures will be implemented with NMFS concurrence or direction.

    c. A feasibility decision will be made and an alternative chosen for the Phase III of the Dry Creek Project within 4 months of the publication of the Opinion. As part of the decision-making process by the Dry Creek Habitat Enhancement Alternatives Group, If applicable: 1) within 6 months of publication of the Opinion, a small-scale habitat enhancement project funded by Sonoma Water will be selected; 2) within 2 years of publication of the Opinion, Sonoma Water will provide funding for implementation of a small-scale enhancement project; 3) within 3 years of publication of the Opinion select a larger-scale preferred alternative enhancement site(s) for Sonoma Water and/or USACE development and implementation; and 4) within 5 years of publication of the Opinion, Sonoma

Water and/or USACE will provide funding and/or construction to implement a larger-scale habitat enhancement project.

The following terms and conditions implement reasonable and prudent measures 5 and 6:

1. The USACE shall complete all measures and objectives outlined in the Proposed Action related to salmonid monitoring and reporting in the Upper River and shall provide timely and thorough updates on progress on these items at NMFS' request.

2. The USACE shall complete all measures and objectives outlined in the Proposed Action related to turbidity reduction investigations and evaluations, monitoring, and reporting in the Upper River and shall provide timely and thorough updates on progress on these items at NMFS' request.

3. The USACE shall implement the short-term turbidity reduction actions outlined in the Proposed Action within 4 years of the issuance of this Opinion.

4. The Turbidity TAC's charge, listed in the Proposed Action and referenced in Appendix C, shall be completed with NMFS's review and approval within 4 months of issuance of this Opinion.

The following terms and conditions implement reasonable and prudent measures 7:

1. Sonoma Water and USACE shall ensure that all TACs and working groups to be developed as part of the Proposed Action are formed and meet on the timeline and frequency described in the Proposed Action and Appendix C, and take measures to ensure that all goals, objectives, and timelines undertaken as part of these TACs are met.

2. Sonoma Water and USACE shall make ongoing reasonable progress on all TAC and working group measures, toward timely satisfaction of all goals and objectives, and will provide accurate documentation of such progress to NMFS within 2 weeks when requested, but not less than annually.

3. If, despite best efforts, TAC and working group timelines cannot be met for reasons beyond the agencies' control, Sonoma Water and/or the USACE will notify NMFS immediately to discuss options for proceeding consistent with this Opinion, since operations that result in deviations from the proposals and assumptions in this Opinion could cause more take than has been analyzed.

The following terms and conditions implement reasonable and prudent measure 8:

1. Turbidity -

    a. The USACE shall provide NMFS online access to all turbidity data from identified gaging locations described in the Proposed Action starting within 1 year of issuance of this Opinion and continuing through the life of this Opinion.

b. For each short-term turbidity reduction action, a written report assessing each action's effectiveness in reducing turbidity from the CVD Outlet to Hopland shall be submitted to NMFS no later than August 15 of the calendar year following implementation.

c. Beginning August 15, 2027, the USACE shall submit annual written reports to NMFS by August 15 of each year. These reports shall describe the development of potential long-term turbidity reduction actions, including Turbidity TAC activities, recommendations, investigations, and modeling efforts, consistent with the Proposed Action.

d. The USACE shall provide NMFS with an analysis of the effects to ESA-listed salmonids using data collected through salmonid and turbidity monitoring in the Upper River. This analysis shall quantify salmonid productivity (i.e., relative spawning success) and juvenile steelhead summer-rearing habitat use between the CVD Outlet and Hopland. If NMFS determines that the results indicate greater-than-anticipated impacts on ESA-listed salmonids (e.g., a substantial reduction in habitat production potential), the USACE shall submit a plan to avoid or minimize these effects to NMFS for review and approval by no later than July 1, 2030.

1. Adaptive Management within the Estuary - If any fish mortalities are observed due to poor water quality during breaching events, Sonoma Water will notify NMFS immediately or as soon as practicable. All mortalities will be identified to species and age class (based on length in mm) and enumerated. The date, time, location (mapped), habitat type, and photographs will also be documented. This information will be compiled into a summary report and submitted to NMFS.

2. Down-ramping at WSD - During WSD down-ramping monitoring surveys, Sonoma Water and USACE shall document any instances of salmonid stranding, including mortalities, and relocation efforts. Reporting will include: the stage changes attributed to down-ramping and the number and species of salmonids observed in the impacted area. Any mortalities shall be identified to species and age class (length in mm), and enumerated. The date, time, location (mapped), photos, and habitat type shall be documented for all salmonid impacts. This information will be submitted to NMFS in the form of a memorandum following any down-ramping event to be surveyed.

3. Annual Report - Unless otherwise specified (i.e., turbidity measures), each year, a report summarizing all USACE, Sonoma Water, and MCRRFCD activities covered in this Opinion shall be prepared and submitted to NMFS no later than January 31.

    a. Construction related activities - The report shall include the dates construction began and was completed; a discussion of any unanticipated effects or unanticipated levels of effects on salmonids, a description of any and all measures taken to minimize those unanticipated effects; the number of salmonids killed or injured during the project action; and photographs taken before, during, and after the activity from photo reference points.

b. Fish Stranding/Relocation - If fish relocation is necessary or fish stranding is documented, the report shall include a description of the location from which fish were removed and the release site including photographs; the date and time of the relocation effort; a description of the equipment and methods used to collect, hold, and transport salmonids; the number of fish relocated by species; the number of fish injured or killed by species and a brief narrative of the circumstances surrounding ESA-listed fish injuries or mortalities; and a description of any problems which may have arisen during the relocation activities and a statement as to whether or not the activities had any unforeseen effects.

c. Design plans and annual reports must be submitted to NMFS North Central Coast Office, Attention: North Coast Supervisor, 777 Sonoma Avenue, Room 325, Santa Rosa, California 95404-6528. These can also be provided via email or through online platforms.

2.10 Conservation Recommendations

Section 7(a)(1) of the ESA directs federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Specifically, "conservation recommendations" are suggestions regarding discretionary measures to minimize or avoid adverse effects of a Proposed Action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

1. To maximize the efficacy of the restoration efforts and to aid in recovery of CCC coho salmon, CCC steelhead and CC Chinook salmon, the USACE and Sonoma Water should work collaboratively with the NMFS, CDFW, and private landowners to identify and prioritize specific areas to implement actions to improve instream habitat conditions for federally-listed salmonids. We encourage the USACE and Sonoma Water to pursue recovery actions (habitat complexity, riparian, sediment, water quality, viability, channel modification, among others) identified in NMFS Recovery Plans and 5-year status reviews (NMFS 2012, 2016d, 2023, 2024a, 2024b) throughout the Russian River watershed.

2.11 Reinitiation of Consultation

This concludes formal consultation for the Russian River Watershed Water Supply and Channel Maintenance Project.

Under 50 CFR 402.16(a): "Reinitiation of consultation is required and shall be requested by the federal agency, where discretionary federal 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."

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 associated physical, chemical, and biological 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 may result from actions occurring within EFH or outside of it and may include direct, indirect, 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 (50 CFR 600.905(b))].

This analysis is based, in part, on the EFH assessment provided by the USACE and Sonoma Water and descriptions of EFH for Pacific Coast Groundfish (PFMC 2023), Coastal Pelagic Species (CPS)(PFMC 1998, 2024) and Pacific Coast Salmon (PFMC 2014) contained in the fishery management plans (FMPs) developed by the PFMC and approved by the Secretary of Commerce.

3.1 EFH Affected by the Proposed Action

The proposed project occurs within EFH for various federally managed fish species within the Pacific Coast Groundfish, CPS, and Pacific Coast Salmon FMPs. The USACE and Sonoma Water have determined that the Proposed Action would adversely affect EFH for various life stages of fish species managed under the Pacific Coast Groundfish, Coastal Pelagic, and Pacific Coast Salmon FMPs. The Proposed Action includes the following activities: reservoir operations, including flow releases into the Russian River and Dry Creek from CVD and WSD, managing Dry Creek habitat enhancements, channel and facility maintenance, estuary management, monitoring, habitat enhancement, and conservation measures, and water diversions and storage (Wohler Pool and Santa Rosa Creek). The determination is based on the potential for project activities to result in disturbance to benthic habitat, increased turbidity, changes to water temperature and flow, and other adverse effects to water quality.

In addition, the project Action Area includes areas designated as Habitat Areas of Particular Concern (HAPC) for various species of fish within the Pacific Groundfish and Pacific Coast Salmon FMPs; estuaries and submerged aquatic vegetation such as eelgrass (*Zostera marina*) are designated HAPC for both FMPs. Salmonid HAPC in the project area also includes complex channels and floodplains, thermal refugia, and spawning habitat. HAPC are described in the regulations as subsets of EFH which are rare, particularly susceptible to human-induced degradation, especially ecologically important, or located in an environmentally stressed area. Designated HAPC are not afforded any additional regulatory protection under the MSA; however, federal projects with potential adverse impacts on HAPC will be more carefully scrutinized during the consultation process.

3.2 Adverse Effects on EFH

NMFS has reviewed the Proposed Action and determined the Proposed Action would adversely affect EFH as follows: benthic disturbance, loss or alteration of benthic habitat; altered hydrology and geomorphology; impaired fish passage; impacts to water quality such as increased turbidity, changes to water temperature and flow, changes to dissolved oxygen; and habitat conditions that increase the risk of fish stranding and increased predation. EFH may also be impacted by habitat enhancement activities in the Action Area. These activities would adversely affect EFH during construction, but may ultimately benefit fish habitat by enhanced fish passage conditions, off-channel habitat refugia, and increased benefits to foraging. There are some differences in how the project is expected to affect EFH designated under each FMP (CPS, Groundfish, Salmon), and are explained in more detail below.

Coastal Pelagic Species FMP.

Amendment 8, Appendix D of the CPS FMP includes the definition of EFH, and this definition considers the estuarine and marine habitat necessary to provide sufficient CPS production to support a maximum sustained yield fishery and a healthy ecosystem. The specific description and identification of EFH for CPS finfish species accommodates the fact that geographic range of all CPS fish varies over time in response to the temperature of the upper mixed layer of the ocean; this generalization is likely true for market squid but few data are available. The east-west geographic boundary of EFH for each individual CPS finfish and market squid is defined to be all marine and estuarine waters from the shoreline along the coasts of California, Oregon, and Washington offshore to the limits of the exclusive economic zone and above the thermocline where sea surface temperatures range between 10°C to 26°C. The southern boundary is consistently south of the US-Mexico border, and the northern border is more dynamic due to the seasonal cooling of the sea surface temperature, and is defined as the position of the 10°C isotherm.

NMFS has determined that Reservoir Operations as described in Section 1.3.1 above, and Estuary Management as described in Section 1.3.4, would adversely affect EFH for fish species managed under the CPS FMP. Species managed under the CPS FMP are not expected to inhabit the Estuary, however, project activities are expected to adversely affect the water quality of the nearshore marine environment that CPS species depend upon. Reservoir operations will continue to result in altered water flow magnitude and temperature from reservoir operations at CVD and WSD, as described in Sections 2.4.4.1 and 2.4.4.2. Reservoir operations will result in increased turbidity (including contaminants and pathogens) and other water quality disturbances, as described in Section 2.5.1.1 and Section 2.5.1.2.

Estuary management activities (Section 1.3.4) will result in changes to estuarine and nearshore habitat conditions during breaching of the Estuary to the nearshore environment. Fish species managed under the CPS FMP are expected to utilize the nearshore marine environment where the breaching occurs. When the Estuary transitions from a closed to open state, poor water quality conditions, increased turbidity, accumulated pollutants from agricultural runoff or accumulated bacteria within the estuarine waters are rapidly released to the nearshore environment (Richards et al., 2018; Largier et al., 2019). While there are few studies that examine the impact to the nearshore habitat from the artificial manipulation of water outflow, or the impacts to the nearshore habitat from the pulse of poor water quality associated with a breaching event, impacts likely do occur, however, the spatial and temporal scale of these impacts and the effect on species managed under the CPS FMP are difficult to quantify. Poor water quality may result in reduced oxygen, high levels of suspended particulate matter, reduced light availability for photosynthesis, and potential release of contaminants into the food web. Sediment pulses resulting from large dam removals have resulted in impacts to the nearshore environment (Rubin et al., 2023), such as changes to the benthic, fish and sub-tidal vegetation communities. While species managed under the CPS FMP may be able to avoid discrete impacts from the pulse of water released from the Estuary during a breaching event, the potential release of contaminants in fine-grained sediments may become biologically available to organisms either in the water column or through food chain processes. Under the existing beach/estuary management no significant water quality impairment has resulted in the observation of adverse effects on aquatic species (Section 9.1.3, BA, ESA, Inc. 2023).

<u>Pacific Groundfish FMP</u>.

The Pacific Groundfish FMP manages more than 90 species over a geographically large and ecologically diverse area. Detailed descriptions of EFH, life histories, prey species, and rearing habitat for each species are provided in Appendix B of the Pacific Groundfish FMP. The overall extent of groundfish EFH for all FMP species is identified as waters and substrate within the following areas: depths less than or equal to 3,500 m (1,914 ft) to mean higher high water level (MHHW) or the upriver extent of saltwater intrusion, defined as upstream and landward to where ocean-derived salts measure less than 0.5 ppt during the period of average annual low flow; seamounts in depth greater than 3,500 m as mapped in the EFH assessment geographic system; and areas designated as HAPCs not already identified by the above criteria. EFH within the project area includes the nearshore area affected by Estuary Management, as described above for the CPS FMP, and the Estuary to the upriver extent of saltwater intrusion.

NMFS has determined that Reservoir Operations as described in Section 1.3.1 above, Estuary Management as described in Section 1.3.4, and habitat enhancement activities as described in Section 1.3.4.3, would adversely affect EFH for fish species managed under the Groundfish FMP. Species managed under the Groundfish FMP may inhabit both the Estuary and nearshore marine environment. Reservoir operations will continue to result in altered modifications in water flow magnitude and temperature from reservoir operations at CVD and WSD, as described in Sections 2.4.4.1 and 2.4.4.2. Reservoir operations will result in increased turbidity (including contaminants and pathogens) and other water quality disturbances, as described in Section 2.5.1.1 and Section 2.5.1.2.

In addition to the adverse habitat effects previously described for CPS EFH, Estuary management activities (Section 1.3.4) will adversely affect Groundfish EFH through risk of entrapment in the Estuary during periods when it is in a closed state. As described in Section 8.1.3.2 of the BA, marine and estuarine groundfish species utilize the Estuary and have access when the Estuary is in an open state, and once the Estuary is closed, species decline due to less than optimal changing habitat conditions (e.g., salinity, temperature and dissolved oxygen). During closed conditions, marine and estuarine species may be less dispersed within the Estuary, and congregate near the river mouth where the highest salinities occur. With or without continued management of the open/closed state of the Estuary, species managed under the Pacific Groundfish FMP will continue to experience these less than optimal conditions on a cyclical basis.

Habitat enhancement activities will result in disturbance to benthic habitat, increased turbidity, and other adverse effects to water quality, by proposed construction activities located in the estuarine portion of the project area (Sections 1.3.4.3 and 2.5.3.6). However, habitat enhancement activities are expected to ultimately provide habitat benefits, as described above in Sections 1.3.4.3, and 2.5.3.6, in the form of increased foraging habitat, and restoration of hydrologic, geomorphic, and sediment processes that will ultimately improve habitat function within the Estuary.

Pacific Coast Salmon FMP.

EFH for Chinook and coho salmon is described in detail in Appendix A of the Pacific Coast Salmon FMP (PFMC 2014), and includes those waters and substrate necessary for salmon production needed to support a long-term, sustainable salmon fishery and salmon contributions to a healthy ecosystem. The geographic extent of salmon freshwater EFH is described as all water bodies currently or historically occupied by Council (PFMC)-managed salmon, including the lateral extent of channels as identified by the ordinary high-water line. In estuarine and marine areas, salmon EFH extends from the extreme high tide line in nearshore and tidal submerged environments within state territorial waters out to the full extent of the EEZ offshore of California, Oregon, and Washington. When considering impassable dams and the freshwater extent of salmon EFH, impassable dams were evaluated as the impassable dams that form the upstream extent of EFH within the designated 4th field hydrologic unit. Although habitats above these dams are not designated as EFH, activities in these areas that may adversely affect the EFH below the dams are subject to the consultation provisions of the MSA.

NMFS has determined that Reservoir Operations as described in Section 1.3.1 above, Estuary Management as described in Section 1.3.4, and habitat enhancement activities in Section 1.3.2 and Section 1.3.4.3, would adversely affect EFH for fish species managed under the Pacific Coast Salmon FMP from the following types of effects: disturbance to benthic habitat, impaired fish passage, increased turbidity, changes to water temperature and flow, and other adverse effects to water quality, and increased predation. Additionally, the project will continue to adversely affect Pacific Coast Salmon HAPC by limiting the formation of complex channels and floodplains, thermal refugia, and impacting spawning habitat through proposed channel maintenance, modified flow regime, and fine sediment deposition. Detailed descriptions of BMPs and conservation measures for salmonids are included in Sections 3.4.2.1 through 3.4.3.9 of the BA and are incorporated into the Proposed Action in Sections 1.3.6.

As described above in Sections 2.4.4.1 and 2.5.1.1.2.1, water releases from CVD result in scour impacts that mobilize streambed sediment, disturb salmonid redds and contribute to bank erosion and increased turbidity. Due to both the magnitude of the flows released and the location of the flow release at the bottom of CVD, these increases in turbidity are likely to continue with the proposed CVD operations. Alternately, intermittent flow releases result in dewatered conditions in spawning and rearing habitat (Section 2.5.1.1.2.5). Water releases from WSD are managed to reduce peak flows, however, some releases may still mobilize the streambed and result in both disturbance and loss to spawning habitat (Section 2.4.4.2). Changes in flow releases from the CVD and WSD may provide cooler water temperatures which benefit spawning and rearing habitat, however, these benefits may not be fully realized given the ongoing effects of increased turbidity. While some reaches of the Action Area have benefitted from habitat enhancements (Section 2.4.4.4), fine sediment loads and increased turbidity following flow releases throughout the Action Area limit the quality and quantity of restored rearing and spawning habitat.

Operations of the CVD and WSD (Sections 2.5.1.1 and 2.5.1.2) will continue to provide flow regulation which may provide cooler water for available salmonid spawning but the high turbidity associated with released flows present a conflicting scenario where species may avoid exposure to, in some cases sublethal and lethal, turbidity levels and utilize habitat with marginal foraging and less suitable water temperatures (Section 2.5.1.1.4.4). Flow regulation that homogenizes flow regimes can result in severely degraded EFH downstream of dams (Kondolf 1997) from the following factors: altered sediment delivery and substrate recruitment; impacted physical processes by reduced channel complexity and homogenization of instream habitat (Moyle and Mount 2007); and reduced growth and survival of invertebrates (Poff and Zimmerman 2010). As described above in Sections 2.4.2.2 and 2.5.1.2.4.4, flow operations resulting in warmer water temperatures may create habitat conditions that increase predation risk. Warmer temperatures often favor predatory species within the project area, and can result in significant chronic adverse effects on long-term development, disease resistance and size-selective mortality of salmonids (Peterson and Kitchell 2001; Kuehne et al 2012). In the Estuary, flow homogenization coupled with shoreline levees can result in fewer off-channel habitat areas that support opportunities for foraging and predator avoidance.

Estuary management, includes adaptive management of the estuary outlet channel and alternative approaches to flood risk reduction is described in Section 2.4.4.7 above. The effects of Estuary Management are described in Section 2.5.3. As described in Section 2.5.3.1, managing both the timing of artificially opening of the estuary with increased flows will be crucial to optimal fish passage habitat conditions for adult salmonid upstream migration. Allowing prolonged closure of the Estuary or breaching the Estuary during compromised water conditions may negatively impact habitat conditions for migrating salmonids. Conditions that increase predation risk are also a factor - outside of and within the Estuary - when migration is impeded, i.e., during prolonged closed conditions.

Water quality within the Estuary fluctuates with river outflows, with the closed and open state of the Estuary, and seasonally. As described in Section 2.5.3.2 and for Pacific Groundfish FMP species above, the closed/open state of the Estuary can rapidly alter the DO, water temperature, and salinity of estuarine waters, which impacts salmonid habitat. Depending on timing, flows, and other factors, benefits to salmon EFH could be realized in either the closed or open state: closed conditions may provide improved rearing habitat and open conditions promote mixing of cold marine water with brackish water in the lower Estuary. Conversely, a closed state may lead to reduced water quality in the form of a stratification of the water column and increased temperatures, and an open state may limit the amount of freshwater rearing habitat.

As described in Section 2.5.2, the 4.5 miles of habitat enhancements constructed in Dry Creek since 2012 have contributed significant improvements to juvenile salmonid rearing habitat, and are expected to result in habitat benefits at the site level, and extending to the population level as the sites become more established. The impacts to habitat on maintaining these existing enhancements is described in Sections 2.5.2.1 and 2.5.2.3, and the complexities of the constraints on future restoration actions is described in Section 2.5.2.4. The short-term habitat impacts of decreased water quality, benthic impacts, and impacts to habitat as a result of dewatering, are anticipated to be offset by the long-term habitat benefits that these enhancements provide to salmon EFH throughout the project area.

The proposed Estuary enhancements are described in Section 2.5.3.6, and if implemented, may provide additional habitat complexity, e.g., large woody debris, or additional wetland or floodplain habitat by enhancing or restoring habitat currently constrained by limited hydrologic connectivity. Construction during habitat enhancement may adversely affect the habitat of species managed under the Pacific Salmon FMP, and will be further identified during project development. These enhancements are expected to contribute, over the long-term, to increased habitat function, prey availability, and rearing habitat within the Estuary.

Eelgrass is a type of submerged aquatic vegetation that forms dense beds of grass-like shoots that provide year-round habitat in soft sediments of the lower intertidal and shallow subtidal areas of estuaries. The three-dimensional structure that eelgrass provides in sandy or muddy soft bottom habitat adds to fish forage and rearing habitat. Eelgrass is recognized as a habitat forming species for the multiple benefits that it provides to the subtidal community (Unsworth et al 2022; Altman et al 2023). In addition to foraging and refuge for young fish and invertebrates, eelgrass traps sediment and stabilizes the substrate, reduces the force of wave energy and subsequent erosion, produces oxygen, filters polluted runoff, absorbs excess nutrients, and increases carbon sequestration. A small bed of eelgrass has been recently mapped in the lower Estuary near Penny Island (Figure 23). Although this small area of eelgrass is only recently formed, eelgrass presence in the Estuary is worth monitoring for the benefits that it provides and the potential for the eelgrass habitat to persist (Munsch et al., 2023). The proposed habitat enhancements provided in Section 2.5.3.6 include areas for additional seagrass restoration that, if implemented, may ultimately benefit EFH designated for fish species managed under the Pacific Salmon and Pacific Groundfish FMPs.

3.3 EFH Conservation Recommendations

NMFS determined that the following conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the adverse effects of the Proposed Action on EFH. The USACE and Sonoma Water should avoid and minimize adverse effects of EFH quantity and quality by:

1. To address impacts to species managed under the Pacific Groundfish FMP, implement Term and Conditions identified to implement Reasonable and Prudent Measures 2, 4, 6, 7 and 8 above (Section 2.9.3);
2. To address the following impacts to species managed under the Pacific Salmon FMP, implement Term and Conditions identified to implement Reasonable and Prudent Measures 1 through 8 (Section 2.9.3) specific to:
    a. Impacts of CVD and WSD operations, which result in increased turbidity and poor water quality conditions, including increased temperatures, on critical life stages of species managed under the Pacific Salmon FMP;
    b. Loss and alteration of habitat, through homogenizing flow such that geomorphic processes are inhibited (Allow for peak flows that will result in sediment pulses and allow for geomorphic processes determined by high-flow events. If natural sediment and wood transport is not possible, consider sediment and wood additions below the CVD and WSD);
    c. Altered hydrology and geomorphology impacts (To the maximum extent possible, CVD and WSD operations should mimic the natural hydrograph and allow for sediment and wood transport. Operations should provide for fish passage, pre-dam water quality conditions, proper timing of life-history stages, and properly functioning channel conditions, avoid strandings and redd dewatering.);
    d. Address fish passage; facilities should provide efficient and functional upstream and downstream adult and juvenile fish passage to ensure safe, effective and timely passage consider natural-like bypass channels, fish ladders and fishlifts, avoiding volitional passage;
    e. Address impacts to water quality from CVD and WSD operations, utilize a selective depth outlet structure that matches released water temperature to the natural water temperature regime of adjacent downstream habitat;
3. Follow the ESA conservation recommendation described in Section 2.10 above; and
4. Conduct annual eelgrass surveys at locations identified in the lower estuary (Section 3.3.3.1 of the BA) following the survey guidelines and recommendations provided in the California Eelgrass Mitigation Policy (NMFS 2014).

Statutory Response Requirement

As required by Section 305(b)(4)(B) of the MSA, the USACE and Sonoma Water must provide a detailed response in writing to NMFS within 30 days after receiving an EFH conservation recommendation. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of NMFS' EFH conservation recommendations unless NMFS and the federal agency have agreed to use alternative time frames for the federal agency response. The response must include a description of the measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the conservation recommendations, the federal agency must explain its reasons for not following the recommendations, including the scientific justification for any disagreements with NMFS over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

Supplemental Consultation

The USACE and Sonoma Water 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 users of this Opinion are USACE, Sonoma Water, and MCRRFCD. Individual copies of this Opinion were provided to the USACE, Sonoma Water, and MCRRFCD. 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 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, and reviewed in accordance with West Coast Region ESA quality control and assurance processes.

5. REFERENCES

A. Articles, Manuscripts, Theses

Abdul-Aziz, O. I., Mantua, N. J., and Myers, K. W. 2011. Potential climate change impacts on thermal habitats of Pacific salmon (*Oncorhynchus* spp.) in the North Pacific Ocean and adjacent seas. Canadian Journal of Fisheries and Aquatic Sciences. 68(9):1660-1680.

Accola, K. 2021. EMP Juvenile Salmon Diet and Prey Availability. Wetland Ecosystem Team – School of Aquatic Fishery Sciences, University of Washington.

Adams, S.R., Keevin, T.M., Kilgore, K.J., and Hoover, J.J. 1999. Stranding Potential of Young Fishes Subjected to Simulated Vessel-Induced Drawdown. Transactions of the American Fisheries Society. 128:1230-1234.

Agrawal, A., Schick, R., Bjorkstedt, E., Szerlong, R., Goslin, M., Spence, B., Williams, T., and Burnett, K. 2005. Predicting the potential historical coho, Chinook, and steelhead habitat in Northern California. NOAA Technical Memorandum, NOAA-TM-NMFS-SWFSC-379, NMFS Santa Cruz Laboratory, Santa Cruz, CA. 33 pp.

Alameda County Water District. 2023. 2022-23 Annual Report for the Alameda Creek Fish Ladder Operations and Water Stewardship (FLOWS) Monitoring Program. Report submitted to NMFS by Alameda County Water District. November 9, 2023.

Alava, J.J., Cisneros-Montemayor, A.M., Sumaila, U.R., and Cheung, W.W. 2018. Projected amplification of food web bioaccumulation of MeHg and PCBs under climate change in the Northeastern Pacific. Scientific Reports. 8(1):1-12.

Allen, M.A., and Hassler, T.J. 1986. Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) - Chinook salmon. U.S. Fish and Wildlife Service Biological Report 82(11.49). U.S. Army Corps of Engineers, TR EL-82-4. 26 pp.

Allen, S. G., J. Mortenson, and S. Webb. 2011. Field Guide to Marine Mammals of the Pacific Coast: Baja, California, Oregon, Washington, British Columbia. University of California Press, Berkeley, United States.

Altman, Safra, Matthew T. Balazik, and Catherine C. Thomas. 2023. Eelgrass Functions, Services, and Considerations for Compensatory Mitigation. Prepared for the U.S. Army Corps of Engineers Engineer Research and Development Center Wetlands Regulatory

Assistance Program, Vicksburg MS. Technical Report ERDC/EL TR-23-1, April 2023. 45 pages.
Badger, D., Kondolf, G.M., and Wolman, M.G. 1991. The Sizes of Salmonid Spawning Gravels. Water Resources Research, 29(7), 2275-2285.
Bain, D. 1990. Examining the validity of inferences drawn from photo-identification data, with special reference to studies of the killer whale (*Orcinus orca*) in British Columbia. Report of the International Whaling Commission, Special 12. 12:93-100.
Baird, R.W. 2000. The killer whale. Cetacean societies: Field studies of dolphins and whales. pp. 127-153.
Baker, H.K, Obedzinski, M., Grantham, T.E., and Carlson, S.M. 2025. Variation in Salmon Migration Phenology Bolsters Population Stability but is Threatened by Drought. Ecology Letters. 28:2.
Baker, P., and Reynolds, F. 1986. Life history, habitat requirements, and status of coho salmon in California. Report to the California Fish and Game Commission.
Barnett-Johnson, R., Grimes, C.B., Royer, C.F., and Donohoe, C.J. 2007. Identifying the contribution of wild and hatchery Chinook salmon (*Oncorhynchus tshawytscha*) to the ocean fishery using otolith microstructure as natural tags. Canadian Bulletin of Fisheries and Aquatic Sciences. 64(12):1683-1692.
Barnhart, R.A. 1986. Species Profiles: Life histories and environmental requirements of coastal fishes and invertebrates – steelhead. U.S. Fish and Wildlife Service, Biological Report 82 (11.60). USACE, TR EL-82-4.
Bash, J., Berman, C., and Bolton, S. 2001. Effects of turbidity and suspended solids on salmonids. Report prepared for the Washington State Transportation Commission, Department of Transportation and in cooperation with U.S. Department of Transportation, Federal Highway Administration. November 2001. 66 pages plus appendices.
Beakes, M.P., Satterthwaite, W.H., Collins, E.M., Swank, D.R., Merz, J.E., Titus, R.G., Sogard, S.M., and Mangel, M. 2010. Smolt transformation in two California steelhead populations: Effects of temporal variability in growth. Transactions of the American Fisheries Society. 139(5):1263-1275.
Beamish, R.J., editor. 2018. The ocean ecology of Pacific salmon and trout. American Fisheries Society, Bethesda, Maryland.
Behrens, D., Brennan, M.B., and Battalio, B. 2015. A quantified conceptual model of inlet morphology and associated lagoon hydrology. Shore & Beach. 83(3):33-42.
Bell, E. 2001. Survival, growth and movement of juvenile coho salmon (*Oncorhynchus kisutch*) over-wintering in alcoves, backwaters and main channel pools in Prairie Creek, California. M.S. Thesis, Humboldt State University
Bell, M.C. 1973. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon, USA. 490 p.
Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineers, North Pacific Division, Portland, Oregon, USA. 353 p.
Berg, L. 1982. The effect of exposure to short-term pulses of suspended sediment on the behavior of juvenile salmonids. Pp. 177-196 in G.F. Hartman et al., [eds.] Proceedings of the Carnation Creek workshop: a ten-year review. Department of Fisheries and Oceans, Pacific Biological Station, Nanaimo, Canada.

Berg, L., and Northcote, T.G. 1985. Changes in territorial, gill-flaring, and feeding behaviour in juvenile coho salmon (*Oncorhynchus kisutch*) following short-term pulses of suspended sediment. Canadian Journal of Fisheries and Aquatic Sciences. 42:1410-1417.

Bigg, M.A., Olesiuk, P.F., Ellis, G.M., Ford, J.K.B., and Balcomb, K.C. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Report of the International Whaling Commission. 12:383-405.

Bilby, R.E., Fransen, B.R., and Bisson, P.A. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences. 53:164-173.

Bilby, R.E., Fransen, B.R., Bisson, P.A., and Walter, J.K. 1998. Response of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead (*Oncorhynchus mykiss*) to the addition of salmon carcasses to two streams in southwestern Washington, USA. Canadian Journal of Fisheries and Aquatic Sciences. 55:1909-1918.

Bjorkstedt, E.P. 2005. DARR 2.0: Updated software for estimating abundance from stratified mark-recapture data. National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz/Tiburon. NOAA-TM-NMFS-SWFSC-368.

Bjorkstedt, E.P., Spence, B.C., Garza, J.C., Hankin, D.G., Fuller, D., Jones, W.E., Smith, J.J., and Macedo, R. 2005. An analysis of historical population structure for evolutionarily significant units of Chinook salmon, coho salmon, and steelhead in the north-central California coast recovery domain. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center. 210 pages.

Bjornn, T.C. 1971. Trout and salmon movements in two Idaho streams as related to temperature, food, stream flow, cover, and population density. Transactions of the American Fisheries Society. 100(3):423-438.

Bjornn, T.C., and Reiser, D.W. 1991. Habitat requirements of salmonids in streams. Pages 83-138 in Meehan, W.R. [editor] Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19.

Bond, M.H. 2006. Importance of Estuarine Rearing to Central California Steelhead (*Oncorhynchus mykiss*) Growth and Marine Survival. Master of Science Thesis. University of California Santa Cruz. 39 pages.

Bond, M.H., Hayes, S.A., Hanson, C.V., and MacFarlane, R.B. 2008. Marine survival of steelhead (*Oncorhynchus mykiss*) enhanced by a seasonally closed estuary. Canadian Journal of Fisheries and Aquatic Sciences. 65:2242-2252.

Bottom, D.L., Jones, K.K., Cornwell, T.J., Gray, A., and Simenstad, C.A. 2005. Patterns of Chinook salmon migration and residency in the Salmon River estuary (Oregon). Estuarine, Coastal and Shelf Science. 64(1):79-93

Boughton, D.A., J.A. Fuller, G. Horton, E.R. Larson, W. Matsubu, and C.A. Simenstad. 2017. Spatial structure of water-quality impacts and foraging opportunities for steelhead in the Russian River Estuary: an energetics perspective. http://doi.org/10.7289/V5/TM-SWFSC-569

Bradford, A.L., Weller, D.W., Punt, A.E., Ivashchenko, Y.V., Burdin, A.M., Vanblaricom, G.R., and Brownell, R.L. Jr. 2012. Leaner leviathans: body condition variation in a critically endangered whale population. Journal of Mammalogy. 93(1):251-266.

Brennan, C.A., Hassrick, J.L., Kalmbach, A., Cox, D.M., Sabal, M.C., Zeno, R.L., Grimaldo, L.F. and Acuña, S., 2022. Estuarine recruitment of longfin smelt (*Spirinchus thaleichthys*) north of the San Francisco estuary. San Francisco Estuary and Watershed Science, 20(3).

Brewer, P.G., and Barry, J. 2008. Rising Acidity in the Ocean: The Other CO2 Problem. Scientific American. October 7, 2008.

Brock, P.M., Hall, A.J., Goodman, S.J., Cruz, M., and Acevedo-Whitehouse, K. 2013. Immune activity, body condition and human-associated environmental impacts in a wild marine mammal. Journal of Wildlife Diseases.

Brown L.R. 1990. Age, growth, feeding, and behavior of Sacramento squawfish (*Ptychocheilus grandis*) in Bear Creek, Colusa Co. California. The Southwest Naturalist. 35(3):249-260.

Brown L.R. and A.M. Brasher. 1995. Effect of predation by Sacramento squawfish (*Ptychocheilus grandis*) on habitat choice of California roach (*Lavinia symmetricus*) and rainbow trout (*Oncorhynchus mykiss*) in artificial streams. Canadian Journal of Fisheries and Aquatic Sciences. 52:1639-1646.

Brown, L.R., and Moyle, P.B. 1981. The impact of squawfish on salmonid populations: a review. North American Journal of Fisheries Management. 1:104-111.

Brown, L.R., Moyle, P.B., and Yoshiyama, R.M. 1994. Historical decline and current status of coho salmon in California. North American Journal of Fisheries Management. 14:237-261.

Buchanan, D.V., Hooton, R.M, and J.R. Moring. 1981. Northern squawfish (*Ptychocheilus oregonensis*) predation on juvenile salmonids in sections of the Willamette River basin, Oregon. Canadian Journal of Fisheries and Aquatic Sciences. 38.3: 360-364.

Busby, P.J., Wainwright, T.C., Bryant, G.J., Lierheimer, L.J., Waples, R.S., Waknitz, F.W., and Lagomarsino, I.V. 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. National Marine Fisheries Service, National Oceanic and Atmospheric Administration. 261 pages.

Bustard, D.R., and Narver, D.W. 1975. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada. 32:667-680.

Cannata, S.P. 1998. Observations of steelhead trout (*Oncorhynchus mykiss*), coho salmon (*O. kisutch*) and water quality of the Navarro River Estuary/Lagoon May 1996 to December 1997. Draft Report, Humboldt State University Foundation. 48 pages, plus tables and figures.

Carretta, J.V., Oleson, E.M., Forney, K., Weller, D.W., Lang, A.R., Baker, J., Hanson, B., Orr, A.J., Barlow, J., and Moore, J.E. 2023. U.S. Pacific Marine Mammal Stock Assessments: 2022. NOAA Technical Memorandum.

Carretta, J. V., E. M. Oleson, K. A. Forney, A. L. Bradford, K. Yano, D. W. Weller, A. R. Lang, J. Baker, A. J. Orr, B. Hanson, J. E. Moore, M. Wallen, and R. L. Brownell, Jr. 2024. U.S. Pacific marine mammal stock assessments: 2023. NOAA Technical Memorandum.

Cavallo, B., Merz, J., and Setka, J. 2013. Effects of predator and flow manipulation on Chinook salmon (*Oncorhynchus tshawytscha*) survival in an imperiled estuary. Environmental Biology of Fishes. 96:393-403.

Cayan, D., Luers, A., Hanemann, M., Franco, G., and Croes, B. 2006. Climate Change Scenarios for California: an Overview. California Climate Change Center.

CDFG. 2002. Coho salmon distribution. GIS Dataset, California Department of Fish & Game, Northern California, North Coast Region Information Services Branch (NCNCR-ISB), Draft, February 2002.

CDFG. 2005. Report to the National Marine Fisheries Service for Fisheries Restoration Grant Program Projects conducted under Department of the Army Regional General permit No. 12 (Corps File No. 27922N) within the United States Army Corps of Engineers, San Francisco District, January 1, 2004 through December 31, 2004. March 1.

CDFG. 2006. Annual report to the National Marine Fisheries Service for Fisheries Restoration Grant Program Projects conducted under Department ofArmy Regional General Permit No. 12 (Corps File No. 27922N) within the U.S. Army Corps of Engineers, San Francisco District, January 1, 2005 through December 31, 2005. CDFG Region 1, Fortuna Office. March 1.

CDFG. 2007. Annual report to the National Marine Fisheries Service for Fisheries Restoration Grant Program Projects conducted under Department ofArmy Regional General Permit No. 12 (Corps File No. 27922N) within the U.S. Army Corps of Engineers, San Francisco District, January 1, 2006 through December 31, 2006. Northern Region, Fortuna Office. March 1.

CDFG. 2008. Annual report to the National Marine Fisheries Service for Fisheries Restoration Grant Program Projects conducted under Department ofArmy Regional General Permit No. 12 (Corps File No. 27922N) within the U.S. Army Corps of Engineers, San Francisco District, January 1, 2008 through December 31, 2008. Northern Region, Fortuna Office. March 1.

CDFG. 2009. Annual report to the National Marine Fisheries Service for Fisheries Restoration Grant Program Projects conducted under Department ofArmy Regional General Permit No. 12 (Corps File No. 27922N) within the U.S. Army Corps of Engineers, San Francisco District, January 1, 2009 through December 31, 2009. Northern Region, Fortuna Office. March 1.

CDFG. 2010. Annual report to the National Marine Fisheries Service for Fisheries Restoration Grant Program Projects conducted under Department ofArmy Regional General Permit No. 12 (Corps File No. 27922N) within the U.S. Army Corps of Engineers, San Francisco District, January 1, 2010 through December 31, 2010. Northern Region, Fortuna Office. March 1.

CDFW and USACE 2017. Don Clausen Fish Hatchery: Russian River Coho Salmon Captive Broodstock Program. Hatchery Genetic Management Plan. Prepared for National Marine Fisheries Service. September 2017; California Sea Grant, 2021. Russian River Coho Salmon and Steelhead Monitoring Report: Winter 2020/21. Windsor, CA.

CDFW and USACE. 2021a. Hatchery and Genetic Management Plan Russian River Steelhead Integrated Harvest Hatchery Program, California. Prepared for: National Oceanic and Atmospheric Administration-National Marine Fisheries Service, Santa Rosa, California. Prepared by: CDFW and USACE, July 2021.

CDFW and USACE. 2021b. Don Clausen Fish Hatchery: Russian River Coho Salmon Captive Broodstock Program. Hatchery Genetic Management Plan. Prepared for National Marine Fisheries Service.

CDFW. 2020. Managed Floodplain Design Criteria and Considerations.

CDFW. 2023. Draft Scientific Basis Report Supplement in Support of Proposed Voluntary Agreements for the Sacramento River, Delta, and Tributaries Update to the San Francisco Bay/Sacramento-San Joaquin Delta Water Quality Control Plan.

CDFW. 2025. Steelhead Report and Restoration Card. California Department of Fish and Wildlife, Fisheries Branch. Accessed: March 2025. https://wildlife.ca.gov/Conservation/Inland-Fisheries/Steelhead-Report-Card#dashboard

CDFW. 2025a. Sonar estimation of California Coastal Chinook Salmon abundance in the Lower mainstem Ell and Van Duzen Rivers, Humboldt County, California 2023-2024. Final Report Prepared by: David Kajtaniak, Amanda Nordstrom, and Dominick Davis. March 27, 2025.

Cech, J.J., Mitchell, S.J., Castleberry, D.T. and McEnroe, M. 1990. Distribution of California stream fishes: influence of environmental temperature and hypoxia. Environmental biology of Fishes. *29*:95-105.

Cederholm, C.J., and Salo, E.O. 1979. The effects of logging road landslide siltation on the salmon and trout spawning gravels of Stequaleho Creek and the Clearwater River basin, Jefferson County, Washington, 1972-1978. FRI-UW-7915. Fisheries Research Institute, University of Washington, Seattle. 99 p.

Cederholm, C.J., Bilby, R.E., Bisson, P.A., Bumstead, T.W., Fransen, B.R., Scarlett, W.J., and Ward, J.W. 1997. Response of juvenile coho salmon and steelhead to placement of large woody debris in a coastal Washington stream. North American Journal of Fisheries Management. 17:947-963.

Chapman, D.W., and Bjornn, T.C. 1969. Distribution of salmonids in streams, with special reference to food and feeding. Pages 153-176 in Northcote, T.G., editor. Symposium on Salmon and Trout in Streams; H.R. Macmillan Lectures in Fisheries. University of British Columbia, Institute of Fisheries.

Chasco, B.E., Kaplan, I.C., Thomas, A.C., Acevedo-Gutiérrez, A., Noren, D.P., Ford, M.J., Hanson, M.B., Scordino, J.J., Jeffries, S.J., and Marshall, K.N. 2017a. Competing tradeoffs between increasing marine mammal predation and fisheries harvest of Chinook salmon. Scientific Reports. 7(1):1-14.

Chasco, B., I. C. Kaplan, A. Thomas, A. Acevedo-Gutiérrez, D. Noren, M. J. Ford, M. B. Hanson, J. Scordino, S. Jeffries, S. Pearson, K. N. Marshall, and E. J. Ward. 2017b. Estimates of Chinook salmon consumption in Washington State inland waters by four marine mammal predators from 1970 to 2015. Canadian Journal of Fisheries and Aquatic Sciences 74:1173-1194.

Chase, S.D., Benkert, R.C., Manning, D.J., and White, S.K. 2000. Results of the Sonoma County Water Agency's Mirabel Rubber Dam/Wohler Pool Fish Sampling Program - Year 5 results: 2000-2004. Sonoma County Water Agency, Santa Rosa, California.

Chase, S., R. Benkert, D. Manning, and S. White. 2004. Sonoma County Water Agency's Mirabel Rubber Dam/Wohler Pool fish sampling program: year 2 results, 2003. Sonoma County Water Agency, Santa Rosa, CA

Chase, S.D., Benkert, R.C., Manning, D.J., and White, S.K. 2005. Sonoma County Water Agency's Mirabel Rubber Dam/Wohler Pool Fish Sampling Program: Year 5 Results: 2004.

Chase, S.D., Manning, D.J., Cook, D.G., and White, S.K. 2007. Historic accounts, recent abundance, and current distribution of threatened Chinook Salmon in the Russian River, California. California Fish and Game. 93(3):130-148.

Church, T. 2024. Memorandum for Record. Documentation of Potential Fish Stranding Events at the Dry Creek Ecosystem Restoration Project, Phase 1. Reported to NMFS by the USACE on May 9, 2024.
Circuit Rider Productions. 1994. Riparian habitat status report. Technical report to Coastal Conservancy. Russian River resource enhancement and public access plan in preparation. Oakland, CA.
Coates, M.J., Guo, Y., and Davies, P.A. 2001. Laboratory model studies of flushing of trapped salt water from blocked tidal estuary. Journal of Hydraulic Research. 39:601-609.
Coates, M.J., and Guo, Y. 2003. The salt wedge position in a bar-blocked estuary subject to pulsed inflows. Estuarine, Coastal and Shelf Science. 58:187-196.
Coble, D.W. 1961. Influence of water exchange and dissolved oxygen in redds on survival of steelhead trout embryos. Transactions of the American Fisheries Society. 90:469-474.
Collins, B.W. 2004. Report to the National Marine Fisheries Service for Instream Fish Relocation Activities associated with Fisheries Habitat Restoration Program Projects Conducted under Department of the Army (Permit No. 22323N) within the United States Army Corps of Engineers, San Francisco District during 2002 and 2003. California Department of Fish and Game, Northern California and North Coast Region. March 24, 2004. Fortuna.
Conrad, J.L. and White, B. 2006. Russian River Coho Salmon Captive Broodstock Program, Broodstock Management and Progeny Release, 2005-2006. Annual Report to NOAA Fisheries. Pacific States Marine Fisheries Commission/California Department of Fish & Game, Warm Springs Hatchery, Geyserville, California 95441. December, 2006.
Cook, D. 2003. Upper Russian River Steelhead Distribution Study. Sonoma County Water Agency. March 2003.
Cook, D. 2004. Russian River Estuary Flow-Related Habitat Project – Survey Methods Report. June 2004
Coulson, T., Benton, T., Lundberg, P., Dall, S., Kendall, B., and Gaillard, J.-M. 2006. Estimating individual contributions to population growth: evolutionary fitness in ecological time. Proceedings of the Royal Society B: Biological Sciences. 273(1586):547-555.
Couture, F., Oldford, G., Christensen, V., Barrett-Lennard, L., and Walters, C. 2022. Requirements and availability of prey for northeastern Pacific southern resident killer whales.
Cramer, S.P., Alley, S.W., Baldrige, J.E., Barnard, K., Demko, D.B., Dettman, D.H., Farrell, B., Hagar, J., Keegan, T.P., Laird, A., Mitchell, W.T., Nuzum, R.C., Orton, R., Smith, J.J., Taylor, T.L., Unger, P.A., and Van Dyke, E.S. 1995. The status of steelhead populations in California in regards to the Endangered Species Act. S.P. Cramer and Associates, Inc., Gresham, OR.
Crozier, L.G., M.M. McClure, T. Beechie, S.J. Bograd, D.A. Boughton, M. Carr, T.D. Cooney, J.B. Dunham, C.M. Greene, M.A. Haltuch, E.L. Hazen, D.M. Holzer, D.D. Huff, R.C. Johnson, C.E. Jordan, I.C. Kaplan, S.T. Lindley, N.J. Mantua, P.B. Moyle, J.M. Myers, M.W. Nelson, B.C. Spence, L.A. Weitkamp, T.H. Williams, and E. Willis-Norton. 2019. Climate vulnerability assessment for Pacific salmon and steelhead in the California Current Large Marine Ecosystem. PLOS ONE 14(7):e0217711.
CSG and Sonoma Water. 2023a. Coho Salmon and Steelhead Monitoring Report. Winter 2022/2023. University of California, Santa Rosa, CA. 41pp.

CSG and Sonoma Water. 2023b. Coho Salmon and Steelhead Monitoring Report. Summer 2023. University of California, Santa Rosa, CA
CSG and Sonoma Water. 2024. An Integrated Monitoring Approach to Support Salmonid Recovery in the Russian River Watershed. 41st Annual Salmonid Restoration Conference, March 26-29, 2024. Santa Rosa, CA.
CSG. 2020. California Sea Grant Coho Salmon and Steelhead Monitoring Report. Spring 2020.
Cushman, R.M. 1985. Review of ecological effects of rapidly varying flows downstream from hydroelectric facilities. North American Journal of Fisheries Management. 5:330-339.
CWR (Center for Whale Research). 2019. Orca Survey Southern Resident Killer Whales ID Guide. March, 2019.
CWR (Center for Whale Research). 2023. Narrative Report for 1305M319DNFFP0009 Item No. 0007 and 0008 - Report of 2023 Southern Resident Killer Whale Census and Photo-ID Catalogue.
CWR (Center for Whale Research). 2024. Orca Survey Results; Southern Resident Killer Whale Census 2024.
Daan, S., Deerenberg, C., and Dijkstra, C. 1996. Increased daily work precipitates natural death in the kestrel. Journal of Animal Ecology. 65(5):539-544.
Davis, G., Foster, J., Warren, C.E., and Doudoroff, P. 1963. The influence of oxygen concentration on the swimming performance of juvenile Pacific salmon at various temperatures. Transactions of the American Fisheries Society. 92:111-124.
de Swart, R.L., Ross, P.S., Vos, J.G., and Osterhaus, A.D.M.E. 1996. Impaired immunity in harbour seals (*Phoca vitulina*) exposed to bioaccumulated environmental contaminants: review of a long-term feeding study. Environmental Health Perspectives. 104(Suppl 4):823.
Dean, R.G. 1973. Heuristic Models of Sand Transport in the Surf Zone. Proceedings of the Conference of Engineering Dynamics in the Surf Zone. Sydney, pp 208-214.
Debier, C., Crocker, D.E., Houser, D.S., Vanden Berghe, M., Fowler, M., Mignolet, E., de Tillesse, T., Rees, J.F., Thome, J.P., and Larondelle, Y. 2012. Differential changes of fat-soluble vitamins and pollutants during lactation in northern elephant seal mother-pup pairs. Comp Biochem Physiol A Mol Integr Physiol. 162(4):323-330.
Debler, W., and Imberger, J. 1996. Flushing criteria in estuarine and laboratory experiments. Journal of Hydraulic Engineering. 728-734.
Diffenbaugh, N.S., Swain, D.L., and Touma, D. 2015. Anthropogenic warming has increased drought risk in California. PNAS Early Edition.
Dill, W.A., and Cordone, A.J. 1997. History and status of introduced fishes in California, 18711996. Fish and Game Fish Bulletin. 178.
Done, J.M., Morss, R.E., Lazrus, H., Towler, E., Tye, M.R., Ge, M., Das, T., Munévar, A., Hewitt, J., and Hoeting, J.A. 2021. Toward usable predictive climate information at decadal timescales. One Earth. 4(9):1297-1309.
Doney, S.C., Ruckelshaus, M., Duffy, J.E., Barry, J.P., Chan, F., English, C.A., Galindo, H.M., Grebmeier, J.M., Hollowed, A.B., Knowlton, N., Polovina, J., Rabalais, N.N., Sydeman, W.J., and Talley, L.D. 2012. Climate Change Impacts on Marine Ecosystems. Annual Review of Marine Science. 4:11-37.
Durban, J., Fearnbach, H., Ellifrit, D., and Balcomb, K. 2009. Size and body condition of Southern Resident Killer Whales. February 2009. Contract report to NMFS, Seattle, Washington. 23p.

Durban, J.W., Fearnbach, H., Barrett-Lennard, L., Groskreutz, M., Perryman, W., Balcomb, K., Ellifrit, D., Malleson, M., Cogan, J., Ford, J., et al., 2017. Photogrammetry and Body Condition. Availability of Prey for Southern Resident Killer Whales. Technical Workshop Proceedings. November 15-17, 2017.
Edwards, E.A., Gebhart, G., and Maughan, O.E. 1983. Habitat suitability information: smallmouth bass. U.S. Depart. Int., Fish and Wild. Serv. FWS/OBS-82/10.36. 47 pp.
EIP. 1994. Sonoma County aggregate resources management plan and environmental impact report. Prepared for Sonoma County Planning Department by EIP Associates, Santa Rosa, CA.
Emig, J.W. 1966. Smallmouth bass. In Inland Fisheries Management. A. Calhoun ed. Department of Fish and Game.
Emmons, C.K., Hanson, M., and Lammers, M. 2019. Monitoring the occurrence of Southern resident killer whales, other marine mammals, and anthropogenic sound in the Pacific Northwest. Prepared for: U.S. Navy, U.S. Pacific Fleet, Pearl Harbor, HI. Prepared by: National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center under MIPR N00070-17-MP-4C419. 25 February 2019. 23p. (00070).
Emmons, C.K., Hanson, M.B., and Lammers, M.O. 2021. Passive acoustic monitoring reveals spatiotemporal segregation of two fish-eating killer whale (*Orcinus orca*) populations in proposed critical habitat. Endangered Species Research. 44:253-261.
Entrix, Inc. 2004. Russian River Biological Assessment. Prepared for Sonoma Water.
Erickson, A.W. 1978. Population studies of killer whales (*Orcinus orca*) in the Pacific Northwest: a radio-marking and tracking study of killer whales. September 1978. U.S. Marine Mammal Commission, Washington, D.C.
ESA. 2022. Dry Creek Ecosystem Restoration General Investigation project Phase II. 100% Design Report. Prepared by ESA for the U.S. Army Corps of Engineers and Sonoma Water. September, 2022.
ESA. 2023. Russian River Biological Assessment and Essential Fish Habitat Assessment. August 2023.
Ettinger, A., Harvey, C., Emmons, C., Hanson, M., Ward, E., Olson, J., and Samhouri, J. 2022. Shifting phenology of an endangered apex predator mirrors changes in its favored prey. Endangered Species Research. 48:211-223.
Evenson, D.F. 2001. Egg pocket depth and particle size composition within chinook salmon redds in the Trinity River, California, M.S. thesis, 63 pp., Humboldt State Univ., Arcata, Calif.
Everest, F.H., R.L. Beschta, J.C.Scrivener, K.V. Koski, J.R. Sedell, and C.J. Cederholm. 1987. Fine sediment and salmonid production: a paradox. In E.O. Salo and T.W. Cundy [ed.] Streamside Management: Forestry and Fishery Interactions. University of Washington Institute of Forest Resources, Seattle, Washington.
Everest, F.H. 1973. Ecology and management of summer steelhead in the Rogue River. Page 49. Oregon State Game Commission, Corvallis, OR.
Fagan, W.F., and Holmes, E.E. 2006. Quantifying the extinction vortex. Ecology Letters. 9(1):51-60.
Fayram, A.H., and Sibley, T.H. 2000. Impact of predation by smallmouth bass on sockeye salmon in Lake Washington, Washington. North American Journal of Fisheries Management 20: 81-89.
Fearnbach, H., and Durban, J. 2021. Body Condition of Southern Resident Killer Whales in

2021.
Fearnbach, H., and Durban, J. 2023. Body Condition of Southern Resident Killer Whales, Fall 2021 to Spring 2022. SeaLife Response Rehabilitation and Research.
Fearnbach, H., and Durban, J. 2024. Body Condition of Southern Resident Killer Whales in late 2023.
Fearnbach, H., Durban, J.W., Barrett-Lennard, L.G., Ellifrit, D.K., and Balcomb, K.C. 2019. Evaluating the power of photogrammetry for monitoring killer whale body condition.
Fearnbach, H., Durban, J.W., Ellifrit, D.K., and Balcomb, K.C. 2018. Using aerial photogrammetry to detect changes in body condition of endangered southern resident killer whales. Endangered Species Research. 35:175–180.
Feely, R.A., Sabine, C.L., Lee, K., Berelson, W., Kleypas, J., Fabry, V.J., and Millero, F.J. 2004. Impact of anthropogenic CO2 on the CaCO3 system in the oceans. Science. 305:362-366.
FishPro and Entrix 2000. FishPro. 2004. Hatchery and Genetic Management Plans for Russian River Fish Production Facilities, Coho Salmon and Steelhead. Draft. Prepared for U.S. Army Corps of Engineers, National Marine Fisheries Service, and the California Department of Fish and Game. In association with Entrix, Inc., Walnut Creek, California. September 20, 2004.
Florsheim, J.L., and Goodwin, P. 1993. Geomorphic and hydrologic conditions in the Russian River, California: historic trends and existing conditions. Prepared for the California State Coastal Conservancy and the Mendocino County Water Agency.
Ford, M.J. 2002. Selection in Captivity during Supportive Breeding May Reduce Fitness in the Wild. Conservation Biology. 16(3):815-825.
Ford, J.K., and Ellis, G.M. 2006. Selective foraging by fish-eating killer whales (*Orcinus orca*) in British Columbia. Marine Ecology Progress Series. 316:185-199.
Ford, J.K.B., Ellis, G.M., and Balcomb, K.C. 2000. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. Vancouver, British Columbia, UBC Press, 2nd Edition.
Ford, J.K.B., Ellis, G.M., Barrett-Lennard, L.G., Morton, A.B., Palm, R.S., and Balcomb, K.C. III. 1998. Dietary specialization in two sympatric populations of killer whales (*Orcinus orca*) in coastal British Columbia and adjacent waters. Canadian Journal of Zoology. 76(8):1456-1471.
Ford, J.K.B., Ellis, G.M., and Olesiuk, P.F. 2005. Linking prey and population dynamics: did food limitation cause recent declines of ‘resident’ killer whales (*Orcinus orca*) in British Columbia?
Ford, M.J., Hempelmann, J., Hanson, M.B., Ayres, K.L., Baird, R.W., Emmons, C.K., Lundin, J.I., Schorr, G.S., Wasser, S.K., and Park, L.K. 2016. Estimation of a killer whale (*Orcinus orca*) population’s diet using sequencing analysis of DNA from feces. PloS One. 11(1):1-14.
Ford, J.K.B., Wright, B.M., Ellis, G.M., and Candy, J.R. 2010. Chinook salmon predation by resident killer whales: seasonal and regional selectivity, stock identity of prey, and consumption rates. Canadian Science Advisory Secretariat. 48p.
Frankham, R., Ballou, J.D., and Birscoe, D.A. 2002. Introduction to Conservation Genetics. Cambridge University Press, Cambridge, United Kingdom.
Fritts, A.L., and Pearsons, T.N. 2004. Smallmouth bass predation on hatchery and wild salmonids in the Yakima River, Washington. Transactions of the American Fisheries Society. 133:4. pp. 880-895.

Frölicher, T.L., Fischer, E.M., and Gruber, N. 2018. Marine heatwaves under global warming. Nature (Letter). Vol 560, 360, August 16.
Fukushima, L., and Lesh, E.W. 1998. Adult and juvenile anadromous salmonid migration timing in California streams. California Department of Fish and Game. 84(3):133-145.
Fuller, J.A. 2011. Extended residency and movement behavior of juvenile steelhead (*Oncorhynchus mykiss*) in the Russian River estuary, California. Master's Thesis, Humboldt State University, Natural Resources: Fisheries
Gamel, C.M., Davis, R.W., David, J.H.M., Meyer, M.A., and Brandon, E. 2005. Reproductive energetics and female attendance patterns of Cape fur seals (*Arctocephalus pusillus pusillus*) during early lactation. The American Midland Naturalist. 153(1):152-170.
Gilpin, M. E., and Soulé, M. E. 1986. Minimum Viable Populations: Processes of Species Extinction. In M. E. Soulé (Ed.), Conservation biology: The science of scarcity and diversity Sunderland, Massachusetts. Pages 19-34.
Golden Gate National Recreation Area. 2008. Biological Assessment of impacts to threatened Steelhead Trout (*Oncorhynchus mykiss*), endangered coho salmon (*O. kisutch*), and designated critical habitat from the wetland and creek restoration at Big Lagoon, Muir Beach, Golden Gate National Recreation Area, National Park Service, Marin County, California.
Good, T.P., R.S. Waples, and P.B. Adams, 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. Commerce, NOAA, NMFS
Goudey, C., S.D. Miles, R. Griffith, J. Chatoian, D. Smith, and E. Vinson. 2002. Ecological Subsections of California [online]. USDA, Forest Service, Natural Resource Conservation District.
Gregory, R.S., and T.G. Northcote. 2003. Surface, planktonic, and benthic foraging by juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in turbid laboratory conditions. Canadian Journal of Fisheries and Aquatic Sciences. 50:233-240.
Gresh, T., J. Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the northeast pacific ecosystem. Fisheries 15(1):15-21.
Halligan, D. 2004. Stream inventory and assessment report for the Ukiah reach of the Russian River, California. Prepared for: Granite Construction Company North Coast Area, Ukiah, CA. Prepared by: Dennis Halligan, Natural Resource Management Corporation, Eureka, CA.
Handeland, S. O., and S. O. Stefansson. 2002. Effects of salinity acclimation on pre-smolt growth, smolting and post-smolt performance in off-season Atlantic salmon smolts (*Salmo salar* L.). Aquaculture 209(1-4):125-137.
Hanson MB, Baird RW, Ford JKB, Hempelmann-Halos J, Doornik DMV, Candy JR, Emmons CK, Schorr GS, Gisborne B, Ayres KL et al., 2010. Species and stock identification of prey consumed by endangered Southern Resident Killer Whales in their summer range. Endangered Species Research. 11 (1):69-82.
Hanson MB, Emmons CK, Ford MJ, Everett M, Parsons K, Park LK, Hempelmann J, Van Doornik DM, Schorr GS, Jacobsen JK. 2021. Endangered predators and endangered prey: Seasonal diet of Southern Resident killer whales. PloS one. 16(3):e0247031.
Hanson MB, Emmons CK, Ward EJ, Nystuen JA, Lammers MO. 2013. Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. The Journal of the Acoustical Society of America. 134(5):3486–3495.

Hanson MB, and Emmons CK. 2010. Annual Residency Patterns of Southern Resident Killer Whales in the Inland Waters of Washington and British Columbia. Revised Draft - 30 October 10. 11p.

Hanson MB, Ward EJ, Emmons CK, Holt MM, Holzer DM. 2017. Assessing the movements and occurrence of southern resident killer whales relative to the US Navy's Northwest Training Range Complex in the Pacific Northwest. Prepared for: US Navy, US Pacific Fleet, Pearl Harbor, HI Prepared by: National Oceanic and Atmospheric Administration, Northwest Fisheries Science Center under MIPR. (Final Report for U.S. Navy under MIPR N00070-15-MP-4C363).

Harder, A.M., W.R. Ardren, A.N. Evans, M.H. Futia, C.E. Kraft, J.E. Marsden, C.A. Richter, J. Rinchard, D.E. Tillitt, and M.R. Christie. 2018. Thiamine deficiency in fishes: causes, consequences, and potential solutions. Reviews in Fish Biology and Fisheries, 28, pp.865-886.

Harrison, L.R., Bray, E., Overstreet, B., Legleiter, C.J., Brown, R.A., Merz, J.E., Bond, R.M., Nicol, C.L. and Dunne, T., 2019. Physical controls on salmon redd site selection in restored reaches of a regulated, gravel-bed river. Water Resources Research, 55(11), pp.8942-8966.

Harvey, B.C. 1986. Effects of suction gold dredging on fish and invertebrates in two California streams. North American Journal of Fisheries Management 6: 401-409.

Harvey, B.C. and White, J.L., 2008. Use of benthic prey by salmonids under turbid conditions in a laboratory stream. Transactions of the American Fisheries Society, 137(6), pp.1756-1763.

Hassler, T.J. 1987. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (pacific southwest) coho salmon. Humboldt State University, California Cooperative Fishery Research Unit; U.S. Fish and Wildlife Service, National Wetland Research Center, Slidell, LA for U.S. Army Corps of Engineers, Coastal Ecology Group, Waterways Experiment Station and for U.S. Department of the Interior, Fish and Wildlife Service, Research and Development, National Wetlands Research Center, Washington, DC, Arcata. 19 Pages.

Hayes, S.A., M.H. Bond, C.V. Hanson, E.V. Freund, E. AndAerson, A.J. Ammann, R.B. MacFarlane. 2006. Steelhead Growth Patterns from Egg to Ocean Entry in their Native Southern Range, Santa Cruz, California.

Hayes, D.B., C.P. Ferreri, and W.W. Taylor. 1996. Active fish capture methods. Pp. 193-220 in B.R. Murphy and D.W. Willis (Editors). Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Hayhoe, K., Cayan, D., Field, C.B., Frumhoff, P.C., Maurer, E.P., Miller, N. L., Moser, S.C.,Schneider, S.H., Cahill, K.N., and E.E. Cleland. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences 101(34): 12422-12427.

Healey, M. C. 1980. Utilization of the Nanaimo River estuary British Columbia Canada by juvenile Chinook salmon *Oncorhynchus tshawytscha*. Fishery Bulletin 77(3): 653-668.

Healey, M.C. 1991. Life history of Chinook salmon (*Oncorhynchus tshawytscha*). Pages 312-393 *in* C. Groot and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver.

Hedgecock, D., M. Banks, K. Bucklin, C.A. Dean, W. Eichert, C. Greig, P. Siri, B. Nyden, and J. Watters. 2002. Documenting biodiversity of coastal salmon (*Oncorhynchus* spp.) in

Northern California. Bodega Marine Laboratory, University of California at Davis. For Sonoma County Water Agency, Contract #TW 99/00-110.
Heintz, R.A., Short, J.W. and Rice, S.D., 1999. Sensitivity of fish embryos to weathered crude oil: Part II. Increased mortality of pink salmon (*Oncorhynchus gorbuscha*) embryos incubating downstream from weathered Exxon Valdez crude oil. *Environmental Toxicology and Chemistry: An International Journal*, *18*(3), pp.494-503.
Hilborn R, Cox SP, Gulland FMD, Hankin DG, Hobbs NT, Schindler DE, Trites AW. 2012. The Effects of Salmon Fisheries on Southern Resident Killer Whales: Final Report of the Independent Science Panel. November 30, 2012. Prepared with the assistance of D.R. Marmorek and A.W. Hall, ESSA Technologies Ltd., Vancouver, B.C. for NMFS, Seattle, Washington and Fisheries and Oceans Canada (Vancouver. BC). 87p.
Holbert S, Colbourne K, Fisk AT, Ross PS, MacDuffee M, Gobas FAPC, Brown TM. 2024. Polychlorinated biphenyl and polybrominated diphenyl ether profiles vary with feeding ecology and marine rearing distribution among 10 Chinook salmon (*Oncorhynchus tshawytscha*) stocks in the North Pacific Ocean.
Holt MM, Tennessen JB, Hanson MB, Emmons CK, Giles DA, Hogan JT, Ford MJ. 2021. Vessels and their sounds reduce prey capture effort by endangered killer whales (*Orcinus orca*). Marine Environmental Research. 170(105429):1-8.
Hubert, W.A. 1996. Passive capture techniques. In B. Murphy and D. Willis (eds.) Fisheries Techniques. Bethesda, Maryland, American Fisheries Society.
Humboldt County. 2002. Memo from Ann Glubczynski, County of Humboldt Public Works, to Margaret Tauzer, National Marine Fisheries Service, entitled "2002 Monitoring Report – Five Fish Passage Enhancement Projects." June 27. 1 p.
Humboldt County. 2003. Memo from Ann Glubczynski, County of Humboldt Public Works, to Margaret Tauzer, National Marine Fisheries Service, entitled "2003 Monitoring Report – Eleven Culvert Replacements for Fish Passage." June 23. 2 pp.
Humboldt County. 2004. Memo from Ann Glubczynski, County of Humboldt Public Works, to Margaret Tauzer, National Marine Fisheries Service, entitled "2004 Monitoring Report – Eleven Culvert Replacements for Fish Passage." June 10. 2 pp.
Hunter, M.A. 1992. Hydropower Flow Fluctuations and Salmonids: A Review of the Biological Effects, Mechanical Causes and Options for Mitigation. Department of Fish and Wildlife. Olympia. WA.
Incardona, J.P., M.G. Carls, H. Teraoka, C.A. Sloan, T.K. Collier, and N.L. Scholz. 2005. Aryl hydrocarbon receptor–independent toxicity of weathered crude oil during fish development. Environmental health perspectives, 113(12), pp.1755-1762.
Incardona, J.P., T.K. Collier, and N.L. Scholz. 2004. Defects in cardiac function precede morphological abnormalities in fish embryos exposed to polycyclic aromatic hydrocarbons. Toxicology and applied pharmacology, 196(2), pp.191-205.
Incardona, J.P., H.L. Day, T.K. Collier, and N.L. Scholz. 2006. Developmental toxicity of 4-ring polycyclic aromatic hydrocarbons in zebrafish is differentially dependent on AH receptor isoforms and hepatic cytochrome P4501A metabolism. Toxicology and applied pharmacology, 217(3), pp.308-321.
Inter-Fluve, Inc. 2010. Dry Creek Current Conditions Report. Prepared for Sonoma County Water Agency, Santa Rosa, CA.
IPCC. 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

[Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

IPCC. 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-24,

Joblon MJ, Pokras MA, Morse B, Harry CT, Rose KS, Sharp SM, Niemeyer ME, Patchett KM, Sharp WB, Moore MJ. 2014. Body condition scoring system for delphinids based on short-beaked common dolphins (*Delphinus delphis*). Journal of Marine Animals and Their Ecology. 7(2):5-13.

Kadir, T. Mazur, L., Milanes, C., and Randles, K.2013 Indicators of Climate Change in California. California Environmental Protection Agency, Office of Environmental Health Hazard Assessment Sacramento, CA.

Kardos M, Zhang Y, Parsons KM, A Y, Kang H, Xu X, Liu X, Matkin CO, Zhang P, Ward EJ et al., 2023. Inbreeding depression explains killer whale population dynamics. Nature Ecology & Evolution.26.

Katz, J., G. Reedy, and D. Hines. 2006. Downstream Migrant Trapping Results and Steelhead (*Oncorhynchus mykiss*) Smolt Abundance Estimate for Lower Austin Creek, 2006. With appendices. 14 pages, plus figures.

Kesner, W.D. and R.A. Barnhart, 1972. Characteristics of the fall-run steelhead trout (*Salmo gairdneri gairdneri*) of the Klamath River System with emphasis on the half-pounder. Calif. Fish Game 58(3):204-220.

Knight, N.J. 1985. Microhabitats and temperature requirements of hardhead (*Mylopharadon conocephalu*s) and Sacramento squawfish (*Ptychocheilus grandis*), with notes for some other native California stream fishes. Ph.D. thesis. University of California, Davis. 161 pp.

Kondolf, G. M. 1997. Hungry water: Effects of dams and gravel mining on river channels. Environmental Management 21:533–551.

Koski, K. V. 2009. The Fate of Coho Salmon Nomads: The Story of an Estuarine-Rearing Strategy Promoting Resilience. Ecology and Society 14(1).

Krahn MM, Ford MJ, Perrin WF, Wade PR, Angliss RP, Hanson MB, Taylor BL, Ylitalo GM, Dahlheim ME, Stein JE et al., 2004. 2004 Status Review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. December 2004. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-62. NMFS, Seattle, Washington. 95p.

Krahn MM, Hanson MB, Baird RW, Boyer RH, Burrows DG, Emmons CK, Ford JKB, Jones LL, Noren DP, Ross PS et al., 2007. Persistent organic pollutants and stable isotopes in biopsy samples (2004/2006) from Southern Resident Killer Whales. Marine Pollution Bulletin. 54(12):1903-1911.

Krahn MM, Hanson MB, Schorr G, Emmons CK, Burrows DG, Bolton JL, Baird RW, Ylitalo GM. 2009. Effects of age, sex and reproductive status on persistent organic pollutant concentrations in ‘‘Southern Resident” killer whales. Marine Pollution Bulletin. 58(10):1522–1529.

Krahn MM, Wade PR, Kalinowski ST, Dahlheim ME, Taylor BL, Hanson MB, Ylitalo GM, Angliss RP, Stein JE, Waples RS. 2002. Status Review of Southern Resident Killer Whales (*Orcinus orca*) under the Endangered Species Act. December 2002. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-54. 159p.

Kuehne, L. M., J. D. Olden, and J. J. Duda. 2012. Costs of living for juvenile Chinook salmon (*Oncorhynchus tshawytscha)* in an increasingly warming and invaded world. Canadian Journal of Fisheries and Aquatic Sciences 69:1621–1630.

Lacy RC, Williams R, Ashe E, Kenneth C. Balcomb III, Brent LJN, Clark CW, Croft DP, Giles DA, MacDuffee M, Paquet PC. 2017. Evaluating anthropogenic threats to endangered killer whales to inform effective recovery plans. Scientific Reports. 7(1):1-12.

Largier, J., K. O'Connor, and R. Clark. 2019. Considerations for management of the mouth state of California's bar-built estuaries. Report to the Pacific States Marine Fisheries Commission and NOAA.

Larson, J.P. 1987. Utilization of the Redwood Creek estuary, Humboldt County, California, by juvenile salmonids. Master's Thesis. Humboldt State University, Arcata, California.

Lee, K, Alava JJ, Cottrell P, Cottrell L, Grace R, Zysk I, Raverty S. 2023. Emerging contaminants and new POPs (PFAS and HBCDD) in endangered southern resident and Bigg's (transient) killer whales (*Orcinus orca*): In utero maternal transfer and pollution management implications. Environmental Science & Technology. 57:360-374.

Lee, D P, and P H Baker. 1975. Eel-Russian River streamflow augmentation study: reconnaissance fisheries evaluation. California Department of Fish and Game

Leidy, R.A. 1984. Distribution and Ecology of Stream Fishes in the San Francisco Bay Drainage. Hilgardia 52:1-175.

Lerner JE, and Hunt BPV. 2023. Seasonal variation in the lipid content of Fraser River Chinook Salmon (*Oncorhynchus tshawytscha*) and its implications for Southern Resident Killer Whale (*Orcinus orca*) prey quality.

Lestelle, L.C. 2007. Coho Salmon (*Oncorhynchus kisutch*) Life History Patterns in the Pacific Northwest and California. Final Report prepared for the US Bureau of Reclamation Klamath Area Office.

Levin, P.S., and Williams J.G. 2002. Interspecific effects of artificially propagated fish: An additional conservation risk for salmon. Conservation Biology. 16(6):1581-1587.

Levings, C. D., C. D. McAllister, J. S. MacDonald, T. J. Brown, M. S. Kotyk, and B.A. Kask. 1989. Chinook salmon (*Oncorhynchus tshawytscha*) and estuarine habitat: a transfer experiment can help evaluate estuarine dependency. p 116-122. *In* C. D. Levings, L. Bl. Holtby, and M.A. Henderson [e.d.] Proceedings of the National Workshop of Habitat Alteration on Salmonid Stock. Can. Spec. Publ. Fish. Aquat. Sci. 105.

Lindley, S. T., R. S. Schick, E. Mora, P. B. Adams, J. J. Anderson, S. Greene, C. Hanson, B. P. May, D. R. McEwan, R. B. MacFarlane, C. Swanson, and J. G. Williams. 2007. Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin. San Francisco Estuary and Watershed Science, 5.

Lusardi, R.A., Hammock, B.G., Jeffres, C.A., Dahlgren, R.A. and Kiernan, J.D., 2020. Oversummer growth and survival of juvenile coho salmon (*Oncorhynchus kisutch*) across a natural gradient of stream water temperature and prey availability: an in situ enclosure experiment. Canadian Journal of Fisheries and Aquatic Sciences, 77(2), pp.413-424.

Maahs and Cannata 1998. The Albion River estuary, its history, water quality and use by salmonids, and other fish and wildlife species. Prepared for the Humboldt County Resource Conservation District and Coastal Land Trust. Yes.

Macdonald, J.S., Levings, C.D., McAllister, C.D., Fagerlund, U.H.M. and McBride, J.R. 1988. A Field Experiment to Test the Importance of Estuaries for Chinook Salmon (*Oncorhynchus tshawytscha*) Survival: Short-Term Results. Canadian Journal of Fisheries and Aquatic Sciences 45(8), 1366-1377.

MacFarlane, R.B., E.C. Norton. 2002. Physiological ecology of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) at the southern end of their distribution, the San Francisco estuary and gulf of the Farallones, California. Fishery Bulletin 100(2):244-257.

Maggini S, Pierre A, Calder PC. 2018. Immune function and micronutrient requirements change over the life course. Nutrients. 10(10):1-27.

Magnusson, A. and R. Hilborn. 2003. Estuarine Influence on Survival Rates of Coho (*Oncorhynchus kisutch*) and Chinook Salmon (*Oncorhynchus tshawytscha*) Released from Hatcheries on the U.S. Pacific Coast. Estuaries 26(4B): 1094-1103.

Marshall, K.A., C. Stier, J.F. Samhouri, R.P. Kelly, and E.J. Ward. 2016. Conservation challenges of predator recovery. Conservation Letters 9(1): 70-78.

Martini-Lamb, J., and Manning, D.J. 2015. Russian River Biological Opinion status and data report year 2014-15. Sonoma County Water Agency, Santa Rosa, CA. p. 10-12

Martini-Lamb, J., and Manning, D.J. 2020. Russian River Biological Opinion status and data report year 2016. Sonoma County Water Agency, Santa Rosa, CA. 315 p.

Martini-Lamb, J. and Manning, D. J. 2023. Russian River Biological Opinion Status and Data Report Year 2020. Sonoma County Water Agency, Santa Rosa, CA. 333 p

Martini-Lamb, J., and Manning, D.J. 2024. Russian River Biological Opinion Status and Data Report Year 2022. Sonoma County Water Agency, Santa Rosa, CA. 303 pp.

Matsubu, W. C. 2019. Tradeoffs of juvenile steelhead (*Oncorhynchus mykiss*) rearing in an intermittently closed estuary, northern California USA. PhD Dissertation, U Washington.

May, C.L., B. Pryor, T.E. Lisle, and M. Lang. 2009. Coupling hydrodynamic modeling and empirical measures of bed mobility to predict the risk of scour and fill of salmon redds in a large regulated river. Water Resour. Res. 45:W05402.

McCormick 1994. Ontogeny and Evolution of Salinity Tolerance in Anadromous Salmonids: Hormones and Heterochrony. Estuaries 17(1A): 26-33.

McElhany, P., M.H. Ruckelshaus, M.J. Ford, T.C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. U.S. Department of Commerce. NOAA Technical Memorandum. NMFS-NWFSC-42.

McHuron EA, Adamczak S, Costa DP, Booth C. 2023. Estimating reproductive costs in marine mammal bioenergetic models: a review of current knowledge and data availability

McMahon, T.E. 1983. Habitat suitability index models: coho salmon. U.S. Department Interior, Fish Wildlife Service. FWS/OBS-82/10.49. 29 pp.

Meehan, W. R. 1991. Influences of forest and rangeland management on salmonid fishes and their habitat. American Fisheries Society Special Publication, volume American Fisheries Society Special Publication 19. American Fisheries Society, Bethesda, MD.

Meehan, W.R., and T.C. Bjornn. 1991. Salmonid distributions and life histories. *In* W.R. Meehan [ed.] Influences of forest and rangeland management on salmonid fishes and their habitats. Special Publication 19. American Fisheries Society, Bethesda, MD.

Melbourne BA, and Hastings A. 2008. Extinction risk depends strongly on factors contributing to stochasticity. Nature. 454:100-103.
Merz, J. E., and Vanicek, C. D. 1996. Comparative feeding habits of juvenile Chinook salmon, steelhead, and Sacramento squawfish in the lower American River, California. California Fish and Game, 82(4), 149-159.
Michel, C.J. 2019. Decoupling outmigration from marine survival indicates outsized influence of streamflow on cohort success for California's Chinook salmon populations. Canadian Journal of Fisheries and Aquatic Sciences, 76(8), pp.1398–1410.
Miller, B.A., and S. Sadro. 2003. Residence time and seasonal movements of juvenile coho salmon in the ecotone and lower estuary of Winchester Creek, South Slough, Oregon. Transactions of the American Fisheries Society 2003. 132:546-559.
Miller, J.A. and Simenstad, C.A. 1997. A comparative assessment of a natural and created estuarine slough as rearing habitat for juvenile chinook and coho salmon. Estuaries 20(4), 792-806.
Mongillo TM, Ylitalo GM, Rhodes LD, O'Neill SM, Noren DP, Hanson MB. 2016. Exposure to a mixture of toxic chemicals: Implications to the health of endangered Southern Resident killer whales. November 2016. NOAA Technical Memorandum NMFS-NWFSC-135. 118p.
Moore, M.E., B.A. Berejikian, C.M. Greene, and S. Munsch. 2021. Environmental fluctuation and shifting predation pressure contribute to substantial variation in early marine survival of steelhead. Marine Ecology Progress Series, 662, pp.139-156.
Morgan, J.D., and G.K. Iwama. 1991. Effects of salinity on growth, metabolism, and ion regulation in juvenile rainbow and steelhead trout (*Oncorhynchus mykiss*) and fall chinook salmon (*Oncorhynchus shawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 48(11):2083-2094.
Mortenson, J. 1996. Human interference with harbor seals at Jenner, California, 1994-1995. Prepared for Stewards of Slavianka and Sonoma Coast State Beaches. Russian River/Mendocino Park District. July 11. 1996.
Moser, M.L., A.F. Olson, and T.P. Quinn. 1991. Riverine and estuarine migratory behavior of coho salmon (*Oncorhynchus kisutch*) smolts. Canadian Journal of Fisheries and Aquatic Sciences 48: 1670-1678.
Moser, S., Ekstrom, J. and Franco, G. 2012. Our Changing Climate 2012 Vulnerability and Adaptation to the Increasing Risks from Climate Change in California. A Summary Report on the Third Assessment from the California Climate Change Center. July. CEC-500-20102-007S.
Mount, J. 1995. California rivers and streams: The conflict between fluvial process and land use. University of California Press.
Moyle, P.B. 2002. Inland Fishes of California. University of California Press.
Moyle, P. B., and J. F. Mount. 2007. Homogenous rivers, homogenous faunas. Proceedings of the National Academy of Sciences 104:5711–5712.
Moyle, P. B. and R. D. Nichols. 1973. Ecology of some native and introduced fishes of the Sierra Nevada foothills in central California. Copeia. 478-490.
Munsch, S.H., Andrews, K.S., Crozier, L.G., Fonner, R., Gosselin, J.L., Greene, C.M., Harvey, C.J., Lundin, J.I., Pess, G.R., Samhouri, J.F., and W.H. Satterthwaite. 2020. Potential for ecological nonlinearities and thresholds to inform Pacific salmon management. Ecosphere, 11(12), p.e03302.

Munsch, S.H., Beaty, F.L., Beheshti, K.M., Chesney, W.B., Endris, C.A., Gerwing, T.G., Hessing-Lewis, M., Kiffney, P.M., O'Leary, J.K., Reshitnyk, L., Sanderson, B.L., Walter, R.K. 2023. Northeast Pacific eelgrass dynamics: interannual expansion distances and meadow area variation over time. Marine Ecology Progress Series. 705: 61-75.

Murphy, M.L., K.V. Koski, J.M. Lorenz, and J.F. Thedinga. 1997. Downstream migrations of juvenile Pacific salmon (*Oncorhynchus kisutch*) smolts. Canadian Journal of Fisheries and Aquatic Sciences 54:2837-2846.

Murray CC, Hannah LC, Doniol-Valcroze T, Wright BM, Stredulinsky EH, Nelson JC, Locke A, Lacy RC. 2021. A cumulative effects model for population trajectories of resident killer whales in the Northeast Pacific.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grand, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples, 1998. Status review of Chinook Salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-35.

Nagrodski, A., G. D. Raby, C. T. Hassler, M. K. Taylor, and S. J. Cooke. 2012. Fish stranding in freshwater systems: sources, consequences, and mitigation. Journal of Environmental Management 103:133–141

Naish KA, Joseph E. Taylor III, Levin PS, Quinn TP, Winton JR, Huppert D, Hilborn R. 2007. An evaluation of the effects of conservation and fishery enhancement hatcheries on wild populations of salmon. Advances in Marine Biology. 53:61-194.

NAS. 2017. Approaches to understanding the cumulative effects of stressors on marine mammals. Washington, DC: The National Academies Press.

Neale JC, Gulland FM, Schmelzer KR, Harvey JT, Berg EA, Allen SG, Greig DJ, Grigg EK, Tjeerdema RS. 2005. Contaminant loads and hematological correlates in the harbor seal (*Phoca vitulina*) of San Francisco Bay, California. Journal of Toxicology and Environmental Health, Part A. 68(8):617-633.

Nelson PA, D Behrens, J Castle, G Crawford, RN Gaddam, SC Hackett, J Largier, DP Lohse, KL Mills, PT Raimondi, M Robart, WJ Sydeman, SA Thompson, S Woo. 2008. Developing Wave Energy In Coastal California: Potential Socio-Economic And Environmental Effects. California Energy Commission, PIER Energy-Related Environmental Research Program & California Ocean Protection Council CEC-500-2008-083.

Nelson BW, Ward EJ, Linden DW, Ashe E, Williams R. 2024. Identifying drivers of demographic rates in an at-risk population of marine mammals using integrated population models. Ecosphere. 15(2):e4773.

Newcombe, C. P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management 16:693-727.

Nickelson TE, Solazzi MF, Johnson SL. 1986. Use of Hatchery Coho Salmon (*Oncorhynchus kisutch*) Presmolts to Rebuild Wild Populations in Oregon Coastal Streams. Canadian Journal of Fisheries and Aquatic Sciences. 43:2443-2449.

Nielsen, J.L. 1992. Microhabitat-specific foraging behavior, diet, and growth of juvenile coho salmon. Transactions of the American Fisheries Society 121:617-634.

NMFS and WDFW. 2018. Southern Resident Killer Whale Priority Chinook Stocks Report. June 22, 2018. 8p.

NMFS, Wildlife WDoFa. 2018. Southern Resident Killer Whale Priority Chinook Stocks Report.

NMFS. 2000. Guidelines for electrofishing waters containing salmonids listed under the Endangered Species Act. June 2000.
NMFS. 2003. Biological Opinion for Department of the Army Permitting of Instream Mining in the Russian River by Shamrock Materials, Inc.
NMFS. 2005a. Endangered and threatened species; designation of critical habitat for 12 evolutionarily significant units of West Coast salmon and steelhead in Washington, Oregon, and California. Final rule. Federal Register 70:170. 2, September 2005:52630-52858.
NMFS. 2005b. Final rule designating critical habitat for seven evolutionarily significant units of Pacific salmon and steelhead in California. National Marine Fisheries Service, Federal Register. Federal Register, Volume 70, page 52488.
NMFS. 2008a. Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water Agency, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River watershed. September 24, 2008.
NMFS. 2008b. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service, Seattle, Washington. 251p.
NMFS. 2008c. Endangered Species Act - Section 7 Formal Consultation Biological Opinion - Effects of the 2008 Pacific Coast Salmon Plan Fisheries on the Southern Resident Killer Whale Distinct Population Segment (*Orcinus orca*) and their Critical Habitat.
NMFS. 2008d. Endangered Species Act Section 7 Consultation Final Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Implementation of the National Flood Insurance Program in the State of Washington Phase One Document-Puget Sound Region. NMFS Consultation No.: NWR-2006-00472. 226p.
NMFS. 2010. Endangered Species Act Section 7(a)(2) Consultation Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation. Programs Administered by the Bureau of Indian Affairs that Support Puget Sound Tribal Salmon Fisheries and Salmon Fishing Activities Authorized by the U.S. Fish and Wildlife Service in Puget Sound from May 1-July 31, 2010 on the Puget Sound Chinook Salmon Evolutionarily Significant Unit and the Puget Sound Steelhead and the Puget Sound/Georgia Basin Rockfish Distinct Population Segments. NMFS Northwest Region. May 5, 2010. NMFS Consultation No.: NWR-2010-01850. 47p. .
NMFS. 2011a. Southern Resident Killer Whales (*Orcinus orca*) 5-Year Review: Summary and Evaluation.
NMFS, 2011b. A Proposed Plan for Minimizing the Effects of Flow Release ramp-downs at Coyote Valley Dam on Threatened Salmon and Steelhead in the Russian River.
NMFS. 2012. Final Recovery Plan for the Central California Coast Coho Salmon Evolutionary Significant Unit. National Marine Fisheries Service, Southwest Region, Santa Rosa, California.
NMFS. 2014. California Eelgrass Mitigation Policy and Implementing Guidelines. NOAA Fisheries, West Coast Region. October 2014.
NMFS. 2016a. Letter from NMFS to USACE summarizing the results of studies to evaluate ramping rates downstream of Coyote Valley Dam as a component of directives stipulated in the 2008 Biological Opinion for Water Supply, Flood Control Operations, and Channel Maintenance conducted by the U.S. Army Corps of Engineers, the Sonoma County Water

Agency, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District in the Russian River Watershed. April 14.
NMFS. 2016b. 5-Year Review: Summary & Evaluation of Central California Coast Steelhead. West Coast Region.
NMFS. 2016c. 5-Year Review: Summary & Evaluation of California Coastal Chinook Salmon and Northern California Steelhead. West Coast Region.
NMFS. 2016d. Final Coastal Multispecies Recovery Plan. National Marine Fisheries Service, West Coast Region, Santa Rosa, California.
NMFS. 2016e. Southern Resident Killer Whales (*Orcinus orca*) 5-Year Review: Summary and Evaluation. December 2016. NMFS, West Coast Region, Seattle, Washington. 74p.
NMFS. 2017a. California State Water Resources Control Board (SWRCB) Order approving petitions for temporary petitions for temporary urgency changes to permit terms and conditions.
NMFS. 2017b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation - Nine Snake River Steelhead Hatchery Programs and one Kelt Reconditioning Program in Idaho.
NMFS. 2018. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response Consultation on effects of the 2018-2027 U.S. v. Oregon Management Agreement.
NMFS. 2019a. Impacts of the Role of the BIA Under its Authority to Assist with the Development of the 2019- 2020 Puget Sound Chinook Harvest Plan, Salmon Fishing Activities Authorized by the U.S. Fish and Wildlife Service, and Fisheries Authorized by the U.S. Fraser Panel in 2019.
NMFS. 2019b. Biological Opinion on Long Term Operation of the Central Valley Project and the State Water Project. October 21, 2019.
NMFS. 2020. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Response - Impacts of the Role of the BIA Under its Authority to Assist with the Development of the 2020-2021 Puget Sound Chinook Harvest Plan, Salmon Fishing Activities Authorized by the U.S. Fish and Wildlife Service, and Fisheries Authorized by the U.S. Fraser Panel in 2020.
NMFS. 2021a. Southern Resident Killer Whales (*Orcinus orca*) 5-Year Review: Summary and Evaluation. NMFS, West Coast Region, Seattle, Washington.
NMFS. 2021b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Response for the Impacts of the Role of the BIA Under its Authority to Assist with the Development of the 2021-2022 Puget Sound Chinook Harvest Plan, Salmon Fishing Activities Authorized by the U.S. Fish and Wildlife Service, and Fisheries Authorized by the U.S. Fraser Panel in 2021. May 19, 2021. NMFS Consultation No: WCRO-2021-01008.
NMFS. 2021c. Revision of the Critical Habitat Designation for Southern Resident Killer Whales: Final Biological Report (to accompany the Final Rule. July 2021. United States National Marine Fisheries Service. West Coast, Region [Non-series Report].

NMFS. 2021d. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Conference Opinion Biological Opinion on the Authorization of the West Coast Ocean Salmon Fisheries Through Approval of the Pacific Salmon Fishery Management Plan Including Amendment 21 and Promulgation of Regulations Implementing the Plan for Southern Resident Killer Whales and their Current and Proposed Critical Habitat. NMFS Consultation Number: WCRO-2019-04074. April 21, 2021. 190p.

NMFS. 2021e. Programmatic Draft Environmental Impact Statement - Expenditure of Funds to Increase Prey Availability for Southern Resident Killer Whales.

NMFS. 2021f. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Surrender and Decommissioning of the Lower Klamath Hydroelectric Project No. 14803-001, Klamath County, Oregon and Siskiyou County, California. Refer to NMFS No: WCRO-2021-01946. December 17, 2021.

NMFS. 2021g. Endangered Species Act Section 7(a)(2) Biological and Conference Opinion for the Issuance of the 5-Year Multi- Sector General Permit for Stormwater Discharges Associated with Industrial Activity, Pursuant to the National Pollution Discharge Elimination System. January 6, 2021.

NMFS. 2021h. National Marine Fisheries Service Reissuance of the Pesticide General Permit for Discharge of Pesticide Pollutants into Waters of the United States. July 29, 2021.

NMFS. 2021i. White Paper on Central Valley Floodplain Management for Salmon: Considerations for Balancing Food Web Productivity and Fish Viability.

NMFS. 2022a. Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Sonoma Water Stream Maintenance Program in Sonoma County, California. April 15, 2022.

NMFS. 2022b. National Marine Fisheries Service Endangered Species Act Section 7 Biological Opinion Programmatic Biological Opinion on the National Program for the Aerial Application of Long-Term Fire Retardants. February 25, 2022.

NMFS. 2022c. Biological and Conference Opinion for the Environmental Protection Agency's 2022 Issuance of the 5-Year Construction General Permit for Stormwater Discharges, Pursuant to the National Pollution Discharge Elimination System. April 1, 2022.

NMFS. 2023. 5-Year Review: Summary & Evaluation of Central California Coast Coho Salmon. West Coast Region.

NMFS. 2024a. 2024 5-Year Review: Summary & Evaluation of California Coastal Chinook Salmon. National Marine Fisheries Service, West Coast Region. 95 pages.

NMFS. 2024b. 2024 5-Year Review: Summary & Evaluation of Central California Coast Steelhead. National Marine Fisheries Service, West Coast Region. 82 pages.

NMFS. 2024c. Endangered Species Act Section 7(a)(2) Biological Opinion, and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Impacts of the Role of the BIA Under its Authority to Assist with the Development of the 2024-2025 Puget Sound Chinook Harvest Plan, the Role of the U.S. Fish and Wildlife Service in Activities Carried out under the Hood Canal Salmon Management Plan and the Office of Conservation Investment funding to the Washington Department of Fish and Wildlife under the Sport Fish Restoration Act in 2024-25, and the Role of the National Marine Fisheries Service in authorizing fisheries consistent with management by the Fraser Panel and Funding Provided to the Washington Department of Fish and Wildlife for Activities Related to Puget Sound Salmon Fishing in 2024-2025.

NMFS. 2024d. Final Environmental Assessment: Russian River Steelhead Integrated Harvest Hatchery Program. National Marine Fisheries Service, West Coast Region. February 2024.
NMFS. 2024e. National Marine Fisheries Service Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response Consultation on the Effects of the Pacific Coast Salmon Fishery Management Plan on the California Coastal Chinook Salmon Evolutionarily Significant Unit Listed Under the Endangered Species Act.
NMFS. 2024f. National Marine Fisheries Service Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson–Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Operations and Maintenance of Existing Fish Passage Facilities at Daguerre Point Dam on the Lower Yuba River. July 30, 2024.
NMFS. 2024g. 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.
NMFS. 2024h. National Marine Fisheries Service Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response Consultation on the Issuance of 17 ESA Section 10(a)(1)(A) Scientific Research Permits in Oregon, Washington, Idaho and California affecting Salmon, Steelhead, Rockfish, Eulachon, and Green Sturgeon in the West Coast Region.
NMFS. 2025. Feature Story: Endangered California Coho Salmon Experience Record-Breaking Spawning Season on Mendocino Coast. NOAA National Marine Fisheries Service, Office of Habitat Conservation. March 04, 2025. Accessed March 31, 2025. https://www.fisheries.noaa.gov/feature-story/endangered-california-coho-salmon-experience-record-breaking-spawning-season-mendocino
Noren DP, Johnson AH, Rehder D, Larson A. 2009. Close approaches by vessels elicit surface active behaviors by Southern Resident Killer Whales. Endangered Species Research. 8(3):179–192.
Noren DP, Johnson S, Boyd D, Ylitalo GM, Lundin J, McCormley M, Jensen ED. 2024. The dynamics of persistent organic pollutant (POP) transfer from female bottlenose dolphins (*Tursiops truncatus*) to their calves during lactation.
Noren DP. 2011. Estimated field metabolic rates and prey requirements of resident killer whales. Marine Mammal Science. 27(1):60–77.
Norman SA, Bowlby CE, Brancato MS, Calambokidis J, Duffield D, Gearin PJ, Gornall TA, Gosho ME, Hanson B, Hodder† J et al., 2004. Cetacean strandings in Oregon and Washington between 1930 and 2002. Journal of Cetacean Research and Management. 6(1):87-99.
NCRWQCB. 2000. Review of Russian River Water Quality Objectives for Protection of Salmonid Species Listed Under the Federal Endangered Species Act. Prepared under contract to the Sonoma County Water Agency, Agreement No. 7-904-110-0. Santa Rosa, California.
Obedzinski, M., D. Lewis, P. Olin, J. Pecharich, and G. Vogeazopoulos. 2007. Monitoring the Russian River Coho Salmon Captive Broodstock Program: Annual Report to NOAA Fisheries. University of California Cooperative Extension, Santa Rosa, California.

Ohlberger J, Schindler DE, Ward EJ, Walsworth TE, Essington TE. 2019. Resurgence of an apex marine predator and the decline in prey body size. Proceedings of the national academy of sciences. 116(52):26682-26689.
Ohlberger J, Ward EJ, Schindler DE, Lewis B. 2018. Demographic changes in Chinook salmon across the Northeast Pacific Ocean. Fish and Fisheries. 19(3):533-546.
Olesiuk, P. F., Bigg, M. A., and Ellis, G. M. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Paper presented at the International Whaling Commission.
Olesiuk PF, Ellis GM, Ford JKB. 2005. Life history and population dynamics of northern resident killer whales (*Orcinus orca*) in British Columbia (pages 1-75). Canadian Science Advisory Secretariat.
Olson JK, Wood J, Osborne RW, Barrett-Lennard L, Larson S. 2018. Sightings of southern resident killer whales in the Salish Sea 1976–2014: the importance of a long-term opportunistic dataset. Endangered Species Research. 37:105-118.
O'Neill S, Ylitalo GM, Herman D, West J. 2012. Using chemical fingerprints in salmon and whales to infer prey preferences and foraging habitat of SRKWs. Evaluating the Effects of Salmon Fisheries on Southern Resident Killer Whales: Workshop 3, September 18-20, 2012. Seattle, WA: NOAA Fisheries and DFO (Fisheries and Oceans, Canada).
O'Neill, S.M., and West, J.E. 2009. Marine distribution, life history traits, and the accumulation of polychlorinated biphenyls in Chinook salmon from Puget Sound, Washington. Transactions of the American Fisheries Society. 138:616-632.
O'Neill SM, Ylitalo GM, West JE, Bolton JL, Sloan CA, Krahn MM. 2006. Regional patterns of persistent organic pollutants in five Pacific salmon species (*Oncorhynchus spp*) and their contributions to contaminant levels in northern and southern resident killer whales (*Orcinus orca*). Presentation at 2006 Southern Resident Killer Whale Symposium, Seattle.
O'Neill SM, Ylitalo GM, and West JE. 2014. Energy content of Pacific salmon as prey of northern and Southern Resident Killer Whales. Endangered Species Research. 25:265–281.
Osborne RW. 1999. A historical ecology of Salish Sea "resident" killer whales (*Orcinus orca*): With implications for management. Doctoral dissertation. University of Victoria,Victoria, British Columbia. 277p.
Osgood, K. E. (editor). 2008. Climate Impacts on U.S. Living Marine Resources: National Marine Fisheries Service Concerns, Activities and Needs. U.S. Dep. Commerce, NOAA Tech. Memo. NMFSF/ SPO-89, 118 p.
Parry. G. 1960. The development of salinity tolerance in the salmon, *Salmo salar* (L.) and some related species. Journal of Experimental Biology 37:425-434.
Pelch, K.E. 2011. Chapter 14 - Endocrine-disrupting chemicals (EDCs) in Norris, D.O., and Lopez, K.H (eds.) in *Hormones and Reproduction of Vertebrates (First Edition): Volume 5 - Mammals.* Academic Press.
Pena Creek Watershed Flow Enhancement Support Tool. 2024. https://experience.arcgis.com/experience/3858d5006c9d43ddae1a0612d5f2ea3d/page/Home-Page. Accessed: March 24, 2025.
Peterson, J.H., and J.F. Kitchell. 2001. Climate regimes and water temperature changes in the Columbia River: Bioenergetics implications for predators of juvenile salmon. Canadian Journal of Fisheries and Aquatic Sciences 58:1831–1841.

Peterson S.H., Hassrick J.L., Lafontaine A, Thome J-P, Crocker D.E., Debier C., Costa D.P. 2014. Effects of Age, Adipose Percent, and Reproduction on PCB Concentrations and Profiles in an Extreme Fasting North Pacific Marine Mammal.

Pettis HM, Rolland RM, Hamilton PK, Brault S, Knowlton AR, Kraus SD. 2004. Visual health assessment of North Atlantic right whales (*Eubalaena glacialis*) using photographs. Canadian Journal of Zoology. 82(1):8-19.

PFMC (Pacific Fishery Management Council). 1998. Description and identification of essential fish habitat for the Coastal Pelagic Species Fishery Management Plan. Appendix D to Amendment 8 to the Coastal Pelagic Species Fishery Management Plan. Pacific Fishery Management Council, Portland, Oregon. December.

PFMC. 2008. Fisheries Regulation Assessment Model (FRAM). An Overview for coho and Chinook v 3.0. Portland, Oregon: PFMC.

PFMC. 2014. Appendix A to the Pacific Coast Salmon Fishery Management Plan, as modified by Amendment 18. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon.

PFMC. 2020. Pacific Fishery Management Council Salmon Fishery Management Plan Impacts to Southern Resident Killer Whales Risk Assessment. Pacific Fisheries Management Council, Portland, OR. May 2020. Published under Agenda Item E.2.a SRKW Workgroup Report 1, June 2020.

PFMC. 2023. Pacific Coast Groundfish Fishery Management Plan for the California, Oregon, and Washington Groundfish Fishery. Pacific Fishery Management Council, Portland, OR. December 2023. 159 pages.

PFMC. 2024. Coastal Pelagic Species Fishery Management Plan as Amended Through Amendment 21. Pacific Fishery Management Council, Portland, Oregon. April 2024. 55 pages.

Phillips, R.W., and H.J. Campbell. 1961. The embryonic survival of coho salmon and steelhead trout as influenced by some environmental conditions in gravel beds. Pages 60-73. Pacific Marine Fisheries Commission; Oregon State University; Oregon State Game Commission Research Division, Corvallis.

Poe, T.P., H.C. Hansel, S. Vigg, D. E. Palmer, and A. Prendergast, 1991. Feeding of predaceous fishes on out-migrating juvenile salmonids in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120(4): 405-420.

Poff, N.L., and J.K.H. Zimmerman. 2010. Ecological responses to altered flow regimes: A literature review to inform the science and management of environmental flows. Freshwater Biology 55(1):194–205.

Porter, M., D. Marmorek, D. Pickard, and K. Wieckowski. 2014. Dry Creek Adaptive Management Plan. Prepared by ESSA Technologies Ltd., for Sonoma County Water Agency, Santa Rosa CA. 32 pp.

Prolysts, Incorporated and Beak Consultants, Incorporated. 1984. Coyote Valley Dam fish mitigation study. Prepared for the U.S. Army Engineer District, Sacramento, CA

Quinn, T.P. 2005. The behavior and ecology of Pacific salmon and trout. American Fisheries Society, Bethesda, Md.

Raverty S, St. Leger J, Noren DP, Burek Huntington K, Rotstein DS, Gulland FM, Ford JK, Hanson MB, Lambourn DM, Huggins J. 2020. Pathology findings and correlation with body condition index in stranded killer whales (*Orcinus orca*) in the northeastern Pacific and Hawaii from 2004 to 2013. PloS one. 15(12):e0242505.

Reimers, P.E. 1973. The length of residence of fall Chinook in Sixes River, Oregon. Research Report of the Fisheries Commission of Oregon 4(2):43 pages.

Reiser, D.W., T.C. Bjornn. 1979. Habitat requirements of anadromous salmonids. Influence of Forest and Rangeland Management on Anadromous Fish Habitat in the Western United States and Canada. W.R. Meehan, editor. United States Department of Agriculture Forest Service General Technical Report PNW-96

Rich, W.H., A.C. Taft, P.R. Needham, and R. Van Cleve. 1944. Report on relation of proposed dams on the Russian River, California, to maintenance and development of fish resources. U.S. Bureau of Reclamation, Region II.

Richards, C.M., Moal, O. and C. Pallud. 2018. Changes in water quality following opening and closure of a bar-built estuary (Pescadero, California). Marine Chemistry, 198, pp.10-27.

Ritter, J.R., and W.M. Brown. 1971. Turbidity and suspended-sediment transport in the Russian River basin, California. Open-File Report 72-316 prepared by the U.S. Department of the Interior, Geological Survey, Water Resources Division in cooperation with the U.S. Army Corps. of Engineers, Menlo Park, California. 100 pages.

Roni, P. and T.P. Quinn. 2001. Density and size of juvenile salmonids in response to placement of large woody debris in western Oregon and Washington streams. *Canadian journal of fisheries and aquatic sciences*, *58*(2), pp.282-292.

Roni, P. K. Hanson, T. Beechie, G. Pess, M. Pollock, D.M. Bartley. 2005. Habitat rehabilitation for inland fisheries. Global review of effectiveness and guidance for rehabilitation of freshwater ecosystems. FAO fisheries Technical Paper. No. 484. Rome, FAO. 116p.

Roni, P., G. Pess, T. Beechie, and S. Morley. 2010. Estimating changes in coho salmon and steelhead abundance from watershed restoration: How much restoration is needed to measurably increase smolt production? North American Journal of Fisheries Management 30:1469-1484.

Ross, P.S., de Swart, R.L., Timmerman, H.H., Reijnders, P.J.H., Vos, J.G., van Loveren, H., and Osterhaus, A.D.M.E. 1996. Suppression of natural killer cell activity in harbour seals (*Phoca vitulina*) fed Baltic Sea herrings. Aquatic Toxicology, 34, 71-84.

RREITF. 1994. Russian River Estuary Study 1992-1993. Hydrological aspects prepared by P. Goodwin and K. Cuffe, Phillip Williams and Associates, LTD; Limnological aspects prepared by J. Nielson and T. Light; and social aspects prepared by M. Heckel, Sonoma County Planning Department. Prepared for the Sonoma County Department of Planning and the California Coastal Conservancy. 186 pages.

Rubin, S.P., Foley, M.M., Miller, I.M., Stevens, A.W., Warrick, J.A., Berry, H.D., Elder, N.E., Beirne, M.M. and Gelfenbaum, G., 2023. Nearshore subtidal community response during and after sediment disturbance associated with dam removal. Frontiers in Ecology and Evolution, 11, p.1233895

Ruggiero, P., C. A. Brown, P. D. Komar, J. C. Allan, D. A. Reusser, H. Lee, S. S. Rumrill, P. Corcoran, H. Baron, H. Moritz, J. Saarinen. 2010. Impacts of climate change on Oregon's coasts and estuaries. Pages 241-256 in K.D. Dellow and P. W. Mote, editors. Oregon Climate Assessment Report. College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, Oregon.

Salmon Modeling and Analysis Workgroup. 2023. FRAM Overview in FRAM Documentation. https://framverse.github.io/fram_doc/ built September 21, 2023. Accessed March 2025.

Salyer, J. C., and K. F Lagler. 1940. The food and habits of the American merganser during winter in Michigan, considered in relation to fish management. The Journal of Wildlife Management, 4(2), 186-219.
Sandercock, F.K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). Pages 397-445 In C. Groot and L. Margolis [editors]: Pacific salmon life histories. University of British Columbia Press, Vancouver, B.C.
Satterthwaite WH, Mohr MS, O'Farrell MR, Anderson EC, Banks MA, Bates SJ, Bellinger MR, Borgerson LA, Crandall ED, Garza JC et al., 2014. Use of Genetic Stock Identification Data for Comparison of the Ocean Spatial Distribution, Size at Age, and Fishery Exposure of an Untagged Stock and Its Indicator: California Coastal versus Klamath River Chinook Salmon. Transactions of the American Fisheries Society. 143(1):117-133.
Satterthwaite, W. H., M. P. Beakes, E. M. Collins, D. R. Swank, J. E. Merz, R. G. Titus, S. M. Sogard, and M. Mangel. 2009. Steelhead life history on California's central coast: Insights from a state-dependent model. Transactions of the American Fisheries Society 138(3):532-548.
Sazaki, S. 1966. Distribution and food habits of king salmon, *Oncorhynchus tshawytscha*, and steelhead rainbow trout, *Salmo gairdnerii*, in the Sacramento-San Juaquin delta, pages 108-114. In: J.L. Turner and D.W. Kelly (comp.). Ecological studies of the Sacramento-San Joaquin Delta. California Department of Fish and Game Fisheries Bulletin 136.
Scavia, D., Field, J. C., Boesch, D. F., Buddemeier, R. W., Burkett, V., Cayan, D. R., Fogarty, M., Harwell, M. A., Howarth, R. W., Mason, C., Reed, D. J., Royer, T. C., Sallenger, A. H., and J. G. Titus. 2002. Climate Change Impacts on U. S. Coastal and Marine Ecosystems. Estuaries, 25(2), 149–164. http://www.jstor.org/stable/1353306.
Schaefer, K.M. 1996. Spawn time, frequency, and batch fecundity of yellowfin tuna (*Thunnus albacares*) near Clipperton Atoll in the eastern Pacific Ocean. Fishery Bulletin. 94(1):98-112.
Schneider 2007. The unique risks to California from human-induced climate change. California State Motor Vehicle Pollution Control Standards; Request for Waiver of Federal Preemption, presentation May 22, 2007.
Schwacke LH, Voit EO, Hansen LJ, Wells RS, Mitchum GB, Hohn AA, Fair PA. 2002. Probabilistic risk assessment of reproductive effects of polychlorinated biphenyls on bottlenose dolphins (*Tursiops truncatus*) from the southeast United States coast. Environmental Toxicology and Chemistry: An International Journal. 21(12):2752-2764.
Scordino, J., 2010. West coast pinniped program investigations on California sea lion and Pacific Harbor seal impacts on salmonids and other fishery resources. Portland: Pacific States Marine Fisheries Commission.
SEC 1996. A history of salmonid decline in the Russian River. Prepared by Steiner Environmental Consulting (SEC) for Sonoma County Water Agency and California State Coastal Conservancy.
Seghesio, E. E. 2011. The influence of an intermittently closed, Northern California Estuary on the feeding ecology of juvenile steelhead (*Oncorhynchus mykiss*) and Chinook salmon (*Oncorhynchus tshawytscha*). Master's thesis. University of Washington, School of Aquatic and Fishery Sciences.
Servizi, J.A. and Martens, D.W., 1991. Effect of temperature, season, and fish size on acute lethality of suspended sediments to coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences, 48(3), pp.493-497.

Servizi, J.A. and D.W. Martens. 1992. Sub-lethal responses of coho salmon (*Oncorhynchus kisutch*) to suspended sediments. Canadian Journal of Fisheries and Aquatic Science 49:1385-1395.

Shapovalov, L., 1944. Preliminary report on the fisheries of the Russian River, California. California Department of Fish and Game.

Shapovalov, L., and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (Salmo gairdneri) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. Inland Fisheries Branch, California Department of Fish and Game.

Shaw, E.A., and Richardson, J.S. 2001. Effects of turbidity on the reactive distance and foraging success of juvenile coho salmon in the laboratory and field. Canadian Journal of Fisheries and Aquatic Sciences, 58(11), 2298-2306.

Shelton AO, Satterthwaite WH, Ward EJ, Feist BE, Burke B. 2019. Using hierarchical models to estimate stock-specific and seasonal variation in ocean distribution, survivorship, and aggregate abundance of fall run Chinook salmon. Canadian Journal of Fisheries and Aquatic Sciences. 76(1):95-108.

Shelton AO, Sullaway GH, Ward EJ, Feist BE, Somers KA, Tuttle VJ, Watson JT, Satterthwaite WH. 2021. Redistribution of salmon populations in the northeast Pacific Ocean in response to climate. Fish and Fisheries. 22(3):503-517.

Shields, M.W. 2023. 2018–2022 Southern Resident killer whale presence in the Salish Sea: continued shifts in habitat usage. PeerJ. 11:e15635.

Shively R.S., T.P. Poe, and S.T. Sauter. 1996. Feeding response by northern squawfish to a hatchery release of juvenile salmonids in the Clearwater River, Idaho. Transactions of the American Fisheries Society. 125:230-236.

Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelheads and coho salmon. Transactions of the American Fisheries Society 113: 142-150.

Smith. J.J. 1982. Fishes of the Pajaro river System. Univ. Calif. Publ. Zool. 115: 85-169.

Smith, J.J. 1990. The effects of the sandbar formation and inflows on aquatic habitat and fish utilization in Pescadero, San Gregorio, Wadell, and Pomponio creek estuary/lagoon systems, 1985-1989. Department of Biological Sciences, San Jose State University, San Jose, California. 38 pages + tables and figures.

Smith, D.M., Cusack, S., Colman, A.W., Folland, C.K., Harris, G.R. and Murphy, J.M., 2007. Improved surface temperature prediction for the coming decade from a global climate model. science, 317(5839), pp.796-799

Snyder, J.O. 1925. The half-pounder of Eel River, a steelhead trout. California Fish and Game 11: 49-55.

Solazzi, M. F., Nickelson, T. E., and Johnson, S. L. 1991. Survival, contribution, and return of hatchery coho salmon (*Oncorhynchus kisutch*) released into freshwater, estuarine, and marine environments. Canadian Journal of Fisheries and Aquatic Sciences, 48(2), 248-253.

Solazzi, M.F., T.E. Nickelson, S.L. Johnson, and J.D. Rodgers. 2000. Effects of increasing winter rearing habitat on abundance of salmonids in two coastal Oregon streams. Can. J. Fish. Aquat. Sci., 57: 906-914.

Sonoma Water and CSG 2020. California Coastal Salmonid Population Monitoring in the Russian River Watershed. 2020. FRGP GRant #P1730412 Annual REport. Santa Rosa, CA. 40pp.
Sonoma Water and CSG. 2023. California Coastal Salmonid Population Monitoring in the Russian River Watershed. 2022/2023. FRGP Grant #P2281002 Annual Report. Santa Rosa, CA. 46pp.
Sonoma Water. 2003. Upper Russian River steelhead distribution study. Sonoma County Water Agency, Santa Rosa, CA. 20 pages.
Sonoma Water. 2007. Historic Accounts, Recent Abundance, and Current Distribution of Threatened Chinook Salmon in the Russian River. Sonoma County Water Agency. Available on: https://www.sonomawater.org/reports.
Sonoma Water. 2008 Chinook Salmon Spawning Study Russian River Fall 2002-2007. Prepared by David Cook. 27 pp.
Sonoma Water. 2014. Dry Creek Adaptive Management Plan. Prepared by ESSA Technologies LTD., Vancouver, CB.
Sonoma Water. 2016. Fish Habitat Flows and Water Rights Project – Draft Environmental Impact Report. July 2016.
Sonoma Water. 2023. Memorandum from Sonoma Water to the USACE re: Forecast Informed Reservoir Operations. Lake Sonoma Release Metrics. 5pp.
Sonoma Water. 2024a. Study Plan: Migration Survival and Travel Time of Salmon and Steelhead Smolts in the Mainstem Russian River. Sonoma Water, Santa Rosa, CA. 28 p.
Sonoma Water. 2024b. Memorandum to NMFS: Reservoir Water Supply Pool Operations Adaptive Management Action. May 7, 2024.
Sonoma Water. 2024c. Memorandum to NMFS: Dry Creek Habitat Enhancement Alternatives Action. May 10, 2024.
Sonoma Water. 2024d. Memorandum to NMFS: Beach Management and Estuary Metric Development. May 10, 2024
Sonoma Water. 2024e. Russian River Estuary Adaptive Beach Management Plan. Prepared by ESA with Bodega Marine Lab, University of California Davis. May 15, 2024.
Sonoma Water. 2024f. Russian River Estuary Habitat Metric Definition and Methodology; update to acre-day methodology. July 16, 2024.
Sonoma Water. 2024g. Chinook Salmon in the Russian River: Plot of total counts from video monitoring system. https://www.sonomawater.org/chinook. accessed July 1, 2024.
Sonoma Water. 2025. Technical memorandum RE: Interim Water Rights Petition Hydrologic Index. Provided to NMFS via email on April. 20, 2025.
Southern Resident Orca Task Force. 2019. Final Report and Recommendations. Cascadia Consulting Group. November, 2019.
Spence, B. C. 2006. Preliminary biological viability criteria for salmonid ESUs in the north-central California coast recovery domain. NOAA's National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz.
Spence, B. C. 2016. North-Central California Coast Recovery Domain. Pages 26 – 47 in T.H. Williams, B.C. Spence, D.A. Boughton, R.C. Johnson, L. Crozier, N. Mantua, M. O'Farrell, and S.T. Lindley. 2016. Viability Assessment for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest. 2 February 2016 Report to National Marine Fisheries Service – West Coast Region from Southwest Fisheries

Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California 95060.
Spence, B. C., and E. J. Dick. 2014. Geographic variation in environmental factors regulating outmigration timing of coho salmon (*Oncorhynchus kisutch*) smolts. Canadian Journal of Fisheries and Aquatic Sciences 71(1):56-69.
Spence, B. C., E. P. Bjorkstedt, J. C. Garza, J. J. Smith, D. G. Hankin, D. Fuller, W. E. Jones, R. Macedo, T. H. Williams, and E. Mora. 2008. A Framework for Assessing the Viability of Threatened and Endangered Salmon and Steelhead in the North-Central California Coast Recovery Domain. U.S. Department of Commerce. NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-423.
Spence, B. C., E. P. Bjorkstedt, S. Paddock, and L. Nanus. 2012. Updates to Biological Viability Criteria for Threatened Steelhead Populations in the North-Central California Coast Recovery Domain. National Marine Fisheries Service, Southwest Fisheries Science Center, Fisheries Ecology Division, Santa Cruz, CA.
Spence, B. C., S.L. Harris, J. Weldon, M.N. Goslin, A. Agrawal, and E. Mora. 2005. Historical occurrence of coho salmon in streams of the central California coast coho salmon evolutionarily significant unit. Page 88. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center.
Spence, B.C., G.A. Lomnicky, R.M. Hughes, and R.P. Novitzki. 1996. An Ecosystem Approach to Salmonid Conservation. Management Technology. TR-4501-966057.
Spitz J, Becquet V, Rosena DAS, Trites AW. 2015. A nutrigenomic approach to detect nutritional stress from gene expression in blood samples drawn from Steller sea lions.
Stein, R.A., P.E. Reimers, and I.D. Hall. 1972. Social interaction between juvenile coho (*Oncorhynchus kisutch*) and fall Chinook salmon (*O. tshawytscha*) in Sixes River, Oregon. Journal of the Fisheries Research Board of Canada 29: 1737-1748.
Stewart, J.D., Durban, J.W., Fearnbach, H., Barrett-Lennard, L.G., Casler, P.K., Ward, E.J., and Dapp, D.R. 2021. Survival of the fattest: linking body condition to prey availability and survivorship of killer whales. Ecosphere. 12(8):e03660.
Stewart, J.D., Fearnbach, H., Cogan, J., Durban, J.W., Ellifrit, D.K., Malleson, M., Pinnow, M., and Balcomb, K.C. 2023. Traditional summer habitat use by Southern Resident killer whales in the Salish Sea is linked to Fraser River Chinook salmon returns.Marine Mammal Science, 39(1), 1-18.
Strange, J.S. 2013. Factors influencing the behavior and duration of residence of adult Chinook salmon in a stratified estuary. Environmental Biology of Fishes. 96: 225-243.
Swain, D.L., B. Langenbrunner, J.D. Neelin, and A. Hall. 2018. Increasing precipitation volatility in twenty-first century California. Nature Climate Change (8): 427-433. May.
Swanson, M.L. 1992. Hydrologic and Geomorphic Impact Analysis of the Proposed Reclamation Plans at Syar Industries Properties in the Russian River near Healdsburg, Sonoma County, CA. Prepared for EIP Associates, Sacramento, CA.
SWFSC. 2023. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-686. https://doi.org/10.25923/039q-q707
SWRCB. 1986. Russian River Project, Decision 1610.

Tabor, R.A., and Shively, R.S. 1993. Predation on juvenile salmonids by smallmouth bass and northern squawfish in the Columbia River near Richland, Washington. North American Journal of Fisheries Management. 13: 831-838.
Taft, A. C., and G. I. Murphy. 1950. The life history of the Sacramento squawfish (Ptychocheilus grandis). California Fish and Game, 36, 147-164.
Thomas, A.C., B.W. Nelson, M.M. Lance, B.E. Deagle, and A.W. Trites. 2017. Harbour seals target juvenile salmon of conservation concern. Canadian Journal of Fisheries and Aquatic Sciences 74(6):907-921.
Thomas, W.G. 1985. Experimentally determined impacts of a small, suction gold dredge on a Montana stream. North American Journal of Fisheries Management. 5:480-488.
Thompson, K. 1972. Determining stream flows for fish life. Pages 31-50. Pacific Northwest River Basins Commission; Instream Flow Requirement Workshop, Portland, Oregon.
Thompson, R. B. 1959. Food of the squawfish *Ptychocheilus oregonensis* (Richardson) of the lower Columbia River. United States Fish and Wildlife Service, Fishery Bulletin 158:43-58.
Thornton, S.J., Toews, S., Stredulinsky, E., Gavrilchuk, K., Konrad, C., Burnham, R., Noren, D.P., Holt, M.M., and Vagle, S. 2022. Southern Resident Killer Whale (*Orcinus orca*) summer distribution and habitat use in the southern Salish Sea and the Swiftsure Bank area (2009 to 2020). Research Document 2022/037, Canadian Science Advisory Secretariat, Fisheries and Oceans Canada.
Thorpe, J.E. 1994. Salmonid Fishes and the Estuarine Environment. Estuaries 17(1A): 76-93.
Tiffan, K.F., T.J. Kock, C.A. Haskell, W.P. Connor, and R.K. Steinhorst. 2009. Water velocity, turbulence, and migration rate of subyearling fall Chinook salmon in the free-flowing and impounded Snake River. *Transactions of the American Fisheries Society*, *138*(2), pp.373-384.
Trites AW, and Donnelly CP. 2003. The decline of Steller sea lions *Eumetopias jubatus* in Alaska: a review of the nutritional stress hypothesis. Mammal review. 33(1):3-28.
Tschaplinski, P.J., and G.F. Hartman. 1983. Winter Distribution of Juvenile Coho Salmon (*Oncorhynchus kisutch*) Before and After Logging in Carnation Creek, British Columbia, and Some Implications for Overwinter Survival. Canadian Journal of Fisheries and Aquatic Sciences. 40(4): 452-461.
Turley, C. 2008. Impacts of changing ocean chemistry in a high-CO2 world. Mineralogical Magazine, February 2008, 72(1). 359-362.
Unsworth, R.K.F., Cullen-Unsworth, L.C., Jones, B.L.H., and Lilley, R.J. 2022. The planetary role of seagrass conservation. Science 377:609-613.
USACE and Sonoma Water. 2000. Russian River Draft Biological Assessment. Interim Report 1: Flood Control Operations at Coyote Valley and Warm Springs Dams. Prepared by Entrix Inc. for: U.S. Army USACE of Engineers, San Francisco, CA and Sonoma County Water Agency, Santa Rosa, CA.
USACE and Sonoma Water. 2004. Russian River Biological Assessment. Prepared by Entrix Inc. for: U.S. Army USACE of Engineers, San Francisco, CA and Sonoma County Water Agency, Santa Rosa, CA. Sept. 29, 2004.
USACE, NMFS, Sonoma Water, MCRRFCD. 1997. Memorandum of Understanding (MOU).
USACE. 1982. Northern California Streams Investigation Russian River Basin Study. Final Report. San Francisco, California. Volume 67 pages 1116-1133. January 9, 2002.

National Marine Fisheries Service. Final Rule: Governing Take of Four Threatened Evolutionarily Significant Units (ESUs) of West Coast Salmonids.
USACE. 1984. Warm Springs Dam and Lake Sonoma: Dry Creek, California: Water Control Manual, Appendix to Master Water Control Manual, Russian River Basin, CA. Sacramento District. September 1984.
USACE. 1986. Coyote Valley Dam and Lake Mendocino, Russian River, California: Water Control Manual. Appendix I to the Master Water Control manual, Russian River Basin, CA. August.
USACE. 1987. page 113. Gravel extraction leading to channel incision on Dry Creek.
USACE. 1991. WSD and Lake Sonoma Project, Russian River Basin, Dry Creek Channel Improvements, Sonoma County, California Operation and Maintenance Manual.
USACE. 1997. Russian River Ecosystem Restoration Reconnaissance Report Mendocino and Sonoma Counties, California. U.S. Army USACE. of Engineers, San Francisco District. September.
USACE. 1998. Exhibit A: Standing Instructions to the Project Operators for Water Control Warm Springs Dam, Lake Sonoma. Water Control Manual, Coyote Valley Dam Lake Mendocino. September.
USACE. 2023. Russian River Turbidity Assessment and Proposed Plan for Sonoma County and Mendocino County, California. Final Report with Addendum.
USACE. 2025. White v. United States Army Corps of Eng'rs, 3:22-cv-06143-JSC (N.D. Cal.) settlement - Supplement to U.S. Army Corps of Engineers' and Sonoma Water's Biological Assessment for the Russian River Watershed Water Supply and Channel Maintenance Project.
Veldhoen N, Ikonomou MG, Dubetz C, MacPherson N, Sampson T, Kelly BC, Helbing CC. 2010. Gene expression profiling and environmental contaminant assessment of migrating Pacific salmon in the Fraser River watershed of British Columbia. Aquatic Toxicology. 97(3):212–225.
Velez-Espino LA, Ford JKB, Araujo HA, Ellis G, Parken CK, Sharma R. 2014. Relative importance of Chinook salmon abundance on resident killer whale population growth and viability. Aquatic Conservation: Marine and Freshwater Ecosystems. 25(6):756-780.
Wallace, M. 2006. Juvenile salmonid use of freshwater slough and tidal portion of freshwater creek, Humboldt Bay, California; 2003 Annual Report. California Department of Fish and Game.
Wallace, M., S. Ricker, J. Garwood, A. Frimodig and S. Allen. 2015. Importance of the stream-estuary ecotone to juvenile coho salmon (*Oncorhynchus kisutch*) in Humboldt Bay, California. California Fish and Game 101(4): 241-266.
Waples, R.S. 1991. Genetic interactions between hatchery and wild salmonids: lessons from the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences 48 (supplement 1):124-133.
Ward E, and Satterthwaite W. 2020. Power analyses for Southern Resident killer whale demographic modeling. NOAA NMFS White Paper.
Ward, E.J., Ford, M.J., Kope, R.G., Ford, J.K.B., Velez-Espino, L.A., Parken, C.K., LaVoy, L.W., Hanson, M.B., and Balcomb, K.C. 2013. Estimating the Impacts of Chinook Salmon Abundance and Prey Removal by Ocean Fishing on Southern Resident Killer Whale Population Dynamics. July 2013. U.S. Dept. Commer., NOAA Tech. Memo., NMFS-NWFSC-123. 85p.

Ward EJ, Holmes EE, Balcomb KC. 2009. Quantifying the effects of prey abundance on killer whale reproduction. Journal of Applied Ecology. 46(3):632-640.

Ward EJ. 2021. Southern Resident Killer Whale Population Status; Time Series of Reproductive Females. Accessed on April 2022.

Wargo Rub, A.M., Som, N.A., Henderson, M.J., Sandford, B.P., Van Doornik, D.M., Teel, D.J., Tennis, M.J., Langness, O.P., van der Leeuw, B.K. and Huff, D.D. 2019. Changes in adult Chinook salmon (*Oncorhynchus tshawytscha*) survival within the lower Columbia River amid increasing pinniped abundance. Canadian Journal of Fisheries and Aquatic Sciences, 76(10), pp.1862-1873.

Warlick AJ, Ylitalo GM, Neill SM, Hanson MB, Emmons C, Ward EJ. 2020. Using Bayesian stable isotope mixing models and generalized additive models to resolve diet changes for fish-eating killer whales Orcinus orca. Marine Ecology Progress Series. 649:189-200.

Wasser SK, Lundin JI, Ayres K, Seely E, Giles D, Balcomb K, Hempelmann J, Parsons K, Booth R. 2017. Population growth is limited by nutritional impacts on pregnancy success in endangered Southern Resident killer whales (*Orcinus orca*). PloS one. 12(6):1-22.

Weitkamp LA. 2010. Marine distributions of Chinook salmon from the west coast of North America determined by coded wire tag recoveries. Transactions of the American Fisheries Society. 139(1):147-170.

Welsh, H.H., Jr., Hodgson, G.R., Harvey, B.C. and Roche, M.F. 2001. Distribution of juvenile coho salmon in relation to water temperatures in tributaries of the Mattole River, California. North American Journal of Fisheries Management 21:464-470.

Westerling, A. L., B. P. Bryant, H. K. Preisler, T. P. Holmes, H. G. Hidalgo, T. Das, S. R. Shrestha. 2011. Climate change and growth scenarios for California wildfire. Climate Change 109(1):445-463.

Western, A.W., Nolan, J.B., Hughes, R.L., and I.C. O'Neill. 1998. Mixing behavior of density-stratified pools. Journal of Hydraulic Engineering: 280-287.

Wiles GJ. 2004. Washington State Status Report for the Killer Whale. March 2004. WDFW, Olympia, Washington. 120p.

Williams R, Lacy RC, Ashe E, Barrett-Lennard L, Brown TM, Gaydos JK, Gulland F, MacDuffee M, Nelson BW, Nielsen KA et al., 2024. Warning sign of an accelerating decline in critically endangered killer whales (*Orcinus orca*). Communications Earth & Environment. 5(1):173.

Williams, T. H., S. T. Lindley, B. C. Spence, and D. A. Boughton. 2011. Status Review Update For Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest. NOAA's National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, CA.

Williams, A. P., J. T. Abatzoglou, A. Gershunov, J. Guzman-Morales, D. A. Bishop, J. K. Balch, and D. P. Lettenmaier. 2019. Observed Impacts of Anthropogenic Climate Change on Wildfire in California. Earth's Future 7, 892–910. https://doi.org/10.1029/2019EF001210.

Williams, A.P., B. I. Cook, and J. E. Smerdon. 2022. Rapid intensification of the emerging southwestern North American megadrought in 2020–2021. Nature Climate Change. Vol 12, March, 232–234.

Williams, A.P., E. R. Cook, J. E. Smerdon, B. I. Cook, J. T. Abatzoglou, K. Bolles, S. H. Baek, A. M. Badger, and B. Livneh. 2020. Large contribution from anthropogenic warming to an emerging North American megadrought. Science 268, 314-318. April 17.

Williams, T.H., B.C. Spence, D.A. Boughton, R.C. Johnson, L. Crozier, N. Mantua, M. O'Farrell, and S.T. Lindley. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. 2 February 2016 Report to National Marine Fisheries Service – West Coast Region from Southwest Fisheries Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California 95060.

Williamson K, and Hillemeier D. 2001. An assessment of pinniped predation upon fall-run Chinook salmon in the Klamath River estuary, CA, 1999. Yurok Tribal Fisheries Program Technical Report, Klamath, CA, pp 50

Wright B.E., Riemer S.D., Brown R.F., Ougzin A.M., and Bucklin K.A. 2007. Assessment of harbor seal predation on adult salmonids in a Pacific Northwest estuary. Ecol Appl 17:338–351

Zamon JE, Guy TJ, Balcomb K, Ellifrit D. 2007. Winter observations of Southern Resident Killer Whales *(Orcinus orca*) near the Columbia River plume during the 2005 spring Chinook salmon (*Oncorhynchus tshawytscha*) spawning migration. Northwestern Naturalist. 88(3):193-198.

Zedonis, P. A. 1992. The biology of the juvenile steelhead (*Oncorhynchus mykiss*) in the Mattole River Estuary/Lagoon, California. M.S. thesis, Humboldt State University, Arcata, CA. 77 pp.

B. Federal Register Notices

50 CFR 222. General Endangered and Threatened Marine Species. 64 FR 14054. Mar. 23, 1999.

50 CFR 226. Designated Critical Habitat.

50 CFR 402. Interagency Cooperation - Endangered Species Act of 1973, as Amended; Final Rule. 51 FR 19957. June 3, 1986.

50 CFR 424. Listing Endangered and Threatened Species and Designating Critical Habitat; Amended Procedures to Comply with the 1982 Amendments to the Endangered Species Act. 49 FR 38908. October 1, 1984.

50 CFR 600. Magnuson Act Provisions; Consolidation and Update of Regulations; Collection-of-Information Approval. 61 FR 32538. June 24, 1996.

62 FR 24588. Endangered and threatened species; threatened status for southern Oregon/northern California coast coho salmon ESU. Federal Register 62:24588-24609. 1997.

64 FR 24049. National Marine Fisheries Service. Final Rule and Correction: Designated Critical Habitat for Central California Coast Coho and Southern Oregon/Northern California Coast Coho Salmon. Federal Register 64: 24049-24062. May 5, 1999.

64 FR 50394: Endangered and Threatened Species; Threatened Status for Two Chinook Salmon Evolutionarily Significant Units (ESUs) in California; Final Rule. Federal Register 64: 50394-50415

69 FR 33102, Final Rule: Endangered and Threatened Species: Proposed Listing Determinations for 27 ESUs of West Coast Salmonids. June 14, 2004

70 FR 37159; Final Rule: Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. June 28, 2005

70 FR 37160. Endangered and Threatened Species: Final Listing Determination for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs. Federal Register 70: 37160- 37204. June 28, 2005.

70 FR 37204. Policy on the Consideration of Hatchery-Origin Fish in Endangered Species Act Listing Determinations for Pacific Salmon and Steelhead. 50 CFR 223, 224. June 28, 2005.
70 FR 52488: Endangered and Threatened Species; Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California; Final Rule. Federal Register 70:52488-52536. September 2, 2005.
70 FR 69903. Endangered and Threatened Wildlife and Plants: Endangered Status for Southern Resident Killer Whales. November 18, 2005.
71 FR 834: National Marine Fisheries Service. Final rule: Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead. Federal Register 71:834-862. January 5, 2006.
71 FR 69054. Endangered and Threatened Species; Designation of Critical Habitat for Southern Resident Killer Whale. November 29, 2006
77 FR 19552: Endangered and Threatened Species; Range Extension for Endangered Central California Coast Coho Salmon. Federal Register 77: 19521–19924. April 2, 2012.
80 FR 7380: Listing Endangered or Threatened Species: Amendment to the Endangered Species Act Listing of the Southern Resident Killer Whale Distinct Population Segment. Federal Register 80: 7380-7390. February 10, 2015.
81 FR 7414. Listing Endangered and Threatened Species and Designating Critical Habitat; Implementing Changes to the Regulations for Designating Critical Habitat. February 11, 2016.
84 FR 44976. Endangered and Threatened Wildlife and Plants; Regulations for Interagency Cooperation. August 27, 2019.
85 FR 81822: Final Rule: Revisions to Hatchery Programs Included as Part of Pacific Salmon and Steelhead Species Listed Under the Endangered Species Act. Federal Register 85: 81822-81837. December 17, 2020
86 FR 41668: Endangered and Threatened Wildlife and Plants; Revision of Critical Habitat for the Southern Resident Killer Whale Distinct Population Segment. Federal Register 86: 41668-41698. August 2, 2021.

C. Personal Communications

B. Cluer, NMFS personal communication, February, 2007
S. Cannata, CDFW personal communication, December 2004
T. Daugherty, NMFS personal communication, 2023
E. Ettlinger personal communication, 2025
M. Kittel, CDFW personal communication
J. McKeon, NMFS personal communication, 2008
J. Martini-Lamb, Sonoma Water personal communication, 2025
J. Smith, Sonoma Water personal communication, 2025
M. Obedzinski, CSG unpublished data
M. Obedzinski, CSG personal communication, 2023
S. White, Sonoma Water personal communication, January 3, 2007

APPENDIX A

Anticipated Take from to the Proposed Action's Monitoring and Research Activities in the Russian River Watershed

Appendix A. Anticipated take of CCC coho salmon, CC Chinook salmon, and CCC steelhead in the Russian River watershed due to the implementation of the Proposed Actions' monitoring and research activities.

Location	Capture Method	Species	Life Stage	Origin	Proposed Take	Unintentional Mortality	Procedure	Project Element(s)
Dry Creek	DSMT	Chinook salmon	smolt	natural	30,000	900	capture, anesthetize, handle, fin clip, release	salmonid migration monitoring
Dry Creek	DSMT	Chinook salmon	smolt	natural	1,000	30	acoustic tag	salmonid migration monitoring, reservoir operations (survival study)
Dry Creek	DSMT	Chinook salmon	smolt	natural	10,000	300	PIT tag	salmonid migration monitoring, reservoir operations (survival study)
Mirabel	DSMT	Chinook salmon	smolt	natural	30,000	900	capture, anesthetize, handle, fin clip, release	estuary management, salmonid migration monitoring
Mirabel	DSMT	Chinook salmon	smolt	natural	1,000	30	acoustic tag	estuary management, salmonid migration monitoring
Mirabel	DSMT	Chinook salmon	smolt	natural	10,000	300	PIT tag	estuary management, salmonid migration monitoring
lower river tribs	DSMT	Chinook salmon	smolt	natural	10,000	300	capture, anesthetize, handle, fin clip, release	estuary management, salmonid migration monitoring
lower river tribs	DSMT	Chinook salmon	smolt	natural	100	3	acoustic tag	estuary management, salmonid migration monitoring
lower river tribs	DSMT	Chinook salmon	smolt	natural	1,000	30	PIT tag	estuary management, salmonid migration monitoring
Dry Creek	DSMT	Coho salmon	smolt/juvenile	natural	5,000	50	capture, anesthetize, handle, fin clip, release	salmonid migration monitoring, Dry Creek habitat enhancement
Dry Creek	DSMT	Coho salmon	smolt/juvenile	hatchery	20,000	200	capture, anesthetize, handle, fin clip, release	salmonid migration monitoring, Dry Creek habitat enhancement
Dry Creek	DSMT	Coho salmon	smolt	hatchery	1,000	10	acoustic tag	salmonid migration monitoring
Dry Creek	DSMT	Coho salmon	smolt	natural	1,000	10	PIT tag	salmonid migration monitoring
Dry Creek	DSMT	Coho salmon	smolt	hatchery	3,000	30	PIT tag	salmonid migration monitoring
Mirabel	DSMT	Coho salmon	smolt/juvenile	natural	5,000	50	capture, anesthetize, handle, fin clip, release	estuary management, salmonid migration monitoring
Mirabel	DSMT	Coho salmon	smolt/juvenile	hatchery	10,000	100	capture, anesthetize, handle, fin clip, release	estuary management, salmonid migration monitoring
Mirabel	DSMT	Coho salmon	smolt	hatchery	1,000	10	acoustic tag	estuary management, salmonid migration monitoring

Location	Capture Method	Species	Life Stage	Origin	Proposed Take	Unintentional Mortality	Procedure	Project Element(s)
Mirabel	DSMT	Coho salmon	smolt	natural	1,000	10	PIT tag	estuary management, salmonid migration monitoring
Mirabel	DSMT	Coho salmon	smolt	hatchery	3,000	30	PIT tag	estuary management, salmonid migration monitoring
lower river tribs	DSMT	Coho salmon	smolt/juvenile	natural	5,000	50	capture, anesthetize, handle, fin clip, release	estuary management, salmonid migration monitoring
lower river tribs	DSMT	Coho salmon	smolt/juvenile	hatchery	10,000	100	capture, anesthetize, handle, fin clip, release	estuary management, salmonid migration monitoring
lower river tribs	DSMT	Coho salmon	smolt	hatchery	1,000	10	acoustic tag	estuary management, salmonid migration monitoring
lower river tribs	DSMT	Coho salmon	smolt	natural	1,000	10	PIT tag	estuary management, salmonid migration monitoring
lower river tribs	DSMT	Coho salmon	smolt	hatchery	3,000	30	PIT tag	estuary management, salmonid migration monitoring
Dry Creek	DSMT	steelhead	smolt/juvenile	natural	20,000	600	capture, anesthetize, handle, fin clip, release	salmonid migration monitoring, Dry Creek habitat enhancement
Dry Creek	DSMT	steelhead	smolt	hatchery	2,000	60	capture, anesthetize, handle, fin clip, release	salmonid migration monitoring, Dry Creek habitat enhancement
Dry Creek	DSMT	steelhead	smolt	hatchery	500	15	acoustic tag	salmonid migration monitoring
Dry Creek	DSMT	steelhead	juvenile	natural	10,000	300	PIT tag	salmonid migration monitoring
Dry Creek	DSMT	steelhead	adult	natural	5	0	capture, release	salmonid migration monitoring, Dry Creek habitat enhancement
Dry Creek	DSMT	steelhead	adult	hatchery	5	0	capture, release	salmonid migration monitoring, Dry Creek habitat enhancement
Mirabel	DSMT	steelhead	smolt/juvenile	natural	20,000	600	capture, anesthetize, handle, fin clip, release	estuary management, salmonid migration monitoring
Mirabel	DSMT	steelhead	smolt	hatchery	6,000	180	capture, anesthetize, handle, fin clip, release	estuary management, salmonid migration monitoring
Mirabel	DSMT	steelhead	smolt	hatchery	500	15	acoustic tag	estuary management, salmonid migration monitoring
Mirabel	DSMT	steelhead	juvenile	natural	10,000	300	PIT tag	estuary management, salmonid migration monitoring
Mirabel	DSMT	steelhead	adult	natural	5	0	capture, release	estuary management, salmonid migration monitoring
Mirabel	DSMT	steelhead	adult	hatchery	5	0	capture, release	estuary management, salmonid migration monitoring

Location	Capture Method	Species	Life Stage	Origin	Proposed Take	Unintentional Mortality	Procedure	Project Element(s)
lower river tribs	DSMT	steelhead	smolt/juvenile	natural	20,000	600	capture, anesthetize, handle, fin clip, release	estuary management, salmonid migration monitoring
lower river tribs	DSMT	steelhead	smolt	hatchery	2,000	60	capture, anesthetize, handle, fin clip, release	estuary management, salmonid migration monitoring
lower river tribs	DSMT	steelhead	smolt	hatchery	500	15	acoustic tag	estuary management, salmonid migration monitoring
lower river tribs	DSMT	steelhead	juvenile	natural	10,000	300	PIT tag	estuary management, salmonid migration monitoring
lower river tribs	DSMT	steelhead	adult	natural	15	0	capture, release	estuary management, salmonid migration monitoring
lower river tribs	DSMT	steelhead	adult	hatchery	15	0	capture, release	estuary management, salmonid migration monitoring
Dry Creek	backpack electrofish/ seine	Coho salmon	juvenile	natural	10,000	100	capture, anesthetize, handle, fin clip, release	Dry Creek habitat enhancement
Dry Creek	backpack electrofish/ seine	Coho salmon	juvenile	hatchery	30,000	300	capture, anesthetize, handle, fin clip, release	Dry Creek habitat enhancement
Dry Creek	backpack electrofish/ seine	Coho salmon	juvenile	hatchery	100	1	acoustic tag	Dry Creek habitat enhancement
Dry Creek	backpack electrofish/ seine	Coho salmon	juvenile	natural	1,000	10	PIT tag	Dry Creek habitat enhancement
Dry Creek	backpack electrofish/ seine	Coho salmon	juvenile	hatchery	3,000	30	PIT tag	Dry Creek habitat enhancement
Dry Creek	backpack electrofish/ seine	steelhead	juvenile	natural	10,000	300	capture, anesthetize, handle, fin clip, release	Dry Creek habitat enhancement
Dry Creek	backpack electrofish/ seine	steelhead	juvenile	natural	100	3	acoustic tag	Dry Creek habitat enhancement
Dry Creek	backpack electrofish/ seine	steelhead	juvenile	natural	5,000	150	PIT tag	Dry Creek habitat enhancement
Dry Creek	backpack electrofish/ seine	Chinook salmon	smolt	natural	100	3	capture, anesthetize, handle, release	Dry Creek habitat enhancement
Dry Creek	snorkel	Coho salmon	smolt/juvenile	natural/hatchery	10,000	na	observe	Dry Creek habitat enhancement

Location	Capture Method	Species	Life Stage	Origin	Proposed Take	Unintentional Mortality	Procedure	Project Element(s)
Dry Creek	snorkel	steelhead	smolt/juvenile	natural/hatchery	10,000	na	observe	Dry Creek habitat enhancement
Dry Creek	spawning ground survey	Chinook salmon	adult/jack	natural/hatchery	2,000	na	observe	reservoir operations (TUCPs)
Dry Creek	spawning ground survey	Coho salmon	adult/jack	natural/hatchery	1,000	na	observe	reservoir operations (TUCPs)
Dry Creek	spawning ground survey	steelhead	adult/jack	natural/hatchery	1,000	na	observe	reservoir operations (TUCPs)
Upper Russian	spawning ground survey	Chinook salmon	adult/jack	natural/hatchery	2,000	na	observe	reservoir operations (TUCPs)
Upper Russian	spawning ground survey	Coho salmon	adult/jack	natural/hatchery	1,000	na	observe	reservoir operations (TUCPs)
Upper Russian	spawning ground survey	steelhead	adult/jack	natural/hatchery	1,000	na	observe	reservoir operations (TUCPs)
Mirabel	video	Chinook salmon	adult/jack	natural/hatchery	20,000	na	observe	reservoir operations (TUCPs, survival study), salmonid migration monitoring
Mirabel	video	Coho salmon	adult/jack	natural/hatchery	5,000	na	observe	reservoir operations (TUCPs, survival study), salmonid migration monitoring
Mirabel	video	steelhead	adult/jack	natural/hatchery	10,000	na	observe	reservoir operations (TUCPs, survival study), salmonid migration monitoring
(direct from hatchery)	na	Coho salmon	smolt	hatchery	1,000	10	acoustic, radio, PIT tag, release	reservoir operations (survival study)
(direct from hatchery)	na	steelhead	smolt	hatchery	1,000	30	acoustic, radio, PIT tag, release	reservoir operations (survival study)
Lower Russian	seine, boat efish, hook and line, gill net, tangle net, fyke trap	Chinook salmon	smolt	natural	500	15	capture, release	reservoir operations (survival study)
Lower Russian	seine, boat efish, hook and line, gill net, tangle net, fyke trap	Coho salmon	smolt	natural	100	1	capture, release	reservoir operations (survival study)

Location	Capture Method	Species	Life Stage	Origin	Proposed Take	Unintentional Mortality	Procedure	Project Element(s)
Lower Russian	seine, boat efish, hook and line, gill net, tangle net, fyke trap	Coho salmon	smolt	hatchery	200	2	capture, release	reservoir operations (survival study)
Lower Russian	seine, boat efish, hook and line, gill net, tangle net, fyke trap	steelhead	smolt	natural	200	6	capture, release	reservoir operations (survival study)
Lower Russian	seine, boat efish, hook and line, gill net, tangle net, fyke trap	steelhead	smolt	hatchery	100	3	capture, release	reservoir operations (survival study)
Lower Russian	seine, boat efish, hook and line, gill net, tangle net, fyke trap	steelhead	adult	natural	5	0	capture, release	reservoir operations (survival study)
Lower Russian	seine, boat efish, hook and line, gill net, tangle net, fyke trap	steelhead	adult	hatchery	5	0	capture, release	reservoir operations (survival study)
Lower Russian	snorkel	Chinook salmon	smolt	natural	500	na	observe	reservoir operations (survival study)
Lower Russian	snorkel	Coho salmon	smolt	natural/ hatchery	500	na	observe	reservoir operations (survival study)
Lower Russian	snorkel	steelhead	smolt	natural/ hatchery	500	na	observe	reservoir operations (survival study)
Estuary	seine	Chinook salmon	smolt/juvenile	natural	2,000	60	capture, anesthetize, handle, fin clip, release	estuary management (habitat enhancement monitoring
Estuary	seine	Chinook salmon	smolt/juvenile	natural	1,000	30	PIT tag	estuary management (habitat enhancement monitoring

Location	Capture Method	Species	Life Stage	Origin	Proposed Take	Unintentional Mortality	Procedure	Project Element(s)
Estuary	seine	Chinook salmon	smolt/juvenile	natural	100	3	acoustic tag	estuary management (habitat enhancement monitoring
Estuary	seine	Coho salmon	smolt/juvenile	natural	500	5	capture, anesthetize, handle, fin clip, release	estuary management (habitat enhancement monitoring
Estuary	seine	Coho salmon	smolt/juvenile	hatchery	1,500	15	capture, anesthetize, handle, fin clip, release	estuary management (habitat enhancement monitoring
Estuary	seine	Coho salmon	smolt/juvenile	natural	250	2	PIT tag	estuary management (habitat enhancement monitoring

Appendix A (continued). Anticipated take of CCC coho salmon, CC Chinook salmon, and CCC steelhead in the Russian River watershed due to the implementation of the Proposed Action's monitoring and research activities.

APPENDIX B

Best Management Practices for Avoiding and Minimizing Effects to Federally-listed Salmonids

Work Window

All ground-disturbing maintenance and restoration activities occurring in the channel (i.e., from top-of-bank to top-of-bank) will take place during the low-flow period, between June 15 and October 31. Exceptions may be made for emergencies or on a project-by-project basis with advance approval from North Coast Regional Water Quality Control Board (NCRWQCB), CDFW, NMFS, and/or USFWS as appropriate.

Prior to significant rainfall, all in-channel equipment and/or diversion structures shall be removed. Exposed soils in upland areas will be stabilized via hydroseeding or with erosion control fabric/blankets. Significant rainfall is defined as 0.5 inch of rain in a 24-hour period.

Work on the upper streambanks of stream channels (e.g., vegetation, road, and v-ditch maintenance) may be conducted year-round as long as erosion and spill BMPs are implemented. Ground disturbing activities will only be conducted during periods of dry weather.

No work will be started that cannot be completed before the onset of a storm event.

Sediment Removal and Debris Clearing

Sediment and debris removal during channel maintenance activities will only be conducted if required to restore hydraulic capacity or prevent severe streambank erosion.

If vegetation removal is required, two- to four-person crews will clear brush by hand with chainsaws and loppers. In heavy brush, a chipper will be used to break up the slash so that it can be disposed of, rather than leaving it to decay in the stream. Larger material will be cut into shorter lengths and removed from the site. Woody material will be cut up and pulled out by a truck with a winch. Trees and limbs would be removed from the stream channel only if required for flood protection. While planting native vegetation will not be a standard practice during channel maintenance activities, occasionally native tree planting projects by volunteer groups will be coordinated or permitted by Sonoma Water.

LWD that are fully or partially buried and do not present a flood hazard shall be allowed to remain in place to provide habitat and to maintain streambank stability. Removal of logs and debris from streams will be a “last resort” when accumulation of debris poses a threat to stability of structures including roads, bridges, and culverts.

Modifications and/or removal of LWD will be limited to material that extends higher than ~approximately 2 ft above the streambed to preserve some instream habitat features unless the log or debris jam is immediately upstream and threatening a culvert or bridge.

Vegetation Management

Mechanical removal is the primary method for managing problematic vegetation. Herbicides will be used only outside of water and minimized to the smallest amount necessary to be effective and only applied above the ordinary high-water mark.

All herbicide use shall be consistent with all Federal Insecticide, Fungicide, and Rodenticide Act label instructions and any use conditions issued by the Sonoma County Agricultural Commissioner.

Application of herbicides to upland areas shall not be made within 72 hours of predicted rainfall.

As required by the Court-Ordered Stipulated Injunction for pesticide use near Pacific salmon-supporting waters in Sonoma County, pesticides specified in the injunction including 1,3-dichloropropene, bromoxynil, carbaryl, chlorpyrifos, diazinon, malathion, methomyl, metolachlor, and prometryn, will not be used within 20 yards of salmon-supporting waters. Sonoma Water will review the details and exceptions in the court order and comply with the herbicide use buffers as appropriate.

Maintenance will consist of clearing vegetation to restore hydraulic capacity. Hand labor using hand tools is the typical clearing method. Heavy equipment will only be used to lift out or clear debris jams not accessible to or too large for hand crews. In areas with mature riparian canopies, some vegetation understory along the channel streambanks and in the main channel that could substantially reduce hydraulic capacity will be removed by mowing (upper third) or hand clearing, as needed.

Native riparian vegetation will not be removed unless it presents a significant flood risk.

Vegetation pruning and removal activities will be conducted under the guidance of a staff biologist, certified arborist, or other vegetation specialist who will be on site to help direct maintenance activities and to consult if questions and/or issues arise.

Vegetation that is noxious, invasive, hazardous, a public safety or fire concern, or could obstruct channel flows will be removed as appropriate. Herbaceous layers that provide erosion protection and habitat value will be left in place. Invasive plant species that inhibit the health and/or growth of native riparian trees will be targeted for removal.

Revegetation shall be regularly monitored for survival at five years or until minimum survival/cover is achieved. If invasive species colonize the area, action shall be taken to control their spread; options include hand and mechanical removal and replanting with native species.

Streambank Stabilization

The repair and stabilization of streambanks is only undertaken when a streambank is weakened, unstable, or failing. These activities will be initiated only by a request from a private landowner after a washout threatens property or structures and would only be initiated in coordination with CDFW.

Streambank stabilization or sediment removal activities will not occur if more than 1,000 ft of channel will be affected by any single project. A separate ESA Section 7 consultation will be initiated for actions that affect more than 1,000 ft of channel, occur more than once every 5 years, or will be within 1,000 ft of a previously armored site.

As part of streambank stabilization efforts, it may also be necessary to remove deposited sediments or vegetation growing on gravel bars. Preference will be given to thinning vegetation on gravel bars, which allows gravel to move over time so that it does not have to be excavated with heavy equipment. While targeted gravel bar removal is not proposed, it may be necessary to remove small amounts of gravel that have deposited within constructed habitat features as-needed to maintain flow and function of those features. If LWD is present in the excavated sediment deposits, it will be removed from the stream only if it threatens to de-stabilize a section of streambank. Otherwise, the LWD will be allowed to remain in the channel. On occasion, it is preferable to straighten a short portion of the channel by cutting off a meander instead of excavating the bar sediments if the streambank cannot be sufficiently stabilized by other means. If this realignment practice is used, mitigating for lost habitat by incorporating native material revetments will be considered.

Staging and Stockpiling of Materials

Staging will occur on access roads, surface streets, or other disturbed areas that are already compacted and only support ruderal vegetation to the extent feasible. Similarly, to the extent practical, all maintenance equipment and materials (e.g., road rock and project spoil) will be contained within the existing service roads, paved roads, or other pre-determined staging areas. Staging areas for equipment, personnel, vehicle parking, and material storage shall be sited as far as possible from major roadways.

All maintenance-related items including equipment, stockpiled material, temporary erosion control treatments, and trash, will be removed within 72 hours of project completion. All residual soils and/or materials will be cleared from the project site.

As necessary, to prevent sediment-laden water from being released back into waters of the State during transport of spoils to disposal locations, truck beds will be lined with an impervious material (e.g., plastic), or the tailgate blocked with wattles, hay bales, or other appropriate filtration material. If appropriate, and only within the active project area where the sediment is being loaded into the trucks, trucks may drain excess water by slightly tilting the loads and allowing the water to drain out through the applied filter.

Building materials and other maintenance-related materials, including chemicals and sediment, will not be stockpiled, or stored where they could spill into water bodies or storm drains or where they will cover aquatic or riparian vegetation.
No runoff from the staging areas will be allowed to enter waters of the State, including the creek channel or storm drains, without being subjected to adequate filtration (e.g., vegetated buffer, hay wattles or bales, silt screens). The discharge of decant water from any on-site temporary sediment stockpile or storage areas to waters of the State, including surface waters or surface water drainage courses, outside of the active project site, is prohibited.

During dry season, no stockpiled soils shall remain exposed and unworked for more than 30 days. During wet season, no stockpiled soils shall remain exposed, unless surrounded by properly installed and maintained silt fencing or other means of erosion control.

All spoils will be disposed of in an approved location. Sediments that are found to contain contaminants exceeding hazardous materials disposal criteria will be stockpiled separately on heavy plastic pending disposal at an appropriate hazardous materials disposal location.

Channel Access

Access points to the channel will be minimized according to need. Access points should avoid large mature trees, native vegetation, or other significant habitat features as possible. Temporary access points shall be sited and constructed to minimize tree removal.

In considering channel access routes, slopes of greater than 20 percent shall be avoided if possible. Any sloped access points will be examined for evidence of instability and either revegetated or filled with compacted soil, seeded, and stabilized with erosion control fabric as necessary to prevent future erosion.

Water Quality and Channel Protection

Upland soils exposed due to maintenance activities will be seeded and stabilized using erosion control fabric or hydroseeding. The channel bed and other areas below ordinary high-water mark are exempt from this BMP.

Erosion control fabric will consist of natural fibers that will biodegrade over time. No plastic or other non-porous material will be used as part of a permanent erosion control approach. Plastic sheeting may be used to temporarily protect a slope from runoff, but only if there are no indications that special-status species would not be impacted by the application.

The site will be properly prepared to make sure the fabric/mat has complete contact with the soil. Sites can be prepared by grading and shaping the installation area; removing all rocks, dirt clods, vegetation, etc.; preparing the seedbed by loosening the top 2 to 3 inches of soil; and applying soil amendments as directed by soil tests, the seeding plan, and manufacturer's recommendations.

The area will be seeded before installing the fabric. All areas disturbed during installation will be re-seeded.

Erosion control fabric will be anchored in place. Anchors can include U-shaped wire staples; metal geotextiles stake pins or triangular wooden stakes.

Other erosion control measures shall be implemented as necessary to ensure that sediment or other contaminants do not reach surface water bodies for stockpiled or reused/disposed sediments.

After sediment removal, the channel shall be graded so that the transition between the existing channel both upstream and downstream is smooth and continuous between the maintained and non-maintained areas and does not present a “wall” of sediment or other blockage that could erode once flows are restored to the channel.

Where pre-maintenance channel form exhibited desirable features, the channel bed will be regraded to mimic the channel form before work was conducted.

Where possible, grading may include channel enhancements such as excavation of a low flow channel, development of a meander, or riffle/pool configurations.

If gravels that have the potential to be utilized for spawning are removed to conduct maintenance activities, the gravels will be carefully removed and stored where maintenance activities will not impact the quality of the gravel. The gravel shall be replaced as close to original conditions as possible upon completion of the maintenance activities. Site selection and instream gravel placement will be implemented in coordination with NMFS and CDFW.

Where in-stream gravel and gravel (or cobble) bars are encountered, sediment removal activities will aim to preserve the overall shape and form of the existing bar or gravel feature.

Construction equipment used within the creek channels will be checked each day prior to work within the creek channel (top of bank to top of bank) and, if necessary, action will be taken to prevent fluid leaks. If leaks occur during work in the channel (top of bank to top of bank), the spill will be contained and affected soils removed.

Salmonid Protection Measures

The USACE, Sonoma Water, and MCRRFD will retain qualified biologists with expertise in the area of anadromous salmonid biology, including handling, collecting, and relocating salmonids; salmonid/habitat relationships; and biological monitoring of salmonids for overseeing work performed within the Action Area. All biologists working on projects will be qualified to conduct fish collections in a manner which minimizes all potential risks to salmonids.

The biologists will monitor the construction sites during placement and removal of cofferdams and channel diversions to ensure that any adverse effects to salmonids are minimized. The biologists will be on site during all dewatering events to capture, handle, and safely relocate steelhead to an appropriate location.

Salmonids will be handled with extreme care and kept in water to the maximum extent possible during rescue activities. All captured fish will be kept in cool, shaded, aerated water protected from excessive noise, jostling, or overcrowding any time they are not in the stream, and fish will not be removed from this water except when released. To avoid predation, the biologists will have at least two containers and segregate YOY from larger age classes and other potential aquatic predators. Captured fish will be relocated, as soon as possible, to a suitable instream location in which suitable habitat conditions are present to allow for adequate survival of transported fish and fish already present.

All work areas located in aquatic habitat will be isolated from the flowing stream and relocate listed salmonids prior to proceeding with in-channel work for channel maintenance or habitat enhancement. The USACE, Sonoma Water, and MCRRFD will:

– Retain a qualified biologist with expertise in anadromous salmonid biology;
– ensure the biologist is onsite during all dewatering events;
– ensure all captured salmonids are properly cared for;
– contact the Santa Rosa Area NMFS and CDFW office immediately if any salmonids are found dead or injured; and
– allow NMFS and CDFW staff or persons designated by the resource agencies to be on-site during dewatering activities.

In the event that the channel is conveying flow or ponding water during proposed activities, the following dewatering and fish relocation measures will be implemented:

A cofferdam, pump station, and re-routing pipeline will be used to dewater a short section of channel at a time. The following dewatering measures will be employed:

– An inflatable cofferdam will be used primarily; however, under some circumstances (e.g., inside large culverts), the cofferdams will be constructed using sand or gravel;
– Pumping rates will be consistent with the existing stream flow to bypass water around the work site;
– Pump intake lines will be protected with screens according to NMFS and CDFW criteria to prevent the entrainment of aquatic species;
– Bypass flows will be released back into the channel near the downstream end of the project area; and.
– Silt bags will be used at the end of the diversion pipe to reduce any sediment discharge downstream and to dissipate flow velocity and prevent scour at the discharge site.

Before and during the dewatering of a work area, fish will be captured and relocated to avoid injury and mortality and minimize disturbance. The following guidelines will apply:

– Before fish relocation begins, a qualified biologist will identify the most appropriate release location(s). Release locations will have water temperatures within 1 degree Celsius (°C) of the capture location and offer ample habitat for released fish and should be selected to minimize the likelihood that fish will reenter the work area or become impinged on the exclusion net or screen.
– The means of capture will be site-dependent and will be selected by a qualified fish biologist who is experienced with fish capture and handling. Complex stream habitat may require the use of electrofishing equipment. Electrofishing will be conducted only by trained personnel following NMFS Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act, June 2000. See:

http://www.nwr.noaa.gov/ESA-Salmon-Regulations-Permits/4d-Rules/upload/electro2000.pdf.

- Handling of salmonids will be limited to permitted personnel. If necessary, personnel will wet hands or nets before touching fish.
- Any pumps used to divert live streamflow, outside the dewatered work areas, will be screened and maintained throughout the construction period to comply NOAA Fisheries' Juvenile Fish Screen Criteria for Pump Intakes (1996) See https://media.fisheries.noaa.gov/dam-migration/fish_screen_criteria_for_pumped_water_intakes.pdf.

Fish will be held temporarily in cool, shaded water in a container with a lid. Aeration will be provided with a battery-powered external bubbler. Fish will be protected from jostling and noise and will not be removed from the container until the time of release. A thermometer will be placed in each holding container and partial water changes will be conducted as necessary to maintain a stable water temperature. Fish will not be held for more than 30 minutes.

- If fish are abundant, capture will cease periodically to allow release and minimize the time fish spend in holding containers.
- Fish will not be anesthetized or measured but will be visually identified to species level, and year classes will be estimated and recorded.
- Any salmonids captured will be scanned for PIT and/or coded wire tags.
- When feasible, initial fish relocation efforts will be performed several days prior to the scheduled start of construction.
- Reports on fish relocation activities will be submitted to CDFW and NMFS in a timely fashion.
- If mortality during relocation exceeds 2 percent per species, relocation will cease and CDFW and NMFS will be contacted immediately or as soon as feasible.

Monitoring and Research Activities

DSMT (rotary screw trap) shall be checked every morning of operation at a minimum. Additionally, periods of peak migration, high flows, and/or debris levels during storm periods may require the traps to be checked more frequently to minimize associated mortality. Salmonids in the traps will be released after measurements and PIT tag implantation, as appropriate. All other fish will be released as soon as possible.

Fyke-net traps shall be checked at least twice per 24-hour period (or more frequently as conditions warrant) to remove captured fish and debris. Any salmonids found in the fyke nets will be released after measurements and PIT tag implantation, as appropriate by species and life history stage. All other fish will be released as soon as possible. Photographs of the downstream migrant fyke-net trap are required and must be submitted to NMFS within 2 days of operating the trap.

All ESA-listed juvenile salmonids captured within the estuary/lagoon will be held in holding buckets or livewells filled with debris-free clean water and equipped with battery powered aerators before and after handling. In addition to holding buckets and livewells, ESA-listed salmonids captured within the stream are also permitted to be held in live cars, which allow water flow-through with stream ambient oxygen and temperature levels. All listed salmonids will be allowed to recover fully before being released back into the water at or close to the location from which they were taken. Water temperatures must be documented within both the sampling and fish holding areas. All precautions will be taken by the researchers to prevent overcrowding in live cars, livewells, and holding buckets and any other excessive stressing of detained fish. Fish should not be detained for more than the minimum time required to collect the necessary data.

ESA-listed salmonids shall be handled with extreme care and kept in water to the maximum extent possible during sampling and processing procedures. When using gear that captures a mix of species, ESA-listed salmonids shall be processed first and be released as soon as possible after being captured to minimize the duration of handling stress.

When using anesthesia (MS-222 or Alka-Seltzer®), extreme care shall be taken to use the minimum amount of substance necessary to immobilize juvenile ESA-listed salmonids for handling and sampling procedures. It is the responsibility of the researcher to determine when anesthesia is necessary for handling and sampling juvenile ESA-listed salmonids.

In the event that debris (rocks, logs, abundant vegetation, etc,) are trapped within the beach seine, researchers will remove debris before fish are centralized in the net to prevent harm. Researchers will select the smallest mesh-size seine or dip-net that is appropriate to achieve sampling objectives while reducing the probability that smaller fish will become gilled in the net.

ESA-listed salmonids shall not be handled if stream temperatures at the capture site exceed 70 degrees Fahrenheit. Under these conditions, fish shall only be identified and counted.

Fin-clips that are collected from juvenile ESA-listed salmonids, as well as any tissues that are collected from juvenile ESA-listed salmonids that are unintentionally killed during research activities, shall be made available to NMFS upon request.

APPENDIX C

Technical Advisory Committees and Working Groups

- either developed or continuing as part of this Opinion

Title	Proposed Members	Tasks/Goals	Timelines
Survival Studies Work Group	Sonoma Water, NMFS, CDFW, USACE, and outside experts	*review data collected from the previous season and develop plans for the upcoming season *address the objectives of each study element of the proposed studies *Develop effective contingency measures to ensure impacts to listed salmonids are minimized. **Salmon and Steelhead Smolt Migration Survival and Travel Time**: Designed to estimate reach-specific smolt migration survival and migration time through the mainstem Russian River. **Piscivorous Fish: Distribution, Relative Abundance and Small-Scale Movement**: Designed to estimate the distribution and relative abundance of large piscivorous fish in the lower River. Based on data collected during the initial year of study and upon consultation with the Survival Studies Work Group, there may be a need to repeat this Study Element for more than 1 year to capture patterns that are related to hydrologic conditions. **Piscivorous Fish Habitat Characterization**: Designed to estimate the quantity and distribution of piscivorous fish habitat in the middle and lower mainstem Russian River. Sonoma Water plans to conduct this Study Element one time during the period covered by this Opinion with pilot studies occurring as needed.	*Meet Annually *Study to occur annually each smolt migration season during the 10-yr period of the Opinion

Title	Proposed Members	Tasks/Goals	Timelines
Reservoir Operations Work Group	Sonoma Water, USACE, NMFS, CDFW, and SWRCB *Sonoma Water proposes to defer to NMFS' recommendation, in coordination with the SWRCB and CDFW on the actions that will be taken with block water.	*Develop projections for Lake Mendocino and Lake Sonoma storage based on existing conditions and hydrologic forecasts to assess water supply that could be made available for a pulse release or a Blockwater release action *Determine the appropriate target blockwater/pulse flow release strategy and develop an operations plan including flow schedules (specific timing, magnitude, and duration of flows) to benefit salmonids.	*During winter/spring and fall Reservoir Operations Adaptive Management periods, the Reservoir Operations Group will communicate via regular conference calls and will share current information and forecasts via e-mail and/or an internet website. *The first meeting of this group will occur <u>within 4 months of issuance of this Opinion</u>, with additional meetings proceeding quarterly. *A draft of the plan will be provided to the Reservoir Operations Group <u>within 1 year of publication of this Opinion</u>. **Lake Mendocino Water Supply Pool Pulse Flow Adaptive Management**: Sonoma Water and USACE anticipate implementation of this action will occur following completion of the operations plan, or <u>within 2 years of issuance of this Opinion</u>. **Lake Sonoma Water Supply Pool Blockwater Release Adaptive Management**: Sonoma Water and USACE anticipate implementation of this action will occur following completion of the operations plan, or <u>within 2 years of issuance of this Opinion</u>.

Title	Proposed Members	Tasks/Goals	Timelines
Dry Creek Habitat Enhancement Alternatives Group	Sonoma Water, USACE, NMFS, and CDFW	*Review and coordinate on the feasibility evaluations for completion of Phase III of the Dry Creek Project. *Review and coordinate on the USACE approval processes required to make changes to the existing Dry Creek Project, and/or to participate in the development and implementation of alternatives at other locations in the Russian River watershed. *All Dry Creek Habitat Enhancement Alternatives Group coordination activities will be documented and reported in meeting minutes, briefing documents, and reports, including information regarding recommended pathways toward completion and schedules/timelines, and work plans.	*Formation of the Group within 2 months of the publication of this Opinion. *Establish feasibility decision point on Phase III of the Dry Creek Project within 4 months of the publication of the Opinion. *If Phase III actions are determined to be infeasible, initiate USACE process to modify the Dry Creek Project and seek approval to use existing funds to complete the modified project or initiate a separate new study/project process for alternatives to the Dry Creek Project in the Russian River watershed. *If applicable, within 6 months of publication of the Opinion, select a small-scale habitat enhancement project to be funded by Sonoma Water (to be implemented by others). *If applicable, within 2 years of publication of the Opinion, Sonoma Water will provide funding for implementation of a small-scale enhancement project (to be implemented by others). *If applicable, within 3 years of publication of the Opinion select a larger-scale preferred alternative enhancement site(s) for Sonoma Water and/or USACE development and implementation *If applicable, within 5 years of publication of the Opinion, Sonoma Water and/or USACE will provide funding and/or construction to implement a larger-scale habitat enhancement project.

Title	Proposed Members	Tasks/Goals	Timelines
Joint Monitoring Team (Dry Creek)	Sonoma Water, USACE, NMFS, and CDFW	*Decide which activity is appropriate if any of the constructed enhancement sites within Dry Creek suffers any damage or is not meeting objectives. *Sonoma Water will work with the JMT, to modify portions of the Dry Creek AMP to reflect Sonoma Water's current methods and experience (including, but not limited to revisions to the effectiveness rating standards).	*Meet annually, including site visits in the late spring/early summer.
Estuary AMP Team	Sonoma Water, NMFS, CDFW, and USACE	*Review recent water quality, fish monitoring, and water level conditions in the Estuary *Discuss any recent, current, or impending closure events as it relates to steps in the AMP decision tree *Provide updates on progress toward Estuary Habitat Enhancements	*Meet monthly to promote adaptive management of the beach, including site visits as needed. *Annually synthesize the past years' data and observations in the form of an annual report, and to update the Estuary AMP. The following, updated timeline on Sonoma Water's commitments to implement an approximately 3-acre habitat enhancement in the Estuary: **Feasibility Study**: Feasibility studies are anticipated to be initiated within 4 months and completed within 2 years of the publication of this Opinion. **Design and Permitting**: Within 5 years of publication of this Opinion, Sonoma Water anticipates completion of permitting and design on the selected enhancement site(s). However, the exact timetable for completion of these actions may vary depending on the site(s) selected. **Construction**: Sonoma Water anticipates that within 5 years of publication of this Opinion, funding for construction will be procured and within 8 years of publication, construction of the enhancement will be completed.

Title	Proposed Members	Tasks/Goals	Timelines
Russian River Turbidity TAC	USACE, NMFS, Sonoma Water, CDFW, NCRWQCB, two outside experts, and other entities identified in the MOU.	*Evaluate and develop potential implementable actions aimed at reducing turbidity in and discharged to the Russian River affecting listed salmonids. *Finalize the TAC charge *Review USACE's proposed turbidity monitoring locations. *Review historical and new turbidity data. *Determine the sources and magnitude of turbidity. *Determine the magnitude and extent of turbidity impacts. *Identify and evaluate solutions. * See Section 1.3.1.3.3 for additional USACE proposed activities either in combination with or independently from the TAC.	*The USACE is establishing an online repository for continuous turbidity data collected. Data will be uploaded no less often than quarterly. A link will be provided to NMFS to access this data within the first 2 months of the issuance of this Opinion. *Conduct a bathymetric survey of Lake Mendocino within 2 years of issuance of this Opinion. *A plan to complete or adjust installation of turbidity meters by December 31, 2025. *Within 1 year of the issuance of this Opinion, develop a plan to maintain, report, and provide accessible (online) turbidity data using USGS guidelines for the duration of the Opinion and provide annual reporting of the analysis of the data to NMFS. *Within 1 year of the issuance of this Opinion, develop a plan to analyze the data to determine if flood control and/or waters supply operations contribute to an increase in turbidity that impacts rearing and spawning habitat in the Upper River between CVD and Jimtown. *Should turbidity data and the analysis confirm that impacts to listed species are likely to occur or indicate effects are worse than expected, the USACE shall provide a draft plan to minimize and avoid these effects to NMFS for review no later than July 1, 2030. *Within 1 year of the issuance of this Opinion, the USACe will meet with the TAC to plan the Short-Term Turbidity Reduction Actions detailed in Section 1.3.1.3.5.